REU Final Presentation

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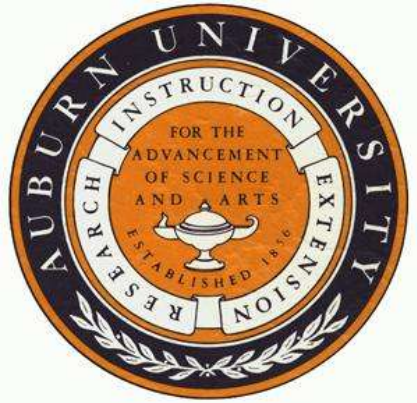


Mission

- Network the Planes and the Ground Control Station (GCS)
  - Planes have AVR microcontrollers (ArduPilot)
  - GCS is an x86 PC (probably running Linux)
- **NEW!!!** Analyze the performance of ZigBee mesh networks

It’s a Bird, it’s a Plane, Oh Wait It’s a Plane

- Completed ArduPilot ↔ XBee interfacing
- Completed GCS ↔ UAV communication
- Over the past two weeks:
  - Major GCS upgrades
    - Fixed CPU usage bug
    - Cleaned up thread synchronization
    - Switched to a logging system (log4j)
    - Added a GUI for arbitrary waypoint loading
    - Integrated collision avoidance code

ArduPilot Joys…

- Software Upgrade
  - Easily merged changes with new ArduPilot 2.6.2
- Testing
  - ArduPilot default mode issues
  - Poor bank angle
    - PID configuration
  - Google Earth flight mapping

Test Flight at the Beach

July 1, 2010

Research

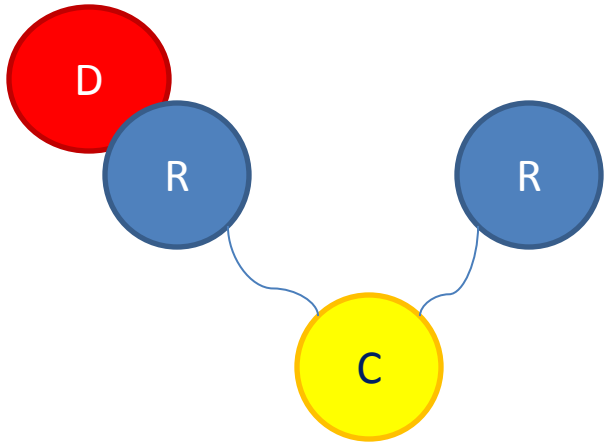
- Performance of a ZigBee PRO mesh network
  - Point-to-Point and Multi-Hop
- Effects of:
  - Moving nodes
  - ~~WLAN interference (AU WiFi)~~

Hypotheseis

- Moving nodes
  - Lots of link failures imply lots of path discovery operations
  - Should show an increase in latency

Experimental Setup

- Benchmark Java programs to send and receive packets using Andrew Rapp's xbee-api
  - In most tests, sent 3 sets of 1000 packets
- Point-to-Point Setup
  - 1.5 meters apart, modules connected to PCs
- Multi-Hop Setup
  - Middle 20 meters away from Source
  - Antenna-less Destination
- Moving Node Setup
  - "Instantaneous" movement
  - Gradual Transition



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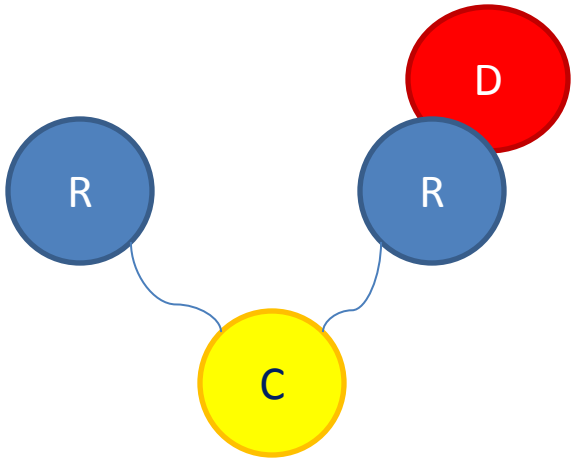
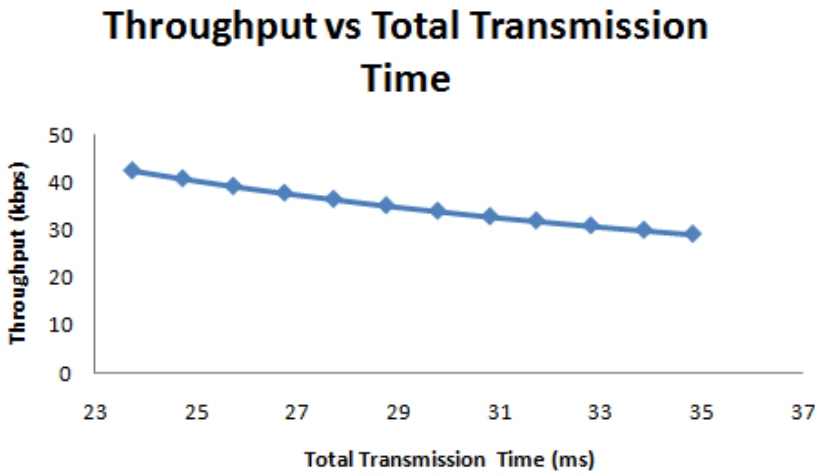
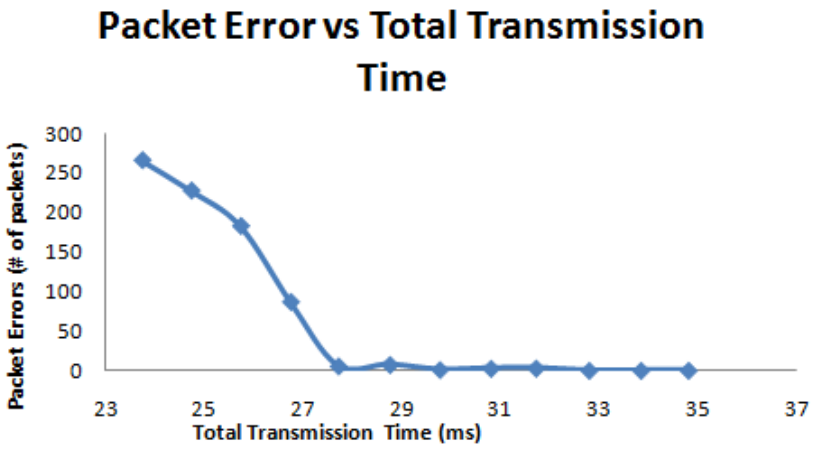


Point-to-Point and Multi-Hop Results

Setup	Average Transmission Time (ms)	Error (# packets)	RSSI (dBm)	Throughput (kbps)
PtP-Sync	39.65	0	-41.33	25.67
PtP-Sync-AT	31.86	0	-39.00	31.90
PtP-Sync-noACK	22.06	0	-42.33	45.96
MH-Sync	58.62	0	-84.33	17.44
MH-Sync-noACK	42.13	9	-86.67	24.56
MH-Sync-no-16bit	62.53	0	-81.67	16.39

Asynchronous Point-to-Point Results





Moving Nodes Results

- “Instantaneous” Movement
  - Packet loss. Lots of it.
  - Network Status Command Frames and Neighbor Tables just not fast enough
    - They update if we wait 15 seconds though…
- Gradual Transition
  - Slightly less throughput
  - Higher latency at fringes, i.e. transition points

Conclusions

- So moving 2 miles in 15 seconds is a tad ridiculous…
  - But real concern with lower power modules and indoor environments
- Many-to-one routing is an alternative
- Planes are cool