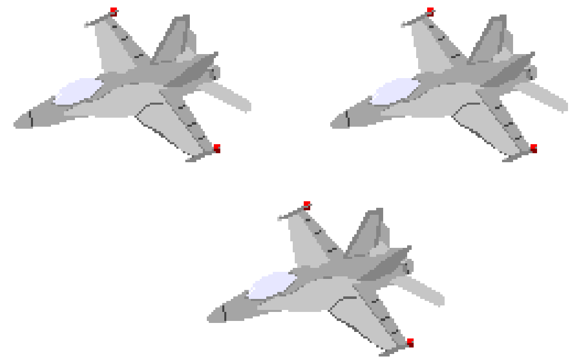
Introduction to Wireless Systems in Aerospace Applications

Presenter: Marc Harrington

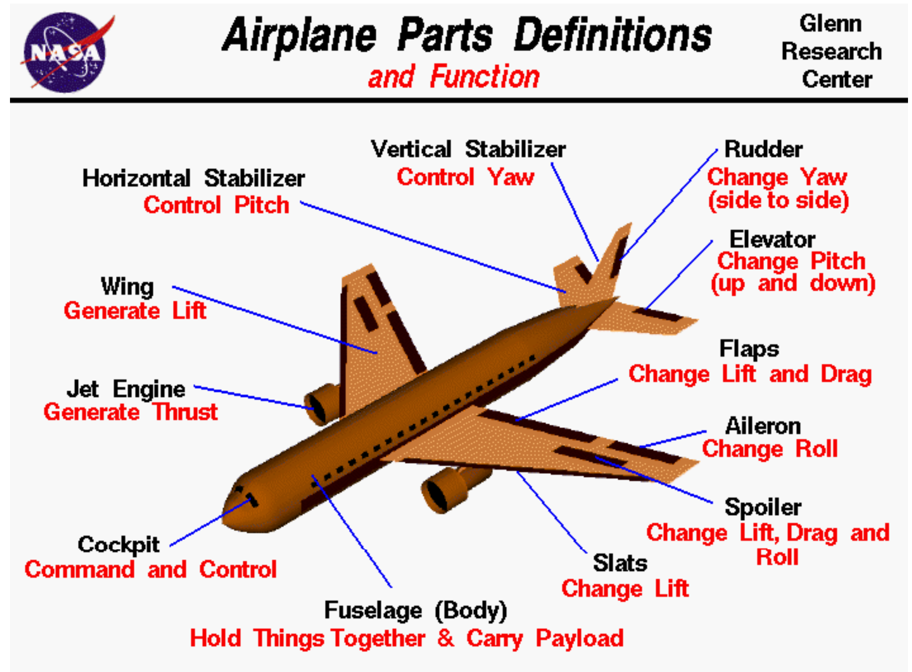
Overview

- Wires vs. Wireless
- Requirements
- Standards
- Protocols
- Security
- Energy
- Future

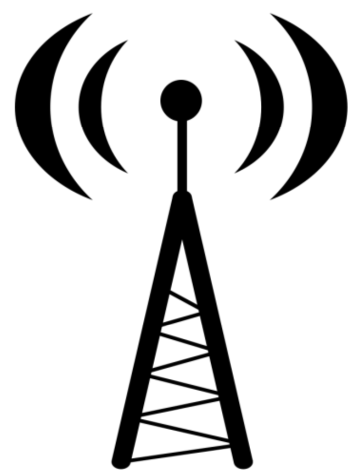


Fly by Wireless?

- Not quite fly by wireless
  - Sensors
    - Fire Detection
    - Stress
    - Temperature
    - Pressure
    - Proximity
    - Vibration
  - Non flight critical systems.. for now
    - Certification 10^-6
    - 1:1,000,000 bit can have an error
    - 99.9999% correct
    - Redundant System



- Aerospace Industry
  - Hard to engineer (internal impedance, baseband processors)
  - Relatively new technology (1985)
  - Many standards (a,b,g,i,j) →international too
  - Hard to certify (10^-6 BER) 1:1,000,000 bits in errors
  - Reliability Issues
  - Military Problems
    - Jamming
    - Encryption

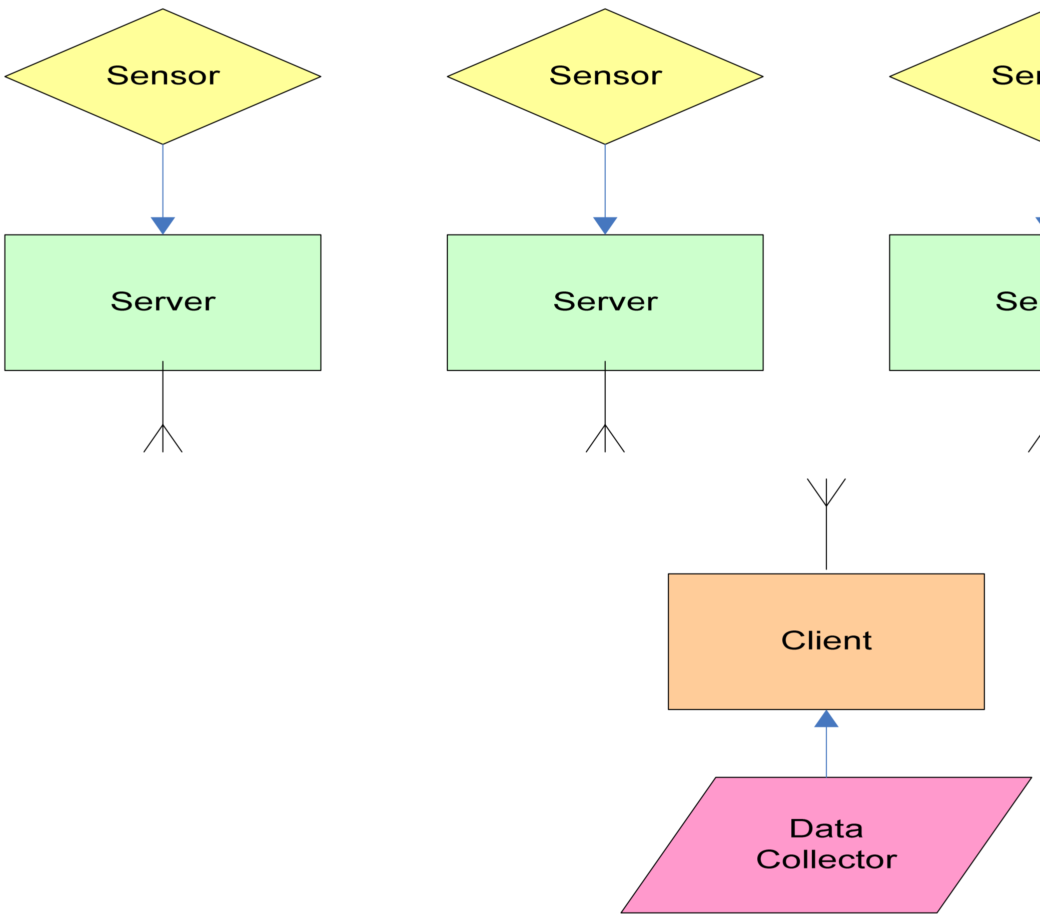


What's wrong with wires?

- Aerospace industry
  - Wires are heavy and expensive
  - Cost
    - Design of wire layout
    - Weight of the wire (at least $1000 per lb) → a lot more for helicopters
      - Fuel consumption
      - Speed
      - Maneuverability
      - Payload
    - Construction and installation
    - Maintenance (wire breakdown)
    - Upgrades

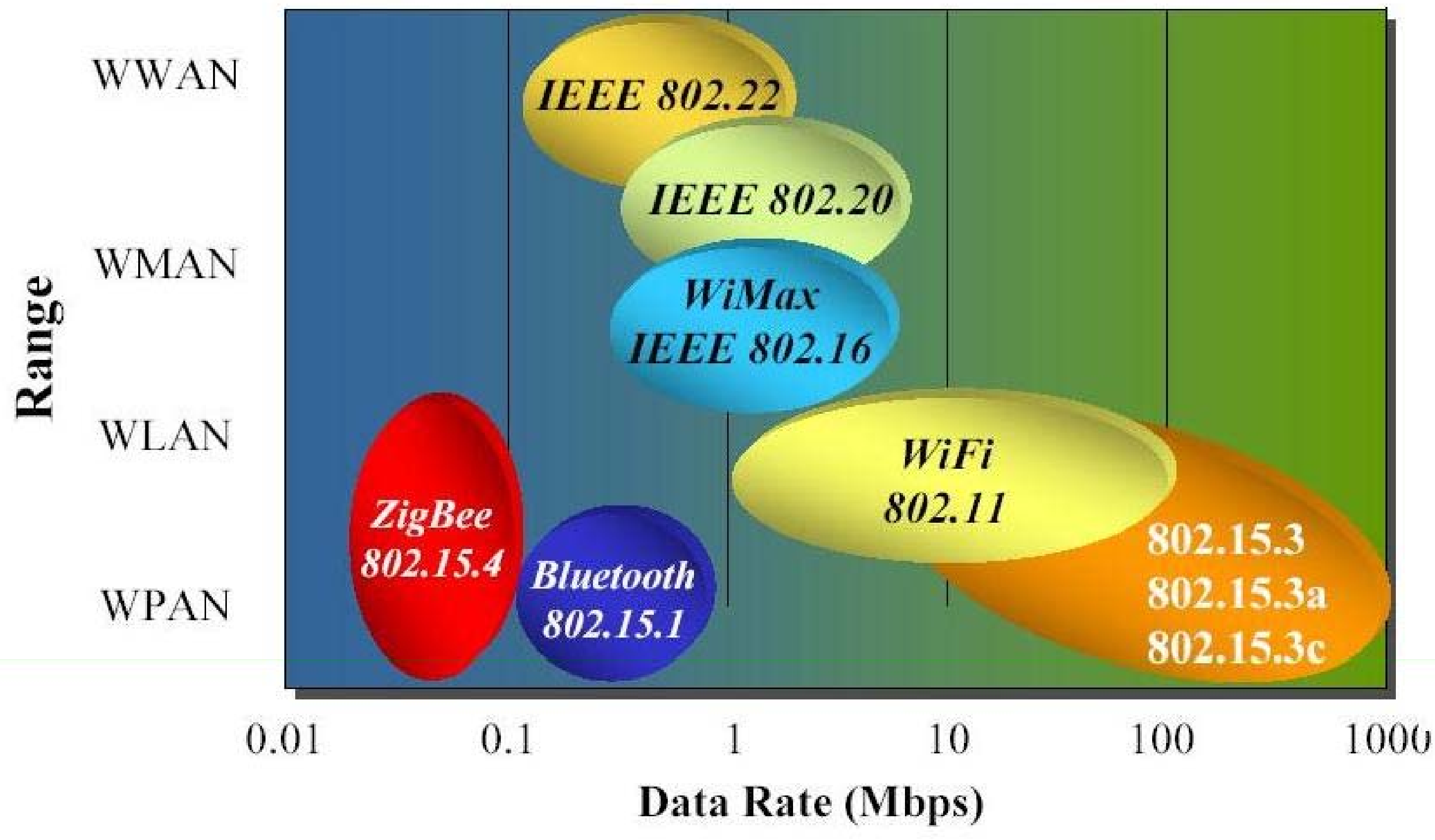
Requirements (Aerospace Industry)

- FAA: Certification requires less than 1:1,000,000 bits in errors
- Min 30 meter range → Want Max: 60 meters
- Min Rate: 157,296 bps
- Battery needs to last at least a year
- Needs to operate in unlicensed frequency band

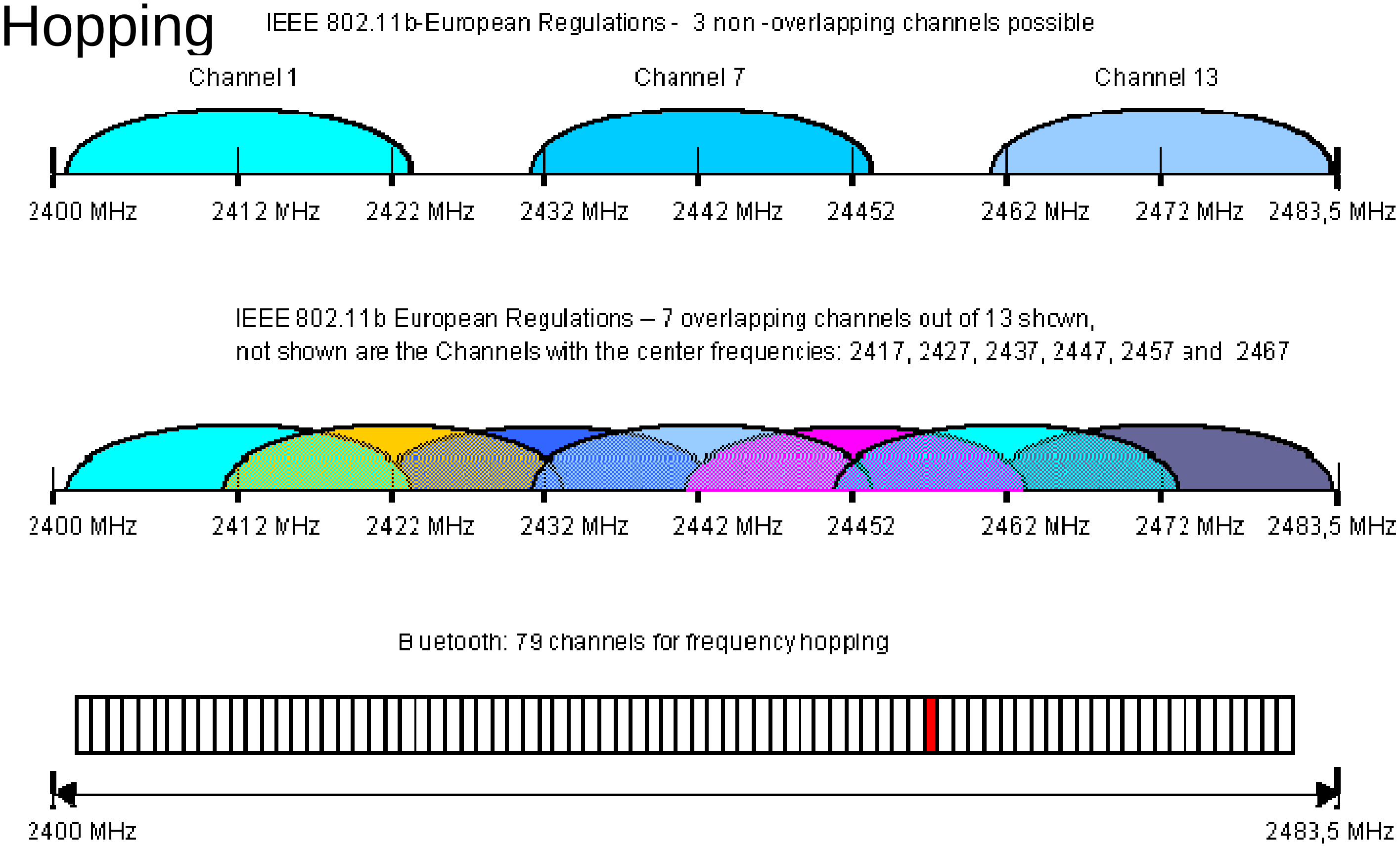


Wireless Standards

- Bluetooth
- Zigbee
- Wifi (IEEE standard 802.11a, 802.11b, 802.11g)
- Ultra wideband (802.15.3) → Energy++ Distance
- TV bands (802.22)→ 2009
- 802.20, 802.16 → WMAN

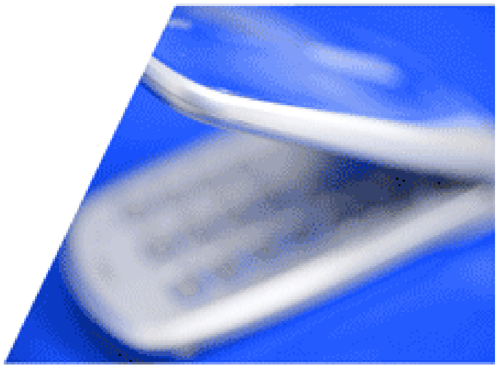


- Bluetooth 2.0 +EDR
  - 1-3 Mbps → (spec 530kbps)
  - Already allowed on aircraft (Smoke Detector)
  - 2.4 Gigahertz band
  - Frequency Hopping



Zigbee

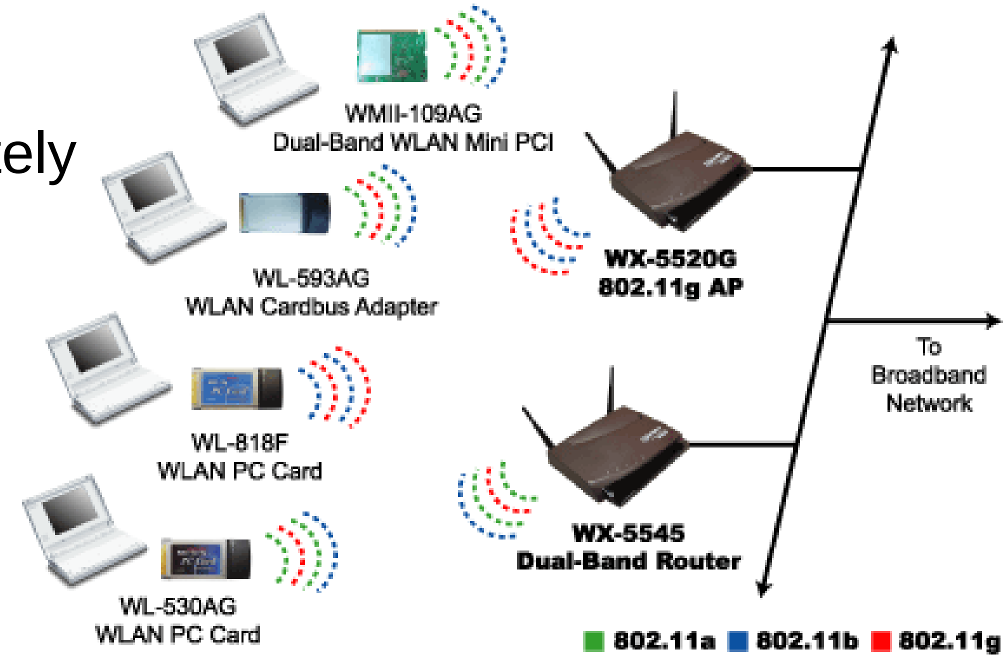
- Operation Band: 2.4-2.483.5 GHz
- Number of Non Overlapping channels: 3
- Max data rate: 250 Kbps
- Lowest Power
- Ex: Industrial Sensors
- Battery Powered

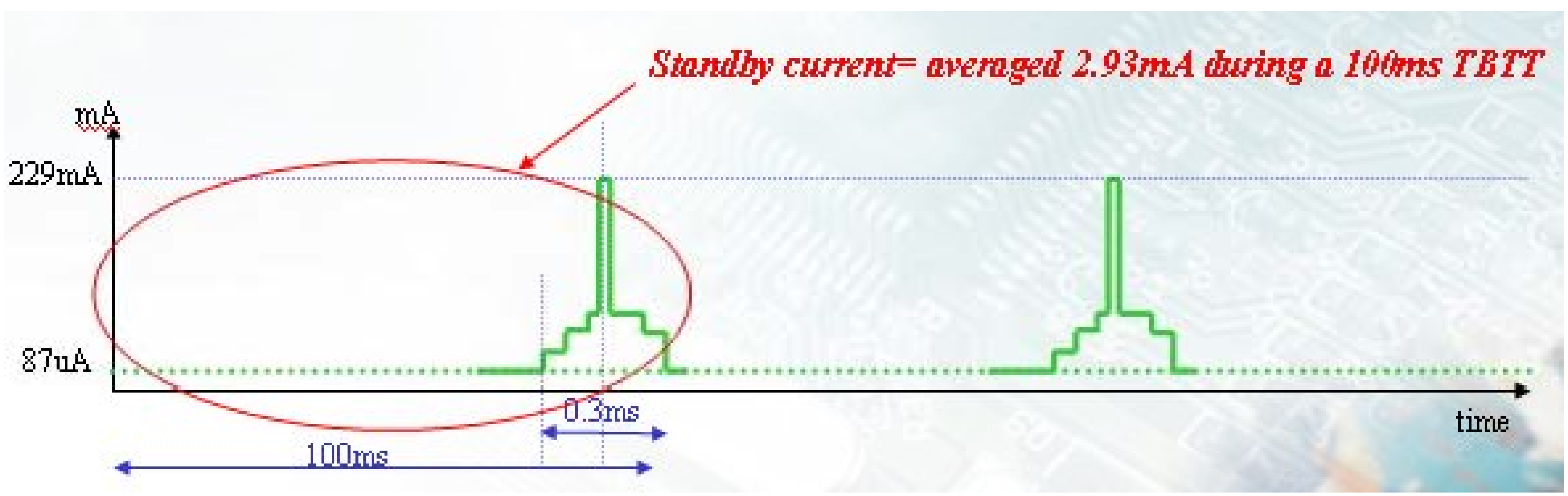


ZigBee™ Alliance
Wireless Control That Simply Works

Wifi 802.11 Standard

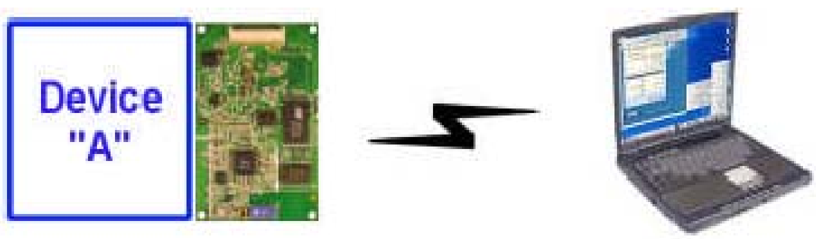
- Data rate good (1-54 Mbps)
- Can shut down almost completely to save power
- Compatible with other 802.11 systems
- 50 meter range
- Designed for TCP/IP

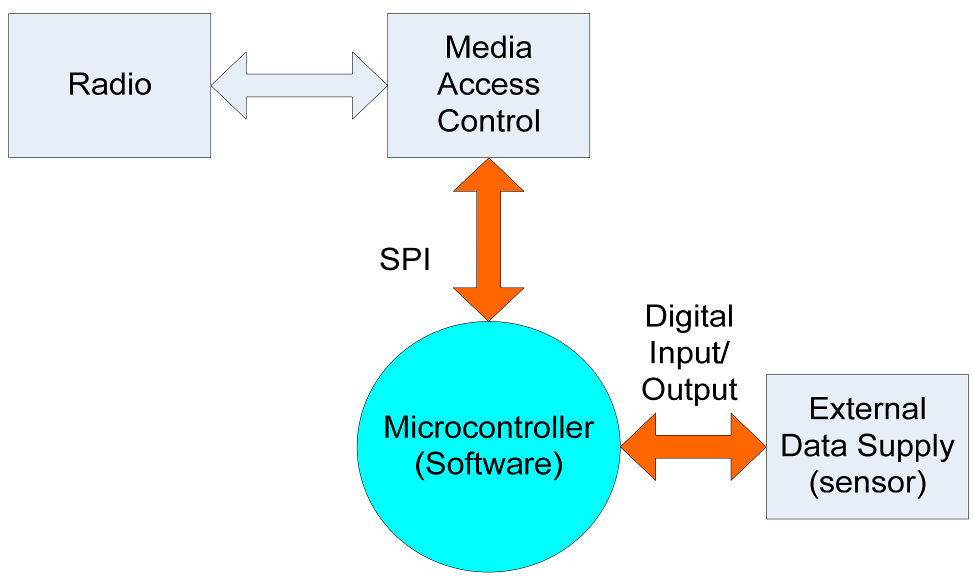




802.11 Hardware

- Hardware created by 3rd party (Ex: Data Hunter)
- COTS
- Focus on embedded software

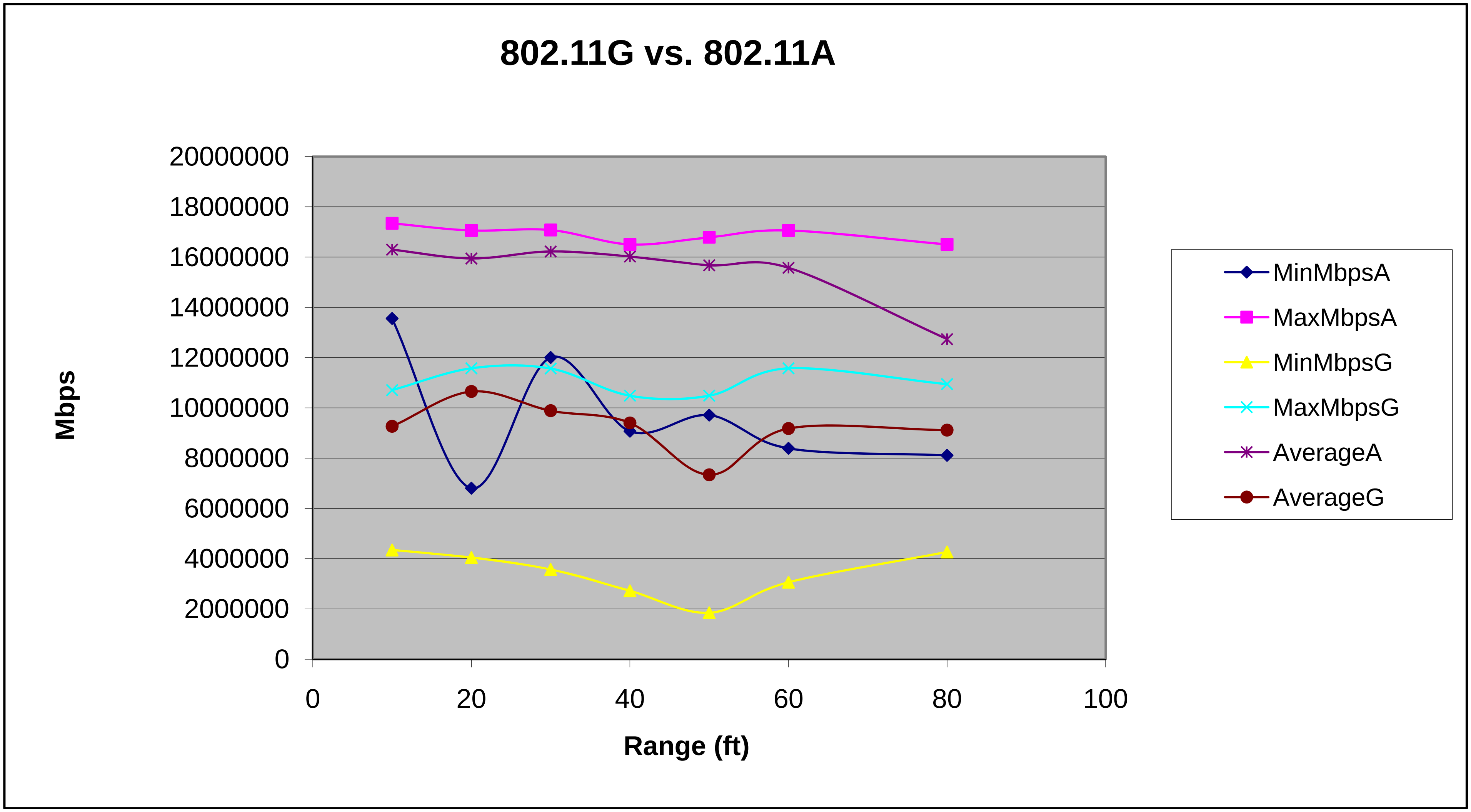




Alphabet Soup

- 802.11b
  - 2.4 gigahertz ISM band
    - Issues with b, g, bluetooth, zigbee, microwaves.
  - 1-11Mbps
- 802.11a
  - 5 gigahertz ISM band
    - No problems, only deals with
    - other a & cordless phones
  - 8-54 Mbps
- 802.11g
  - 2.4 gigahertz ISM band
  - 8-54 Mbps
  - Issues with b, g, bluetooth, zigbee, microwaves.
- 802.11n draft 2.0
  - Standard not finalized (1.5 years)
  - MIMO

Which One is Better?



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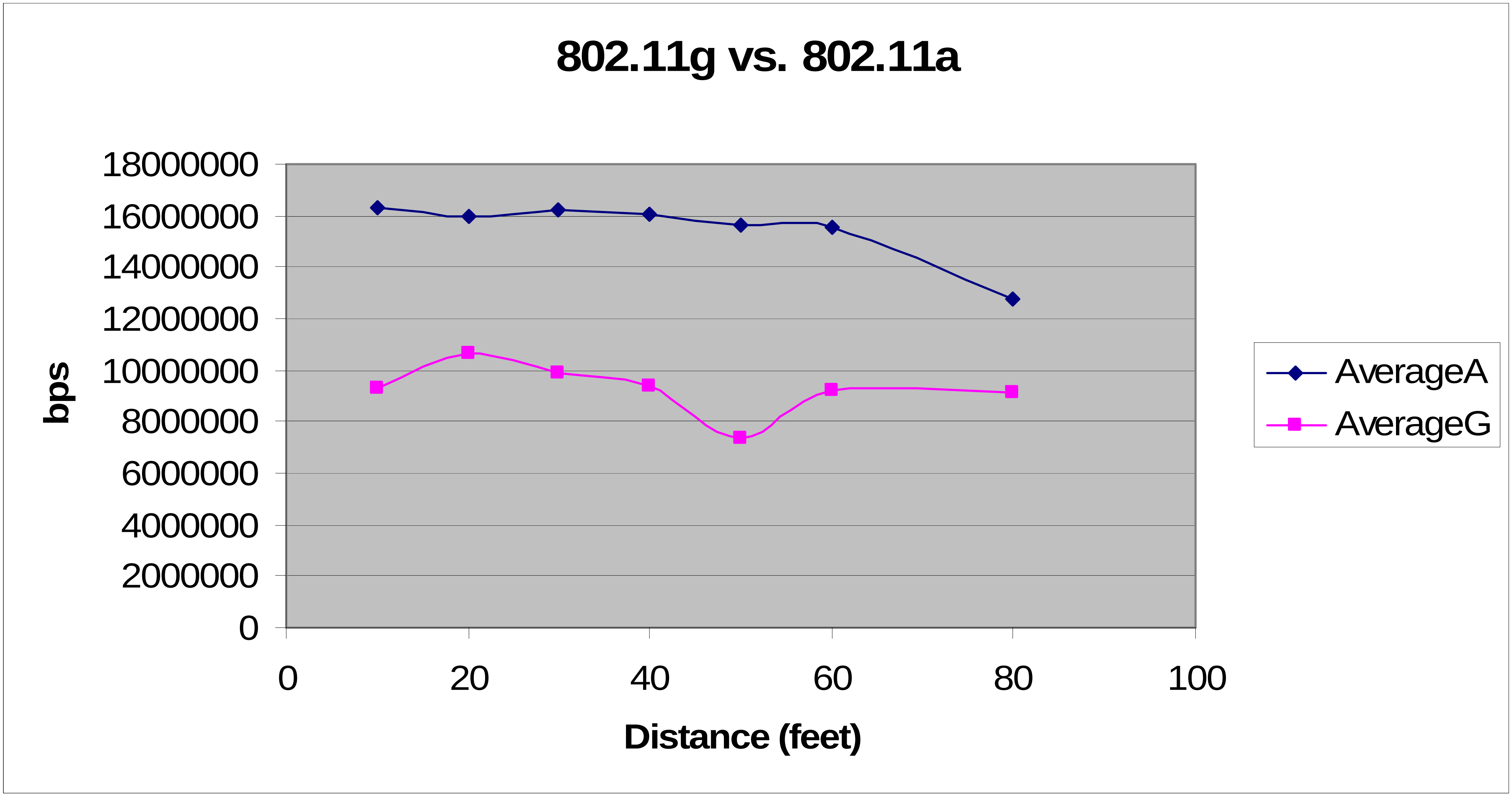
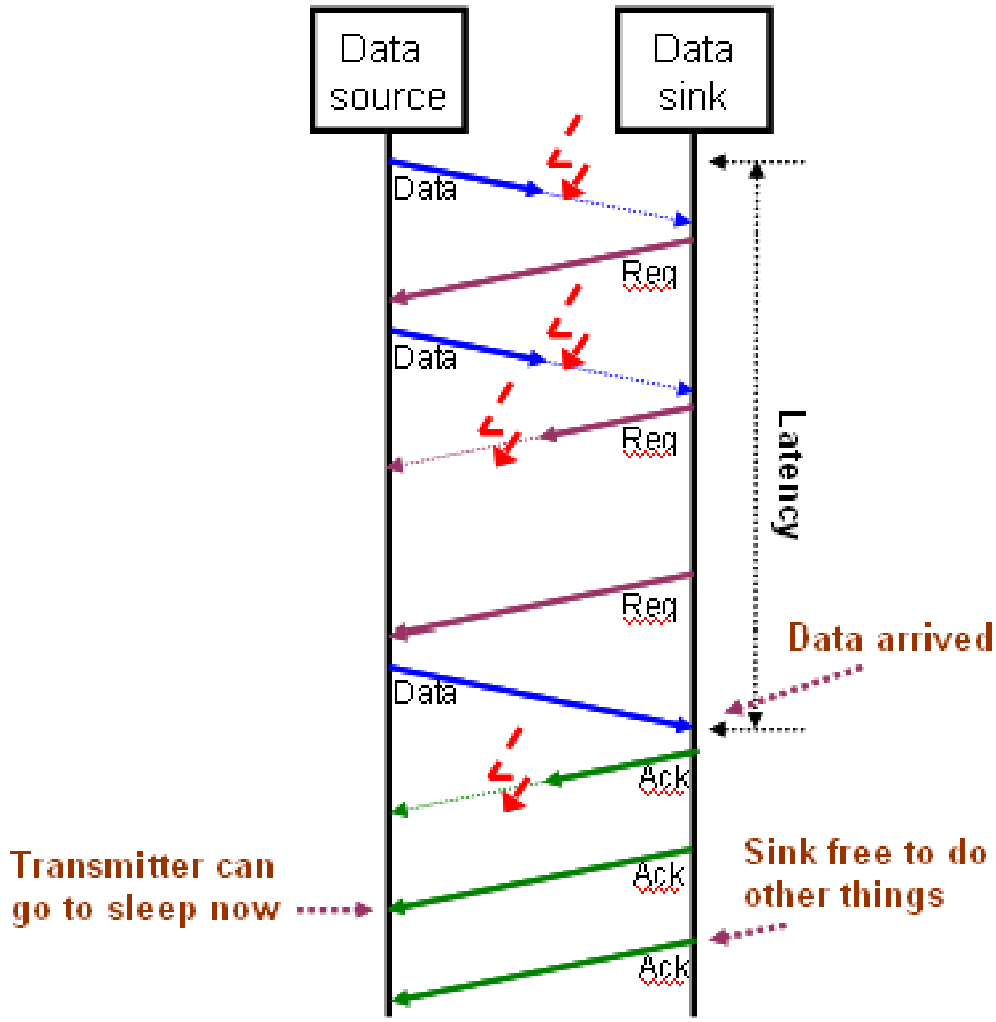


Transmission Protocol

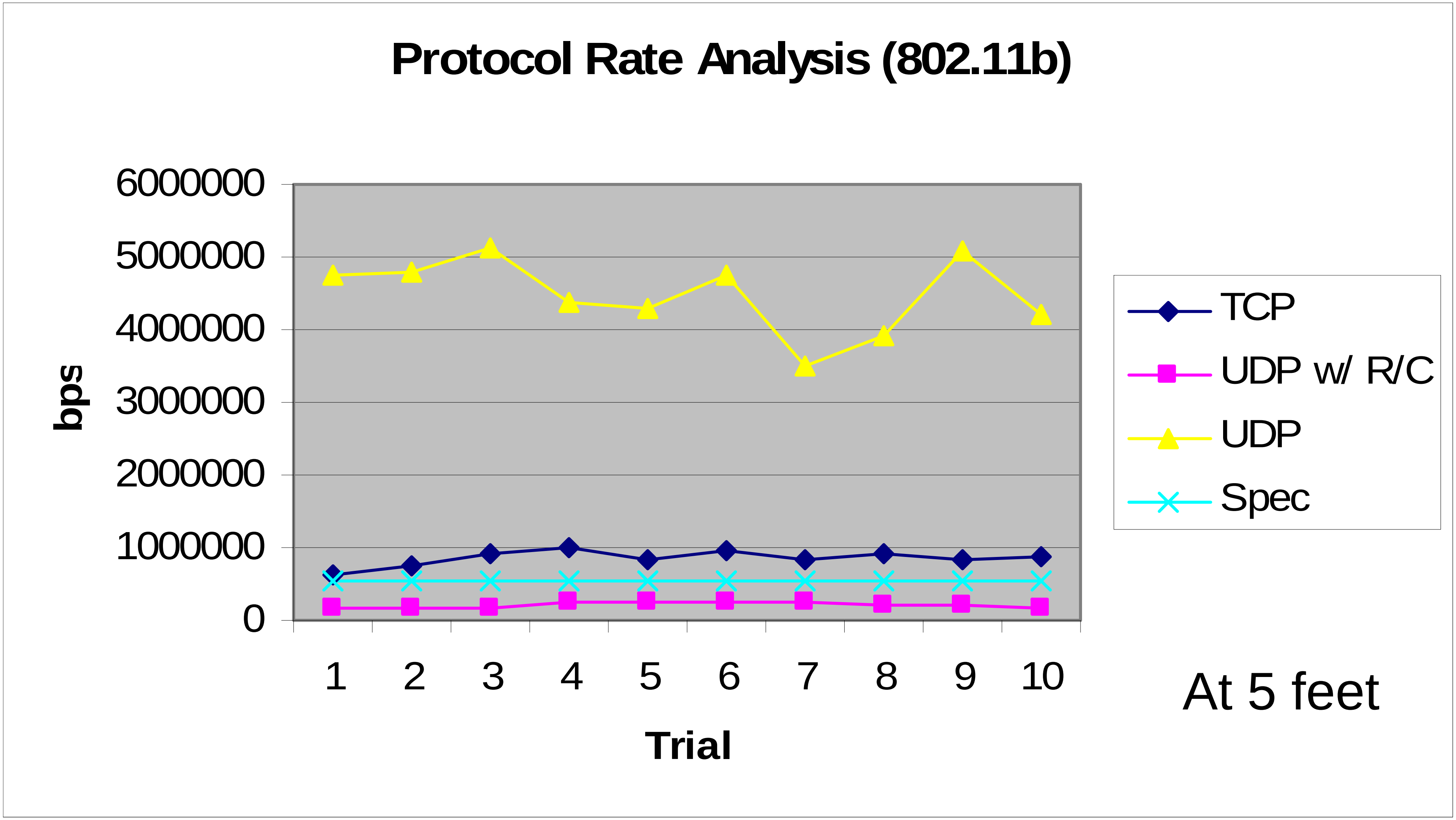
- 802.11 standard requires TCP/IP or UDP/IP
- TCP (Transmission Control Protocol)
  - Connection based protocol
  - Has a request and respond algorithm
  - Robust
  - Guaranteed quality of data if connection is possible
- UDP (User Datagram Protocol)
  - Non connection based protocol
  - When data is sent no guarantees
  - Faster than TCP
- IP (Internet Protocol)
  - Way of addressing other network nodes through use of a system specified number (IP Address)

Which Protocol to Use?

- UDP
  - Algorithm to ensure quality of data needed to be created.
    - RTS/CTS →
- TCP
  - Built in algorithms to ensure quality of data
- Test was necessary to see difference

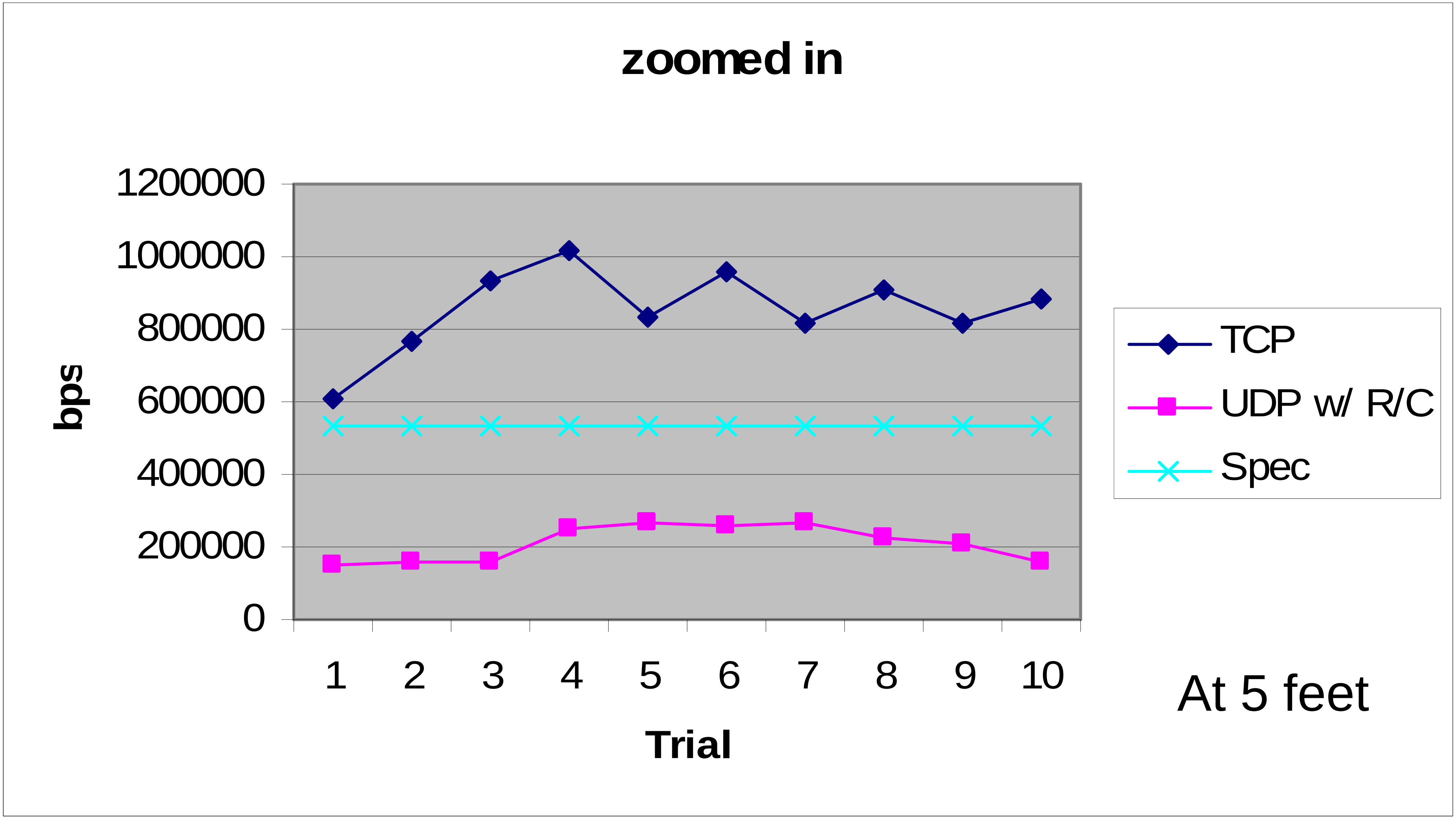


Analysis



At 5 feet

More Analysis

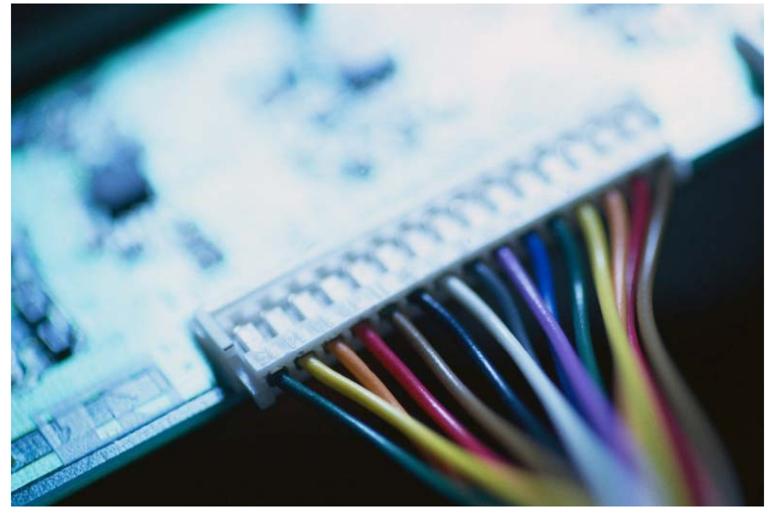


Security

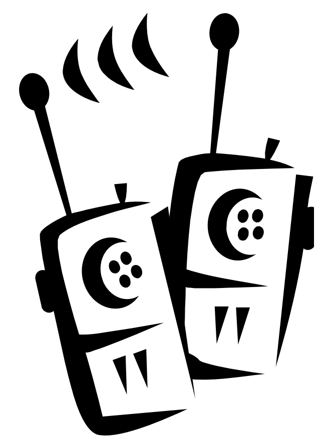
- Jamming
  - High Frequency Band
  - Redundancy
- AES 128
  - NSA Secret Level Classification
- AES 256
  - NSA Top Secret Level Classification
- Non Classified data transfer

- Shut down unnecessary parts of the chip
  - Microcontroller
  - Radio
- WDT wakes up system after set amount of time
- 87 uA used during sleep
- Turn on only when needed
- RFID wakeup (Stanford Group)
- Recharge Batteries (Laser, Magnetic)

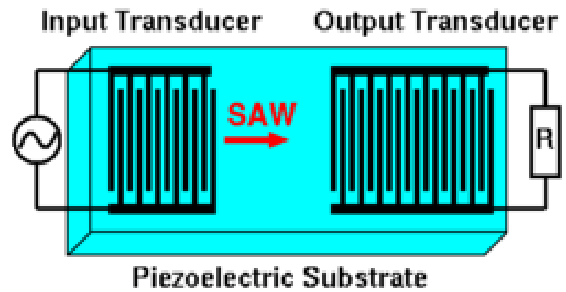
If it's so easy why isn't everyone doing it?



- No Standard
- Needs industry to push
- High risk
- Uncertainty
- Wires work
- Needs own frequency band for higher integrity jobs
- Would need to rely on COTS
- Sustainability
- No one solution fits all



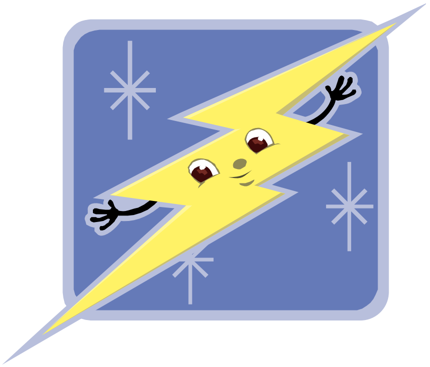
- Surface Acoustic Wave (sensors)
  - Piezoelectric
  - Zero Energy on sensor side
  - Chemical, optical, thermal, pressu d torque

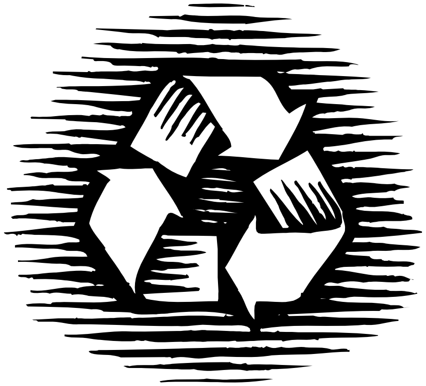


- Passive RFID
  - Tracking
  - Friend or Foe?
  - Aircraft Information

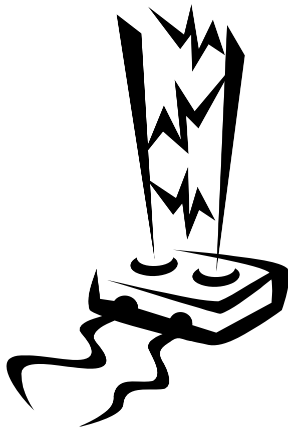
- Active RFID
  - Powered
  - Microchip
  - Range

- Energy harvesting
  - Solar
  - Thermal
    - 40uW /5degree
  - Wind
    - Drag
  - Kinetic
    - Piezoelectric
    - Helicopters (constant vibration)
  - EM Waves





- 1553 Wireless Standard
  - Fiber Optics ratified
- Frequency Bands
  - Aerospace Vehicle Systems Institute (AVSI)
  - International
  - Bandwidth



Special Thanks

- Goodrich Aerospace Vergennes, VT
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