The need for Low Power Ultra Reliable communication technologies for IoT

Testing Performance and reliability of IoT Devices and protocols

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Agenda

- ✓ Setting the scene
- ✓ Connectivity options
- ✓ The need for testing the performance aspects of IoT devices/protocols with the focus on the challenges from a radio point of view.
- ✓ Practical testing of IoT devices
- ✓ Co-existence and interoperability testing
- ✓ Certification testing
- ✓ Requirements of the test system....

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IoT..Setting the scene

Situating IoT

Domestic IoT:

- Pill box, freezer
- Thermostat
- Locks
- Personal area (fitness)

Industrial IoT:

- Windmill-parks
- Big structures (high rise buildings, bridges)
- Communal services
- Machine to Machine communication
- Medical

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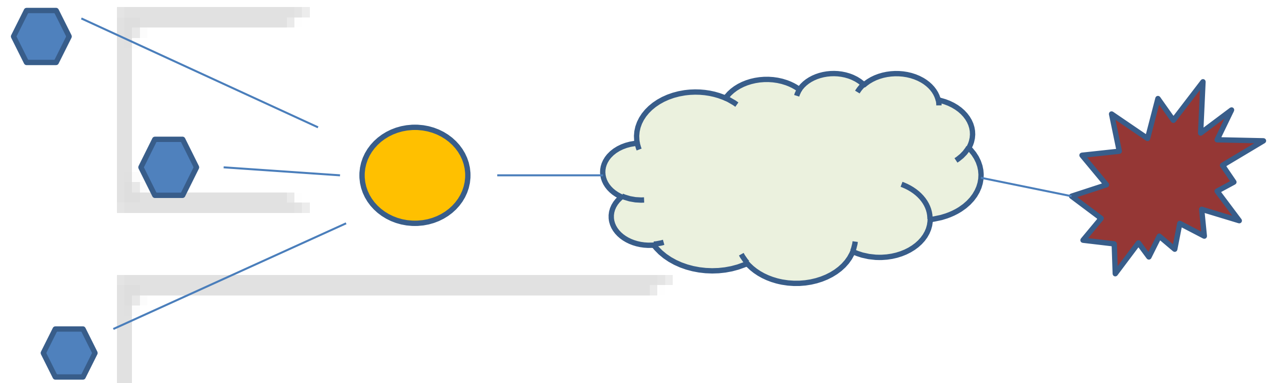
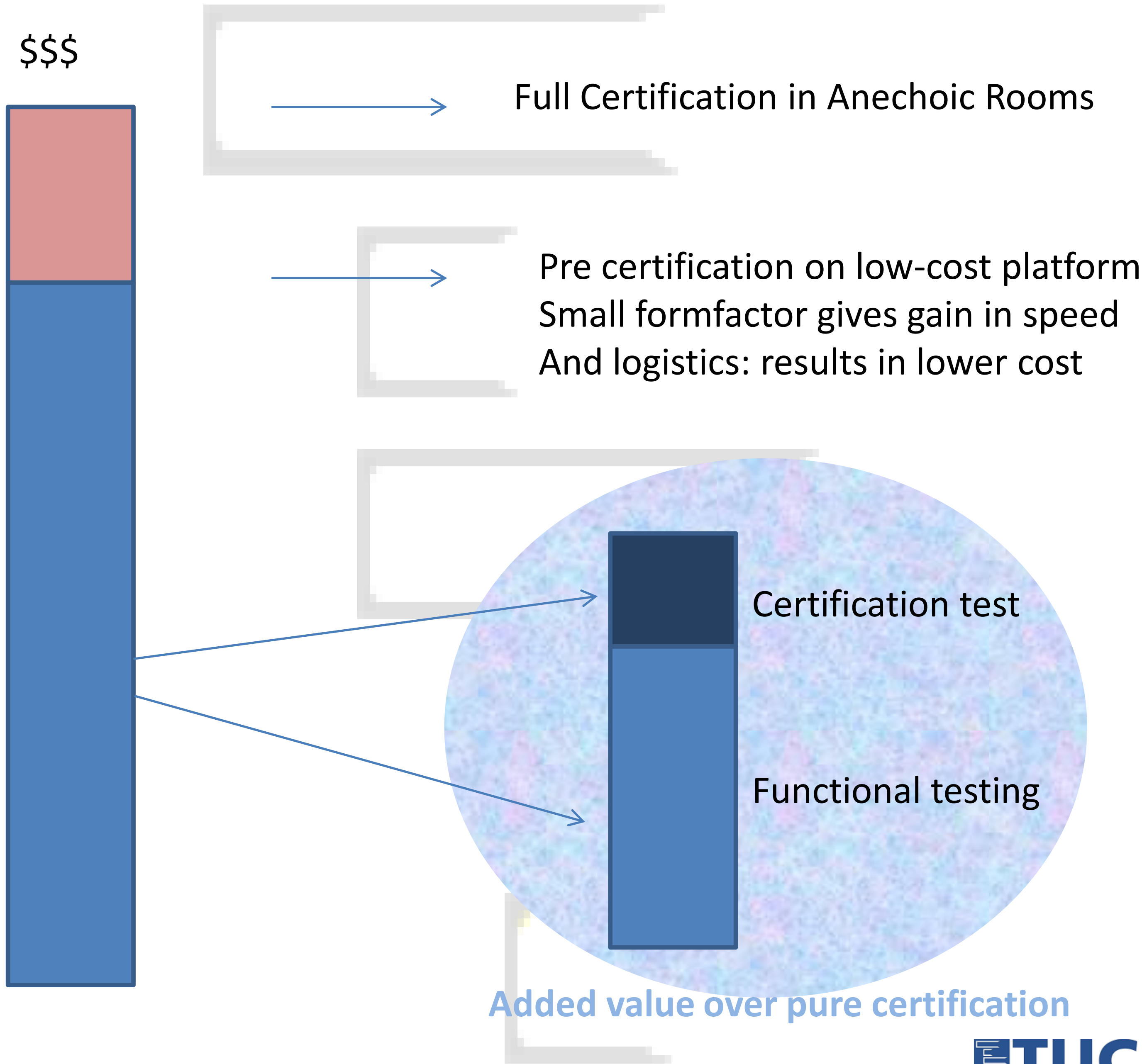
IoT Players

- End devices
- Alliances
- Certification labs
- Operators
- Gateways mfrs
- APP



Financials

- End device mfrs , large volumes very low cost , rely on chip-mfrs for certification
- Need to test RF in integrated design
- Operators want to test e-t-e
- Gateway Mfrs need to test and certify
- There are 1000’s of devices that need to be certified. The certification test specifications prescribed by ETSI are costly so there is a need for low cost pre-certification methods.



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Internet of Things (IoT) connectivity options

Technologies

Established technologies:

New emerging networking options such as Thread as an alternative for home automation applications

Whitespace TV technologies being implemented in major cities for wider area IoT-based use cases.

Requirements

Range, data requirements, security and power demands and battery life will dictate the choice of one or some form of combination of technologies.

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key characteristics

Bluetooth Smart
similar range to Bluetooth
reduced power consumption
small chunks of data

Frequency: 2.4GHz (ISM)
Range: 50-150m (Smart/BLE)
Data Rates: 1Mbps (Smart/BLE)

The "Wi-Fi Certified" trademark can only be used by Wi-Fi products that successfully complete Wi-Fi Alliance interoperability certification testing.

Frequencies: 2.4GHz and 5GHz bands
Range: Approximately 50m
Data Rates: 600 Mbps maximum, but 150-200Mbps is more typical

low-power operation
high security
robustness
high scalability
high node counts

Frequency: 2.4GHz
Range: 10-100m
Data Rates: 250kbps

Standard: GSM/GPRS/EDGE, UMTS/HSPA,
LTE Frequencies: 900/1800/1900/2100MHz
Range: 35km max for GSM; 200km max for HSPA
Data Rates: 170kps (GPRS) upto 10Mbps (LTE)

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key characteristics

CONNECTS WITH THREAD

Based on 6LowPAN,
IPv6 networking protocol
complement to WiFi for use in a home automation setup.
Mesch nw self healing

Frequency: 2.4GHz (ISM)
Range: N/A
Data Rates: N/A

Z-WAVE PLUS

low-power RF comm. Techn.
home automation controllers and sensors
Optimized for communication of small data packets

Frequency: 900MHz (ISM)
Range: 30m
Data Rates: 9.6/40/100kbit/s

NFC Near Field Communication

NFC is a set of protocols that enable two electronic devices to establish communication by bringing them within centimeters of each other.

Frequency: 13.56MHz (ISM)
Range: 10cm
Data Rates: 100–420kbps

6LoWPAN IPv6-based Low-power Wireless Personal Area Networks

Network-protocol instead of IoT application protocol
defines encapsulation and header compression mechanisms.

Frequency: adapted and used over a variety of networking media
Range: N/A
Data Rates: N/A

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key characteristics

SIGFOX
One network A billion dreams

Wide-range technology
range comes between WiFi and cellular.
ISM bands, which are free to use
without the need to acquire licenses.
small battery

Frequency: 900MHz
Range: 30-50km (rural environments), 3-10km (urban environments)
Data Rates: 10-1000bps

neul

TV White Space spectrum
high scalability
high coverage
low power
low-cost

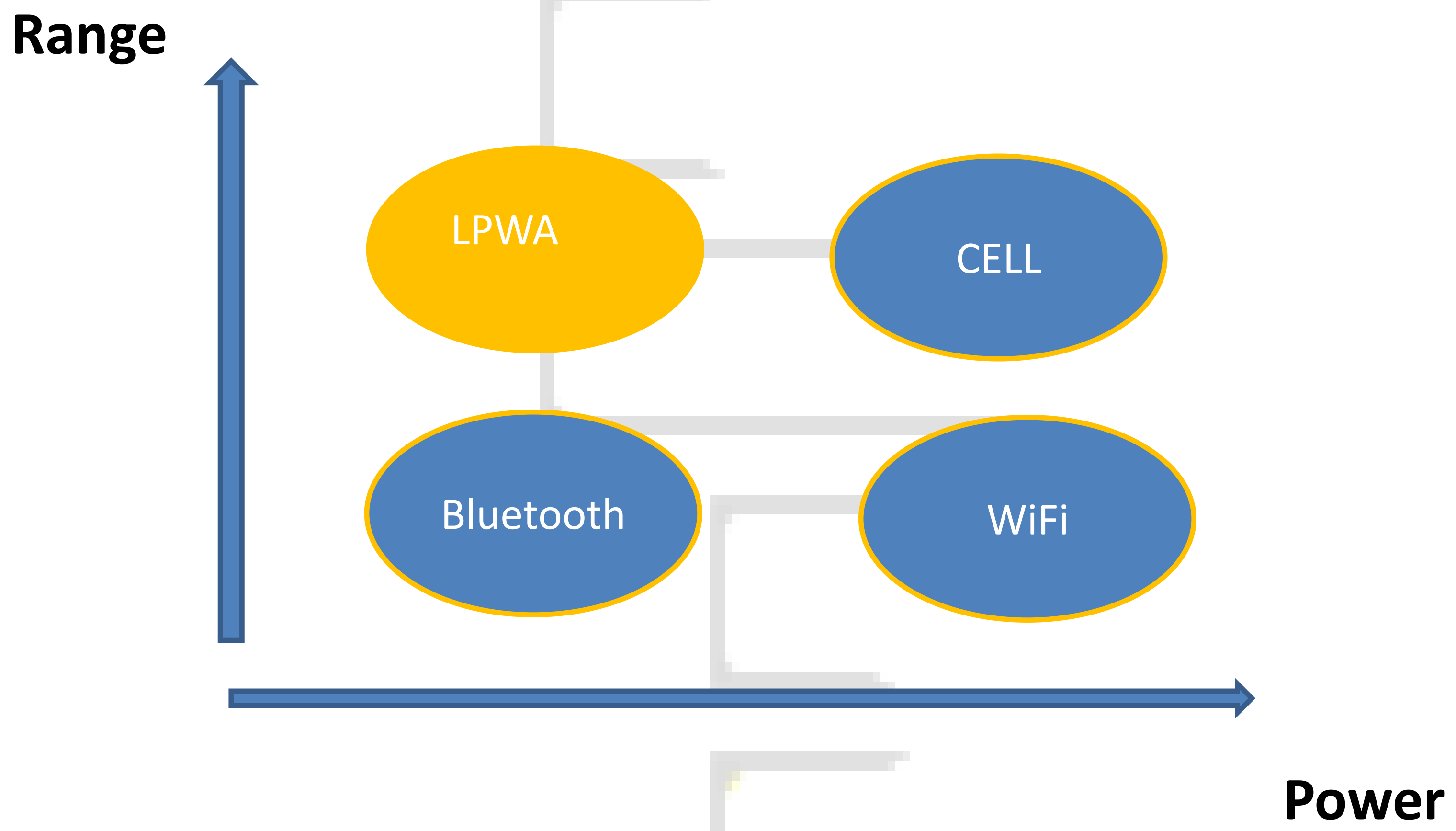
Frequency: 900MHz (ISM), 458MHz (UK), 470-790MHz (White Space)
Range: 10km
Data Rates: Few bps up to 100kbps

LoRa™

Sigfox and Neul equivalent
wide-area network (WAN) applications
low-power WANs
bi-directional
millions and millions of devices

Frequency: Various
Range: 2-5km (urban environment), 15km (suburban environment)
Data Rates: 0.3-50 kbps.

The need for testing the performance



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Performance testing IoT

The NEW requirement in IoT is a radio system that can do Long Range Low Power

- E-T-E performance of IoT eco system is depending on :
  - Radio performance
  - Protocol
- Radio performance aspects are
  - Radiated power , sensitivity
  - Power , battery
  - Distance
  - Interference aspects   Co-excistance (Industrial Scientific Medical)
- Requirements of the test system:
  - Repeatability
  - Control of parameters
  - Over The Air testing

- **Compatibility ..interoperability: KEY to the IoT concept**

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Performance testing IoT

Some of these technologies use mesh techniques. In order to improve the reliability, the mesh network needs to organize and repair itself—this needs to be tested/exercised.

- Practical testing of IoT devices can be challenging--
  - o Battery operated devices are often sealed, so no access to RF ports
  - o If devices do have RF connectors they are usually fragile and difficult to make reliable connections
  - o Conclusion **test Over The Air**
  - o completely isolate from outside interference in order to get reliable, repeatable tests.

- Different technologies (BT, Zigbee, Thread) all operate in ISM band; Coexistence testing of these technologies is important

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ETSI EN300 220 Lora WAN Certification

4.2.1.1 Frequency error or frequency drift
4.2.1.2 Average power/ 4.2.1.3Effective radiated power
4.2.1.4.1 Frequency hopping spread spectrum devices (number of hopping channels, dwell time and Return Time)
4.2.1.4.2 Direct sequence or other spread spectrum than FHSS (Power density Measurement)
4.2.1.5 Transient power
4.2.1.6 Adjacent channel power for channelized equipment
4.2.1. 7 Modulation band-width
4.2.1.8 Unwanted emissions in the spurious domain
4.2.1.9 Frequency stability under low-voltage conditions (Applies to battery-operated transmitters)
4.2.1.10 Duty cycle
4.2.1.11.1 Minimum transmitter off-time (Applies to transmitters using LBT)
4.2.1.11.2 Minimum listening time (Applies to transmitters using LBT)

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4.2.1.11.3 Maximum dead time (Applies to transmitters using LBT)
4.2.1.11.4 Maximum transmitter on-time (Applies to transmitters using LBT)
4.2.1.11.5 Time-out-timer (in the frequency bands 433,050 MHz to 434,790 MHz or 869,7 MHz to 870 MHz)
4.3.2 Receiver sensitivity (Applies to receivers with LBT)
4.3.3 Receiver LBT threshold (Applies to receivers with LBT)
4.3.4 Adjacent channel selectivity (Applies to Category 1 receivers)
4.3.5 Blocking
4.3.6 Spurious response rejection (4.3.6 C Applies to Category 1 receivers E 5.1.4.5)
4.3.7 Receiver spurious radiation

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Those tests should be done in

- -Full Anechoic room
- -Anechoic room with groundplane
- -Open Area Test site

ETSI Specification of Test Fixture to be used when DUT has an integrated small aperture antenna with no external 50 Ohm access

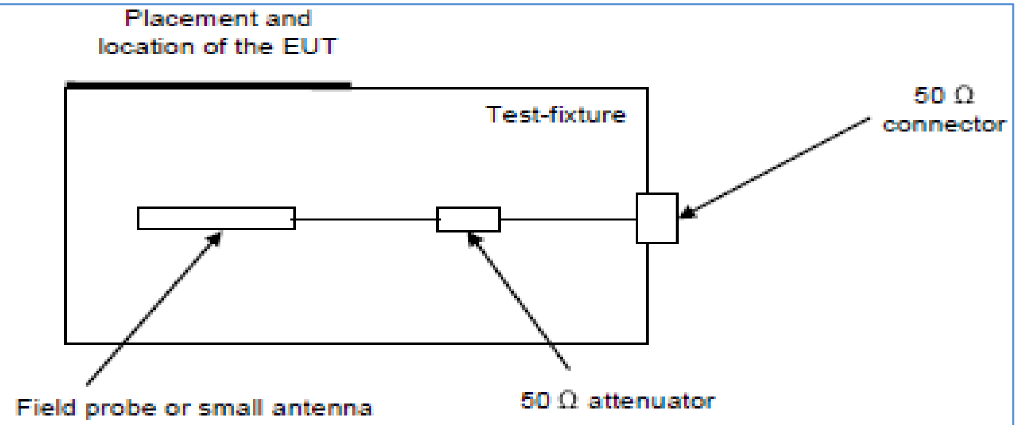


Figure 2: Test fixture

Why do you need to test?

<u>Specific requirements of IoT communications systems</u>

- reach/distance
- Low Power
- Battery live
- Sensitivity (noise floor)
- Reliability
- Infrequent communications

<u>Testing implications</u>

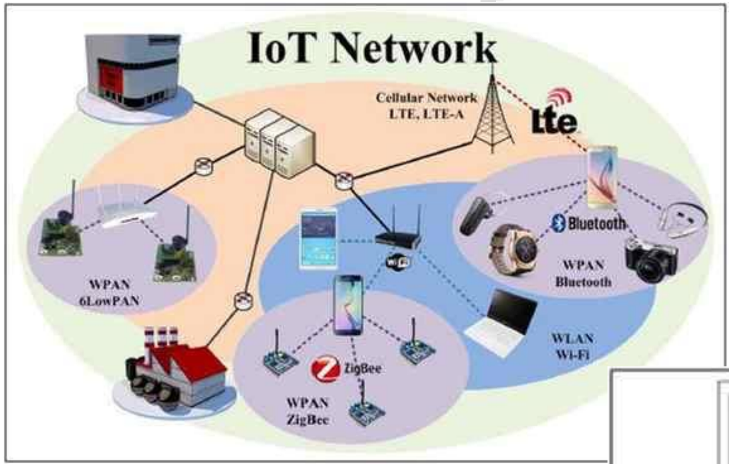
- Certification testing
- Functional testing
- Protocol level testing
- RF level testing
- Topologies
- Cost

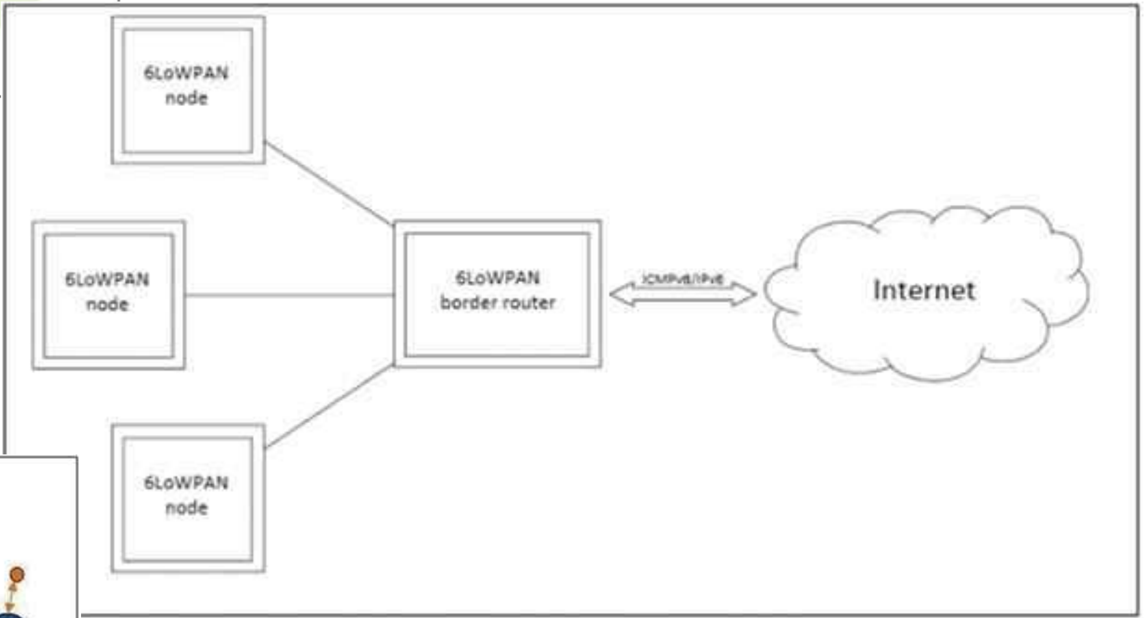
Wireless Testing: Critical, Difficult

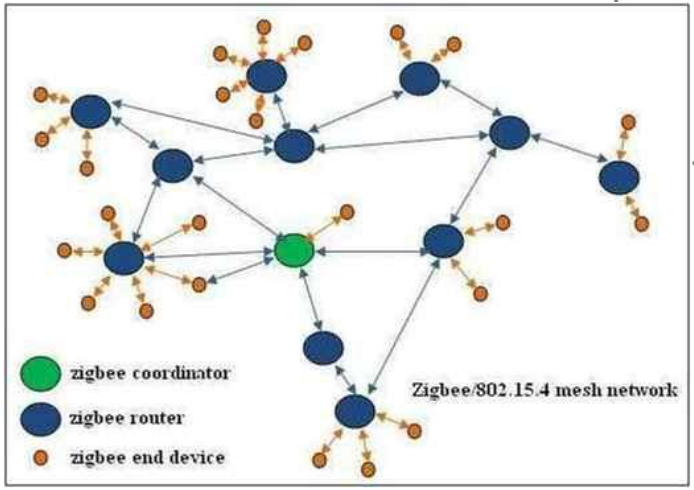
- Why is wireless testing critical?
  - To ensure reliability & quality of voice, video and delay-sensitive data services in the presence of noise, motion and multipath
- Why is wireless testing so difficult?
  - Engineers are unable to obtain repeatable results due to variables in the environment
    - Noise, motion and other channel conditions constantly change
    - Modern devices constantly adapt to these changing conditions

The market needs a *compact cost-effective* wireless platform that provides *repeatable real-life conditions* in labs around the world

Topologies







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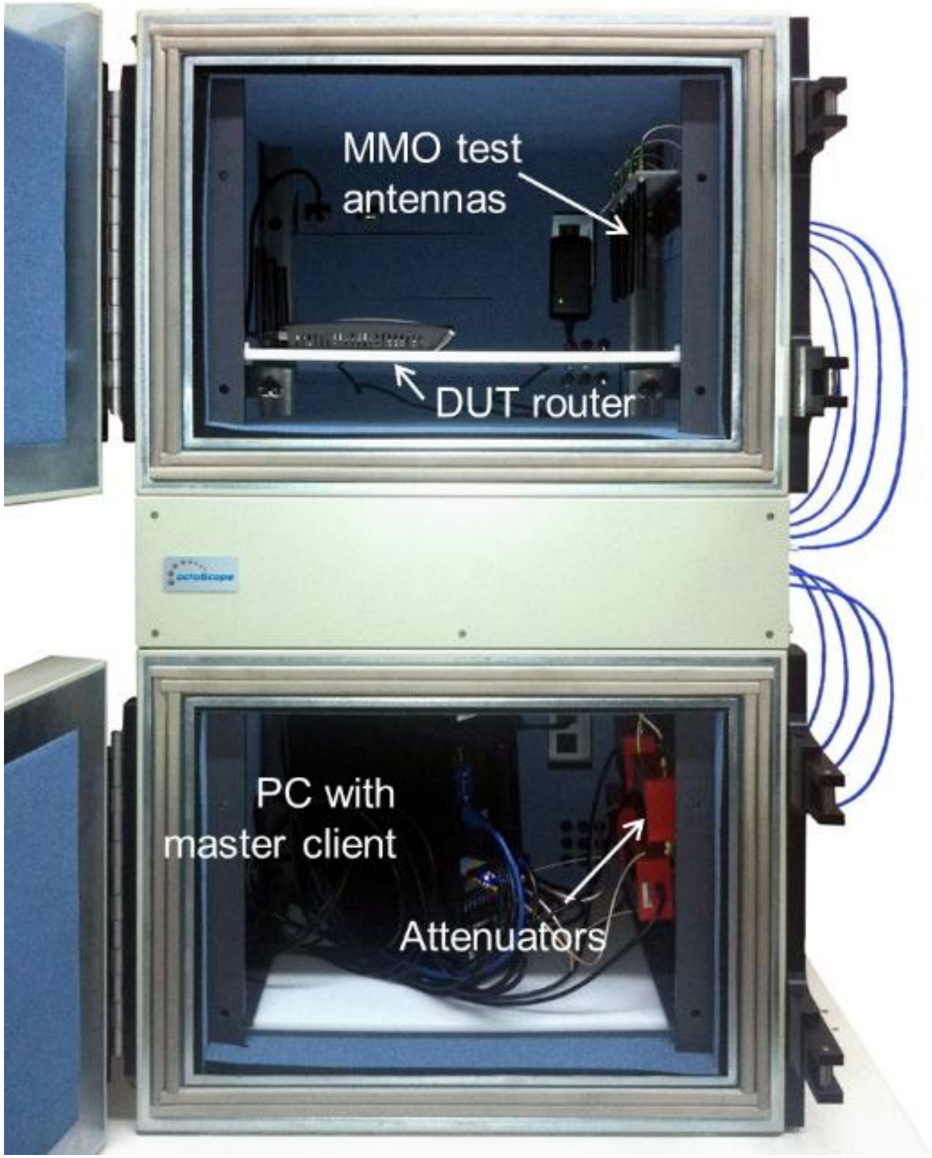
Practical testing of IoT devices



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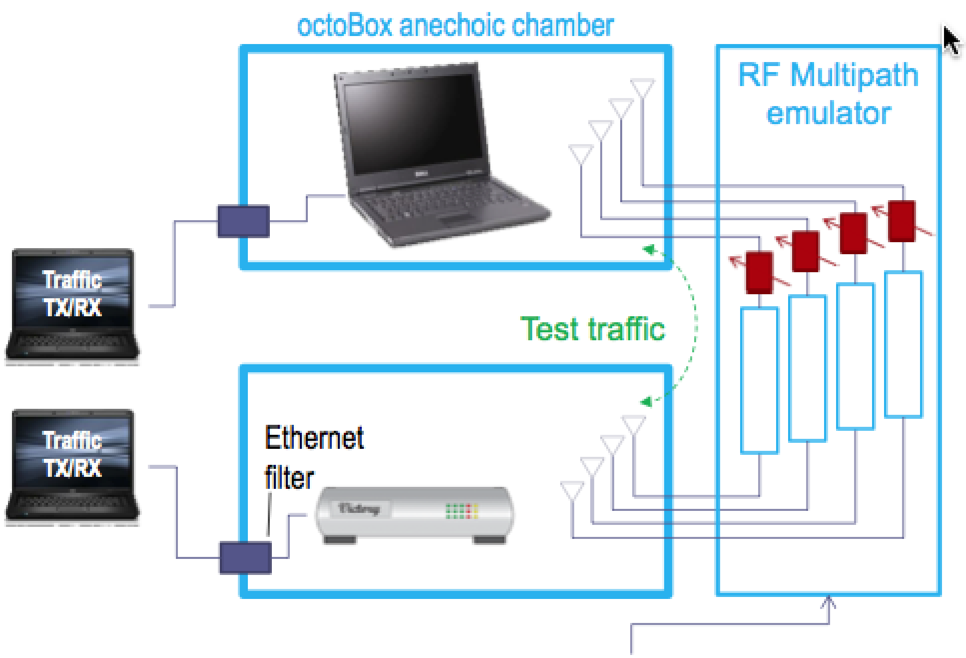
the requirements of the test system



Multipath emulator introduces de-correlation bringing MIMO gains into a small anechoic testbed.

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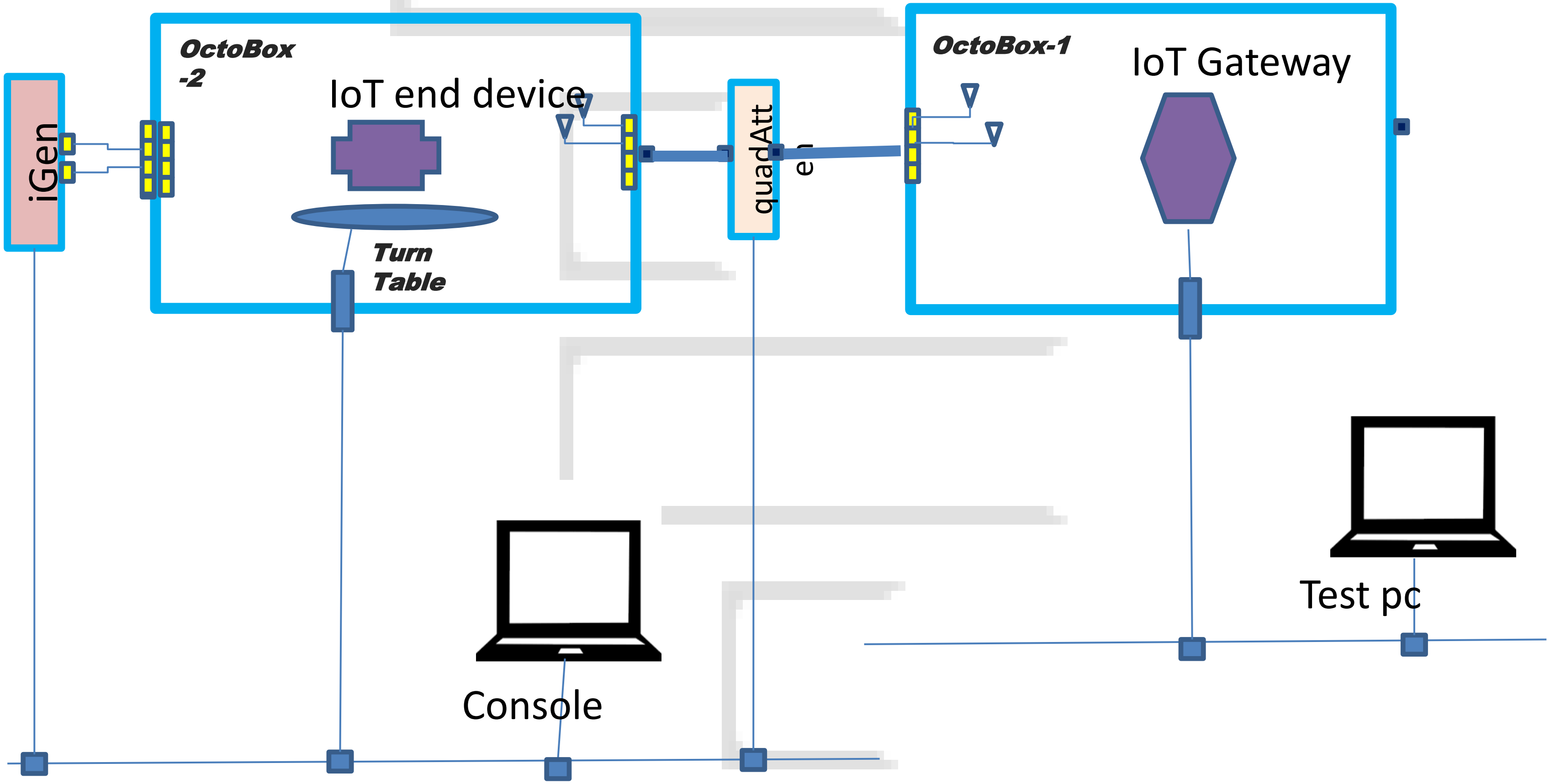

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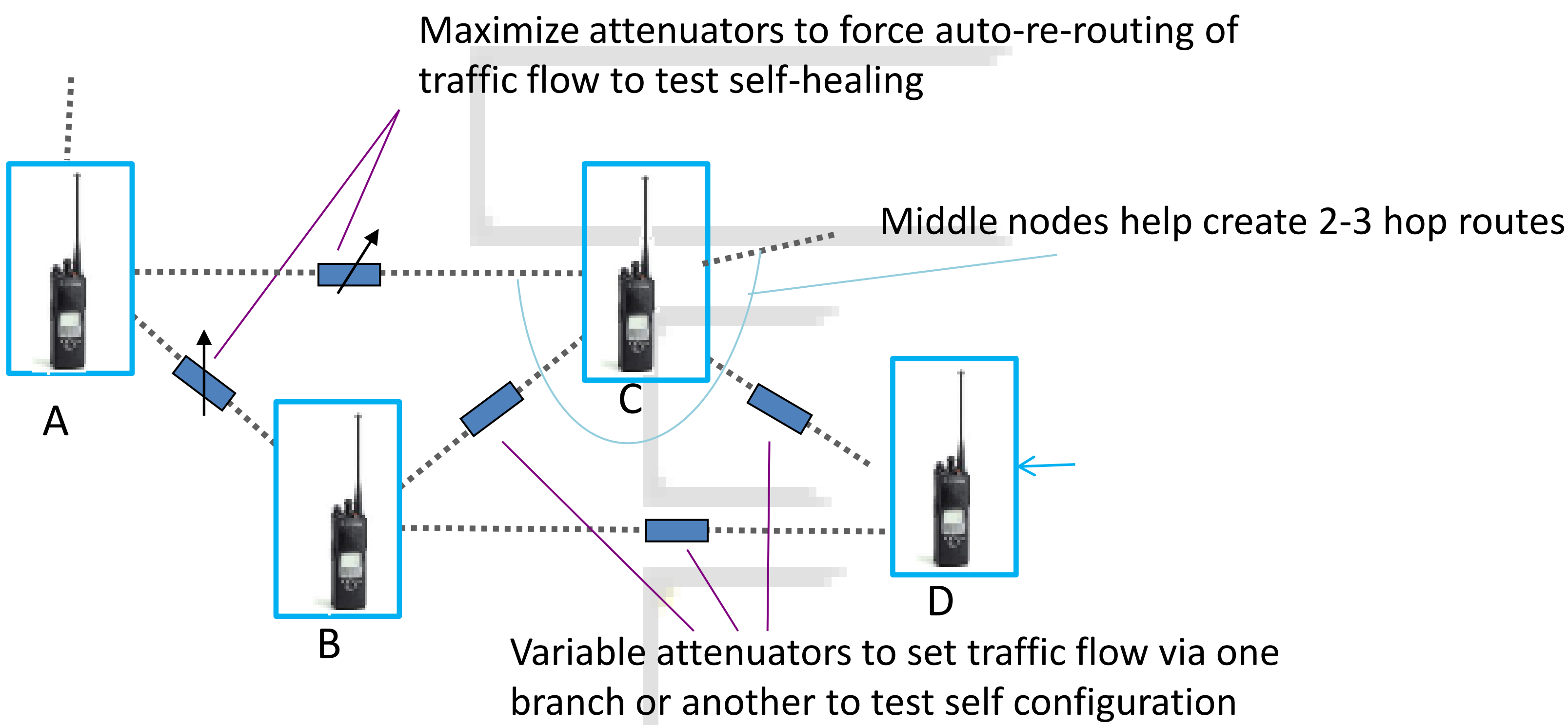
Wireless Mesh Test Configuration

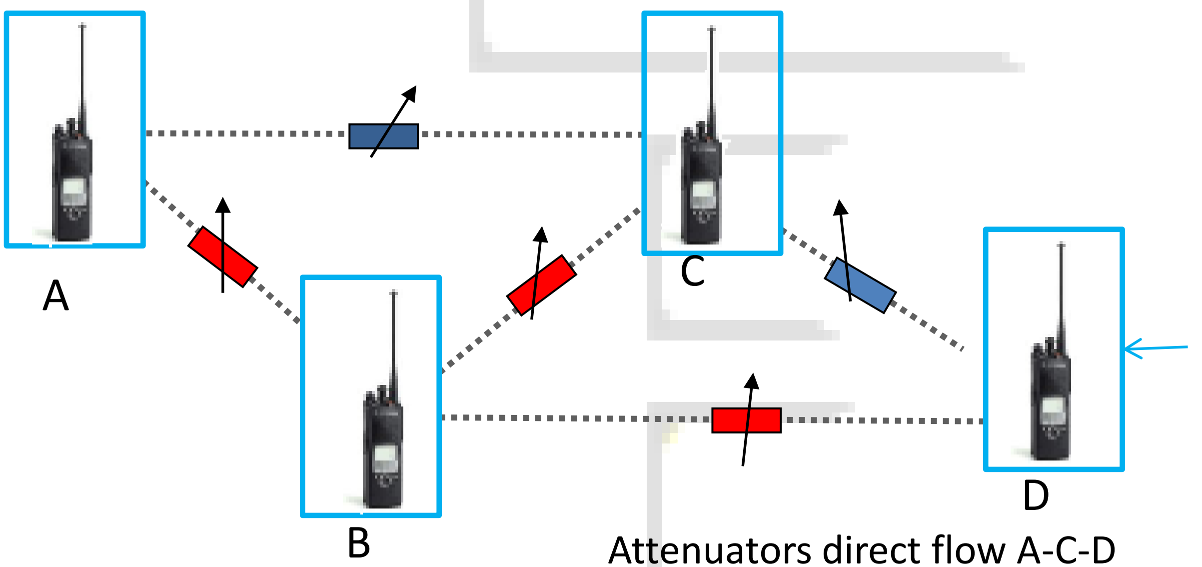
Flexible configuration, can be used for:

- 2, 3 hop scenarios
- Routing flow manipulations
- Recovery from lost nodes/rerouting
- Link quality measurements



2-Hop Scenario: Perfect Routing Conditions

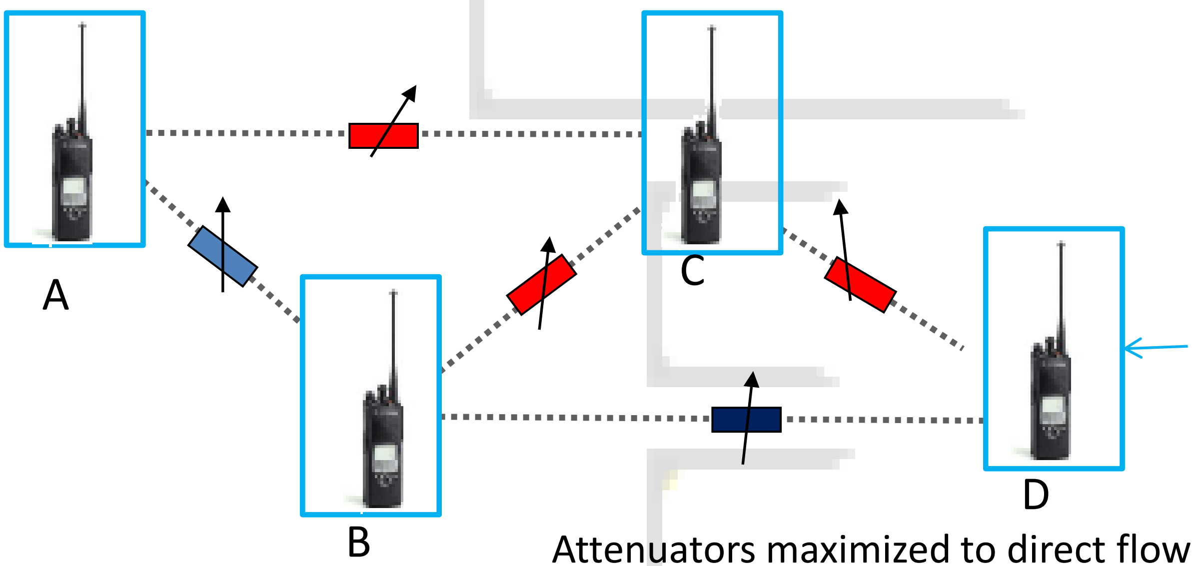
Link	Attenuation (dB)
A->C	0
A->B	63
B->C	63
B->D	63
C->D	0



Attenuators direct flow A-C-D

2-Hop Scenario: Perfect Routing Conditions

Link	Attenuation (dB)
A->C	63
A->B	0
B->C	0
B->D	63
C->D	0



Attenuators maximized to direct flow from A-B-D.
Expect three hops.

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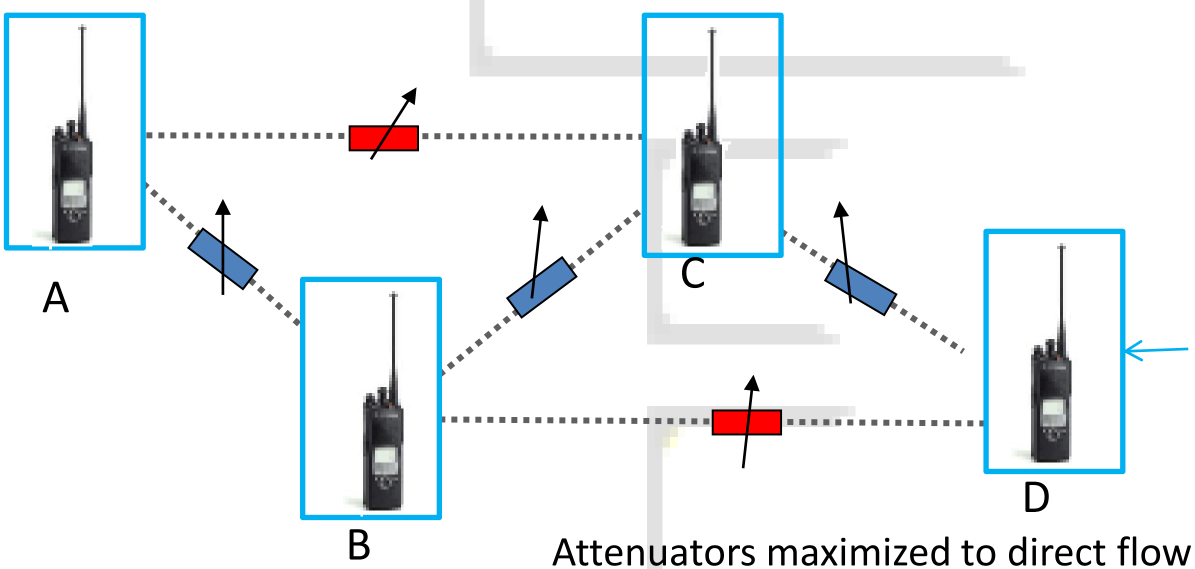
3-Hop Scenario: Perfect Routing Conditions

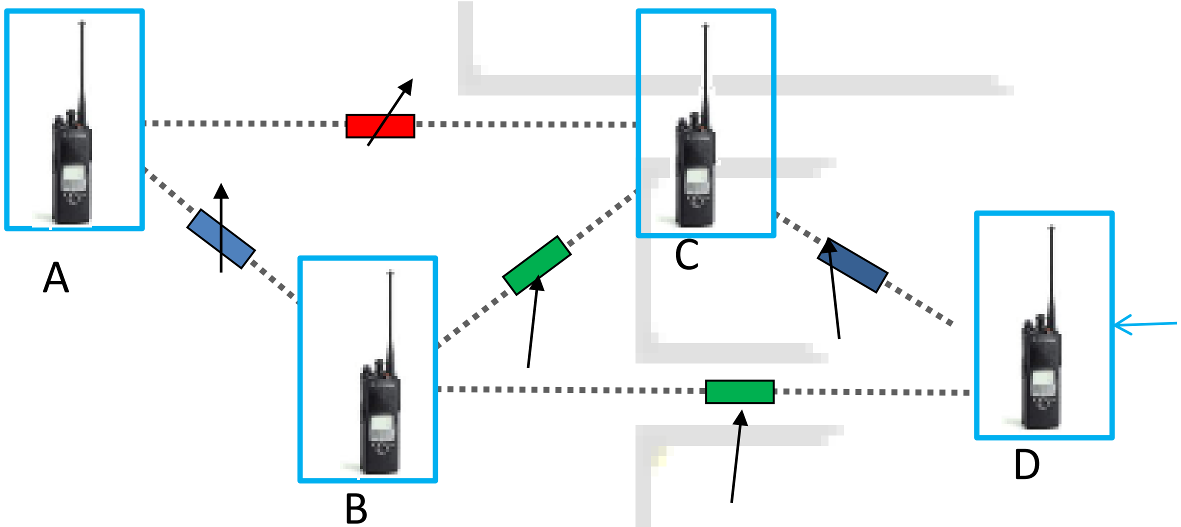
Link	Attenuation (dB)
A->C	63
A->B	0
B->C	0
B->D	63
C->D	0



Attenuators maximized to direct flow from A-B-C-D.
Expect three hops.

3-Hop: With variable flow

Link	Attenuation (dB)
A->C	63
A->B	0
B->C	0-63
B->D	0-63
C->D	0



Attenuators maximized to direct flow from A-B-D.
Expect three hops, but could also see priority changing as the link strength is lowered or increased.

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Thank you

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