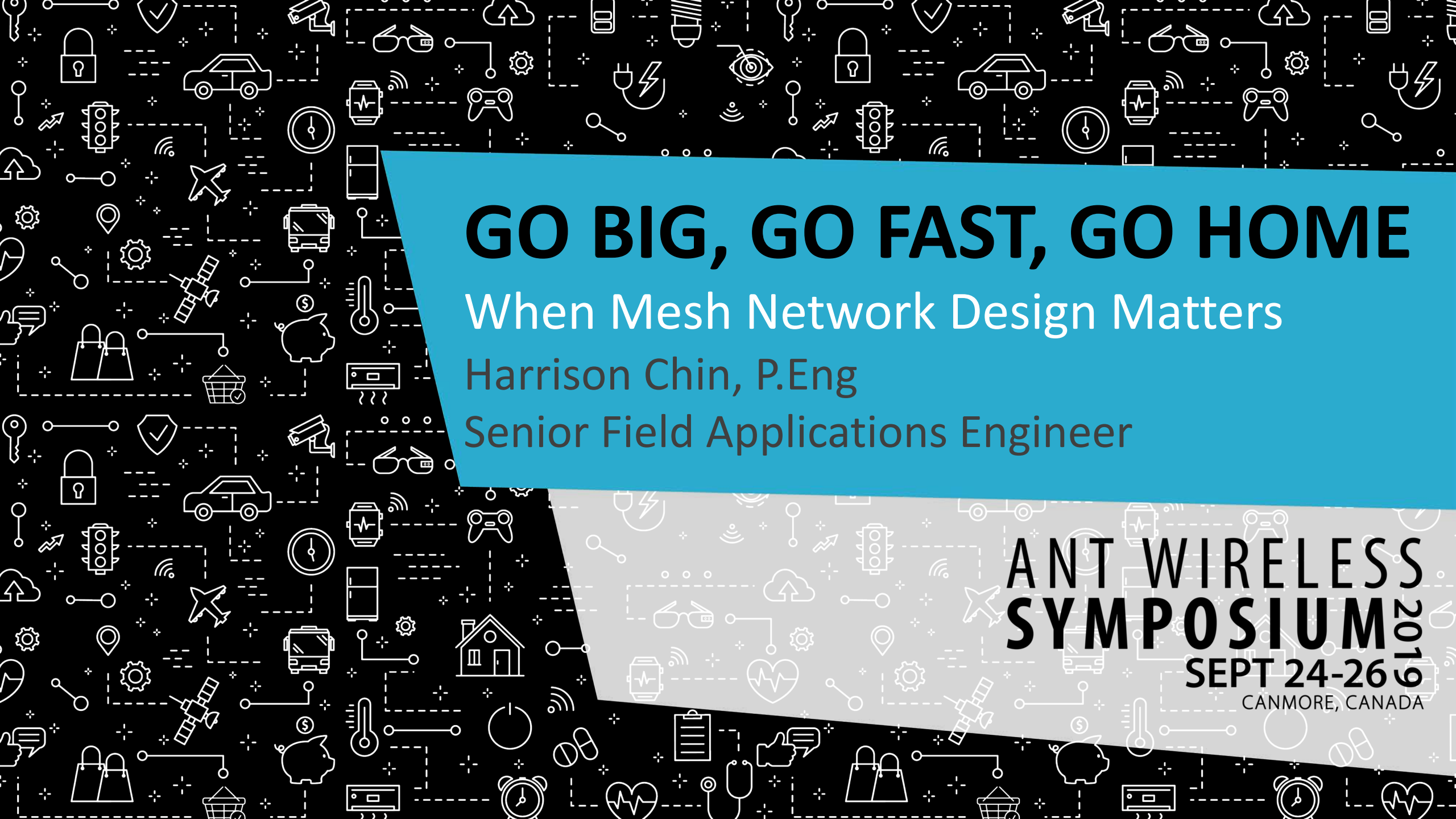

GO BIG, GO FAST, GO HOME

When Mesh Network Design Matters

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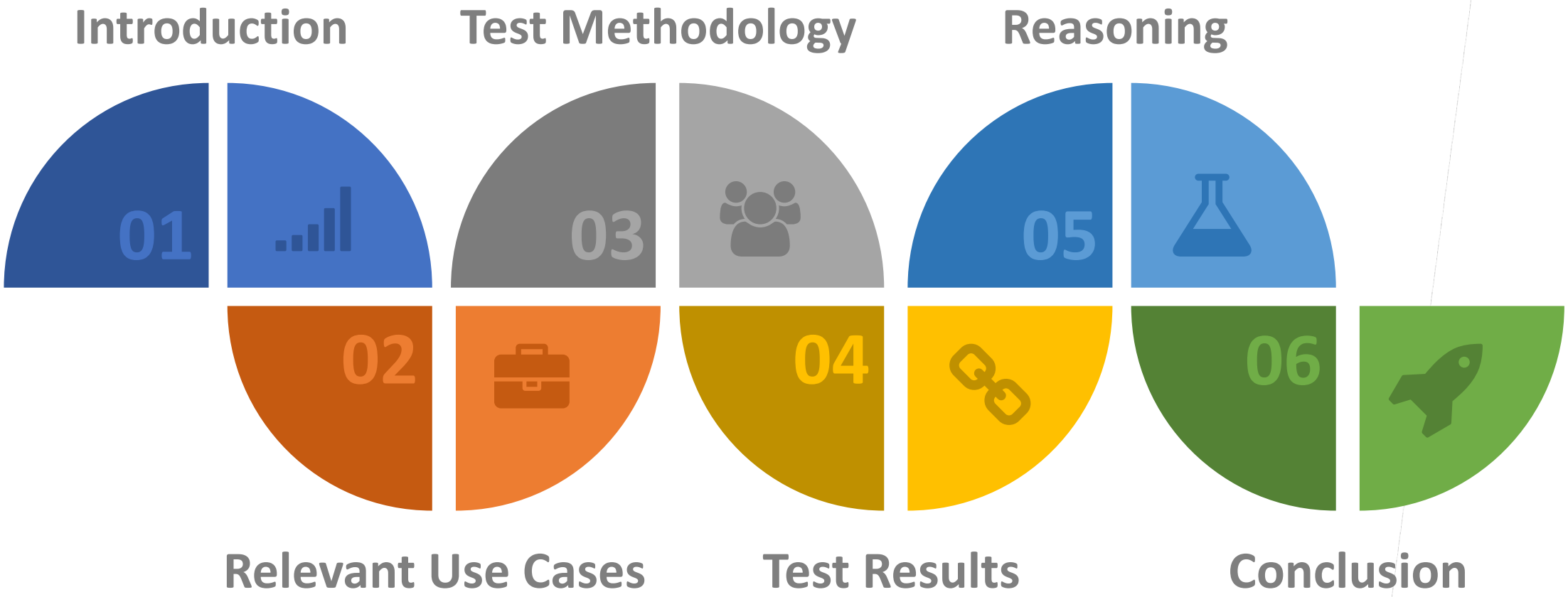
Senior Field Applications Engineer

ANT WIRELESS SYMPOSIUM 2019
SEPT 24-26
CANMORE, CANADA

OVERVIEW



WHAT IS A MESH NETWORK?

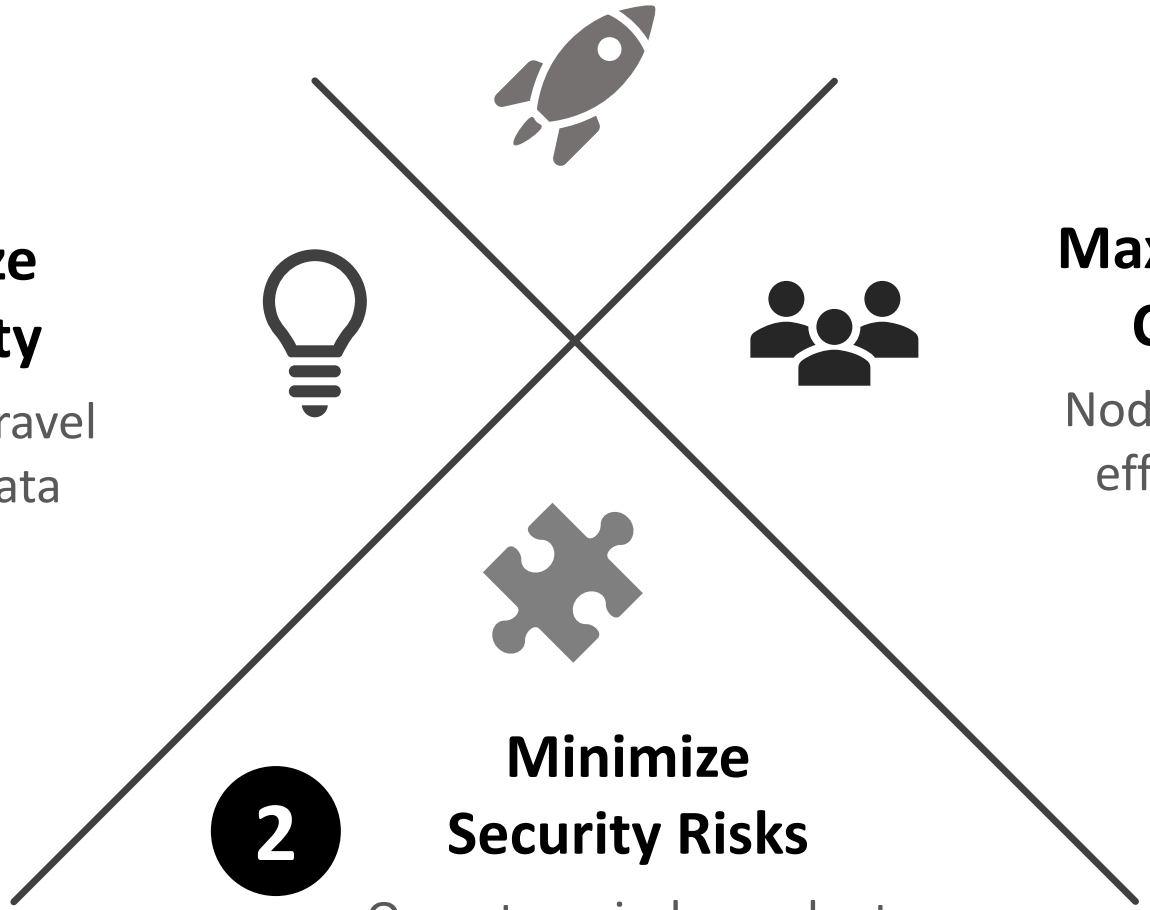
A system of interconnected nodes which cooperatively transport data from one node to another.

WHY USE A MESH NETWORK?

1

Maximize Reliability

Redundant travel paths for data



2

Minimize Security Risks

Operate as independent networks

3

Maximize Area Coverage

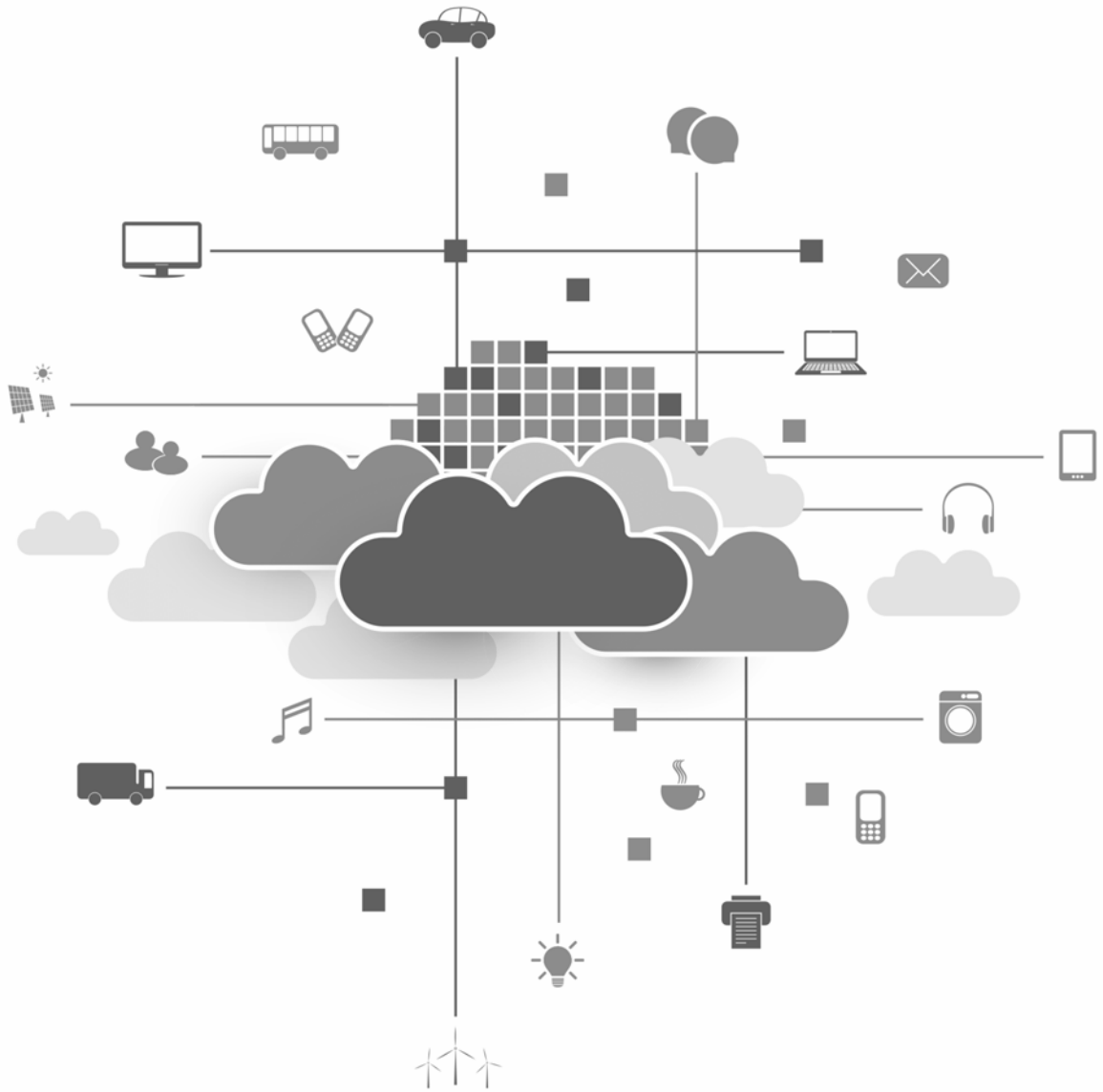
Nodes extend the effective range

USER INTERACTIVE SYSTEMS

Latency sensitive

Use cases

- Home automation
  - Lighting control
  - Door bells
  - Digital assistants



USE CASE
LIGHTING CONTROL

- Users expect instantaneous response
  - Within 100ms or less
- Users expect consistency
  - Groups of lights change together

LIGHTING CONTROL SPECIFICATIONS

- Bytes of data per packet
  - State data
    - On/Off
    - Intensity
- Infrequent events
  - Minutes between changes
- Strict latency bounds

OBSERVATIONAL SYSTEMS

Throughput sensitive

Use cases

- Process management
  - Office space management
  - Asset tracking
  - Vertical farm monitoring

USE CASE
ASSET TRACKING

- Hundreds of physical assets
- Data is required in a regular and reliable basis
  - Location, temperature, motion
  - Timescale in seconds to minutes
- Operate under a variety of environmental conditions
- Straightforward to deploy in scale

ASSET TRACKING SPECIFICATIONS

- Dozens of bytes per packet
  - Location
  - Sensor data
- Periodic events
  - Seconds between asset updates
- Large volume of concurrent traffic
  - All node data is important

KEY PERFORMANCE INDICATORS

Use Case	Latency	Throughput	Reliability
Lighting Control	✓		✓
Asset Tracking		✓	✓

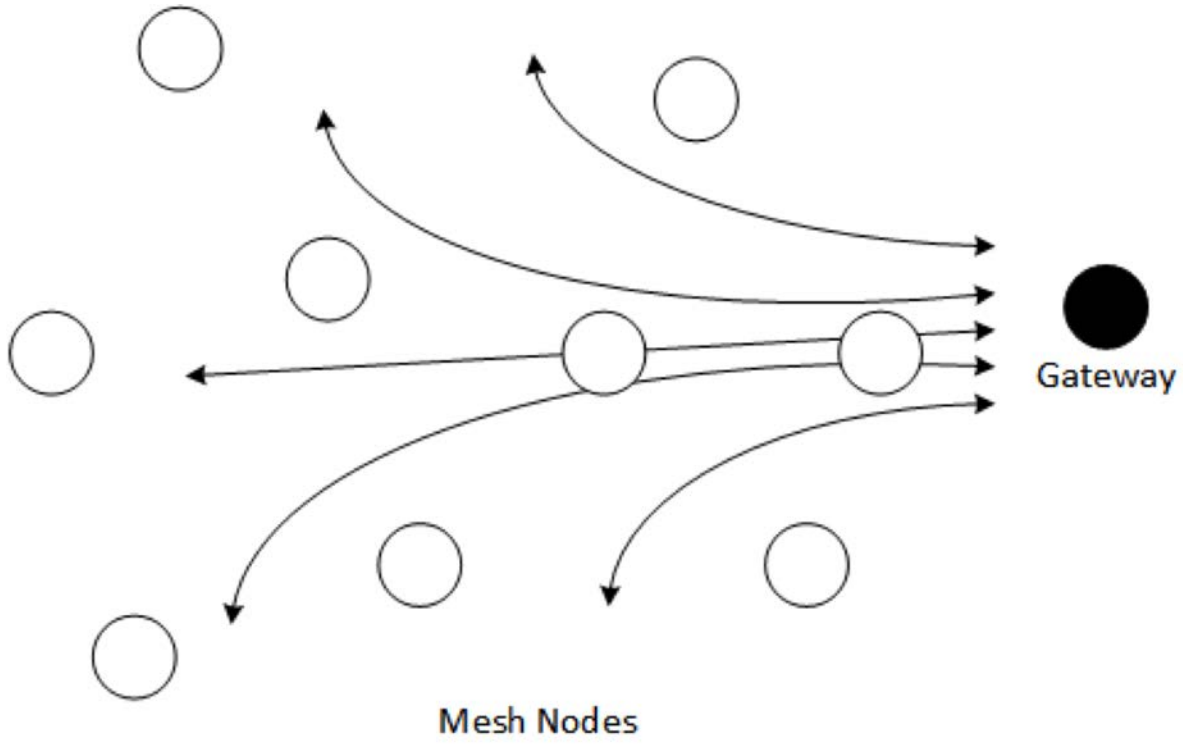
HOW DO WE MEASURE PERFORMANCE?

- Average Round Trip Time - Latency
  - Request a response from a node and measure how long it took
- Aggregate Gateway Throughput - Throughput
  - $$\frac{\text{number of bytes received from all nodes}}{\text{total time for all successful responses}}$$
- Average Success Rate - Reliability
  - $$\frac{\text{number of responses received}}{\text{total number of requests}}$$

PING TESTING

- Gateway-based Architecture
  - Phone/switch is the gateway for lighting
  - Cellular/Satellite/Hardline bridge for Asset tracking

PING TESTING



TEST FRAMEWORK

Bluetooth Mesh	ANT BLAZE
nRF52832-based modules	nRF52832-based modules
Certified nRF BLE Mesh 3.1.0	ANT BLAZE Libraries
Test software provided by Nordic Semiconductor	Test software provided by Garmin

TRAFFIC PATTERNS

Single Ping

- One node responds
- Lights…visible feedback

Group Ping

- 10 nodes respond
- Many sensors relaying data to gateway

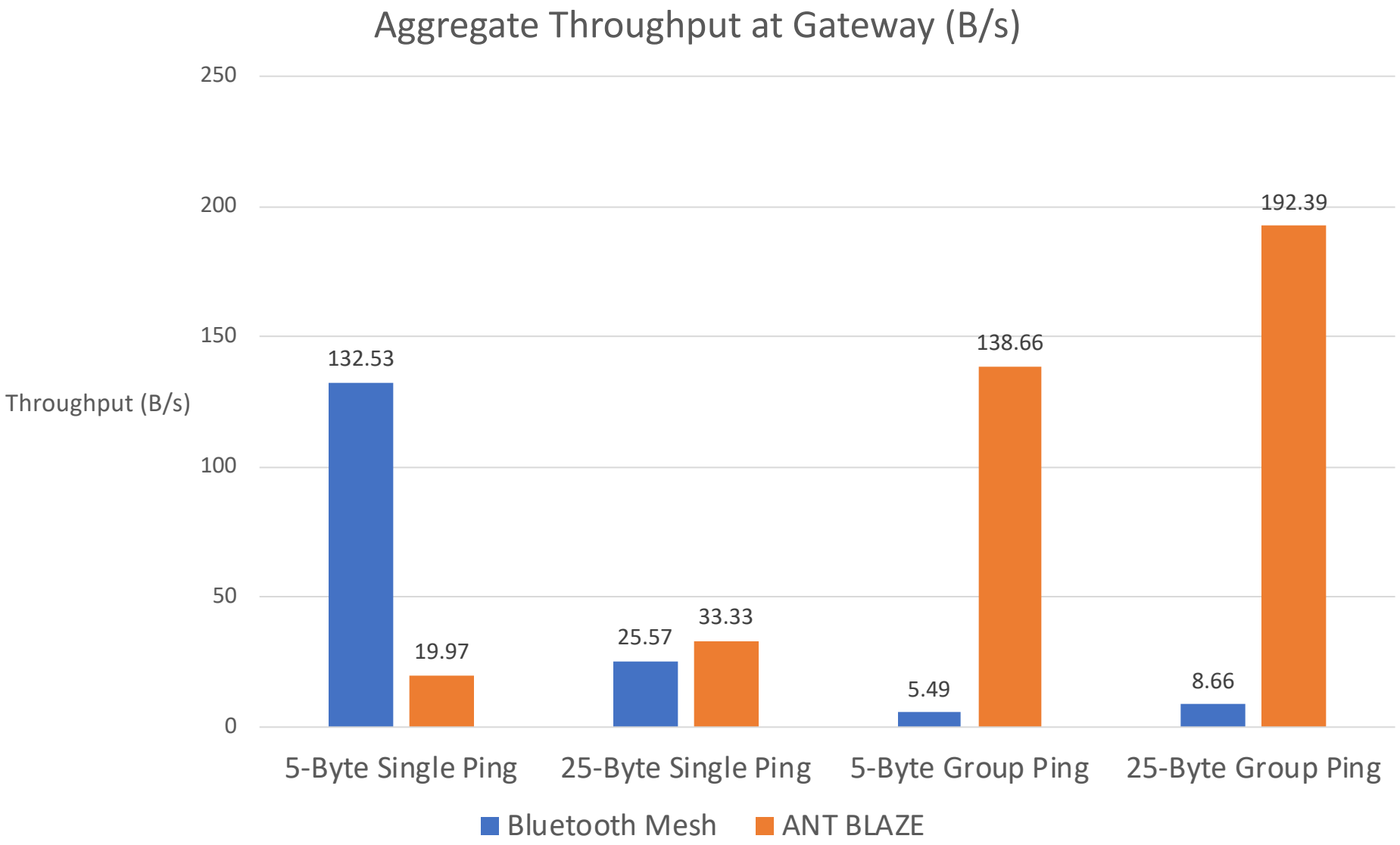
LAYOUT - DENSE - 30 NODES

DENSE – 30 NODES

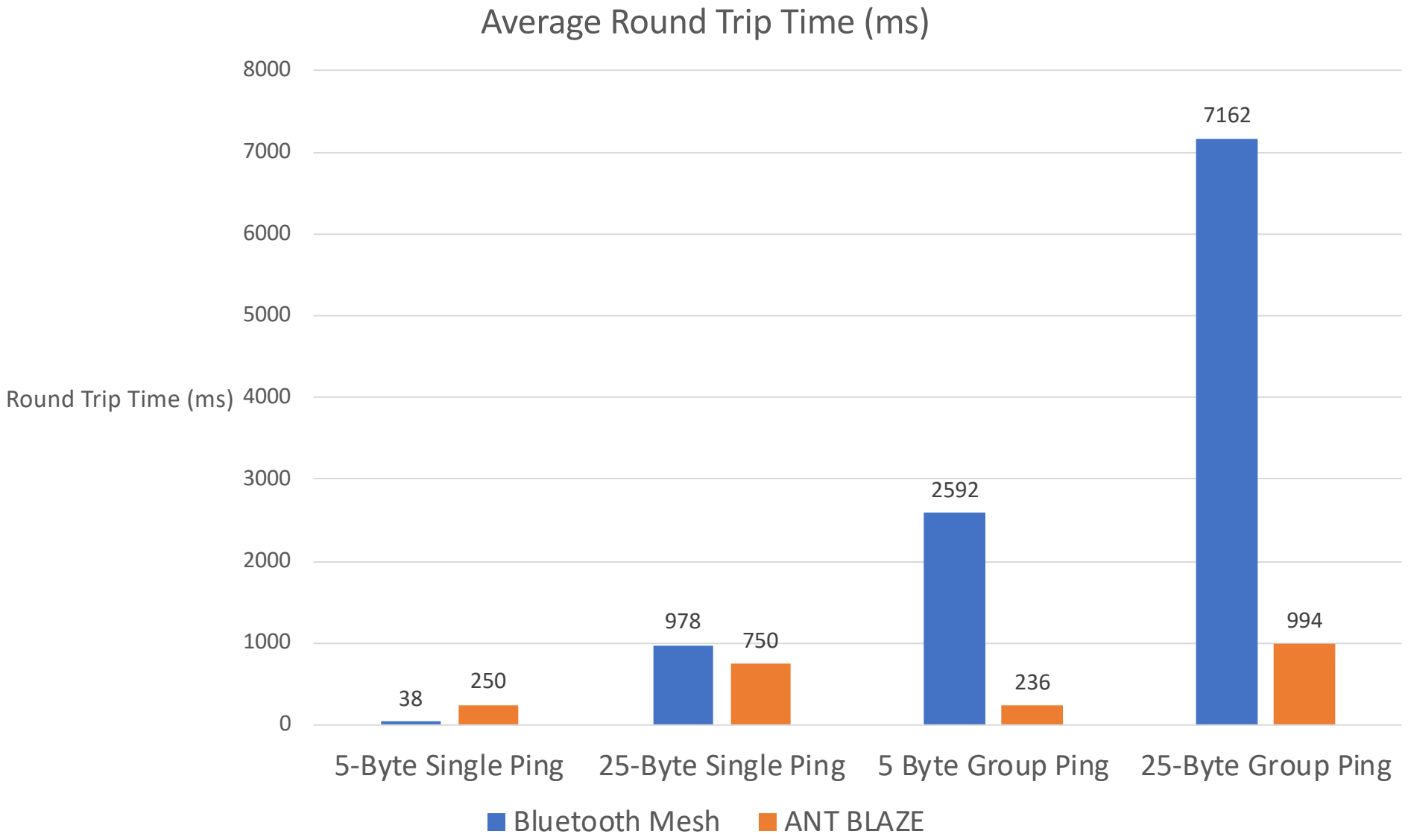
Test Setup

- ~4m spacing between nodes
- ~8m spacing between relays
  - 4 relays in 30 nodes
- Kitchen Environment
  - Reduced BLE ADV Traffic

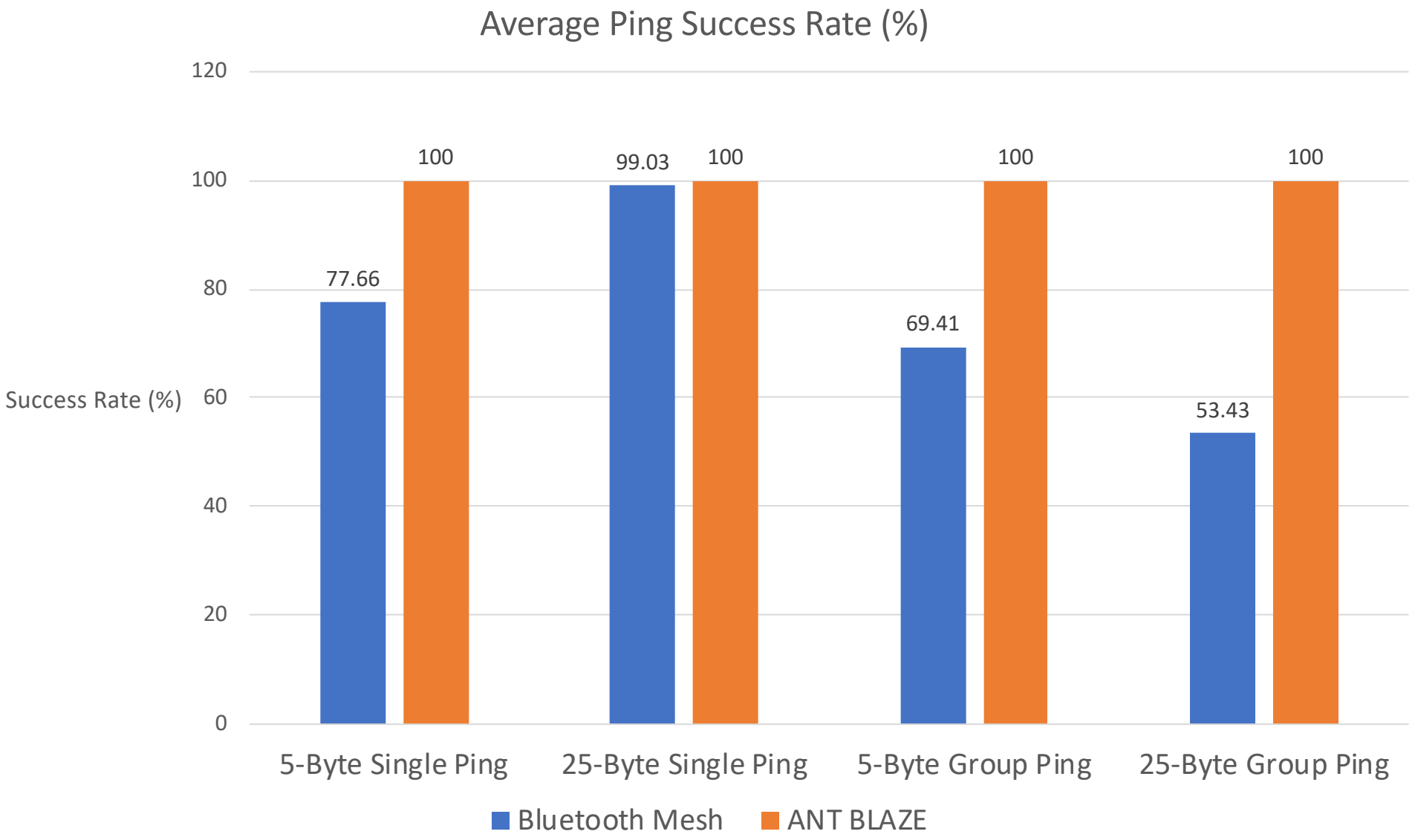
DENSE – 30 NODES



DENSE – 30 NODES



DENSE – 30 NODES



LAYOUT – SPARSE – 30 NODES

SPARSE – 30 NODES

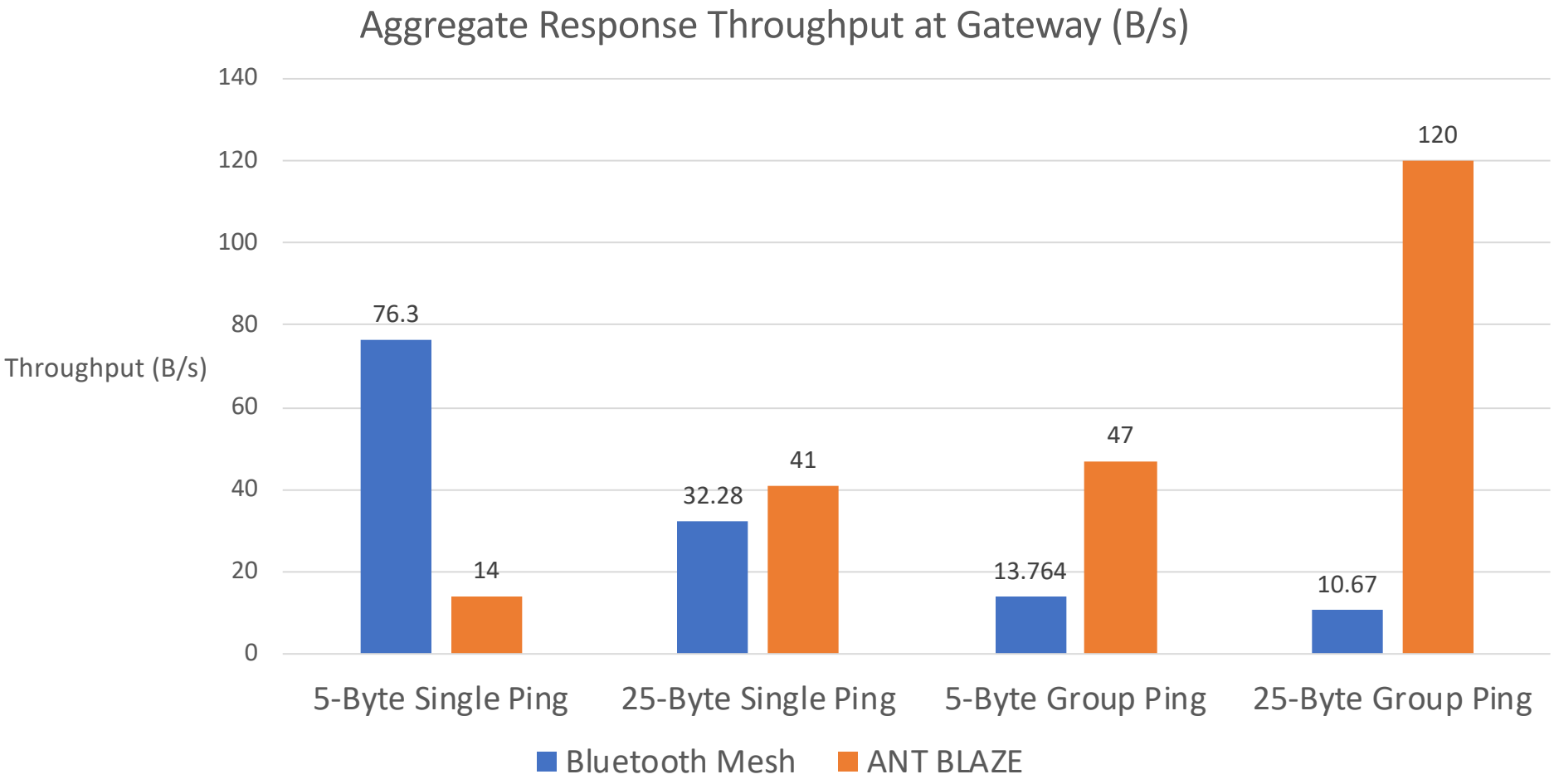
Test Setup

- ~10m Spacing
- 30 Nodes Total
- All Relays
- 100 Test Cycles
- Increased BLE ADV Traffic

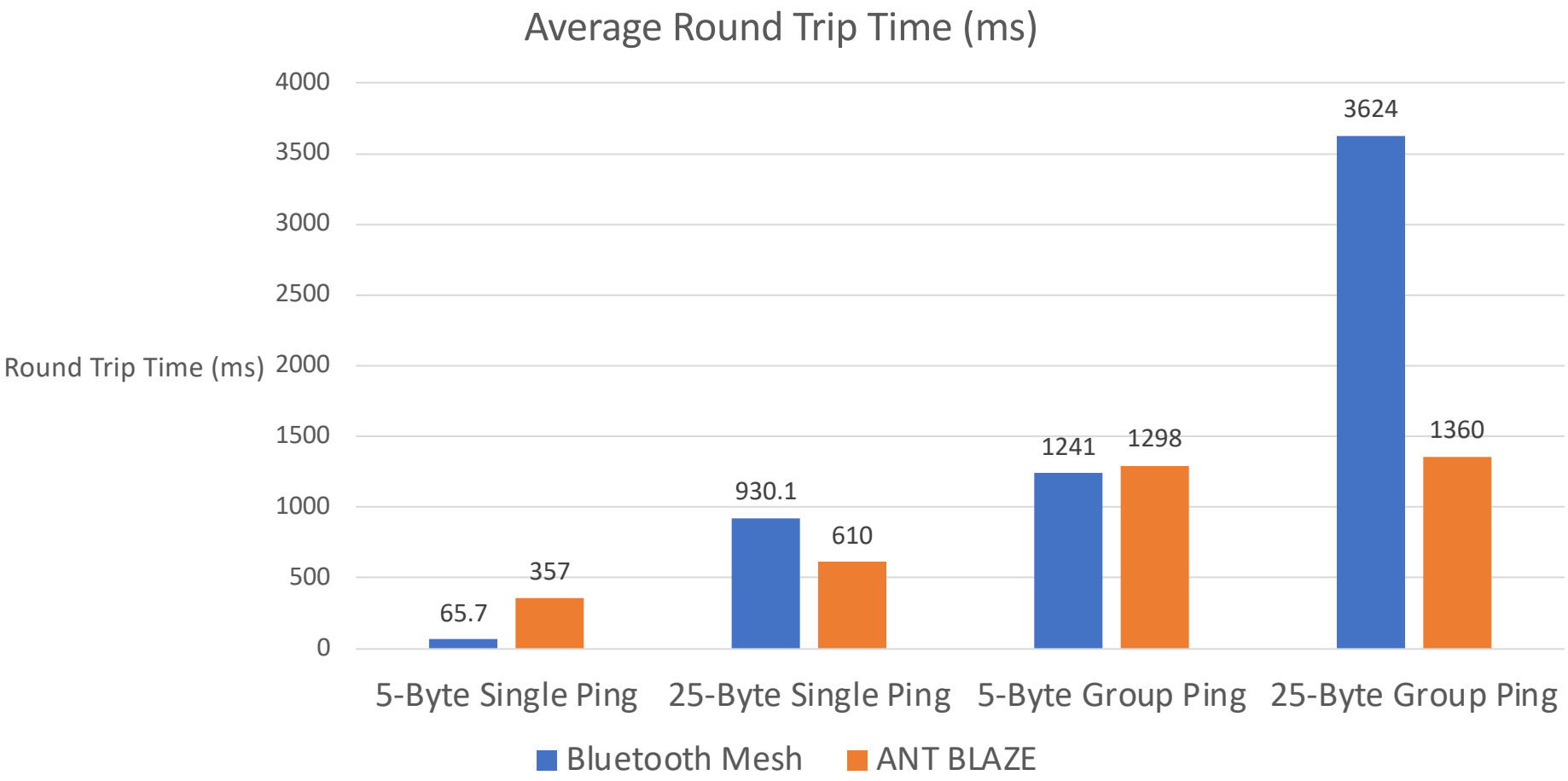
Logan and Rainer

*May not be a representative depiction of all interns

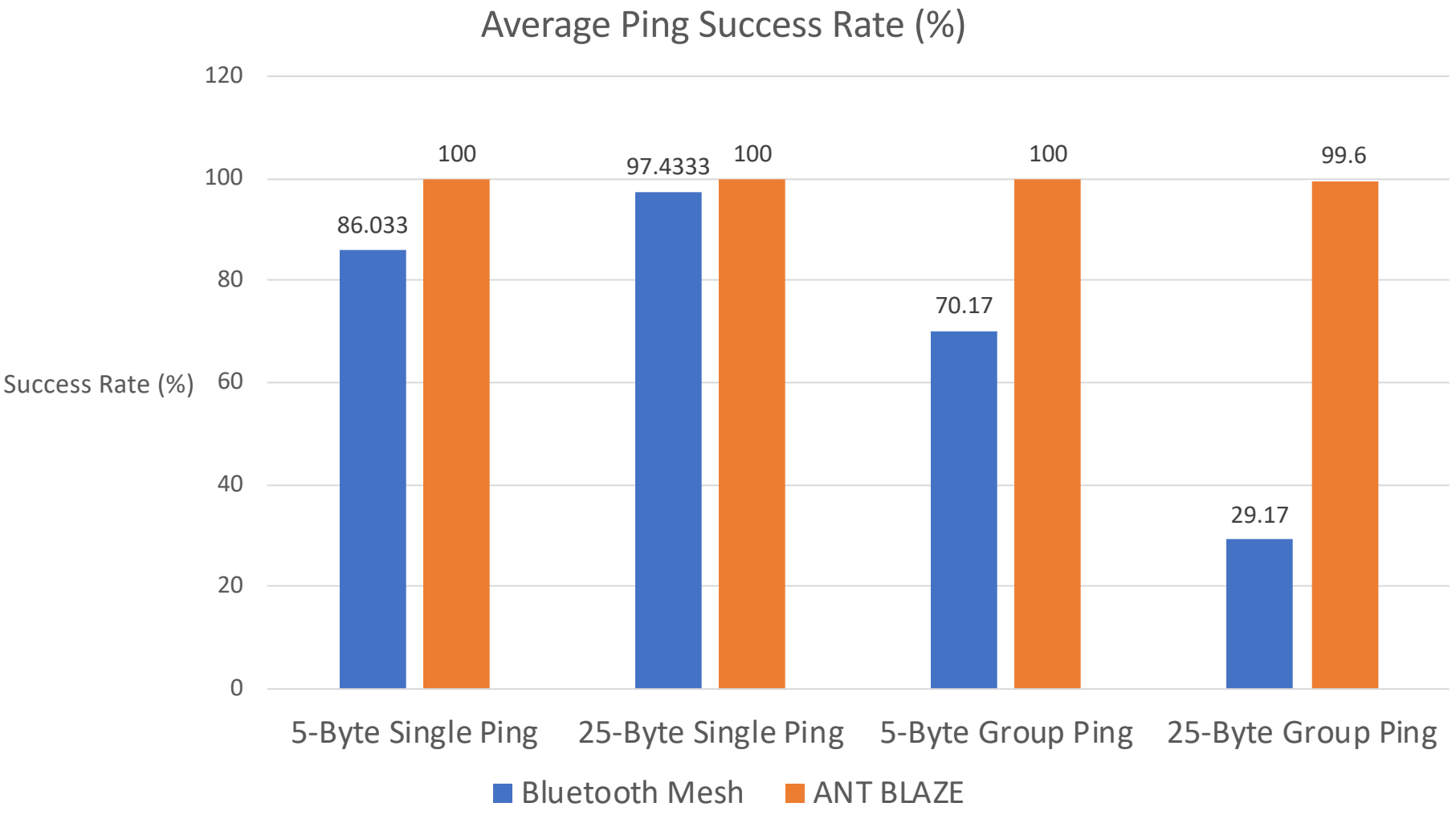
SPARSE – 30 NODES



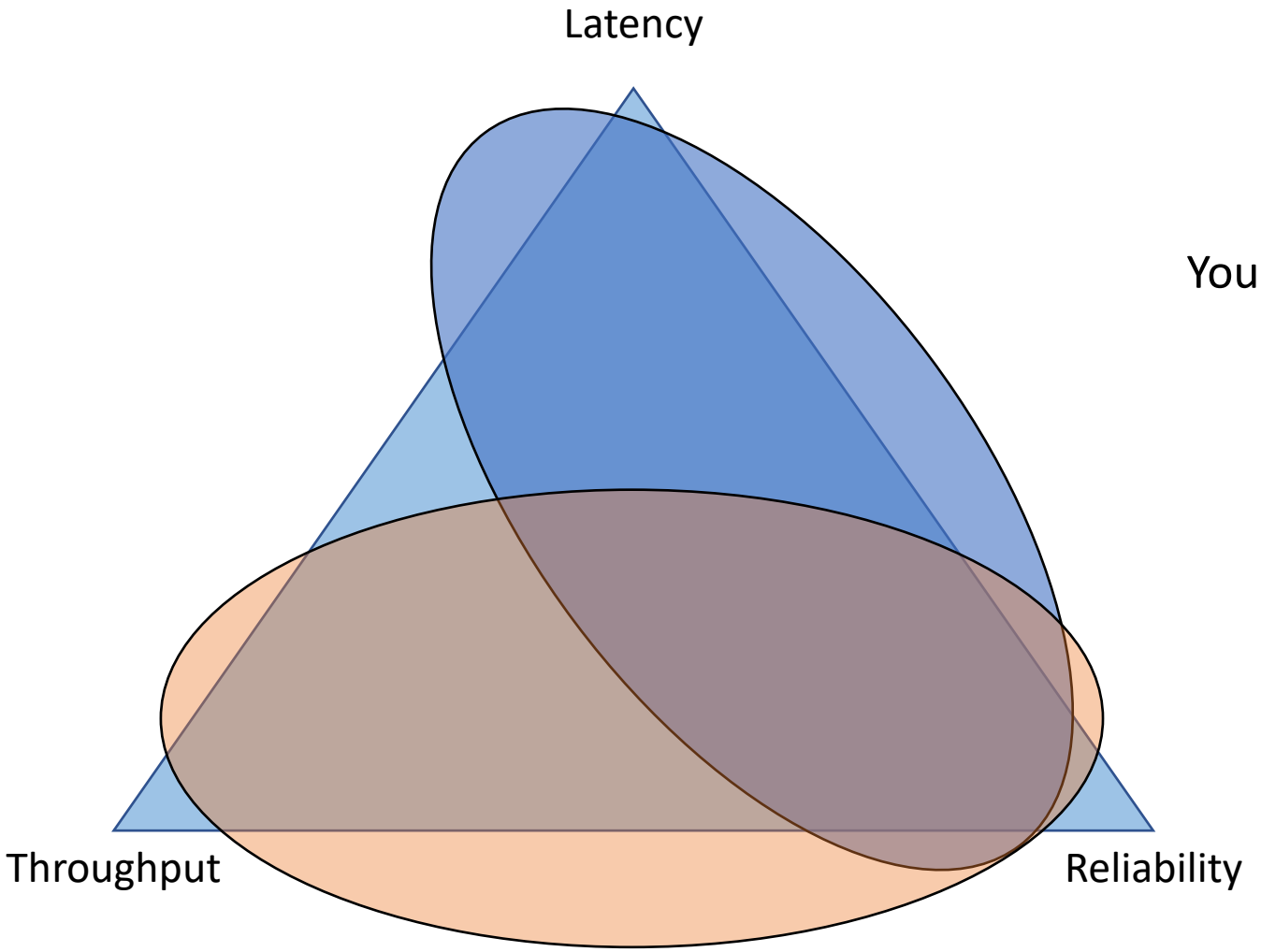
SPARSE – 30 NODES



SPARSE – 30 NODES



TRADE-OFF TRIAD
!= CONJOINED TRIANGLES OF SUCCESS



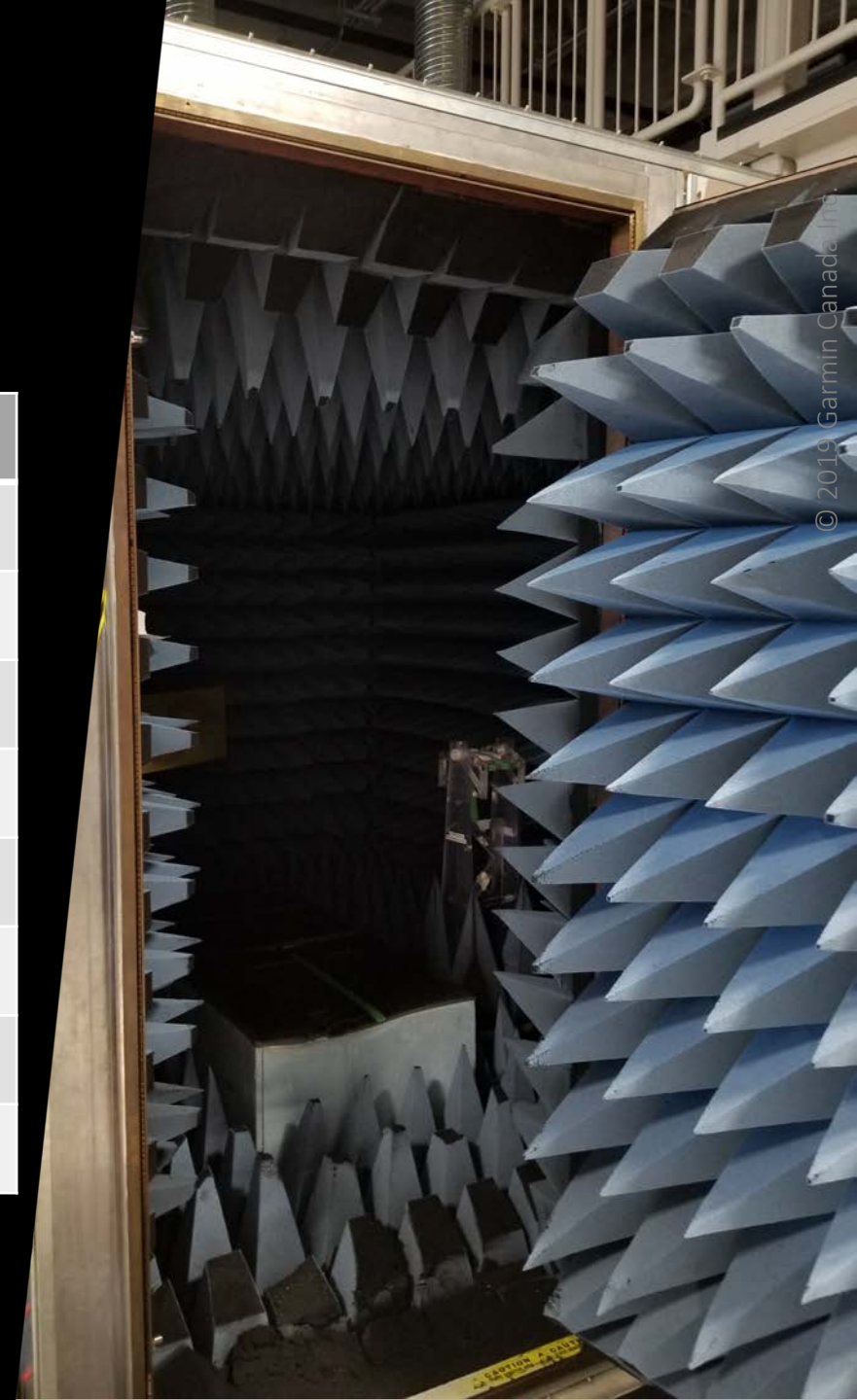
You can only pick two.

WHY? SHARING A LIMITED RESOURCE… AIR TIME

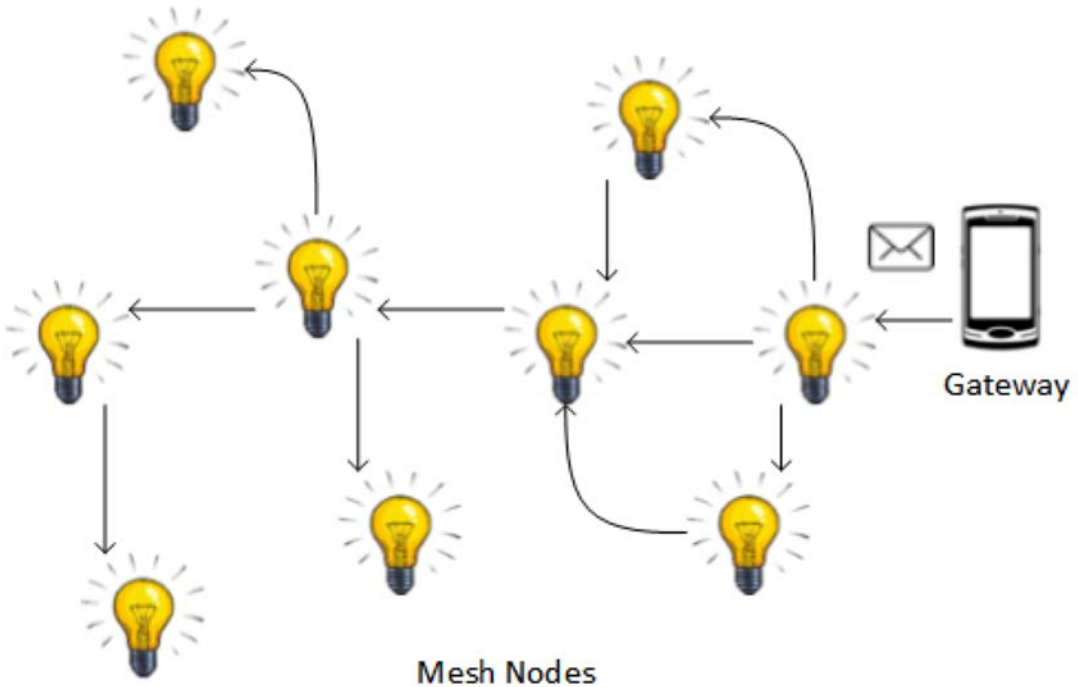
- Fundamental contention between…
  - Keeping nodes busy with required data transfers
    - “Throughput”
  - Keeping nodes available to listen for new data requests
    - “Latency”
  - Keeping nodes aware of failed data transfers
    - “Reliability”

TUNING PARAMETERS FOR THE RIGHT BALANCE

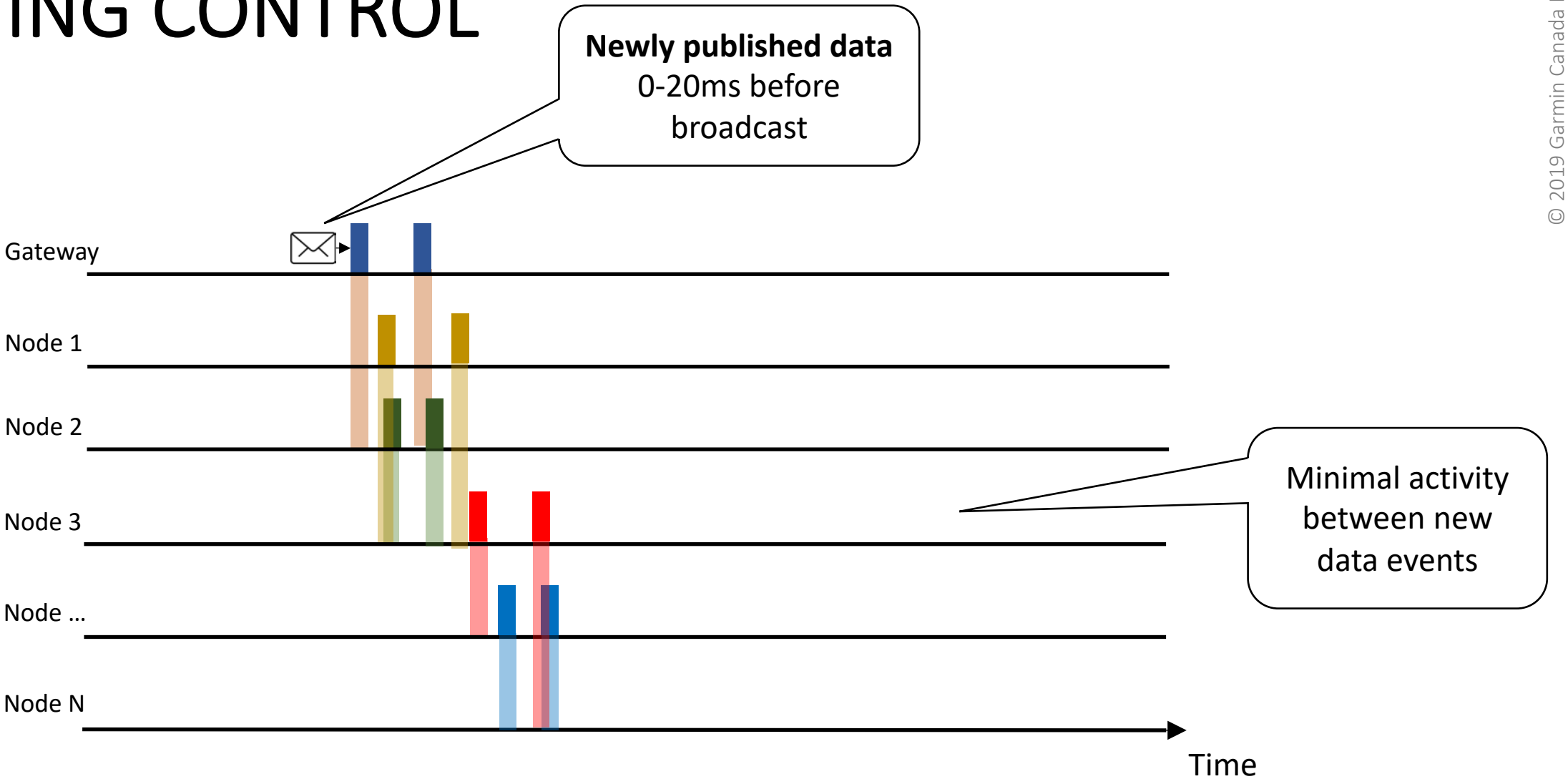
Parameter	Bluetooth Mesh	ANT BLAZE
RF channel	N/A, ADV channels	78 channels, Up to 3
App level retries	SAR and/or model calls	Library calls in app
Proxy ADV Interval	Modify for density	N/A, As needed
Transmission interval	Modify for concurrency	N/A, Built-in
Transport layer repeats	Modify for interference	N/A, Built-in
Relay count	Modify for coverage	N/A, All relay
Time-to-live	Modify for coverage	N/A
Bearer layer repeats	Modify for interference	N/A



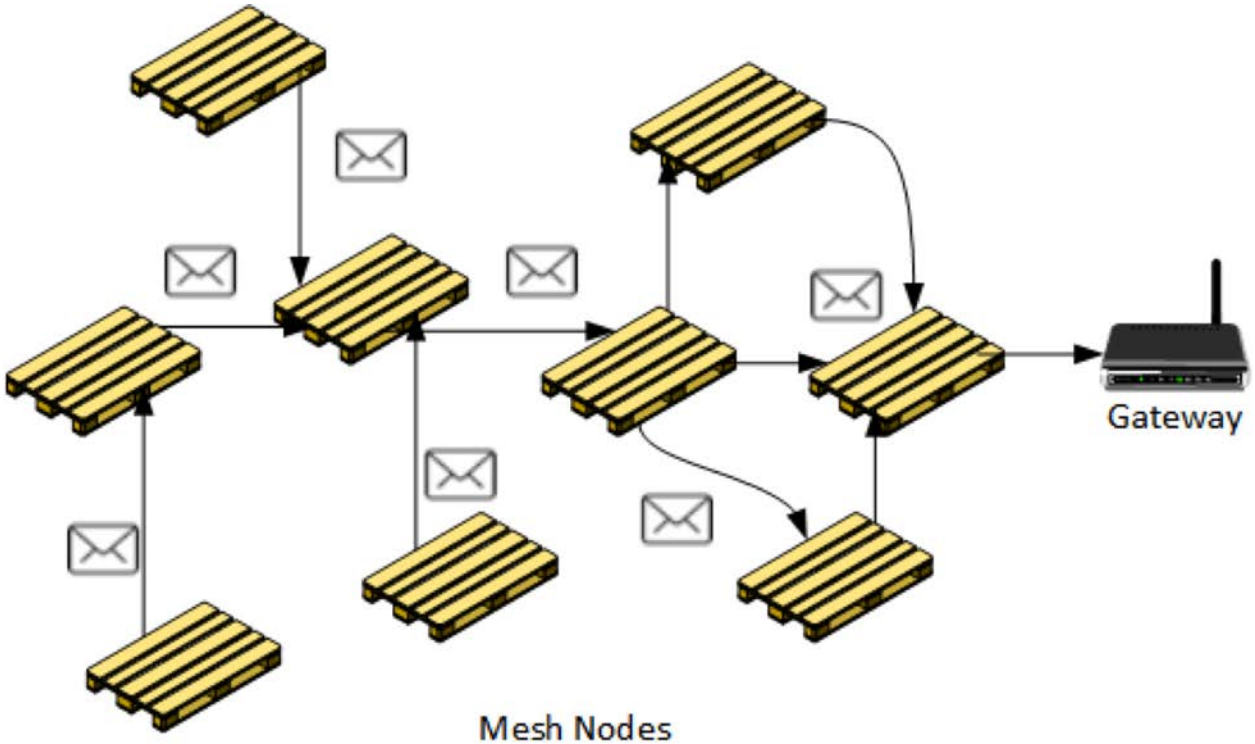
LIGHTING CONTROL RE-IMAGINED



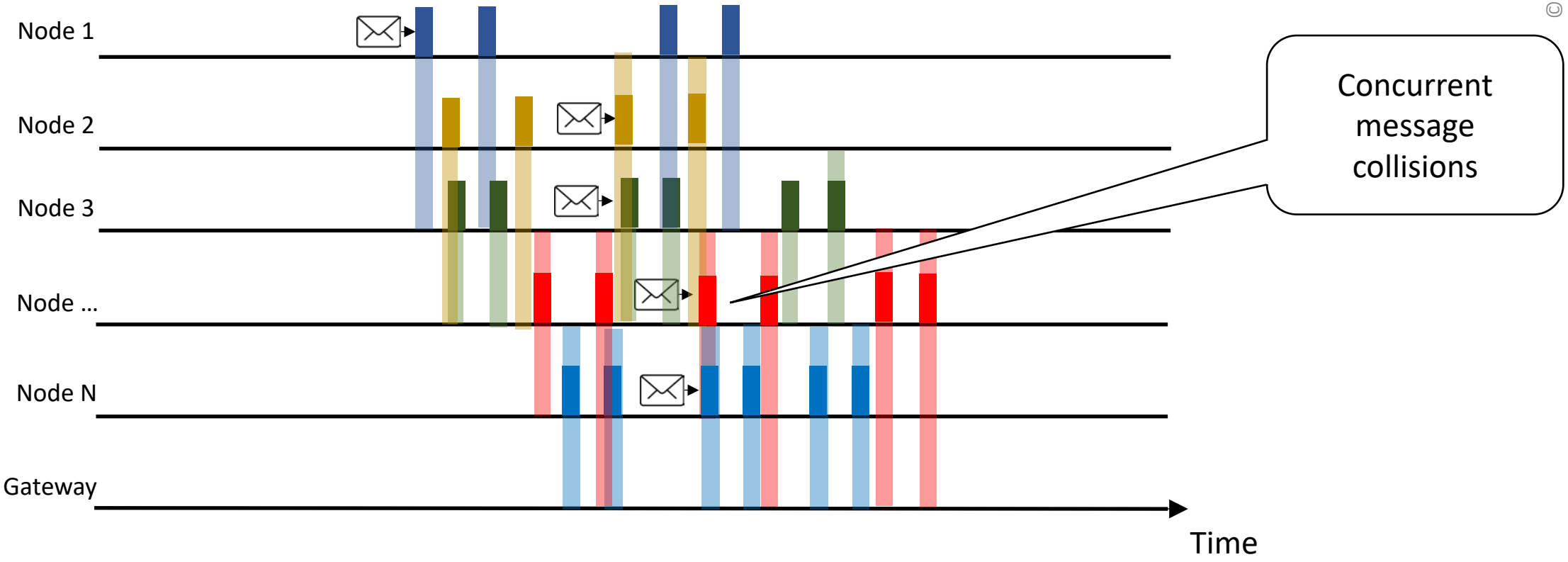
BLUETOOTH MESH TIME DOMAIN LIGHTING CONTROL



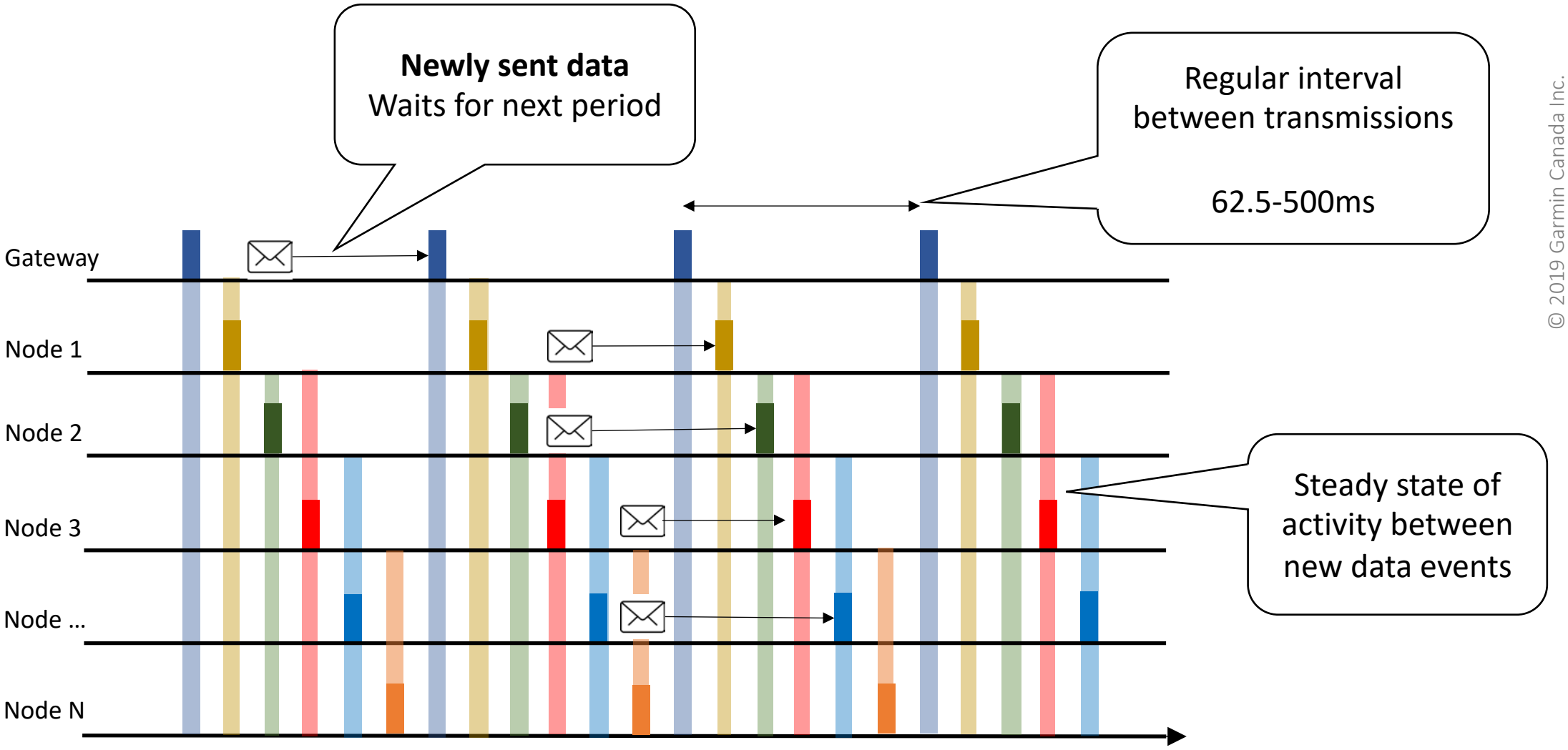
ASSET TRACKING RE-IMAGINED



BLUETOOTH MESH TIME DOMAIN ASSET TRACKING



BLAZE BROADCAST TIME DOMAIN BOTH USE CASES



“CONTEXT IS FOR KINGS” - Hint: “Starfleet” Captain

- What are your requirements?
  - Latency
  - Throughput
  - Device count
- Where are the nodes being deployed?
  - Commercial
  - Residential
  - Industrial

CONCLUSION

- Is ultra-low latency required?
  - Data suggests look into Bluetooth Mesh

- Is increased throughput more important?
  - Data suggests look into ANT BLAZE

QUESTIONS?