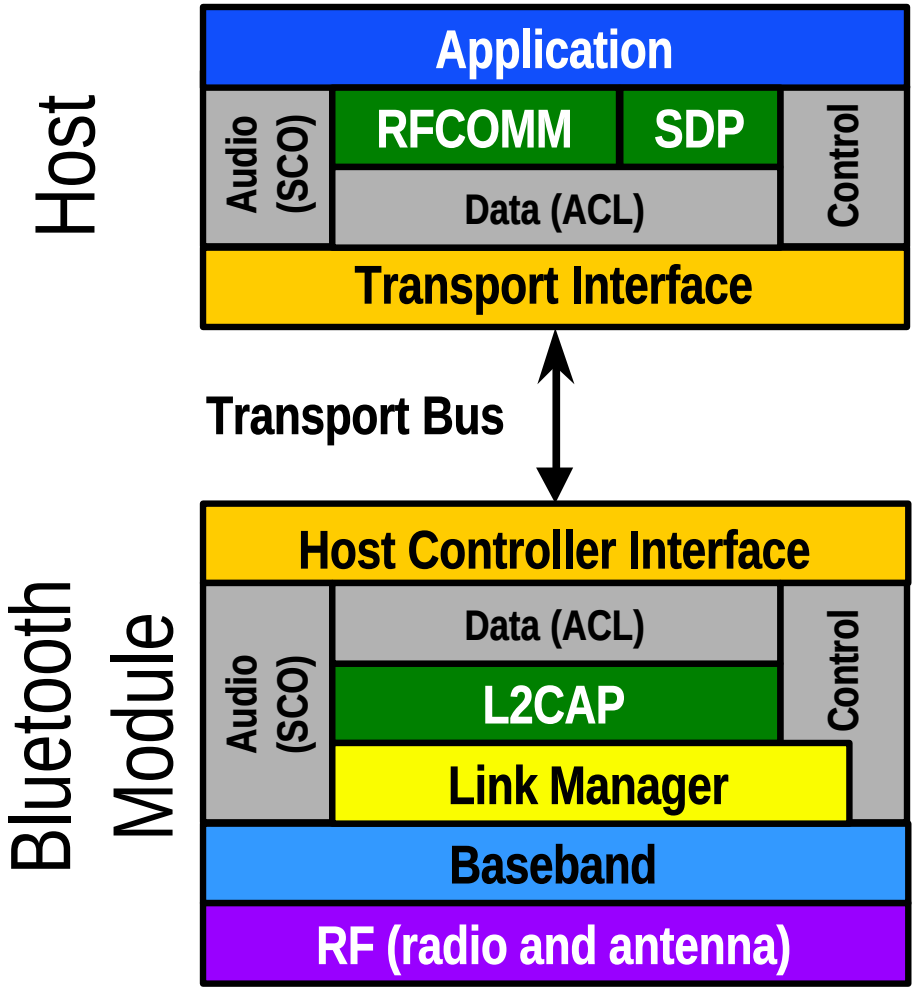
Inside Bluetooth



Host Application

API and Legacy Support Modules

Bluetooth HCI Driver

Physical I/F

Physical I/F

HCI Firmware

Logical Link Control & Data Adaptation

Physical Link Control

Data Processing & Transmission Mgmt.

Transmission/Reception

L2CAP

Logical Link Control and Adaptation Protocol

- Manages the creation and termination of virtual connections with other Bluetooth devices
  - Negotiates and/or dictates parameters
    - Including Security and Quality of Service (QoS)
- Manages ACL data flow between the host and Link Manager
  - Multiplixing of multiple concurrent host I/O operations
  - Segmentation And Reassembly (SAR) of various data formats for baseband compatibility

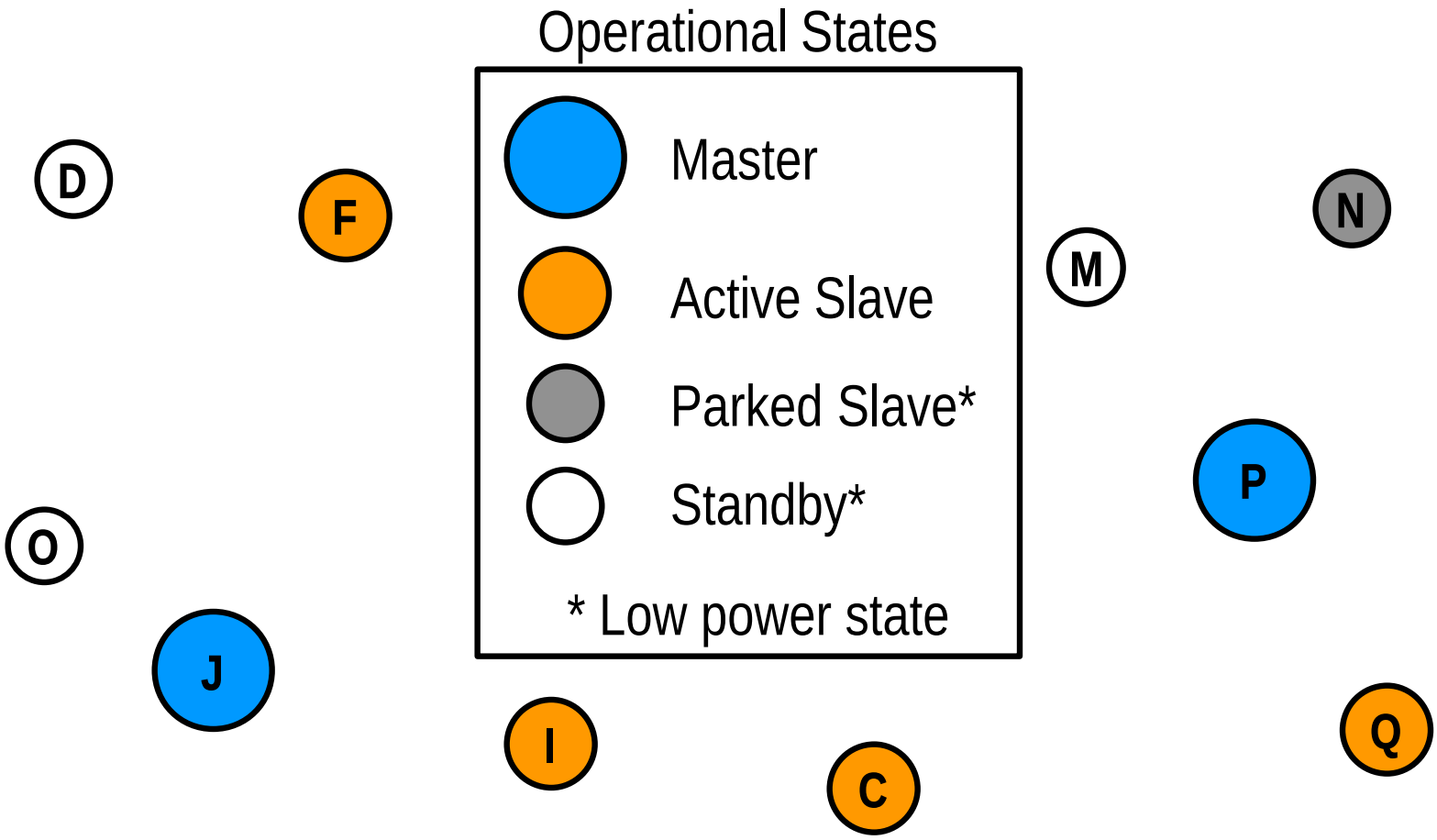
Link Manager

- Physically manages creation, configuration, and termination of device to device links
- Also manages ACL data flow between the L2CAP and Baseband through established links
  - Forwards data from the L2CAP to the Baseband with its associated link specific transmission parameters
  - Forwards data from the Baseband back to the L2CAP associated to its specific source link

Baseband

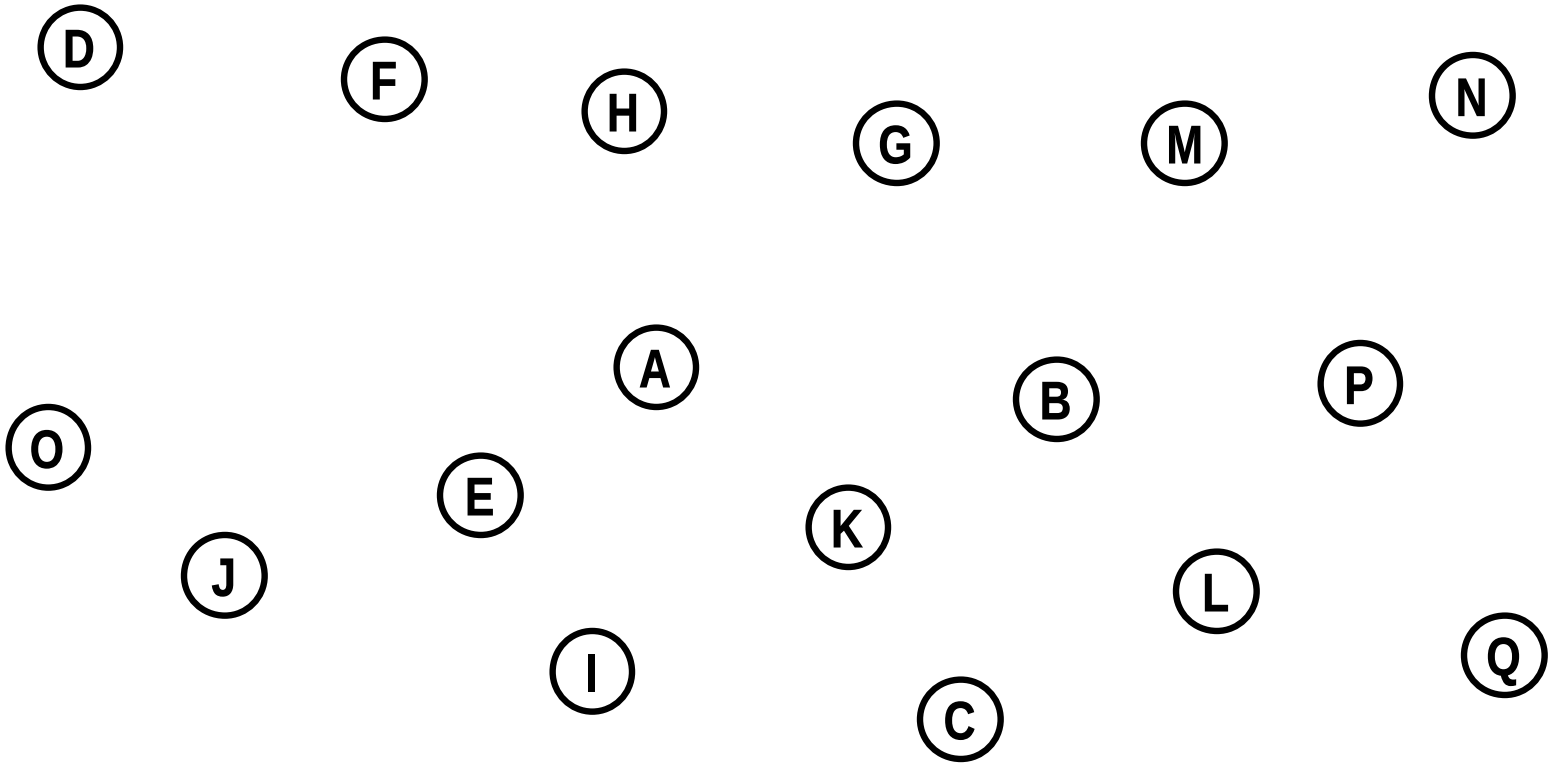
- Performs all digital data processing operations
  - Speech coding
  - Data whitening
  - Optional encryption/decryption
  - Packetization
  - Header and payload error detection and correction
- Calculates and controls transmission frequency
  - Supporting Bluetooth's 80 channel Frequency Hopping (FH) spread spectrum transmission method

How Does Bluetooth Work?



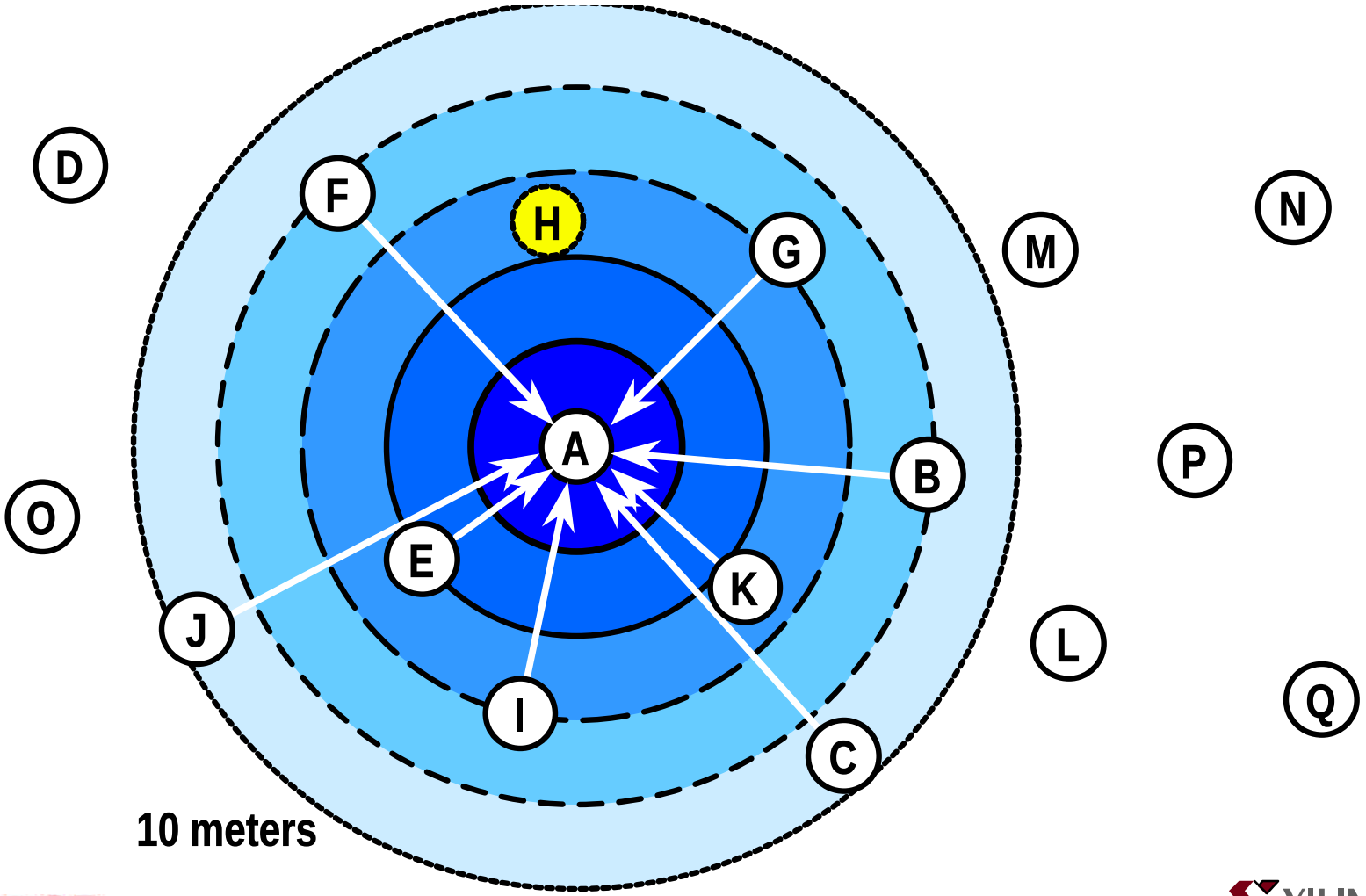
In the Beginning

- Initially Bluetooth devices only know about themselves
  - Everyone passively monitors in Standby mode
  - No devices are synchronized



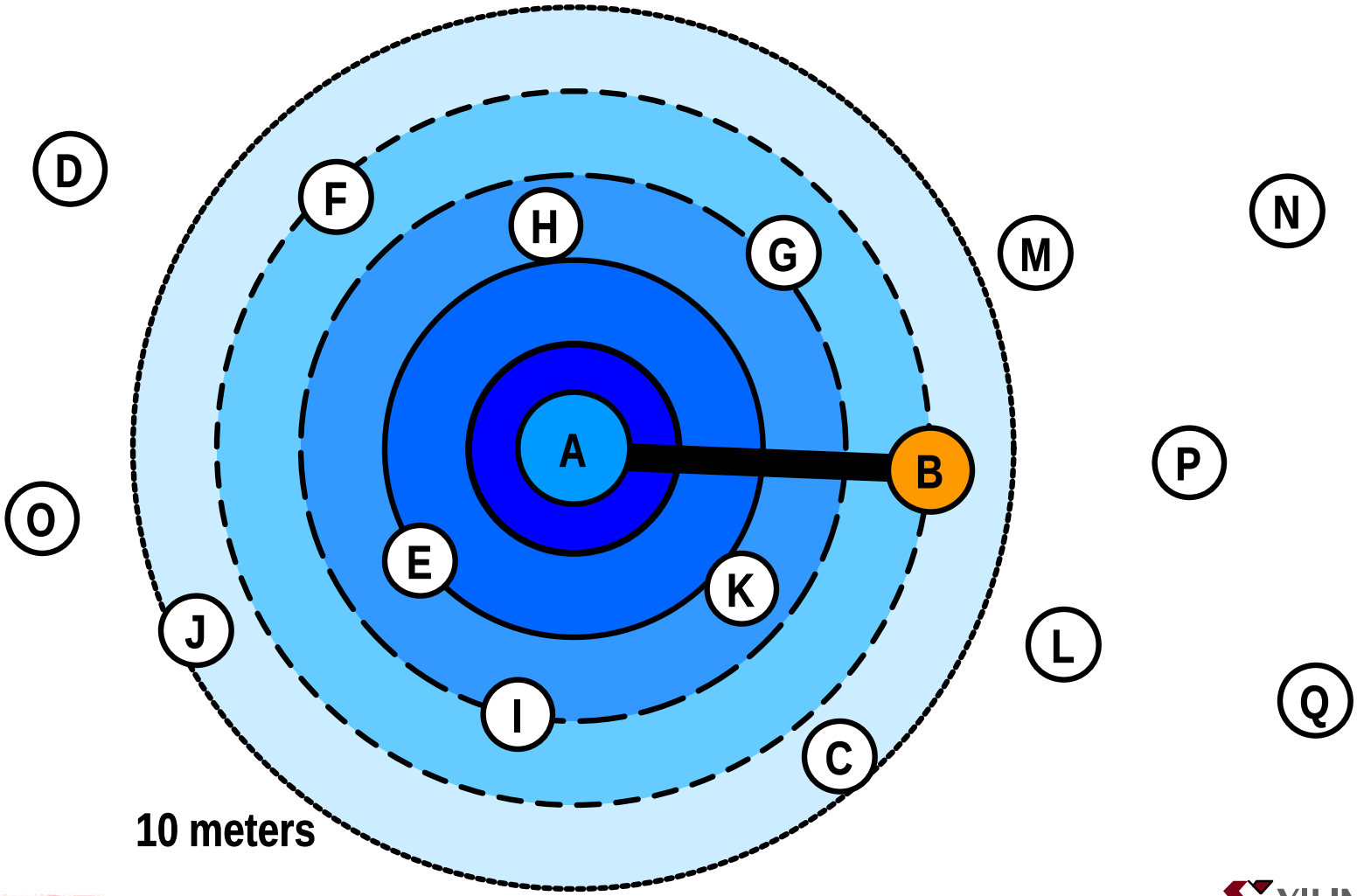
Inquiry
Discovering Who's Out There

- Inquiry discovers what other devices within range



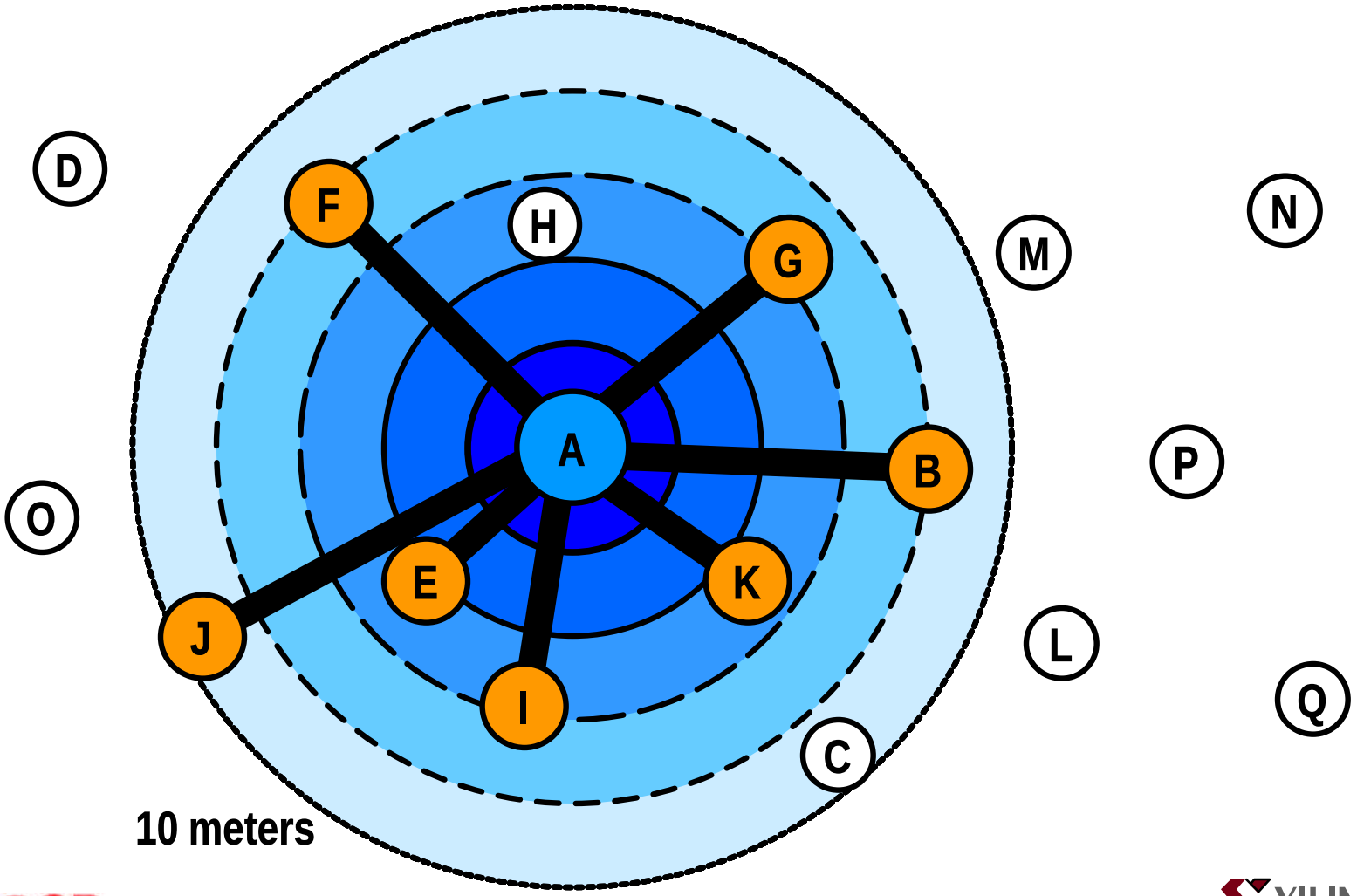
Paging
Creating a Piconet

- Paging creates a Master/Slave link called a Piconet



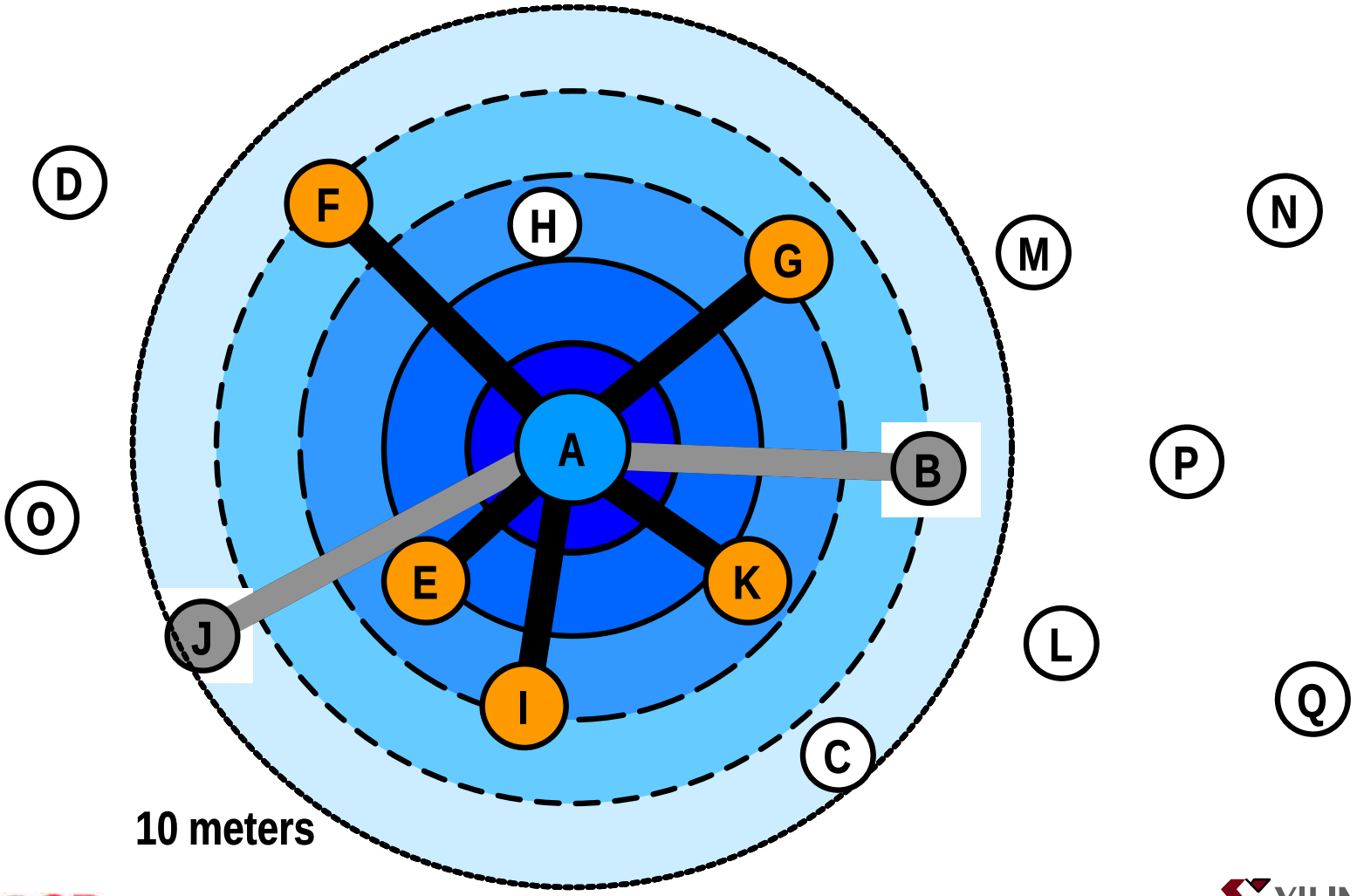
Expanding a Piconet (1)

- Successive Pages can attach up to 7 Active Slaves to a Piconet at one time



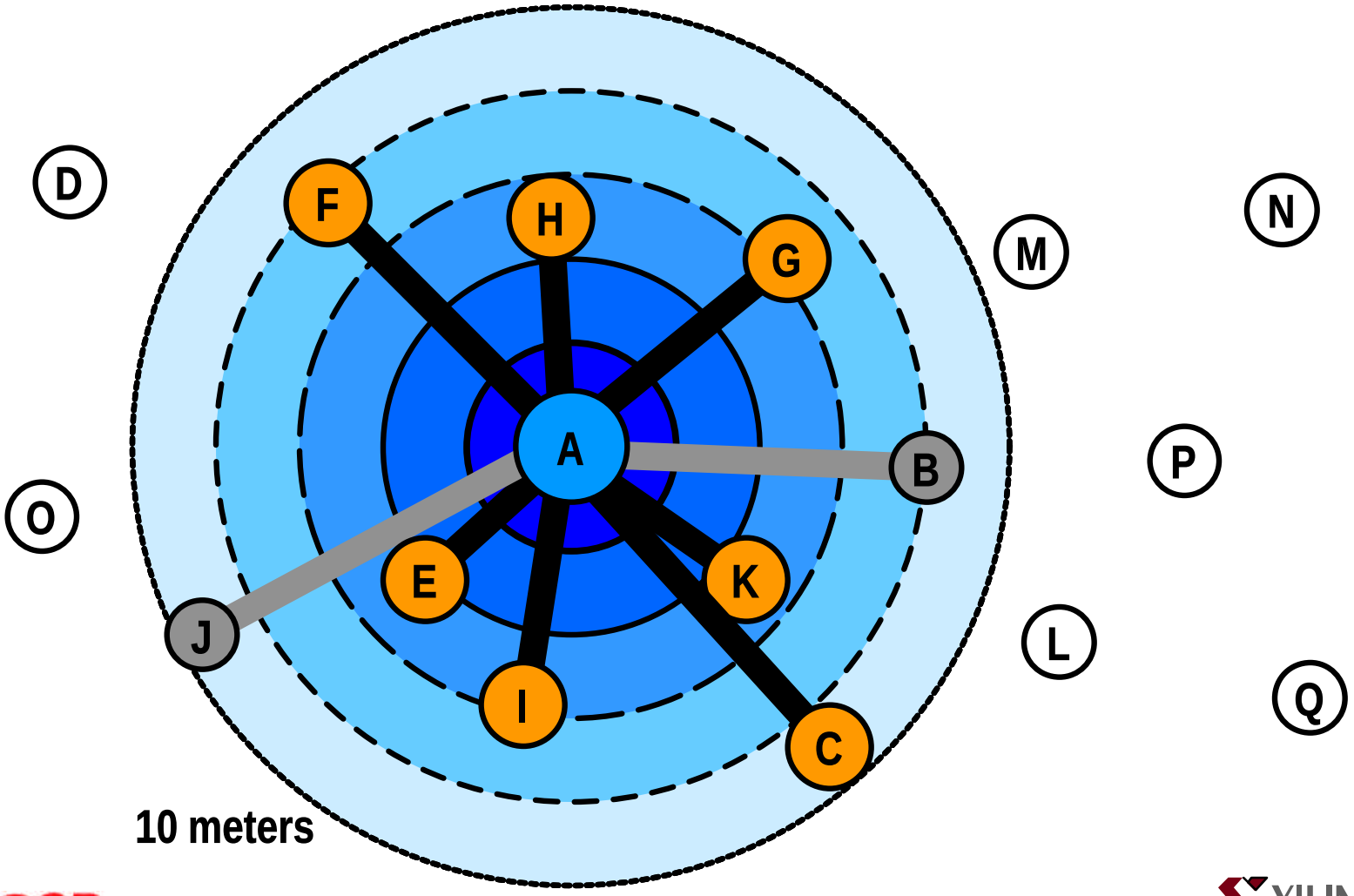
Parking

- To save power and/or to connect to even more devices Active Slaves can be Parked *(up to 256 total!)*



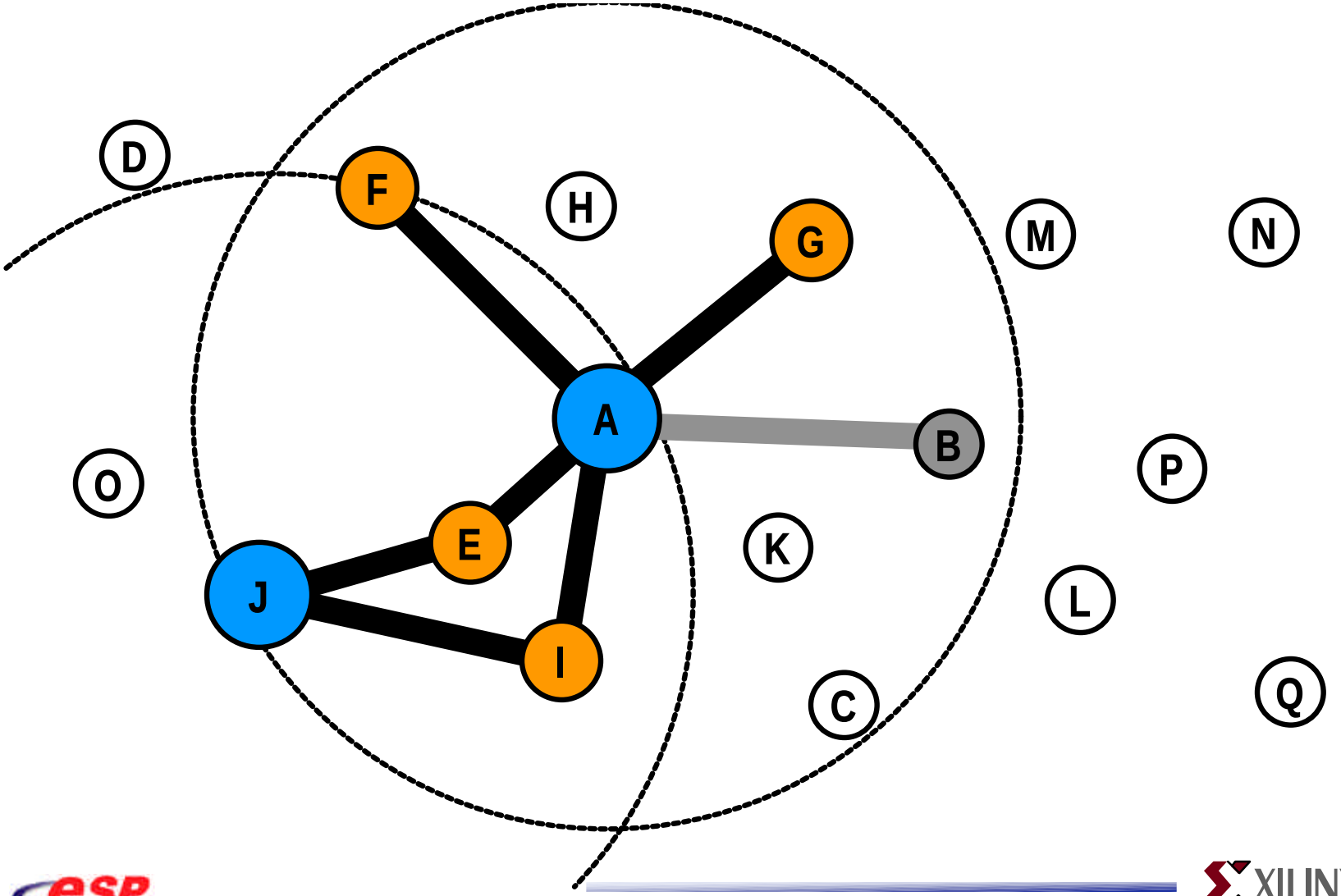
Expanding a Piconet (2)

- Masters can then attach additional Active Slaves using Active Member Addresses freed up through Parking



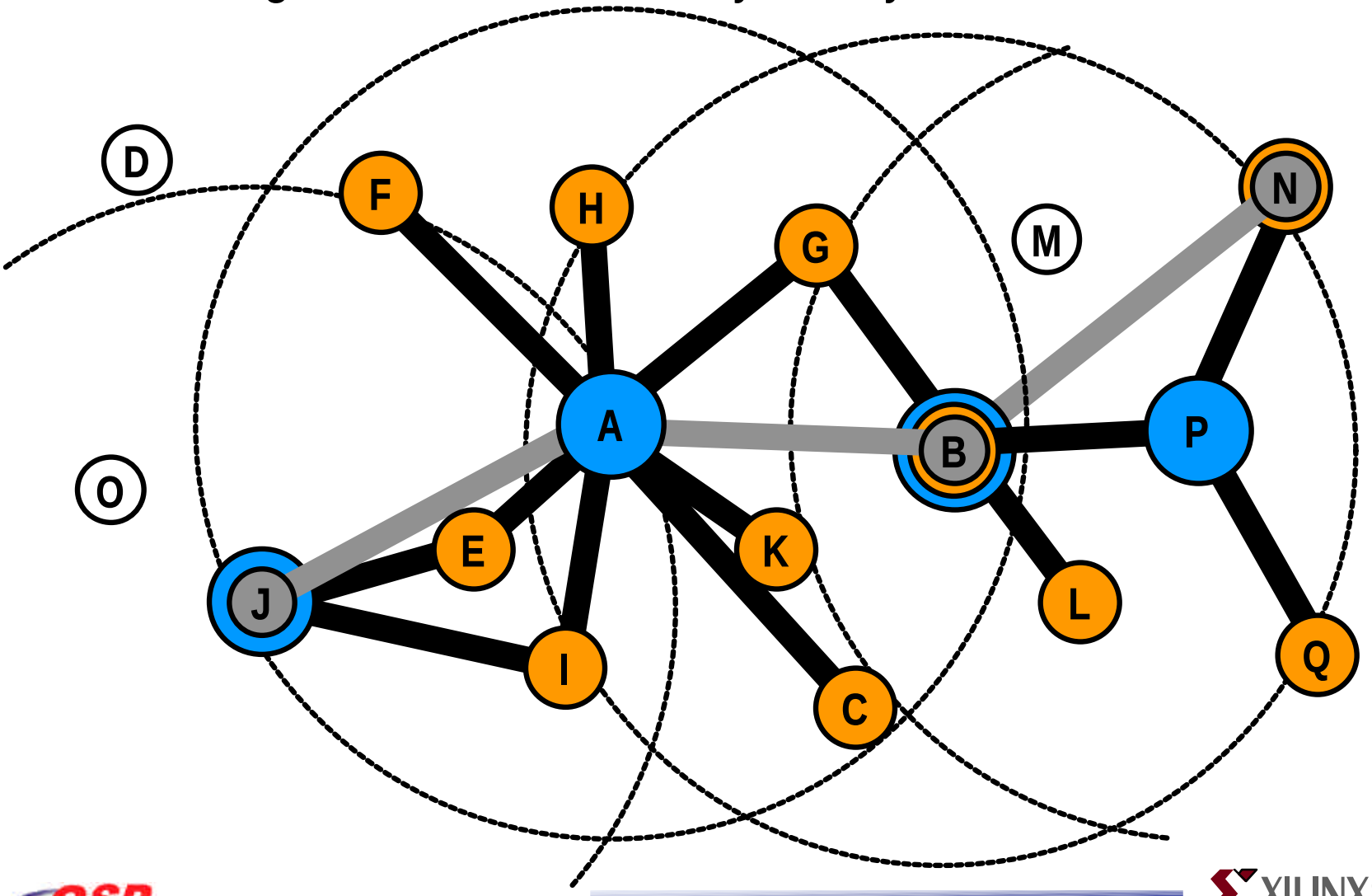
Scatternets

- Bluetooth devices can participate in multiple Piconets simultaneously creating a topologies called Scatternets



Advanced Scatternets

- Scatternets can evolve into extremely complex structures creating a rich fabric of many, many, devices



Bluetooth Radio Basics

- Normal range: 10 meters
- Normal xmit power: 1 milliWatt
- Receiver sensitivity: -70 dB
- Frequency band: 2.4 GHz(ISM)
- Max data rate: 721Kbps + 56Kbps X 3 (voice)

Bluetooth Radio Frequency Band

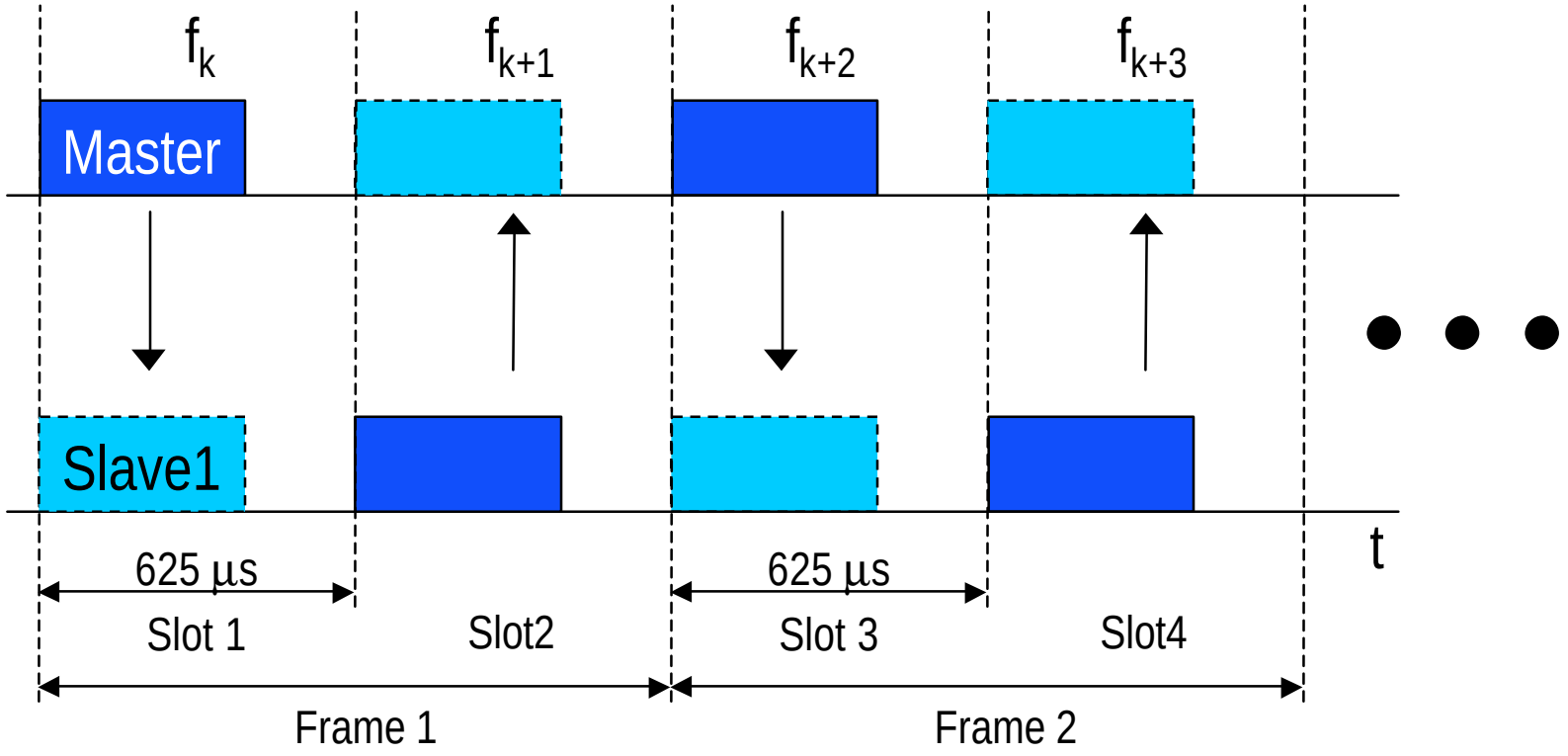
- ISM (Industrial, Scientific, Medical) band
  - 2.402GHz - 2.480GHz (79MHz total bandwidth)
- Advantages
  - Free
  - Open to everyone worldwide
- Disadvantages
  - Noise sources from everywhere
    - Cordless phones, microwave ovens, garage door openers, other wireless LAN technologies, baby monitors,...

Bluetooth's Noise Solutions

- Frequency Hopping (FH) Spread Spectrum technology
  - Divides the band into 79 separate 1MHz channels
- Uses short packets and makes 1600 hops/second
  - Minimizes exposure to noisy channels
  - Enables bad voice packets to be discarded
- Forward Error Correction (FEC) of data packets
  - Data often recoverable even on a noisy channel without retransmission

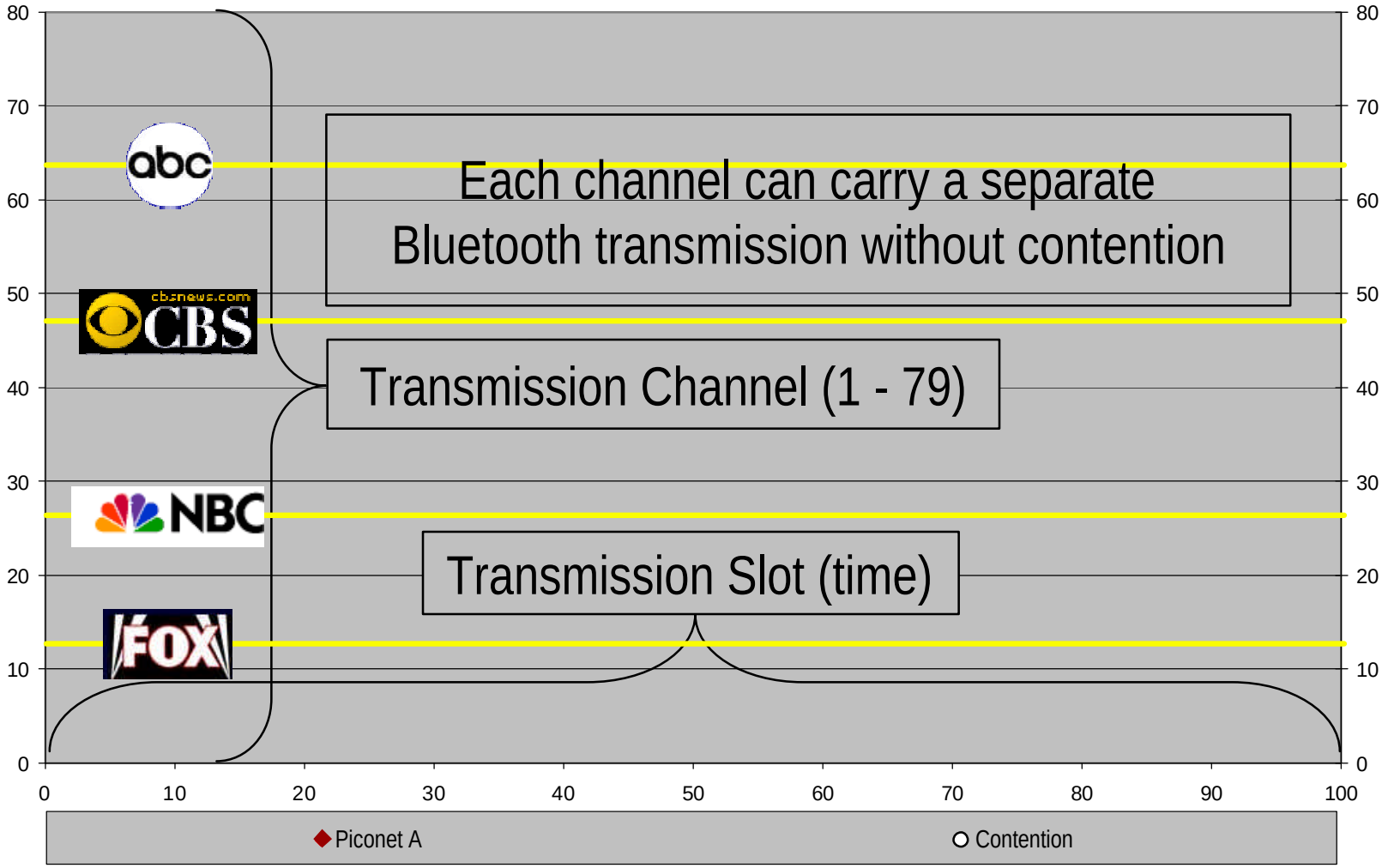
Bluetooth Transmission Protocol

Frequency Hopping & Time Division Duplexing

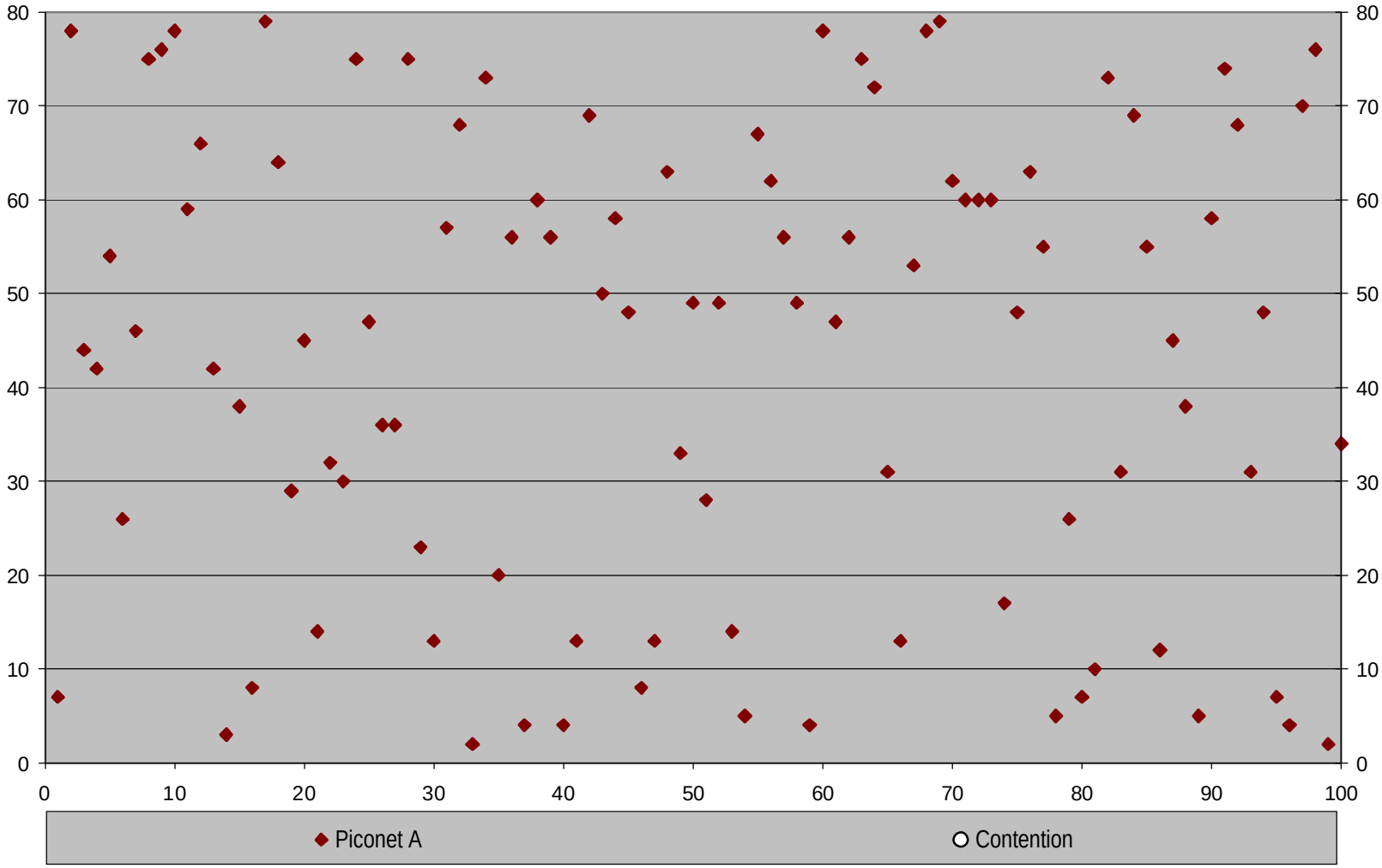


- Complete packet transmission occurs during a Slot
- Frequency hops from Slot to Slot to Slot
- Frames define matched Master / Slave Slot transmissions

Frequency Hopping
Graphically Illustrated

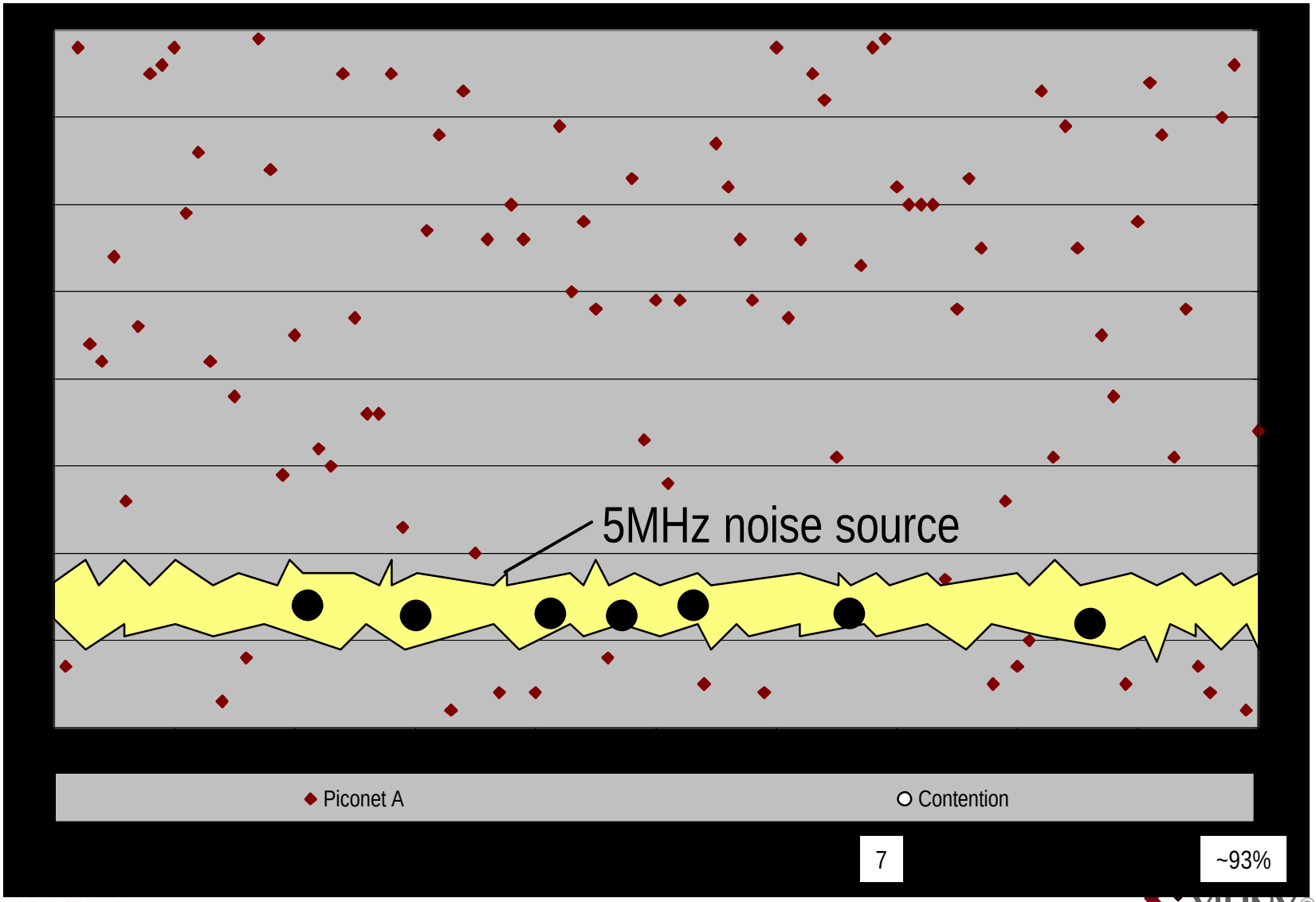


Each Bluetooth Piconet Randomly Changes Frequency Slot by Slot

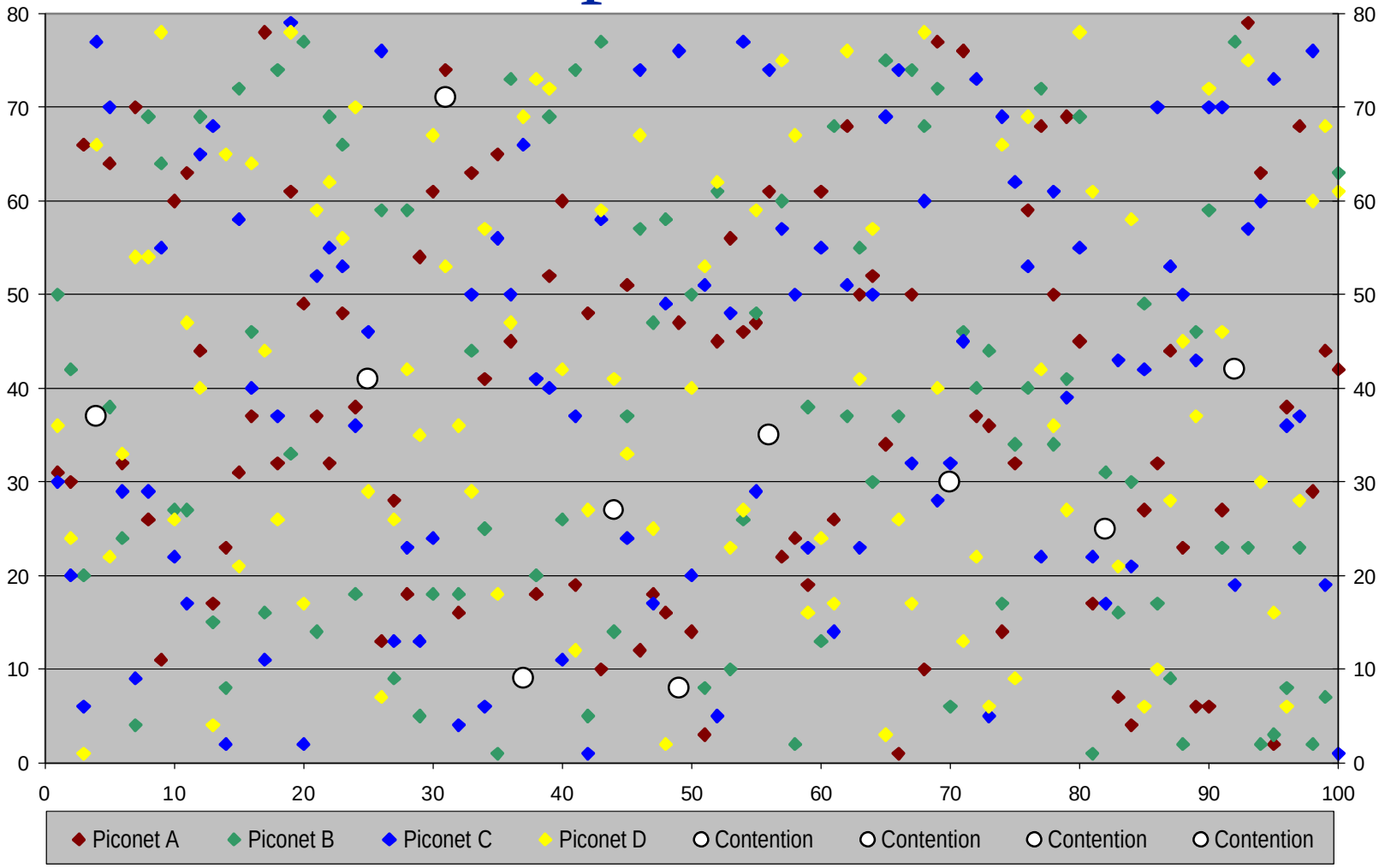


Active Piconets: 1 Total Transmission Slots: 100 Transmission Slots Hit: 0 Transmission Efficiency: ~100%

Frequency Hopping Minimizes Exposure to Data Loss Due to Noise

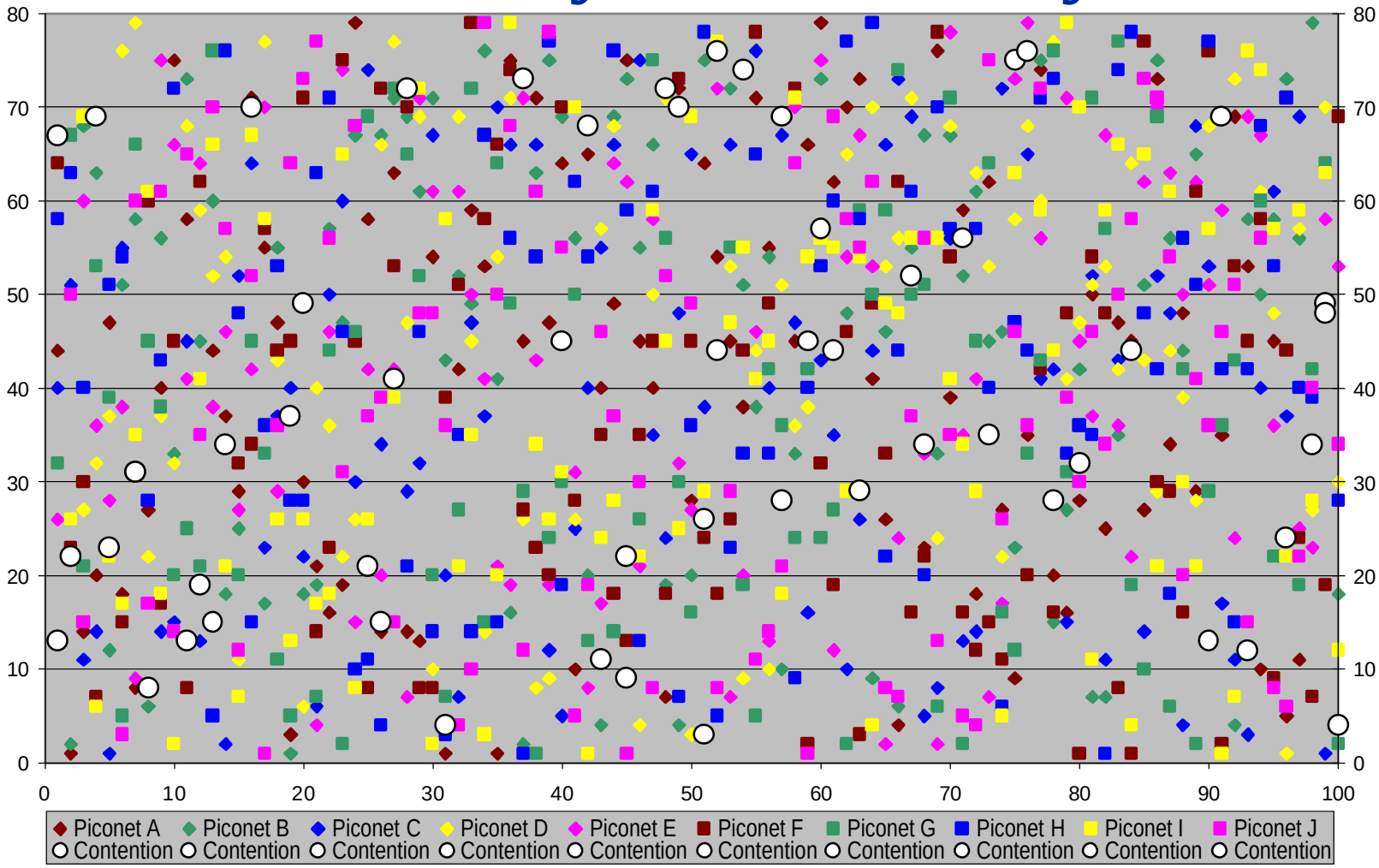


Frequency Hopping With Multiple Piconets



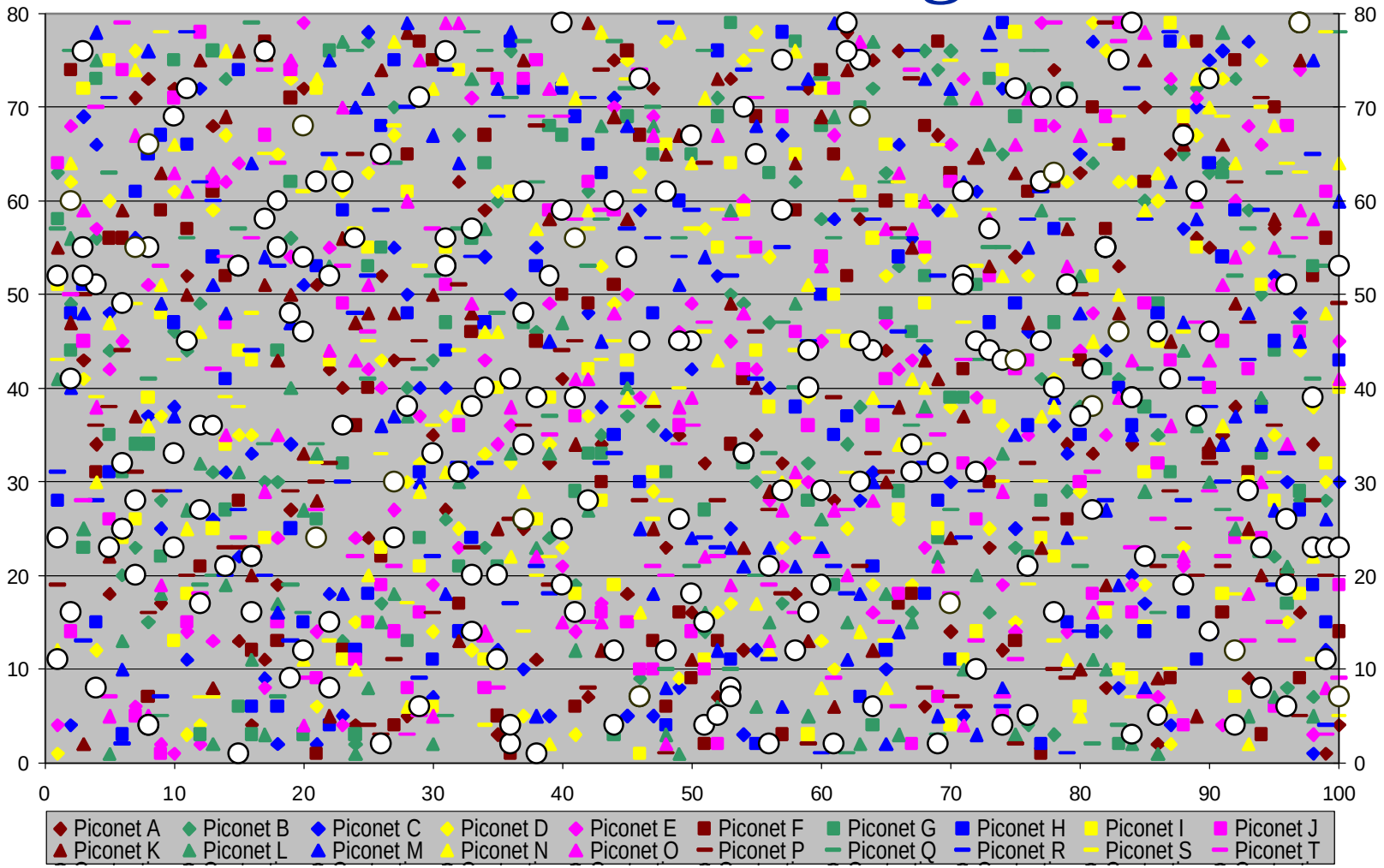
Active Piconets: 4 Total Transmission Slots: 400 Transmission Slots Hit: 20 Transmission Efficiency: ~95%

Bluetooth Piconets Degrade Gracefully with Density...



Active Piconets: 10 Total Transmission Slots: 1000 Transmission Slots Hit: 112 Transmission Efficiency: ~89%

...And Maintain Reasonable Performance Even In High Densities



Active Piconets: 20 Total Transmission Slots: 2000 Transmission Slots Hit: 420 Transmission Efficiency: ~79%