



Zigbee Mesh Networking

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Raoul van Bergen
Field Application Engineer Embedded – EMEA
Digi International





ZigBEE

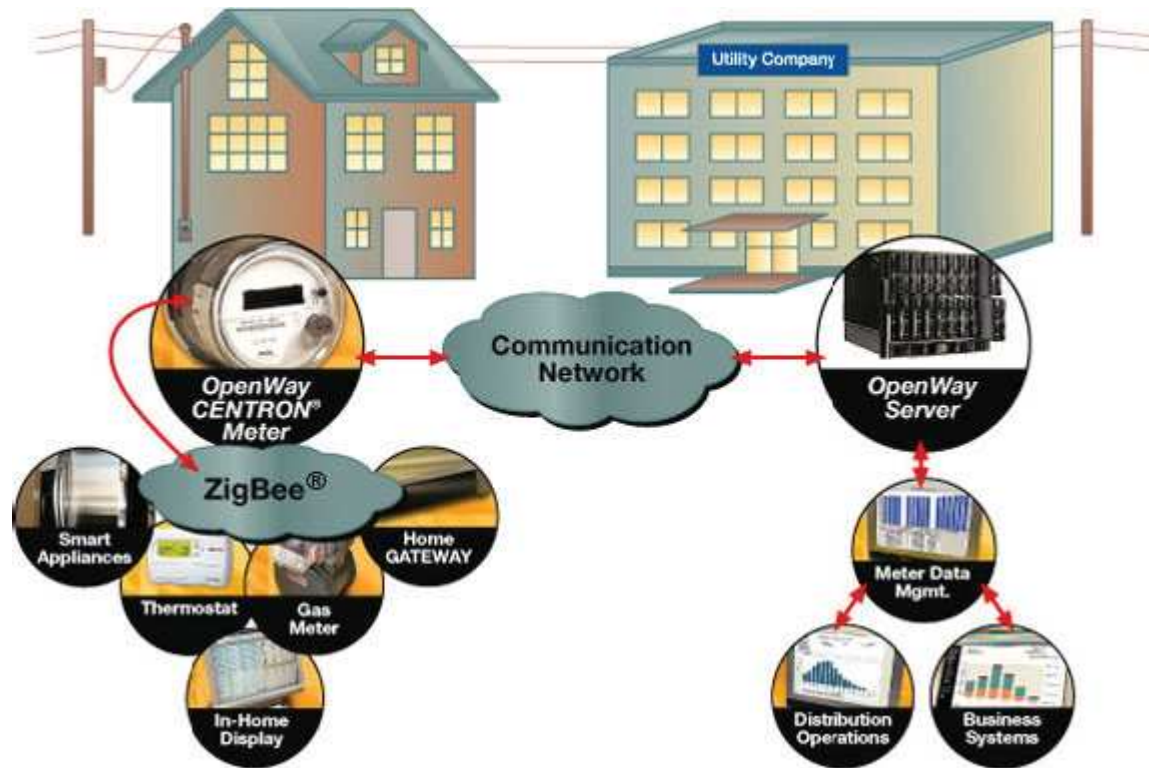


ZigBee® Alliance
Wireless Control That Simply Works



Fundamentals of ZigBee

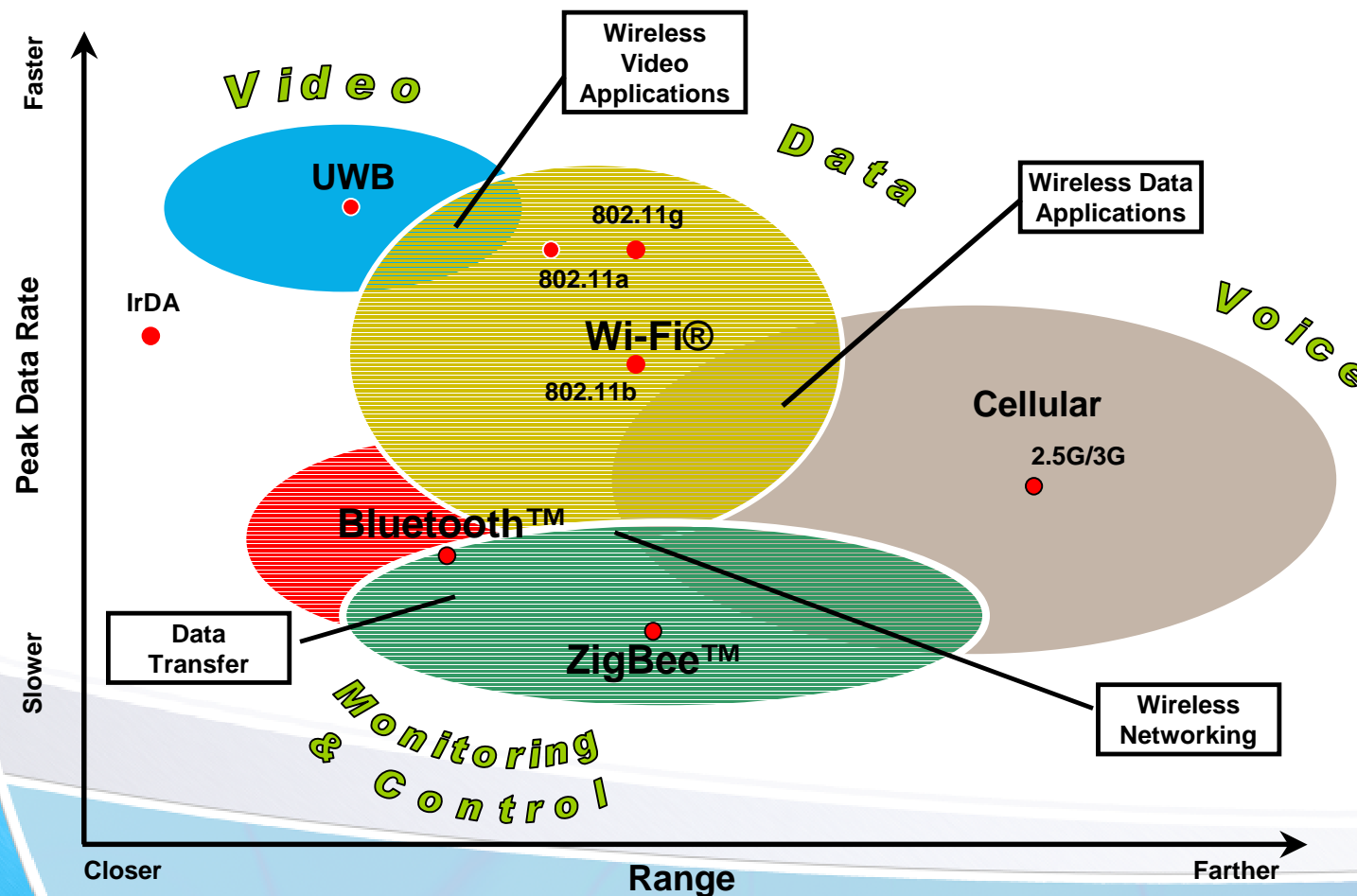
- Low Cost
- Low Power
- Security-enabled
- Reliable
- Initial Target Markets were AMR, Building Automation, and Industrial Automation (M2M Comms)





ZigBee Protocol

- Where Does ZigBee Fit?
 - Data Rate vs. Range vs. Battery Life (not shown)





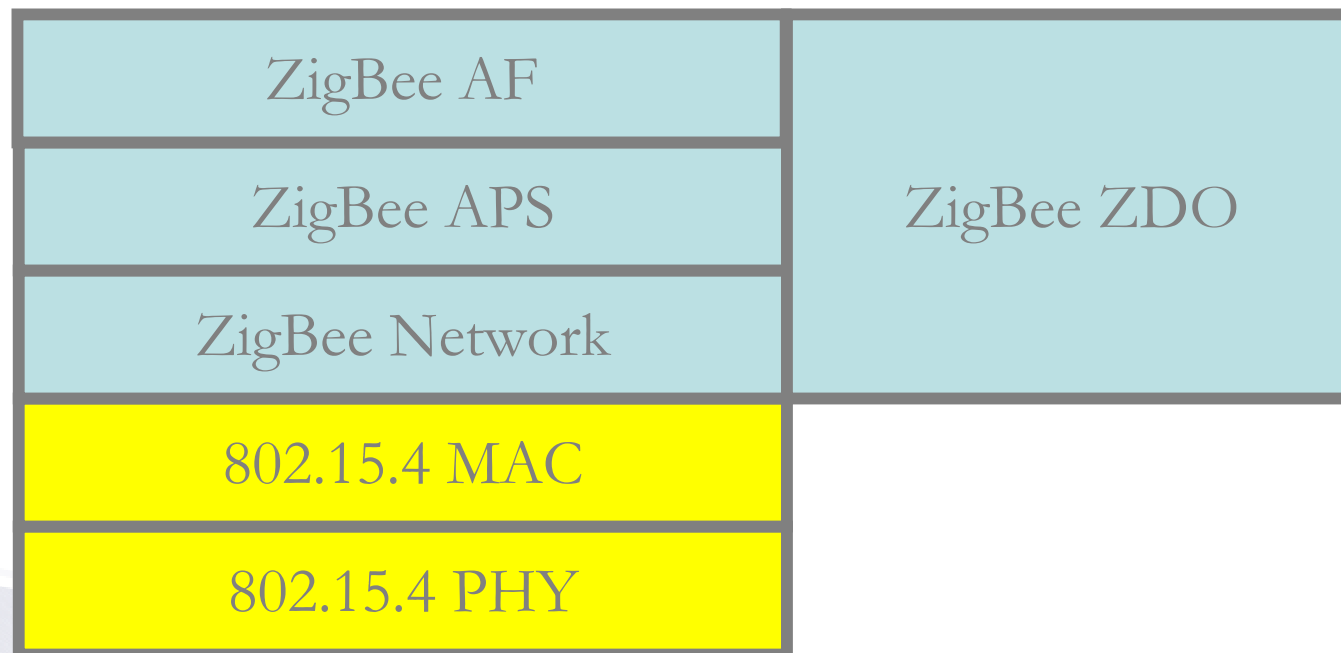
Wireless Standards Comparison

Feature(s)	IEEE 802.11b	Bluetooth	ZigBee
Battery Life	Hours	Days	Years
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	Enumeration up to 3 seconds	Enumeration up to 10 seconds	Enumeration up to 30 milliseconds
Range	100m-1000m	10m	70m-300m (ETSI), 1600m (FCC)
Extendability	Roaming possible	No	Yes
RF Data Rate	11Mbps	1Mbps	250Kbps
Security	Authentication Service Set ID (SSID)	64-bit, 128-bit	128-bit AES and Application Layer user defined



ZigBee Protocol

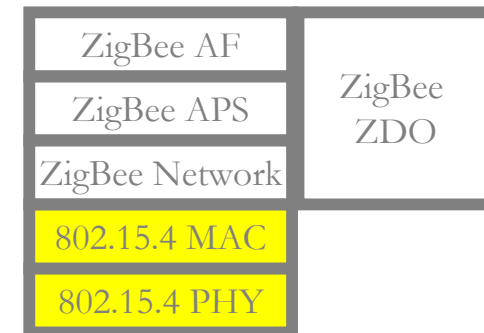
- How Does ZigBee Work?
 - ZigBee is a Networking Protocol that Rides on Top of the IEEE 802.15.4 Radio Protocol





802.15.4 Protocol

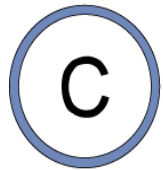
- 802.15.4 Specifications
 - Supported Networks
 - Point-Point
 - Point-Multipoint/Star
 - Types of Nodes
 - Coordinator
 - End Node
 - Reliable Delivery
 - CSMA/CA
 - MAC-level (pt-pt) Retries/Acknowledgments
 - 64-bit IEEE and 16-bit short Addressing
 - 16 DSSS RF Channels





802.15.4 Protocol

- 802.15.4 Nodes in a PAN (Personal Area Network)



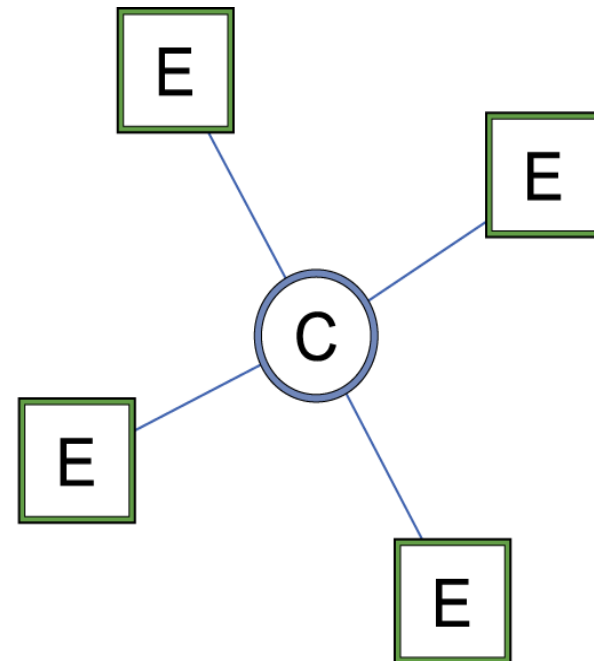
Coordinator

One per PAN
Establishes/Organizes a PAN
Mains-powered



End Device

Several can be in a PAN
Low power





ZigBee Protocol

- Supported Networks

- Point-Point
- Point-Multipoint/Star
- **MESH**

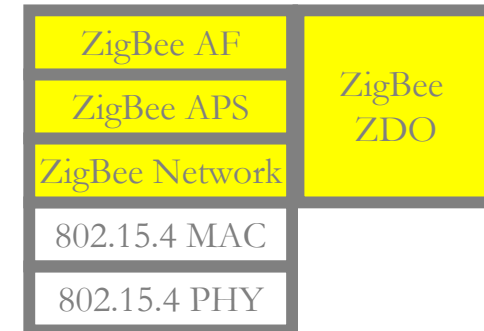
- Types of Nodes

- Coordinator
- End Node
- **ROUTER**

- Reliable Delivery

- CSMA/CA
- MAC-level (pt-pt) Retries/Acknowledgments
- **MESH NETWORK-level (multi-hop) Retries/ACKs**

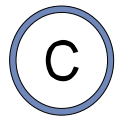
- 16 DSSS RF Channels





ZigBee Protocol

- ZigBee Nodes in a PAN (Personal Area Network)



- **Coordinator**

- One per PAN
- Establishes/Organizes a PAN
- Mains-powered



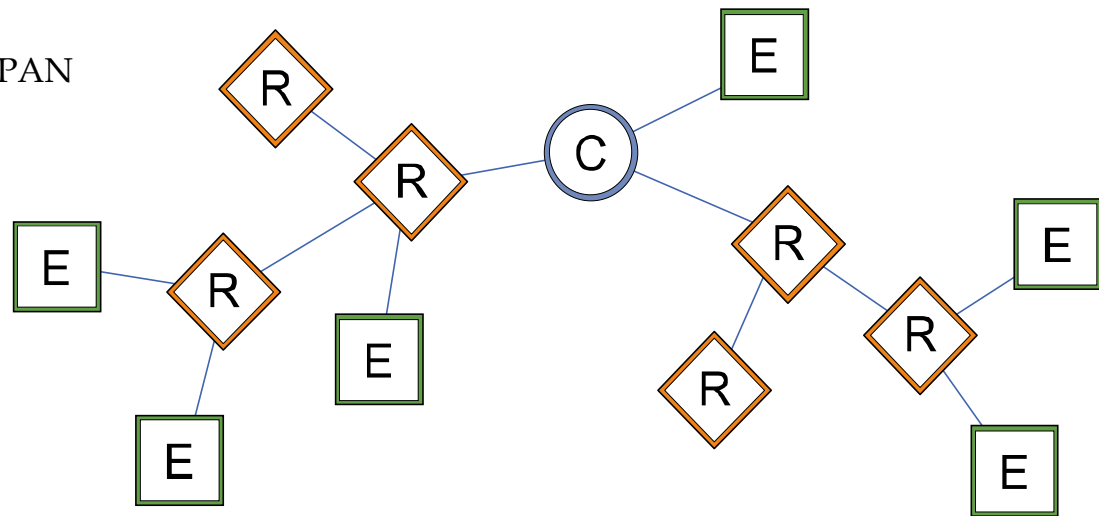
- **Router**

- Optional
- Several can be in a PAN
- Mains-powered



- **End Device**

- Several can be in a PAN
- Low power





ZigBee Protocol

- ZigBee Specifications

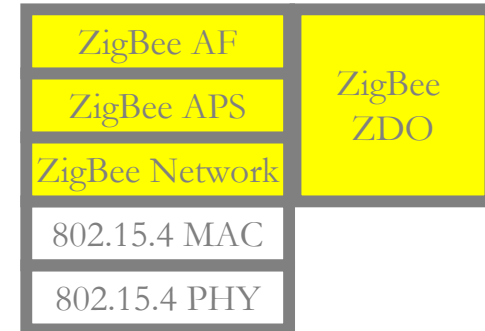
- Addressing

- 64-bit IEEE Address

- Unique to every 802.15.4 device in the world
 - Permanent, assigned during mfg

- 16-bit Network Addressing

- Unique to each module within a PAN
 - Used in Routing Tables
 - Used for data transmissions, etc.
 - Volatile Address - Can Change





ZigBee Protocol needs/uses

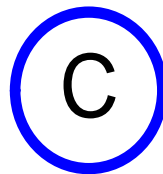
- 802.15.4 Data Transmission modes
 - Broadcast Mode
 - To send a broadcast packet to all radios regardless of 16-bit or 64-bit addressing
 - Unicast Mode – Guaranteed Delivery
 - 64-bit IEEE Addressing
 - Destination 64-bit Address to match 64-bit source address of intended receiver.
 - 16-bit Network Addressing
 - Destination 16-bit Address to match 16-bit source address of intended receiver



ZigBee Protocol

PAN Network Formation

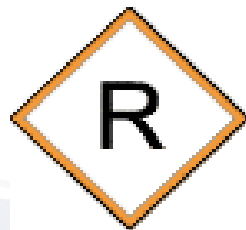
- Coordinator must select an unused operating channel and PAN ID
 - Energy scan on all channels
 - Sends Beacon request (**Broadcast** PAN ID)
 - Listens to all responses and logs the results
- After the Coordinator has started, it will allow nodes to join to it for a time based on the specified Node Join Time





ZigBee Protocol

- Router Startup
 - A new Router must locate a Router that has already joined a PAN or a Coordinator
 - Sends a **Broadcast** PAN ID on each channel
 - Returns sent via **Unicast**
 - Router will then try to join to a Router or Coordinator that is allowing joining





ZigBee Protocol

- End node: Low-power Sleep Modes
- End Node Startup
 - A new End node must locate a Router that has already joined a PAN or a Coordinator
 - Sends a **Broadcast** PAN ID on each channel
 - Returns sent via **Unicast**
 - End node will then try to join to a parent (Router or Coordinator) that is allowing joining

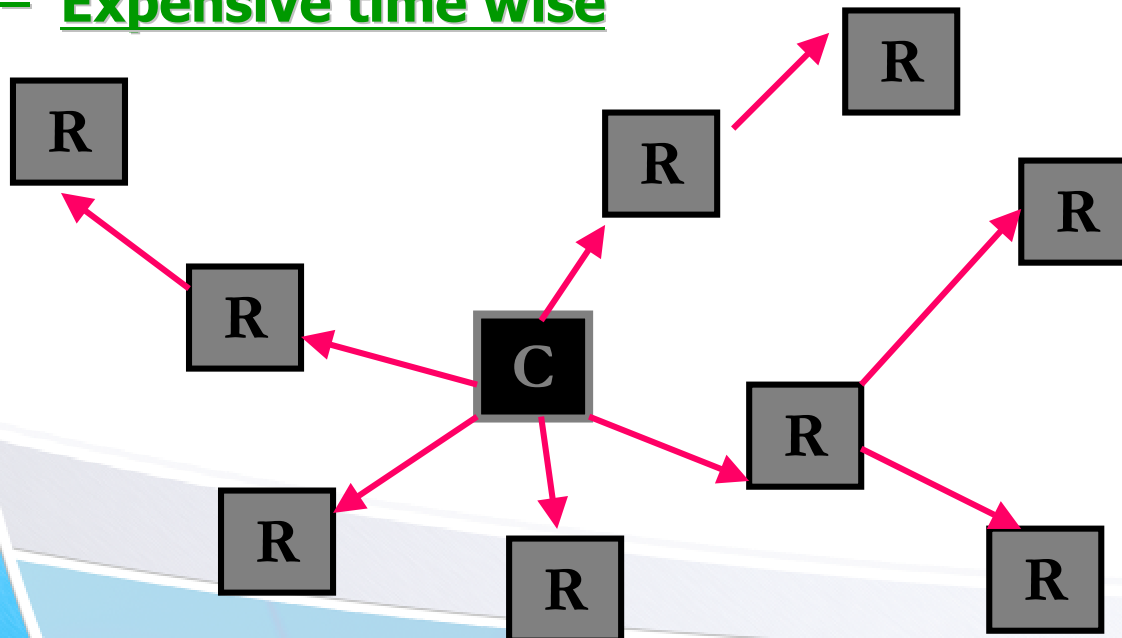
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E



ZigBee Protocol

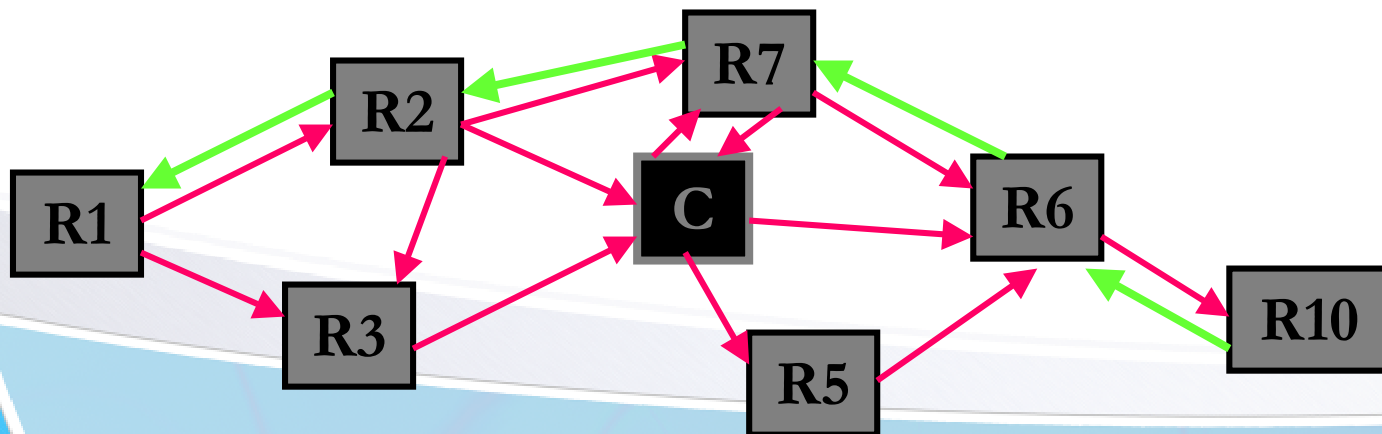
- Broadcast Transmissions - Relayed to All Nodes
 - No Acks are transmitted – Routers listen to neighboring Routers to know if message was retransmitted
 - Retransmit if neighbors are not heard (up to 2 times)
 - Broadcast Transaction Table used to ensure Routers do not repeat a message they have already repeated
 - **Expensive time wise**








ZigBee Protocol

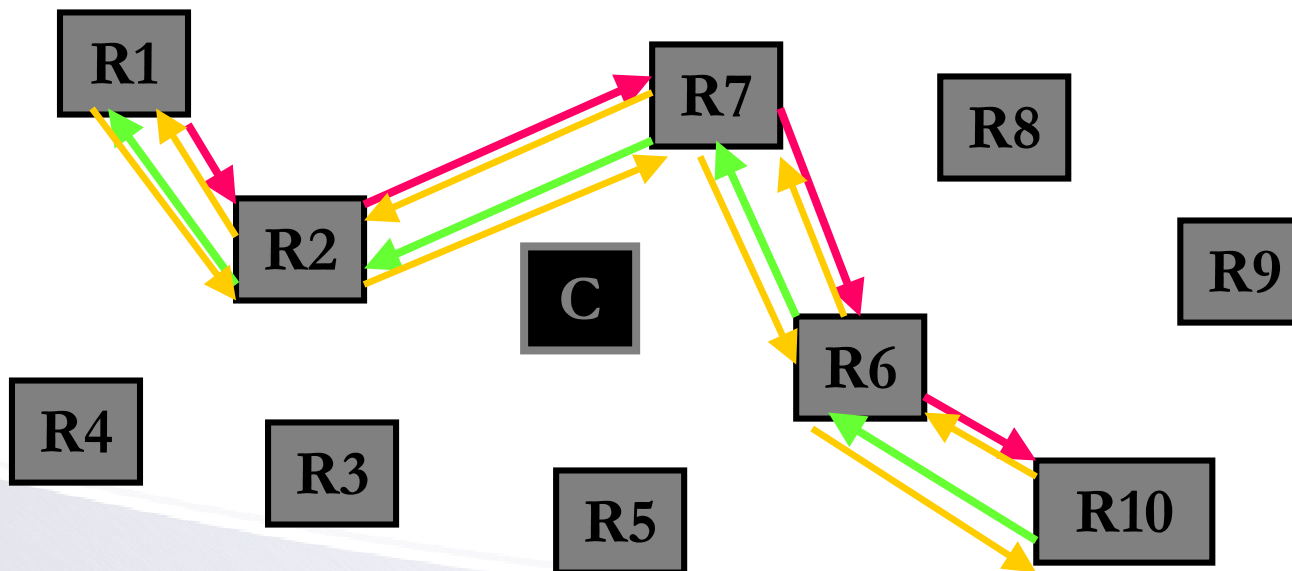
- Route Discovery consists of the following commands:
 - Route Request (**broadcast**)
 - 64-bit address used to find the local 16-bit address (Network address discovery)
 - Routing tables based on 16-bit address
 - Route Reply (**unicast**)
 - Positive acknowledgement returned
 - If node is gone- Network address discovery fails





ZigBee Protocol

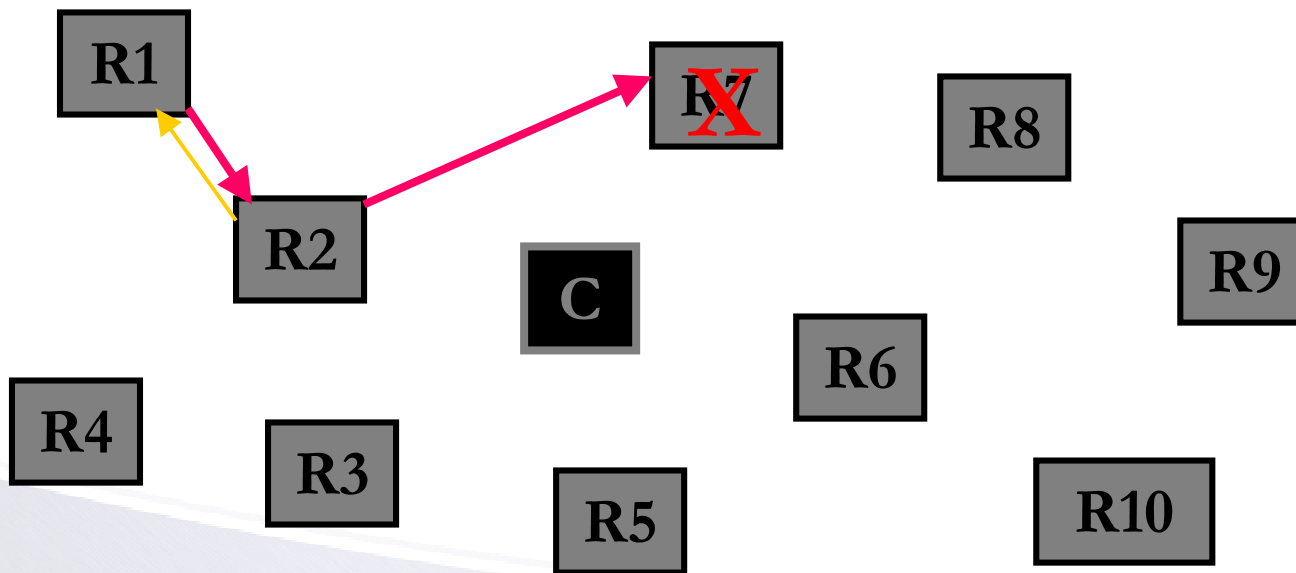
- Normal Data Transmissions (Unicast - established Network)
 - R1 must transmit data to R10. 
 - MAC ACKs are transmitted for each hop. 
 - One Network ACK is transmitted from the Destination node back to the Source 





ZigBee Protocol

Disabled Node

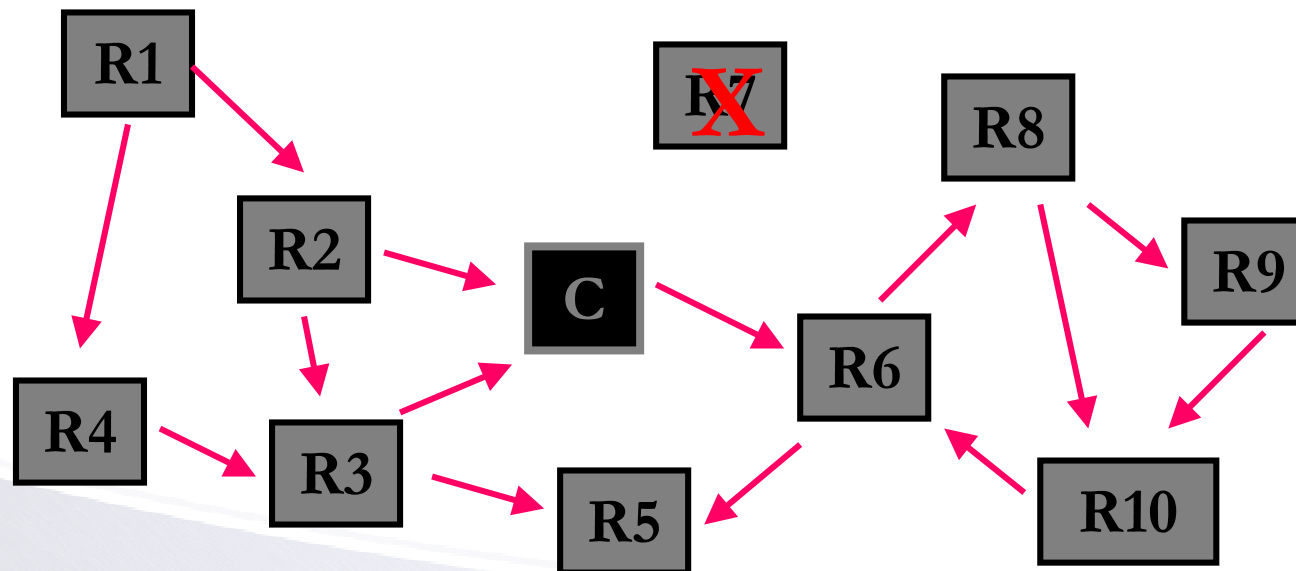




ZigBee Protocol

Disabled Node

- New Route Discovery Request (**broadcast**)
64-bit address used to find the local 16-bit address
(Network address discovery)

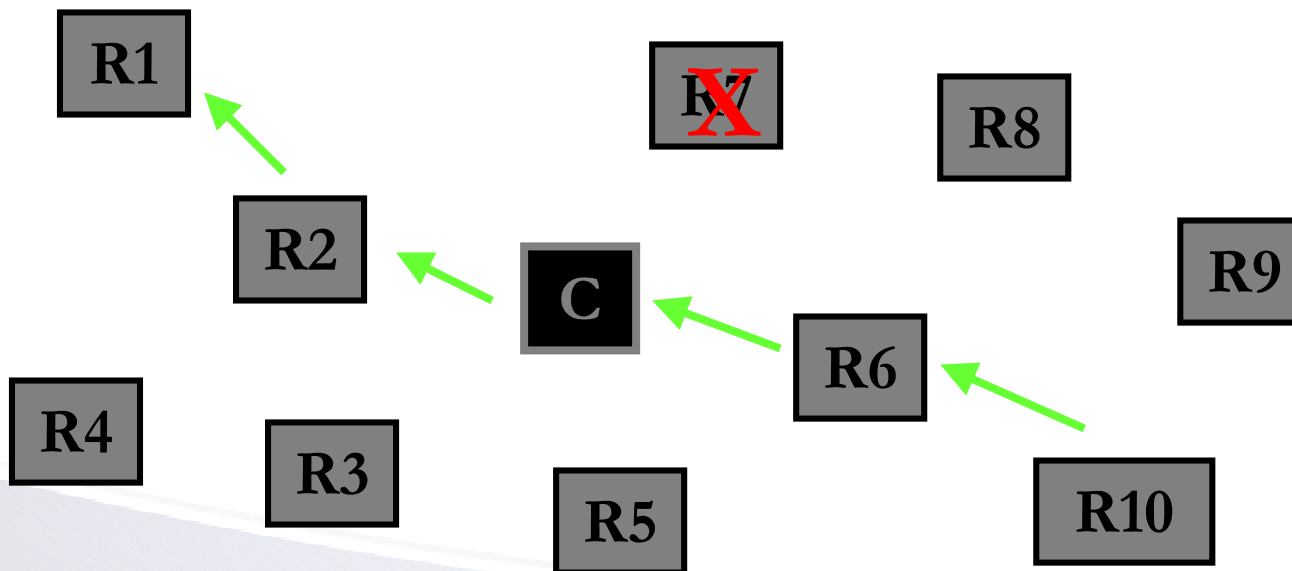




ZigBee Protocol

Disabled Node

- New Route sent back along best path (**unicast**)
- Coordinator not necessary after network setup





Questions & Answers