

Chapter 32-33

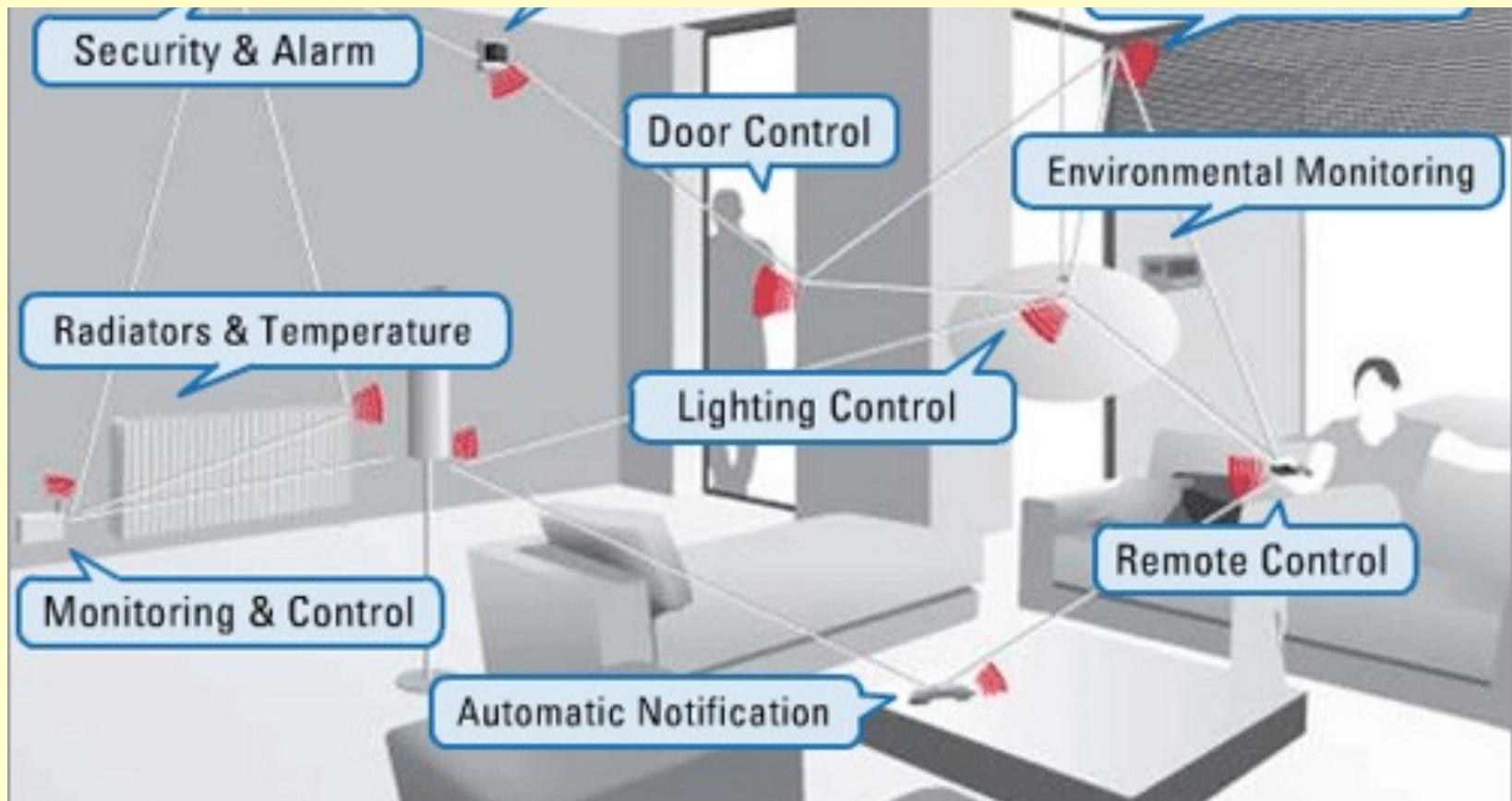
Emerging Technologies

The Internet Of Things

Internet Of Things

- ◆ **Awkward term used for embedded systems on the Internet**
 - ◆ **Generally not operated by humans**
 - ◆ **Can access one another or cloud services**
- ◆ **Examples**
 - ◆ **Scientific sensor systems**
 - ◆ **Home automation systems**
 - ◆ **Smart grid**
 - ◆ **Retail systems**

Home automation example



Smart City example



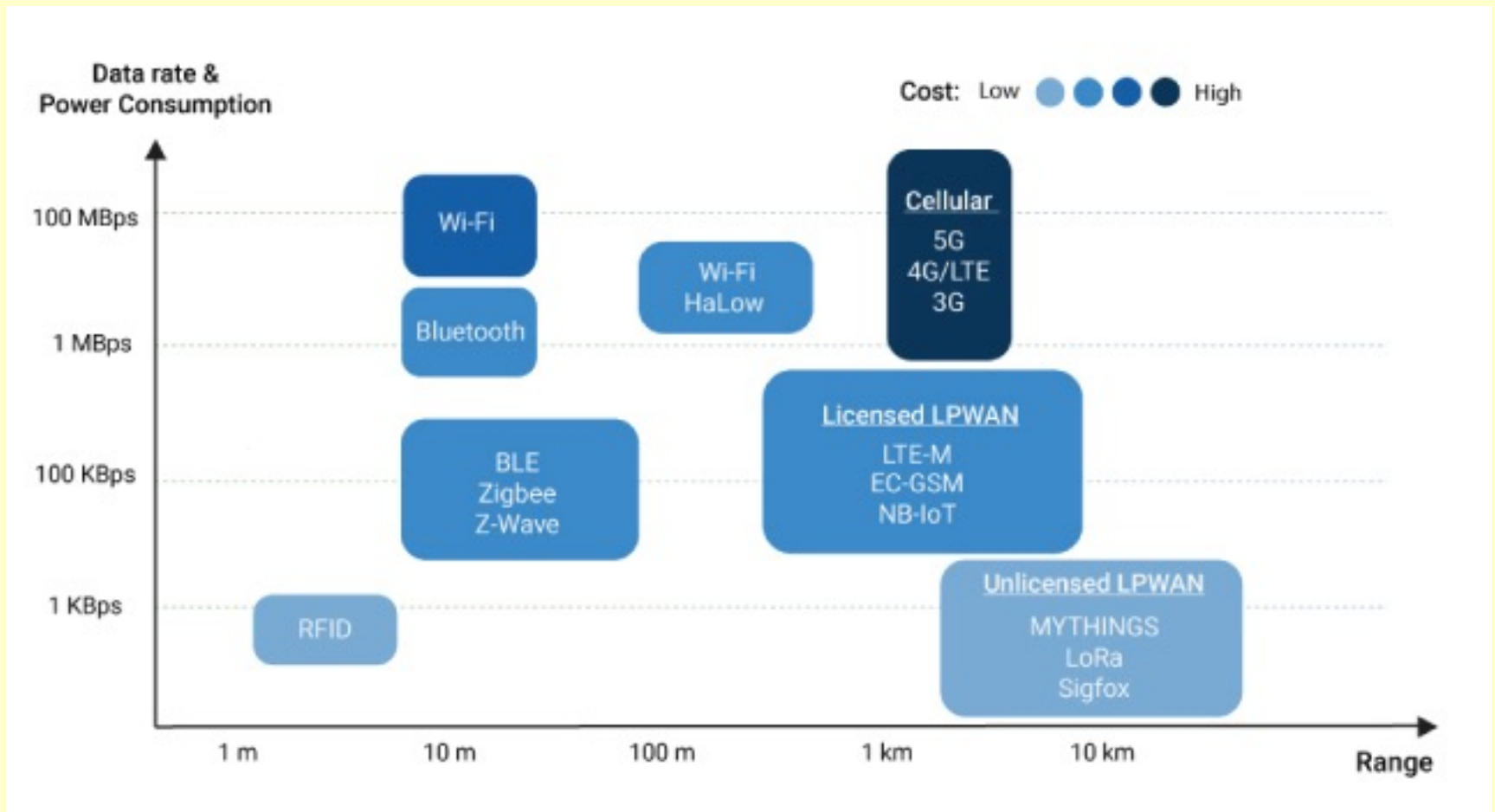
Technology Characteristics

- ◆ **Low power**
 - ◆ Energy harvesting (e.g., door latch)
 - ◆ Multi-year battery life
- ◆ **Wireless communication**
 - ◆ Necessary in many situations (to much wiring otherwise)
 - ◆ Enables mobility

Technology Characteristics

- ◆ **Low latency**
 - ◆ To be able to interact between vehicles moving at high speed
- ◆ **Long range communication**
 - ◆ City wide
- ◆ **Moving devices**
 - ◆ Requires fast roaming

Different wireless standards for IoT



Source: <https://behrtech.com/blog/6-leading-types-of-iot-wireless-tech-and-their-best-use-cases/>

Different wireless standards for IoT

Key IoT Verticals	LPWAN (Star)	Cellular (Star)	Zigbee (Mostly Mesh)	BLE (Star & Mesh)	Wi-Fi (Star & Mesh)	RFID (Point-to-point)
Industrial IoT	●	○	○			
Smart Meter	●					
Smart City	●					
Smart Building	●		○	○		
Smart Home			●	●	●	
Wearables	○			●		
Connected Car					○	
Connected Health		●		●		
Smart Retail		○		●	○	●
Logistics & Asset Tracking	○	●				●
Smart Agriculture	●					

● Highly applicable ○ Moderately applicable

Source: <https://behrtech.com/blog/6-leading-types-of-iot-wireless-tech-and-their-best-use-cases/>

Wireless Mesh Network

- ◆ Useful when individual nodes have very low power (limited range)
- ◆ Allows a set of nodes to communicate even if some nodes cannot communicate directly
- ◆ Each node agrees to forward packets on behalf of neighbors

Example Wireless Mesh Technology

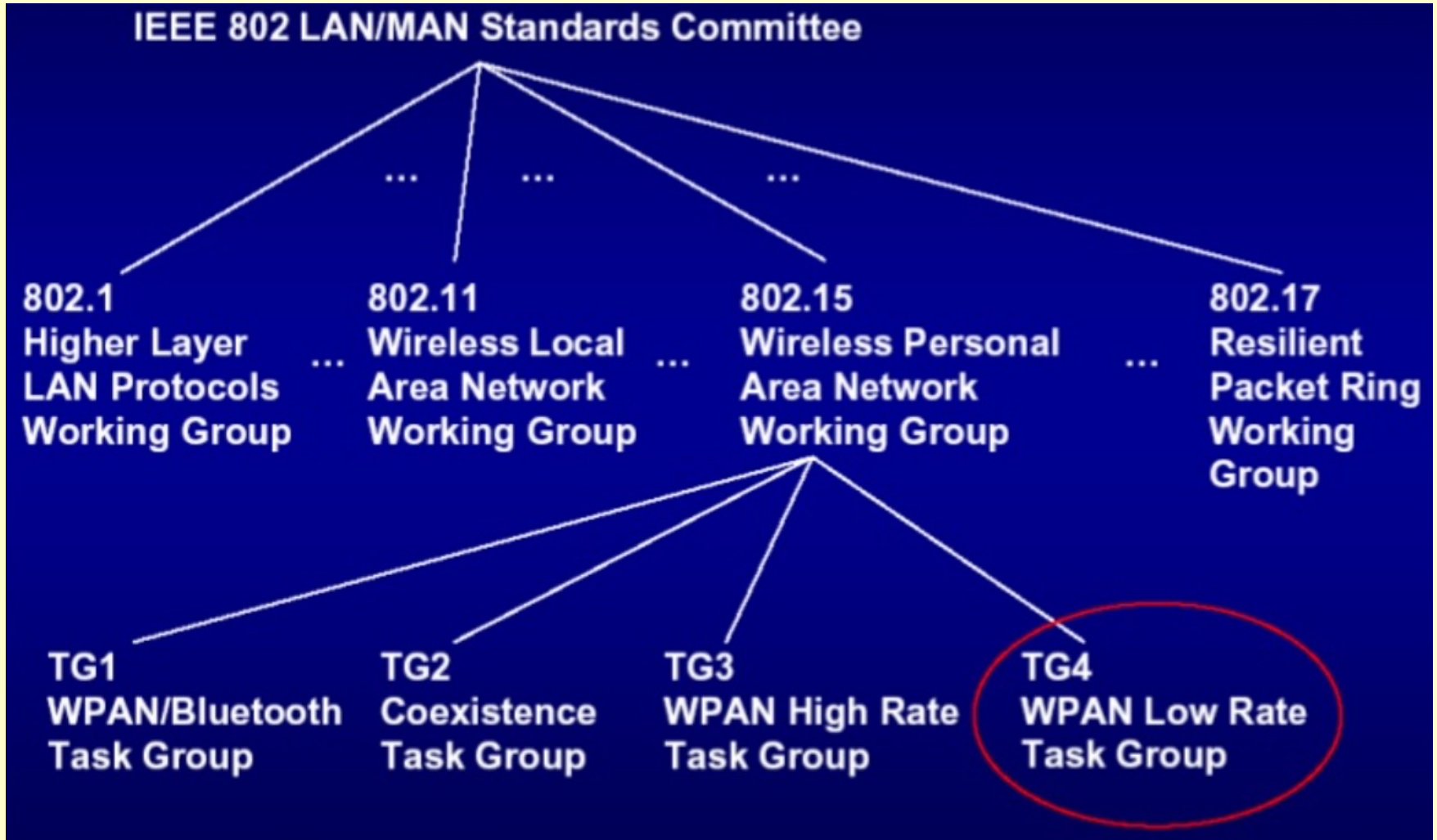
◆ ZigBee IP

- ◆ Created by ZigBee Alliance
- ◆ Uses IEEE 802.15.4 wireless radios
- ◆ Intended for smart grid

◆ ZigBee protocol stack

- ◆ Goal is to run IPv6, TCP, and HTTP
- ◆ Includes many other protocols

IEEE 802 work group structure



802.15.4 Wireless Characteristics

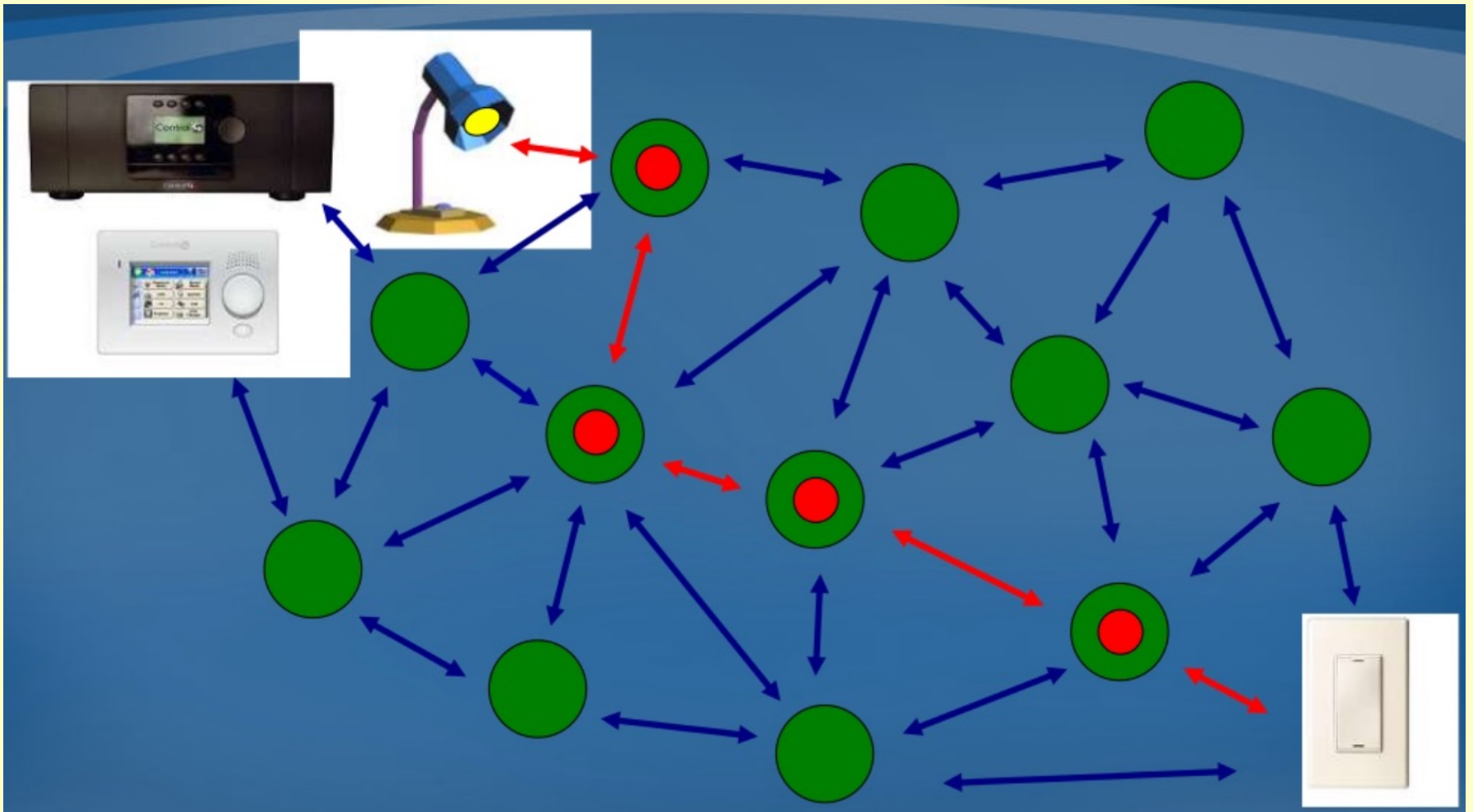
- ◆ Goal is low power, and result is
 - ◆ Extremely low data rate
 - ◆ Extremely small MTU
 - ◆ Limited distance

Property	Value
Networking paradigm	Packet switching
Maximum data rate	250 Kbps
Payload size (MTU)	102 octets
Maximum distance	10 meters

ZigBee IP Mesh Routing

- ◆ **One or more border routers**
 - ◆ **Connect to global Internet**
 - ◆ **Are more powerful than other nodes**
- ◆ **Set of ZigBee IP routers (ZIP routers)**
 - ◆ **Attach to appliances**
 - ◆ **Form a mesh**
 - ◆ **Forward traffic to border router**

ZigBee Mesh network



ZigBee to Internet

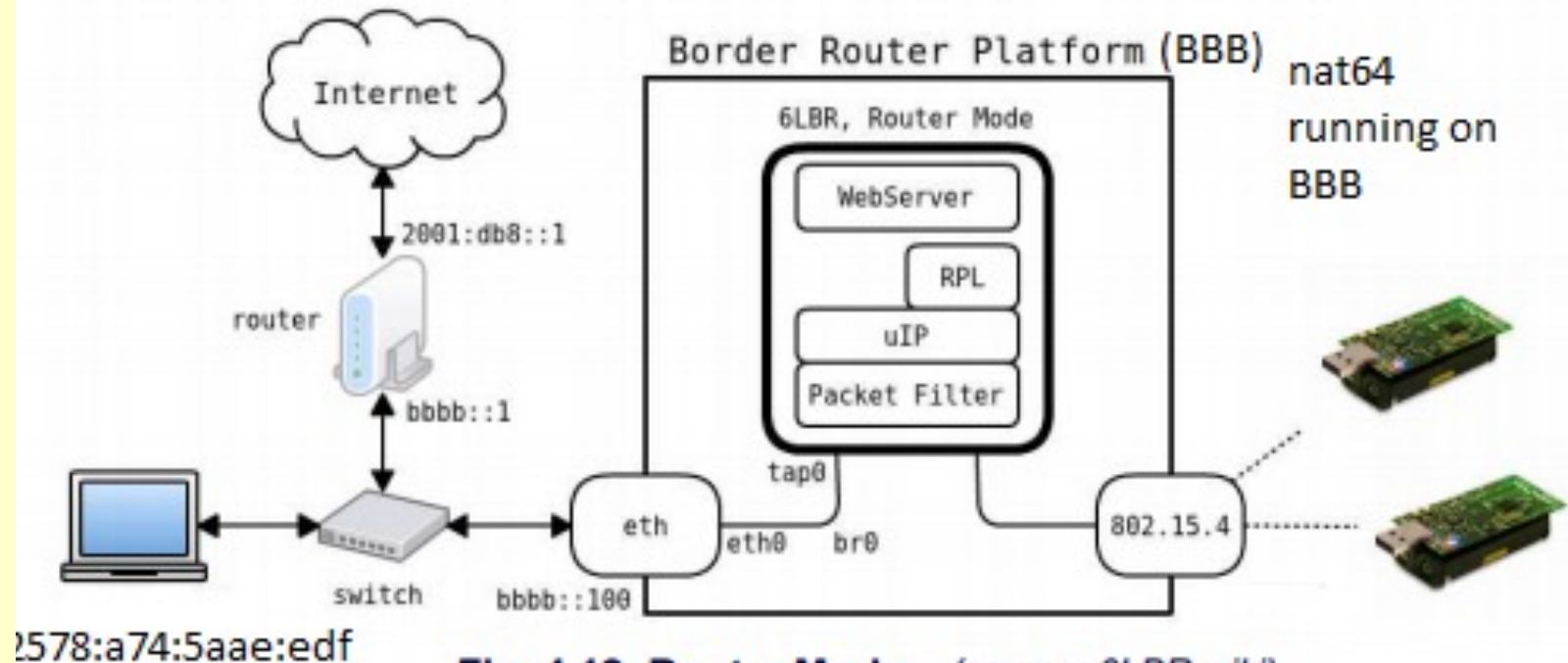


Fig. 4.12. Router Mode (source: 6LBR wiki)

Major Items In The ZigBee Protocol Stack

Application Protocols			
TLS	PANA	mDNS and DNS-SD	MLE
TCP and UDP			
IPv6, ICMPv6, and 6LoWPAN-ND		RPL	
6LoWPAN adaptation			
IEEE 802.15.4			

- ◆ Resulting stack is large
- ◆ Design is more general-purpose than necessary
- ◆ Technology may be a triumph of politics and economics

LoRa and LoRaWAN

- ◆ **Another set of wireless standard used in IoT scenarios where long range is important**
- ◆ **LoRa is the physical layer, using license-free sub-gigahertz radio frequency bands (868 MHz in Europe) to achieve data rates between 0.3 kbit/s and 27 kbit/s up to 10 km**
- ◆ **LoRaWAN acts mainly as a network layer protocol for managing communication between LPWAN gateways and end-node devices**

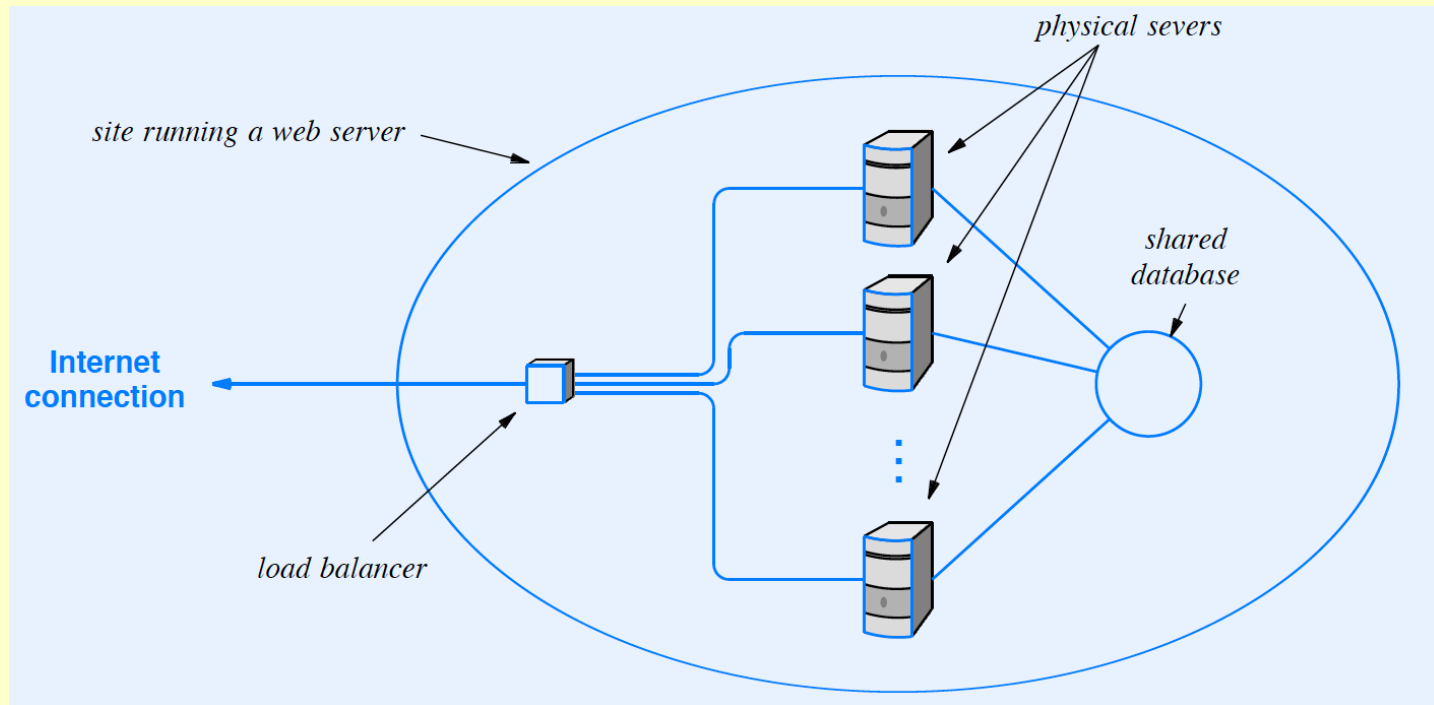
Mentimeter time!

Other trends in networking

A Few Key Technologies

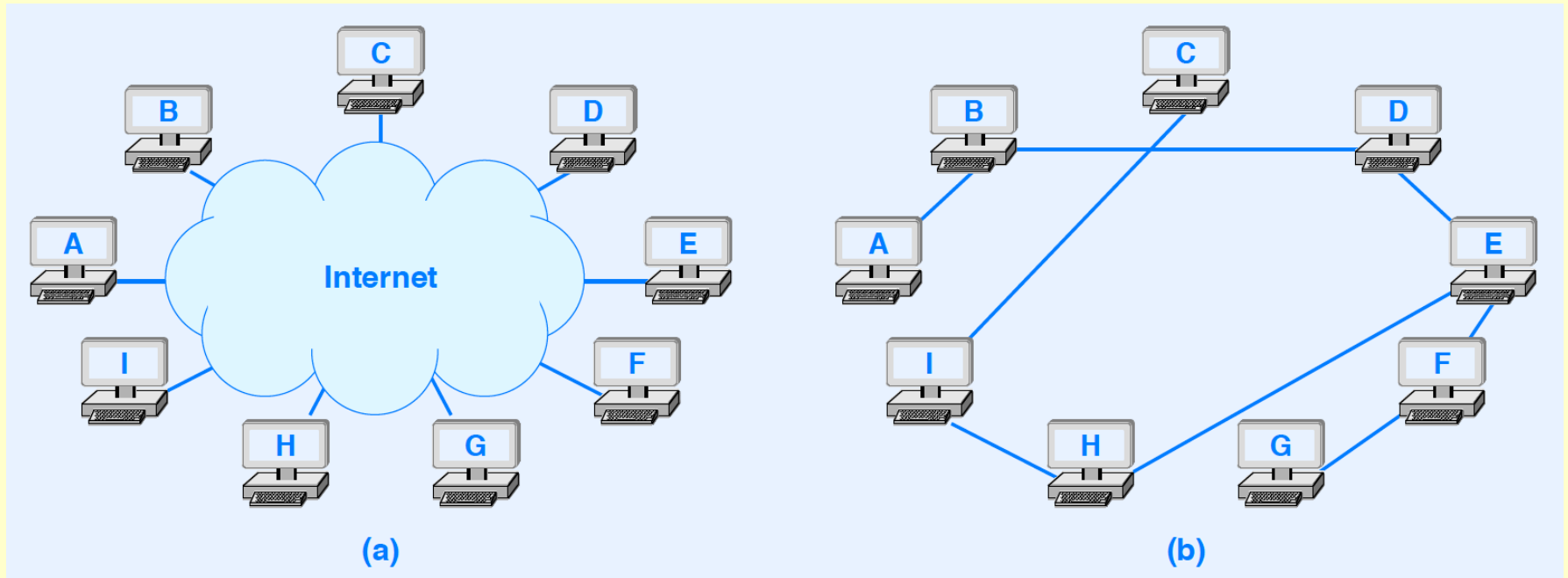
- ◆ **Content Caching**
- ◆ **Peer-To-Peer Communication**
- ◆ **Universal Representation (XML)**
- ◆ **Wireless networks that support mobility**
- ◆ **Higher-speed access technologies (>1 Gbps)**
- ◆ **Cloud computing and cloud data centres**

Web Load Balancers



- ◆ Load balancer distributes HTTP requests across servers
- ◆ Path from servers back to client may be higher speed

Overlay Networking



- a. Physical connection of computers to the Internet
- b. Logical network imposed by overlay routing

Other Trends

- ◆ **Switch to digital telephony and digital video**
- ◆ **Increased use of social networking and social media**
- ◆ **Distributed data centers and migration**

Kahoot time!