

# Connectivity Solutions for the Industrial Internet of Things (IIoT)

## Class 3: Wireless Options

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Louis W. Giokas

# This Week's Agenda

Monday	IIoT Landscape
Tuesday	Wired Options
Wednesday	Wireless Options
Thursday	Architectures for Individual Plants
Friday	Distributed Operations and External Connections

# Course Description

The Industrial Internet of Things (IIoT) consists of components and systems that interconnect industrial equipment together and, potentially with external systems. These are distributed systems that may span a great area inside a particular facility, and may interconnect facilities. In addition, external systems are typically added to the mix to facilitate control and analysis of the data. In this course we will look at the components, primarily communications, and how they are interconnected and architected.

# Today's Agenda

- Overview
- Wi-Fi
- Bluetooth
- RFID
- Cellular
- Conclusion/Next Class

# Overview

- Wireless technologies are playing an increasing important part in industrial applications
  - Improvements in bandwidth and reliability
  - New types of applications
  - Remote devices
- Ease of installation and reconfiguration can be a driving force

# Overview

- Today we approach our subject through the lens of the types of technologies involved
  - Wi-Fi (in-plant, high bandwidth)
  - Bluetooth (in-plant, low bandwidth, low cost)
  - RFID (material tracking, warehouse applications)
  - Cellular (remote devices, utility applications)
- Through each of these there may run any number of protocols, as we studied yesterday

# Overview

- Mesh networks
  - The ability to dynamically create networks with wireless devices is a major plus in industrial applications
- Roaming
  - Many devices and systems allow roaming for seamless communications as devices move around

# Wi-Fi

- Wi-Fi is a CSMA/CD protocol, but is different from wired Ethernet because of the medium
- Wi-Fi is a half duplex protocol
- All stations use the same channel with collision avoidance effected by a DCF (Distributed Control Function)
  - Stations transmit only when the channel is clear
  - All transmissions are acknowledged
    - Is a transmission is not acknowledged, a collision is assumed



# Wi-Fi

- Protocol Summary

Protocol	Frequency	Channel Width	MIMO	Maximum data rate (theoretical)
802.11ax	2.4 or 5GHz	20, 40, 80, 160MHz	Multi User (MU-MIMO)	2.4 Gbps <sup>1</sup>
802.11ac wave2	5 GHz	20, 40, 80, 160MHz	Multi User (MU-MIMO)	1.73 Gbps <sup>2</sup>
802.11ac wave1	5 GHz	20, 40, 80MHz	Single User (SU-MIMO)	866.7 Mbps <sup>2</sup>
802.11n	2.4 or 5 GHz	20, 40MHz	Single User (SU-MIMO)	450 Mbps <sup>3</sup>
802.11g	2.4 GHz	20 MHz	N/A	54 Mbps
802.11a	5 GHz	20 MHz	N/A	54 Mbps
802.11b	2.4 GHz	20 MHz	N/A	11 Mbps
Legacy 802.11	2.4 GHz	20 MHz	N/A	2 Mbps

# Wi-Fi

- Wi-Fi systems adapted to industrial environments are available from a number of vendors
  - Hardened enclosures
    - Allow placement in harsh environments
  - OEM modules
    - Include in your own designs

# Wi-Fi

- Some examples of Industrial Wi-Fi devices

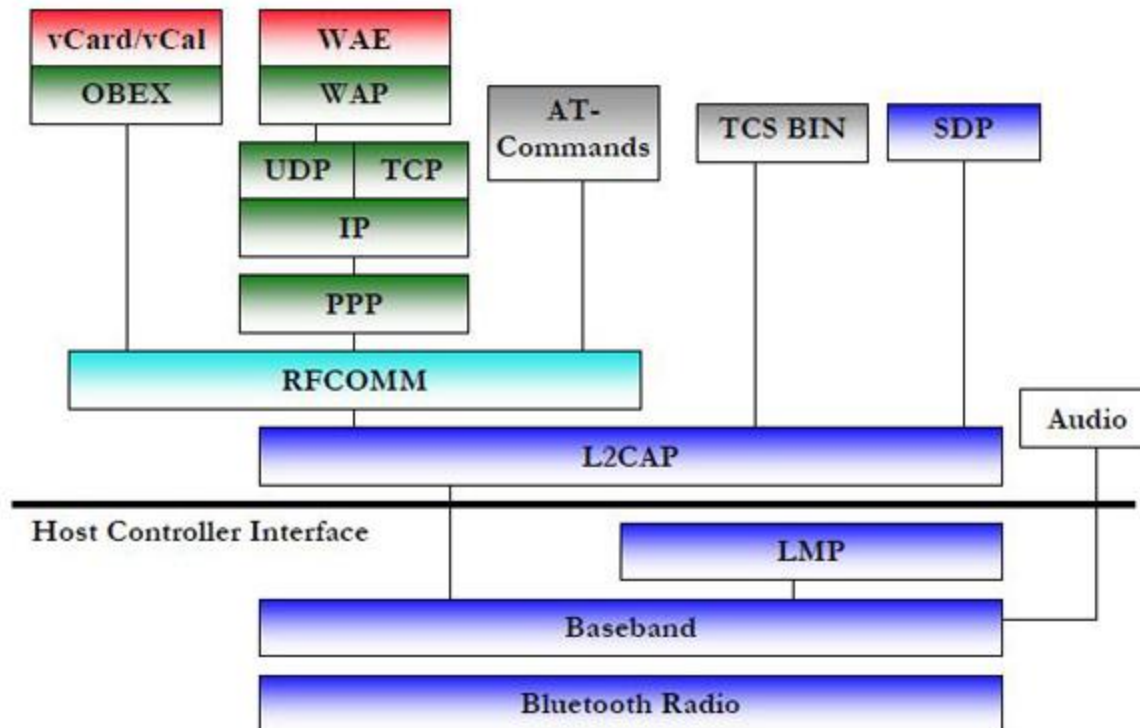


# Bluetooth

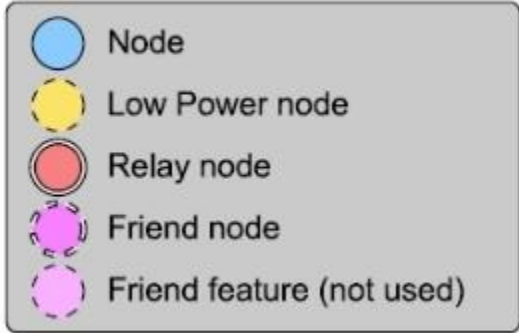
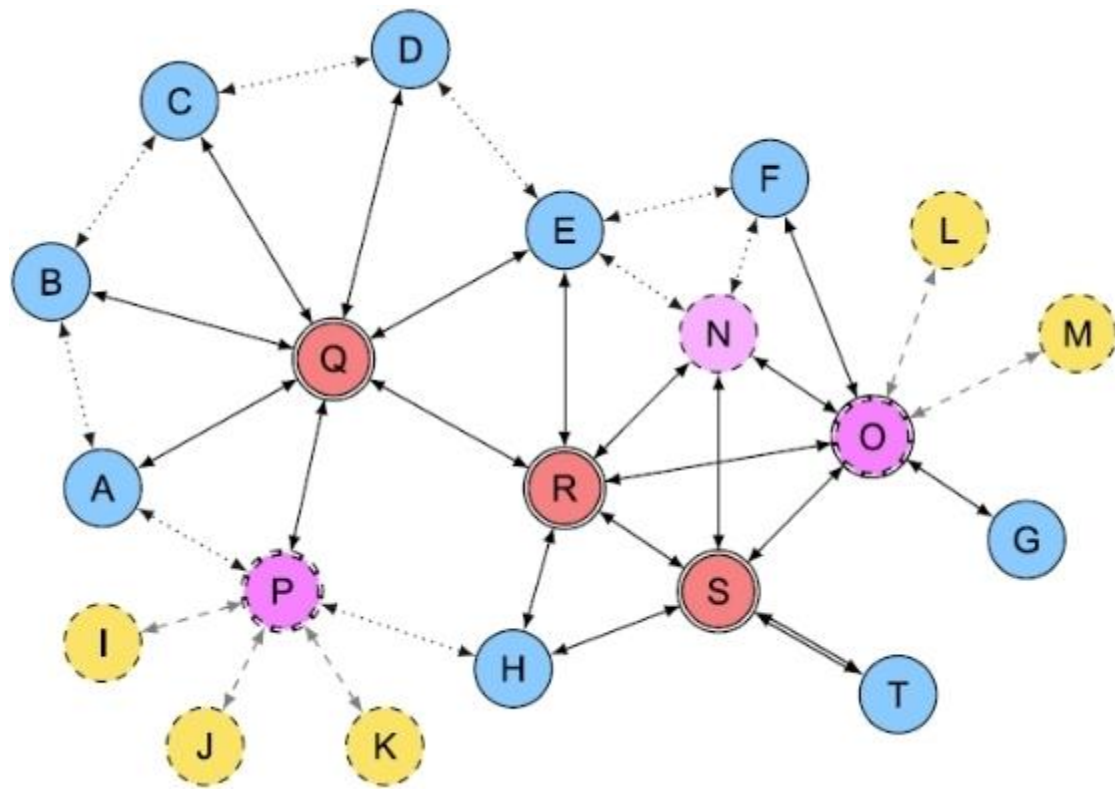
- Short distance protocol
- Frequency band from 2.4 to 2.85MHz
  - Unlicensed frequency band
- Spectrum is divided into multiple channels
  - Standard: 78 of 1MHz
  - Low Energy: 40 of 2MHz
  - Frequency hopping is used (nominally 1.6KHz)
- Each device can communicate with up to 7 devices

# Bluetooth

- Protocol Stack



# Bluetooth

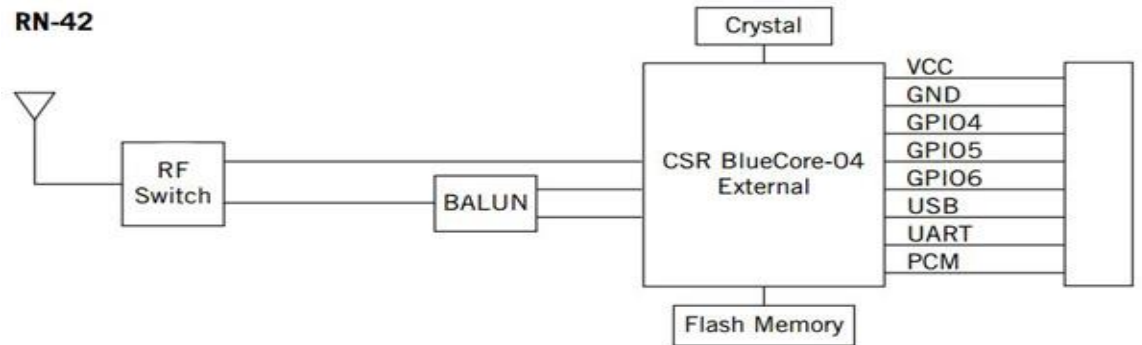


# Bluetooth

- In industrial applications Bluetooth can replace low capacity wiring for sensor and simple actuator applications
- Allows devices to be designed to store data and then transmit when a connection is made
  - Effects device design and implementation
- Allows devices to be mobile without central control of connectivity

# Bluetooth

- Typical industrial Bluetooth device





# RFID

- This technology allows tagging of equipment and material
- Tags can be active or passive
- Systems consist of the tag (a microchip and antenna), a reader and a computer system to process the data
- Allows a unique serial number for every part

# RFID

- Readers can be hand-held or fixed
  - Hand-held readers are portable and are often used for inventory applications
  - Fixed readers note the movement of items past a location
    - Allows tracking of material through a facility
- Sensors can be attached to the tag. Tags have limited data storage
  - E.g., temperature sensor

# RFID

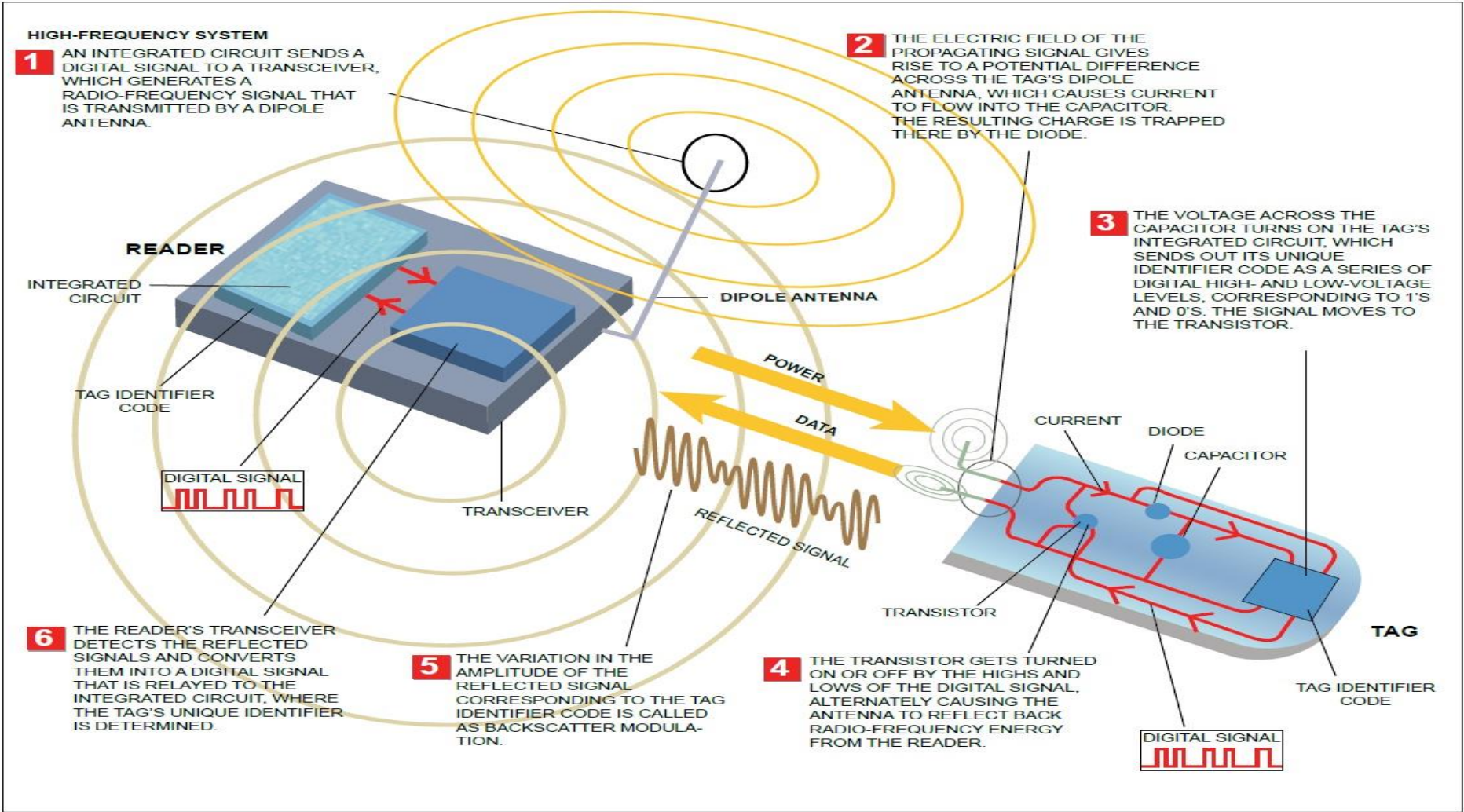
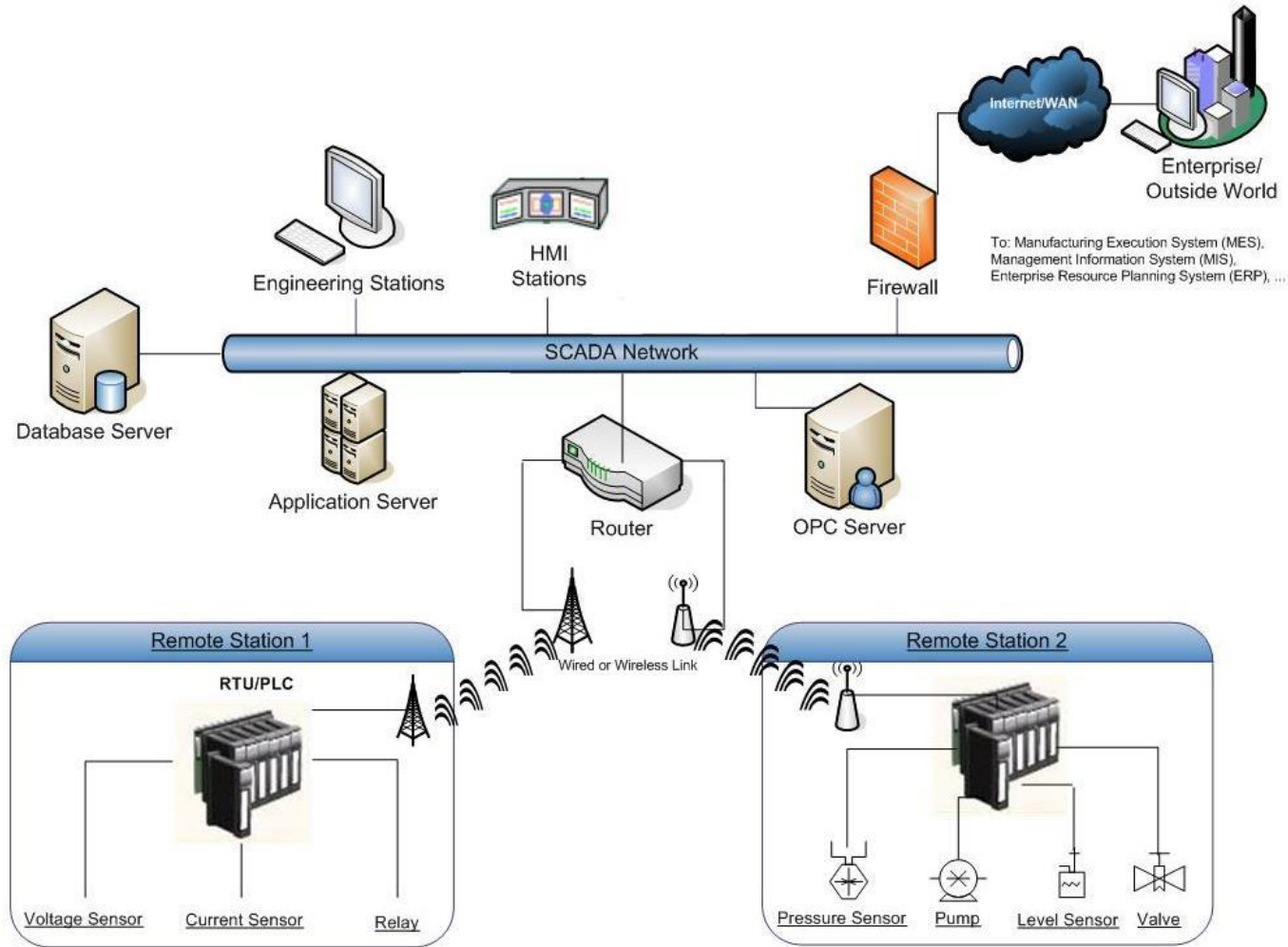


Fig. 1: RFID architecture and working

# Cellular

- Cellular connections are typically used in SCADA applications (e.g., utilities)
- Offered by standard cellular carriers
- Cellular connections come in two types
  - Circuit Switch Data
    - Not much used now
  - Packet Data
    - Always on IP connection
    - Billed by the kilobyte
    - Useful when proprietary communications would be prohibitive

# Cellular



OpenControl SCADA Network Architecture

# Conclusion/Next Class

- We have looked at the wireless options for IIoT connectivity
- Included are Wi-Fi, Bluetooth, RFID and Cellular
- Next class we will look at how these methods can be used in a single plant environment