What Is a Wireless Sensor Network?[1]

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A wireless sensor network (WSN) is a system designed to remotely monitor and control a specific phenomenon or event. WSNs are mostly used in agriculture to monitor environmental conditions and control irrigation (Aqeel-ur-Rehman et al. 2014). The WSN has the following advantages over traditional stand-alone sensors and controllers.

- *Site specificity*: Sensors can be positioned close to production fields.
- *Target specificity*: Network nodes can be customized to monitor only the variables of interest, reducing the number of sensors deployed and the cost of the network.
- *High spatial resolution:* Multiple nodes can be used to increase the number of sensors and controllers per unit area.

WSNs consist of nodes, routers, and a gateway (Figure 1). There are two types of nodes: sensor nodes (SNs) and actuator nodes (ANs) (Aqeel-ur-Rehman et al. 2014). Routers are used to extend the communication range or circumvent an obstacle. The gateway is the device that allows the management (control) of the network and aggregates the information received from the nodes to send real-time or near real-time data to a user platform.

When the gateway is connected to a local laptop, the user can locally control and monitor the WSN. Adding a cellphone modem or an Internet modem to the gateway guarantees remote management.

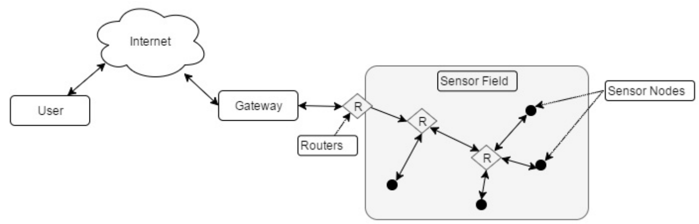

Figure 1. WSN components.
Credits: Thiago Borba Onofre, UF/IFAS

Power Consumption and Conservation

When a sensor node or a router runs out of power, it will disconnect from the WSN and negatively impact the application. In order to extend the network lifetime, energy conservation techniques must be used. Solar panels are the most popular solution for recharging the batteries of WSN components. Another approach to save energy is a technique called sleeping, which allows nodes, routers, and gateways to sleep during their idle times (Akyildiz et al. 2002).

The gateway is important because it coordinates the communication aspect of the WSN as well as its sleeping protocol. At a given time, the gateway wakes up nodes and routers. Data are exchanged, and then the nodes and

1. This document is AE521, one of a series of the Department of Agricultural and Biological Engineering, UF/IFAS Extension. Original publication date January 2018. Visit the EDIS website at http://edis.ifas.ufl.edu.

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Reviewed: 01/2026

routers go back to sleep. Sleeping is necessary for WSNs to save power. A sensor node generally spends 90% of its time sleeping.

WSN Technologies

A communication protocol defines the rules of how data are exchanged. The most popular communication protocols for WSNs are Wi-Fi, Bluetooth, and ZigBee. Wi-Fi is excellent for data exchange and is ideal where the power supply is not a problem, like in household devices. Bluetooth is also popular and is present in many battery-powered devices, such as watches, mice, keyboards, and other electronics. Bluetooth is a good option with low power consumption, short communication range, and high data rate. ZigBee requires even less power than Bluetooth and has a longer communication range, but it is quite slow. ZigBee would not be suitable for surfing the Internet or transmitting photos from a wireless camera, but it is well-suited for transmitting data from sensors in a field. In a very fast data-logging event, sensors and controllers usually report a simple dataflow (few bytes) each minute. Table 1 summarizes the three technologies accordingly with communication range and typical applications.

ZigBee radios can operate at 2.4 GHz, 900 MHz (US), and 868 MHz (Europe), while Wi-Fi and Bluetooth operate at 2.4 GHz (Akyildiz et al. 2002). The lower the radio frequency, the larger (broader) the communication range. For example, commercial wireless radios that use the ZigBee protocol operating in 900 MHz can communicate up to 14 miles (with directional antennas), while the 2.4 GHz radios have a communication range of 650 meters (2,000 feet in a straight line) (Digi International Inc. 2017).

Increased water vapor in the atmosphere during rainy or foggy days as well as in metal structures such as cars and buildings negatively impacts the communication range, resulting in temporary network communication failure. This happens because water and metal absolve, reflect, and attenuate wireless waves. Routers must be used to overcome these obstacles and guarantee a successful signal link between gateways and nodes (Yick, Mukherjee, and Ghosal 2008).

A good WSN design will provide the gateways with smooth Internet connectivity. A dependable range of communication is essential to establish and maintain autonomy within the WSN. If communication is lost due to power failures in the nodes, the WSN has self-healing and self-organization capabilities, which guarantee an autonomous setup once power is reestablished (Yick, Mukherjee, and Ghosal 2008). This can provide researchers and decision makers with better real-time data quality to make in-time crop management adjustments, saving natural and economic resources while increasing production efficiency.

Conclusion

WSN technology has a vast potential to improve resource use efficiency, irrigation management, and frost protection in agriculture and facilitate site-specific weather monitoring as well as monitoring of plant disease risk levels.

References

Akyildiz, I. F., W. Su, Y. Sankarasubramaniam, and E. Cayirci. 2002. “Wireless sensor networks: a survey.” *Comput. Netw.* 38(4): 393–422.

Aqeel-ur-Rehman, Abu Zafar Abbasi, Noman Islam, and Zubair Ahmed Shaikh. 2014. “A review of wireless sensors and networks’ applications in agriculture.” *Computer Standards & Interfaces* 36(2): 263–270.

Digi International Inc. 2017. “900 MHz versus 2.4 GHz.” Accessed on February 2, 2017. https://www.digi.com/resources/standards-and-technologies/rfmodems/frequency-comparison

Yick, Jennifer, Biswanath Mukherjee, and Dipak Ghosal. 2008. “Wireless sensor network survey.” *Comput. Netw.* 52(12): 2292–2330.

Table 1. Wireless technologies comparison.

	Typical Range (ft)	Power Consumption	Application Examples
Wi-Fi	100	High	Wireless Internet connection
Bluetooth	30	Medium	Wearable devices (watches)
ZigBee	2,000	Low	Wireless sensor and actuator network