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Human Movement Detection in Wi-Fi Mesh Networks

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Abstract:

Wireless networks, including mesh networks, can not only transmit information among various network devices but can also monitor changes or variations in the transmission signals used to communicate the information. Monitoring changes or variations in transmission signals can indicate presence, motion, lack of motion, or other characteristics about the physical space in which the wireless network operates without the need for additional equipment or dedicated devices.

Keywords:

Smart device, WiFi, Bluetooth, Internet-of-Things, electronic assistant, smart home, automation, privacy, security, motion, mesh network, signal, signal transmission, variation in signal, signal monitoring.

Background:

As the Internet-of-Things expands, smart devices continue to proliferate. Internet-connected thermostats, appliances, vehicles, phones, lights, and machines are found in all areas of life, including home, work, business, recreation, and school. Many of these internet-connected devices communicate using wireless networks and wireless protocols. Although a primary purpose of such wireless communication is to transfer information between or among the various devices, the transmission signals themselves can provide additional information. In particular, changes or variations in the transmission signals can indicate presence or lack of presence of a person, animal, or object in the physical space of the wireless network. Changes or variations can also indicate motion, lack of motion, changes in motion, or cessation of motion in the physical space of the wireless network. Advantageously, the additional information can be

derived from the existing wireless network without additional equipment, hardware, or other devices.

Description:

Wireless networks, including mesh networks, can not only transmit information among various network devices but can also monitor changes or variations in the transmission signals used to communicate the information. Monitoring changes or variations in transmission signals can indicate presence, motion, lack of motion, or other characteristics about the physical space in which the wireless network operates without the need for additional equipment or dedicated devices.

Wireless networks, such as Wi-Fi, Bluetooth, and mesh networks like Zigbee, Z-wave, and others all involve wirelessly connected components. Some components include routers, switches, plugs, repeaters, lights, thermostats, appliances, and many other types of devices. The wireless components can also connect to and interact with one another. For example, a home theater system that is turning on could send a signal that instructs the lights in the room to dim after a certain amount of time. The components may also be connected to other devices via the internet or other network connections. In such cases, the wireless components can be accessed and manipulated using a web browser, an application on a mobile device, a local remote, or programing system (e.g., voice commands, home automation systems).

As these various devices communicate with one another, wireless electromagnetic signals pass throughout the physical space or geography of the wireless network. For example, consider the room illustrated in Figure 1. Figure 1 shows three separate wireless nodes, which could be routers, switches, plugs, or the like. The three nodes can send, receive, repeat, and monitor various signals. As shown in Figure 1, signal one bounces off a wall, signal two is passed from

one node to another, and signal three passes directly between nodes without obstacle or interference.

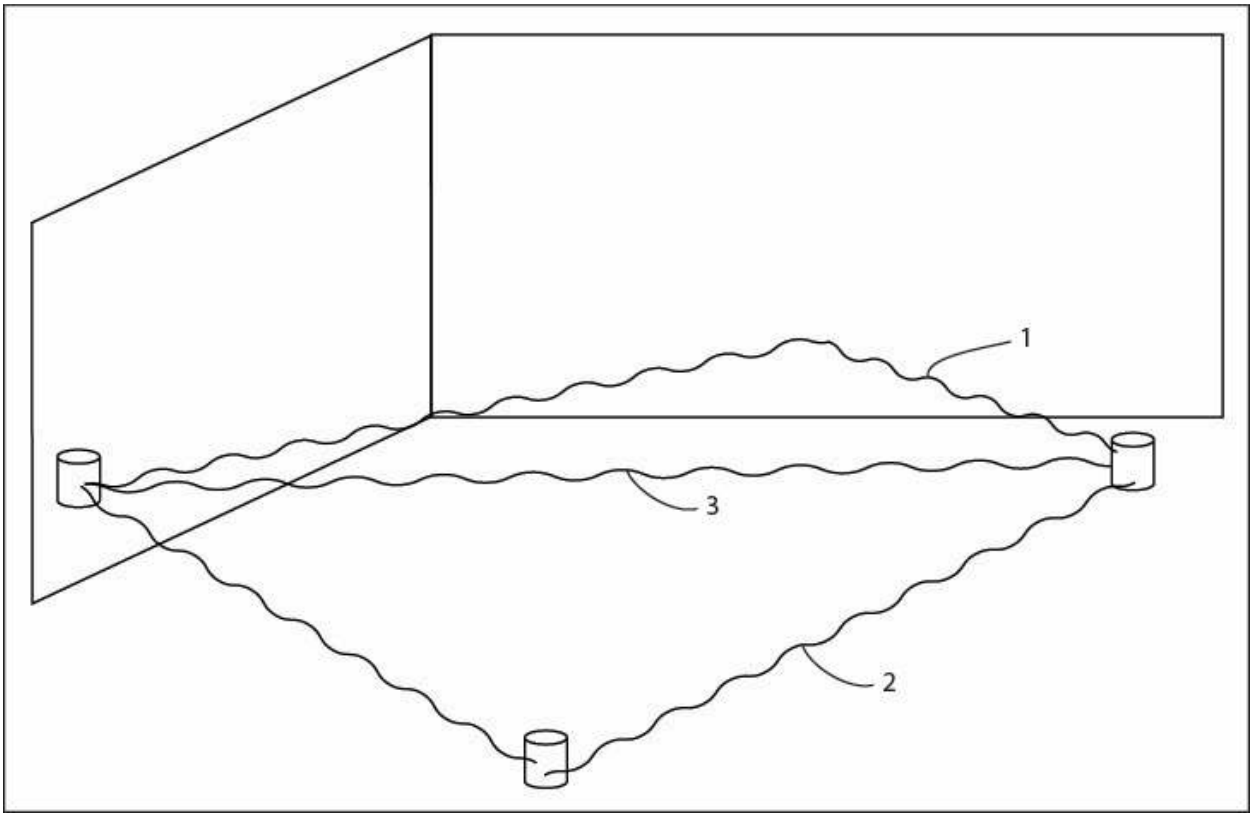

Figure 1

As illustrated in Figure 1, the wireless signals can fill the geographic space of the wireless network. At any given time, the wireless network can assemble a baseline for the geographic space of the wireless network that contains information about the construction of the geographic space. Different substances interact differently with the wireless signals. By comparing the various signals to historical data, a set of signal profiles, or the like, the system can determine the composition of the geographic space, which can include the location of various substances, objects, persons, or animals within the space.

For example, consider the room illustrated in Figure 2, which is the same as the room of Figure 1 but now includes a person.

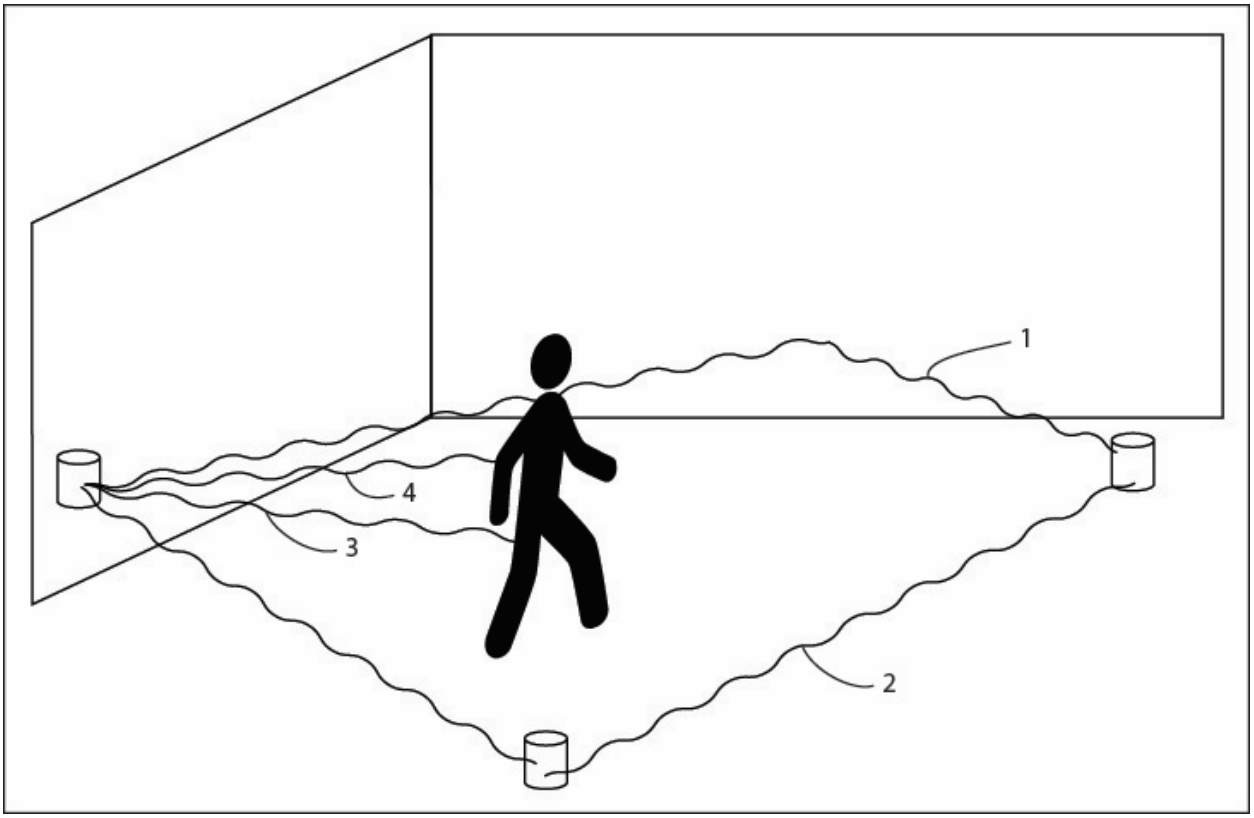

Figure 2

As shown in Figure 2, signal three now interacts with the person standing in the room. New signal four could be another signal from a node or could be a signal reflected back to the sending node from the person. The interaction of wireless signals with the person can result in slight changes to the spectrum or profile of the wireless signal, including changes to channel state information. Although not shown in Figure 2, a wireless signal could pass through or near the person and continue on to another node in the room.

By comparing the particular signals to a library of signals profiles or to a before and after profile of the geographic space of the wireless network, the system can identify the presence of a person without the need for specialized equipment, such as cameras, infrared detectors, mechanical or vibration detectors, or dedicated motion detectors.

In certain environments, it can be advantageous to detect the presence of a person without the need for cameras or other light sensitive or motion sensitive devices. For example, a wirelessly connected thermostat could adjust the temperature in a meeting room to accommodate a large crowd. Further, a thermostat could adjust the temperature in a home differently based on whether a person or the family pet is in a room.

The baseline or reference point from which to determine changes in the geographic space can be determined using machine-learning algorithms. Consider Figure 3, which illustrates the person of Figure 2 in motion. As the wireless signals interact with other objects, including other wireless signals, the signals themselves can experience interference and change, even if only slightly. As the person moves through the room, signals three and four change (illustrated as 3a/4a prior to interacting with the person and 3b/4b after interacting with the person). By comparing the changes in signals three and four to the continuity of signals one and two, the system can model the movement of the person through the room.

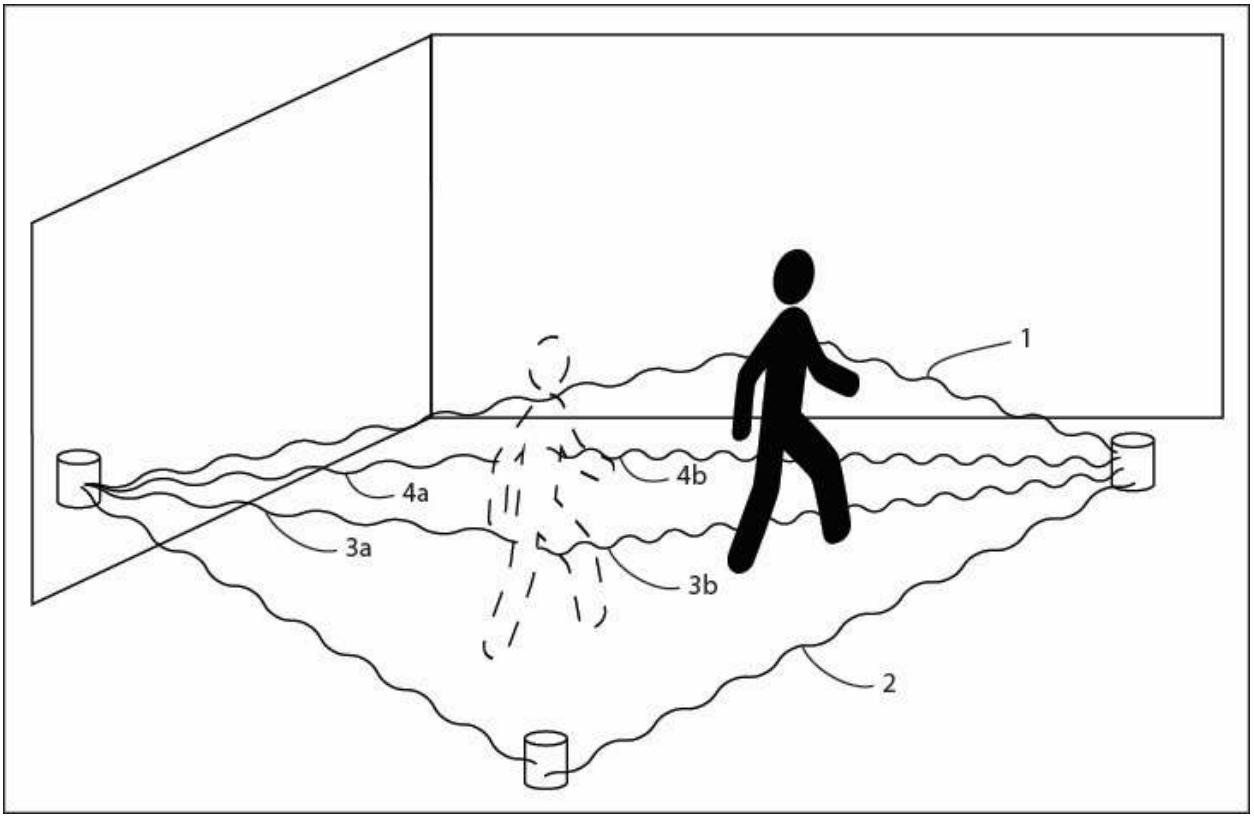

Figure 3

In some circumstances, the wireless system described here can supplement or possibly even replace security systems, occupancy systems, motion detection or motion cessation systems, and the like. Such a system could detect the presence or motion of intruders, distinguish between person falling rapidly or a person simply bending down to retrieve something, for example.

The system is not limited use with animate objects. Inanimate objects, especially electronic objects, also interact with and can change the wireless signals of the wireless network. The system can assemble profiles for various types of objects and substances and monitor those objects and substances. The assembled profiles could also aid in placing portable or mobile wireless nodes to improve overall signal transmission and reception among the various wireless components.

Monitoring changes or variations in the transmission signals used to communicate information in wireless networks can reveal additional information about the geographic space of the wireless network such as presence, motion, lack of motion, or other characteristics about the physical space in which the wireless network operates.