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MOVING/ROTATING ANTENNAS FOR WIRELESS ACCESS POINTS

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ABSTRACT

Conventionally, the position and orientation of antennas for wireless access points depends on the position in which a wireless access point is oriented during installation and typically does not change unless the positioning of the wireless access point is changed. Thus, wireless antenna position/orientation typically remains static once an access point is installed. Techniques proposed herein introduce a sensor fusion approach for controlling the direction/orientation of wireless access point antennas in order to improve wireless communications for wireless networks.

DETAILED DESCRIPTION

Wireless access point (AP) positioning is an activity that is performed once during installation/deployment of a wireless AP and very rarely re-evaluated. Defining the position of an AP means also defining the position and orientation of its antennas. Typically, any such decision is static and has a large impact on the quality of communication over wireless channels provided by an AP for clients and for monitoring activities. This is true for both regular wireless local area network (e.g., Wi-Fi®) and industrial IoT applications.

In some systems, such as mesh systems, a large density of antennas may be utilized for a deployment, which adds another dimension to the problem: it can be expensive to install the antennas, especially if the density of devices (e.g., Internet of Things (IoT) devices) that are to be served is sparse. The same issue can occur for systems in which devices that are to be served may be sparse and may be moving (e.g., trains or other moving vehicles) such that antenna direction may need to be re-positioned based on device location in order to provide the best coverage for devices.

This submission provides a sensor fusion approach for controlling the direction/orientation of wireless access point antennas in order to improve wireless communications for wireless networks. As a starting point to the approach, it is assumed that antennas for APs (or whole APs) may be mounted on movable and rotating supports, such as rails and moving arms, or similar movable/rotating mounts/mechanisms. For example, in some instances, antennas may be mounted on poles such that rotation (or software-driven beamforming) may be utilized for the tracking of a moving device that is to be served (e.g., a moving vehicle).

A central controller may control the position and the orientation of each and every antenna in a deployment, as illustrated in Figure 1, below. During operation, the controller can collect measurements and, by leveraging machine learning, can determine an optimal position and the rotation of each antenna for a given wireless scenario (e.g., current wireless clients and users in a given deployment). Such operation can be utilized for both Wi-Fi environments, using 802.11v measurements or cross-AP measurements, or for industrial environments, with client devices direct providing feedback. The controller may also be able the next best position/orientation for antennas by using data fusion (e.g., images from cameras, signal strength, time of arrival, etc.), thereby combining different inputs of information about all clients and flows to serve.

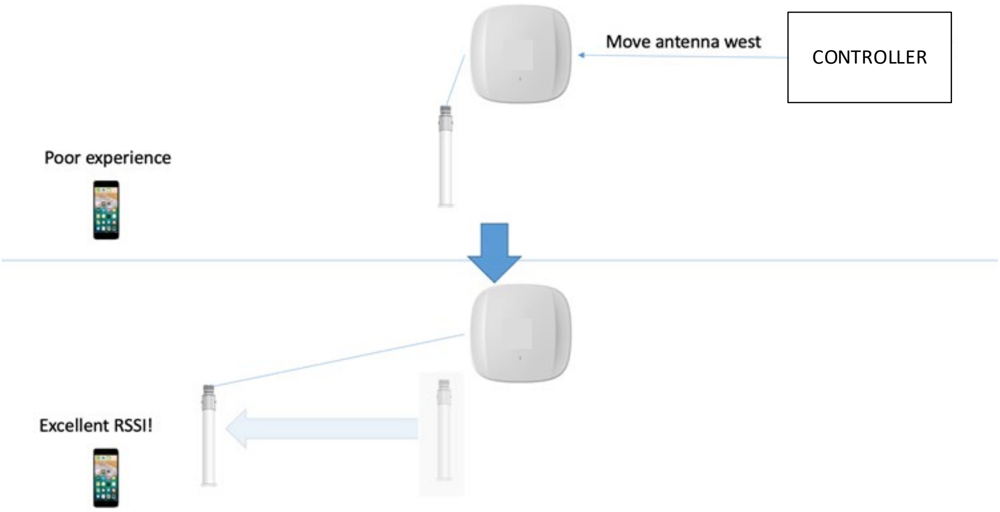

Figure 1: Example Movable/Rotating Antenna Environment

In some instances, the controller may also be able to control cameras in order to provide the best input data for the data fusion and may be able to follow devices and monitor areas of the deployment according to predictions and next needs. For instance, the controller may know (or predict) that there will be a large number of activities (e.g., clients moving, etc.) in a given area, and then program cameras to observe the area. In another example, the controller may be capable of sensing that its predictions regarding device movement may not be accurate enough and may move the cameras and antennas to be able to cope for this accuracy and provide further improvements for the system.

In some environments if the number of devices (e.g., moving robots, etc.) is limited enough, using moving antennas may allow for reducing the number of antennas that may be utilized for a deployment. For example, the controller may monitor device movement and follow devices through antenna movements and rotation. If the controller handles scheduling for the system, then controller can also adapt the scheduling according to antenna movement.

An antenna will typically maintain its “color/frequency” in a mesh implementation, but it can also change color such that the choice of color/frequency may depend on the redundancy required for devices within the coverage of a system. Consider various example mesh scenarios for which coverage may be provided, as shown in Figure 2, below.

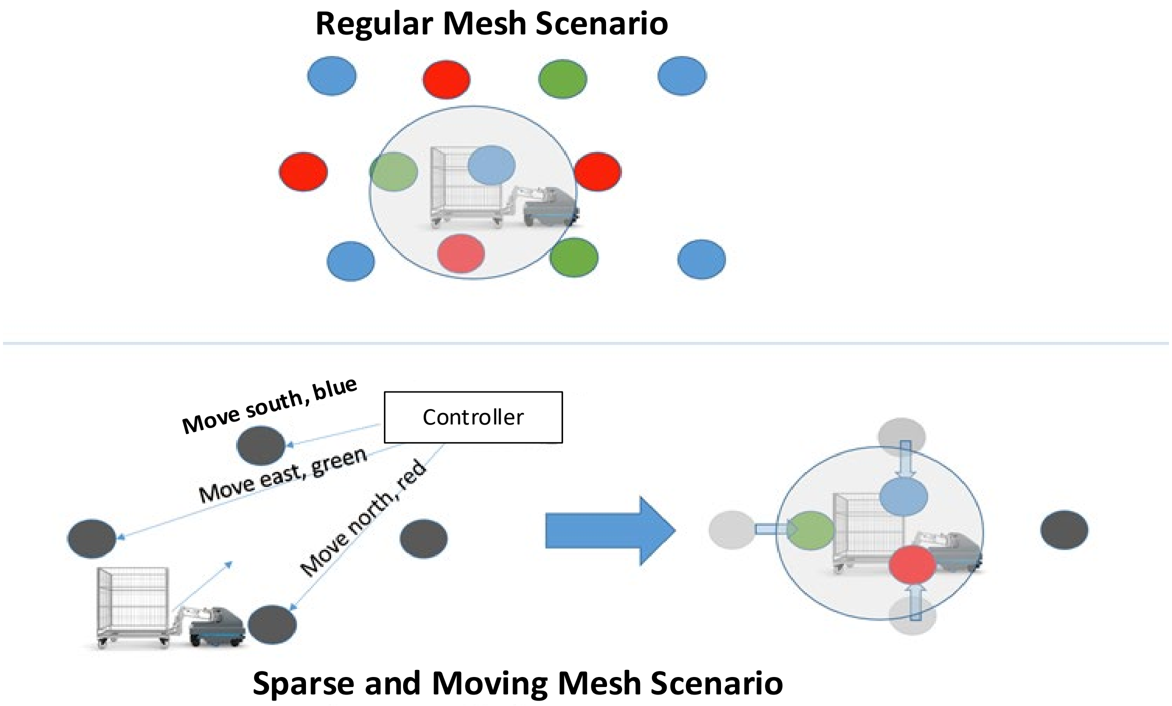

Figure 2: Example Mesh Scenarios

In regular mesh scenario (with fixed antennas) as shown in Figure 2, a substantial degree of density for antennas may be needed to provide enough redundancy to each device for which coverage is to be provided. However, in a sparse and moving mesh scenario, the controller is able to direct antennas and program them with the right frequency to provide service for a given device.

For example, as shown in Figure 2, the device may be moving towards the center of the 4 antennas, whose color is dark grey, to signify that they are not currently used nor set in any frequency. In this scenario, the controller can direct the antennas to move and what color (frequency) to use such that the antennas can provide red/green/blue coverage for the device as it moves to its position, as illustrated on the right side of Figure 2.

Figure 3, below, illustrates example details for another scenario in which a pole radio can be rotated and beamforming can be used to follow movement of vehicle (e.g., a train, as shown in the example of Figure 3).

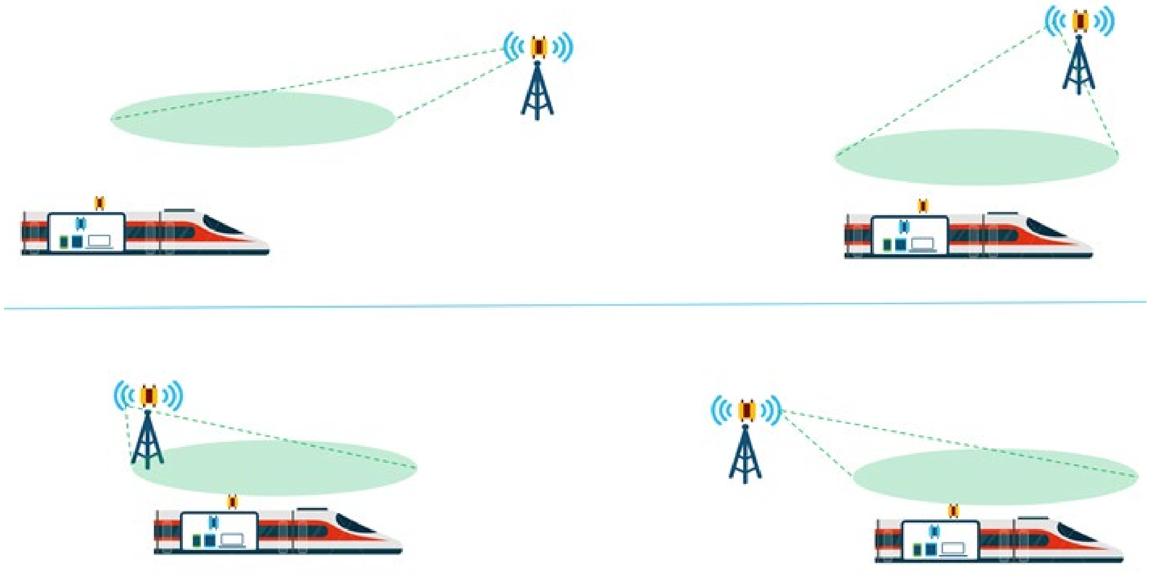

Figure 3: Example Movement and Beamforming Scenario

Controlling the position/orientation of wireless AP antennas (or whole APs) may provide various benefits over fixed position deployments, such as increasing the quality of connectivity for critical clients, increasing coverage for clients, and, in some instances, potentially reducing the number of antennas needed for covering a given area/number of clients.

Further, techniques proposed herein may be utilized for both phased array antenna implementations and mechanical implementations. For use cases involving moving vehicles on a track, such as trains, beamforming and moving antennas would provide the best coverage for trains as they move along tracks. In one example, physical movement tracked by Light Detection and Ranging (LIDAR) sensors and learned through reinforcement learning can provide for the ability to determine the best match of antenna radiation volume (the donut) and train position for each of multiple trains.

Initially, a train's antennas could be marked to be "visible" from the sensors, for example, with a white cross that is visible from a camera providing a reference point at which to direct the camera. The best value for antenna radiation volume can depend on the physical location of a given train, the physical location / orientation of the train AP's antennas, and the actual shape of the radiating pattern. A learning phase could be performed for each train approaching a track side AP using continuous sounding Null Data Packets

(NDPs) varying the track side AP antenna positions around the direct path pointing to the reference point on a given train.

Other tracking mechanisms may be utilized to track the movement of a moving device, such as a vehicle, such as through constant monitoring of a vehicle signal, a vehicle sharing its route, its GPS location and speed, or via using doppler measurements or cameras and lidars. In some instances, vibration sensors can be utilized that are sensitive to a vehicle (e.g., train) approaching, infrared / lasers that sense a vehicle crossing, and/or the like.

Although satellite tracking has been utilized for to provide antenna rotation cellular implementations, techniques proposed herein as applied to WLAN implementations may be distinguished from cellular implementations. For example, the controller may coordinate antennas for multiple APs and may also adapt scheduling to provide improved tracking as may be otherwise provided for a cellular implementation. Further, techniques proposed herein can leverage learning to match the radiation pattern of a track side AP and, thus, determine the exact location of a train AP's antennas. However, in the case of a satellite, the whole satellite is a dot in the sky and the radiation pattern is optimal in a particular pointing direction, which may not provide the directional granularity of directing an antenna to the exact location of a moving vehicle as may be provided through the techniques of this proposal.

Accordingly, techniques proposed herein provide for the ability to control the movement/rotation of antennas for wireless APs such that a controller can direct the position/orientation of antennas (or whole APs) using a variety of approaches, such as sensor fusion approaches and beamforming approaches, among others.