The Dilemma of **Warehouse Automation**

A deep dive into the differences of a standard traditional Wi-Fi network to a Rajant Kinetic Mesh® network in terms of coverage, capability and stability in a warehouse environment.

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RAJANT

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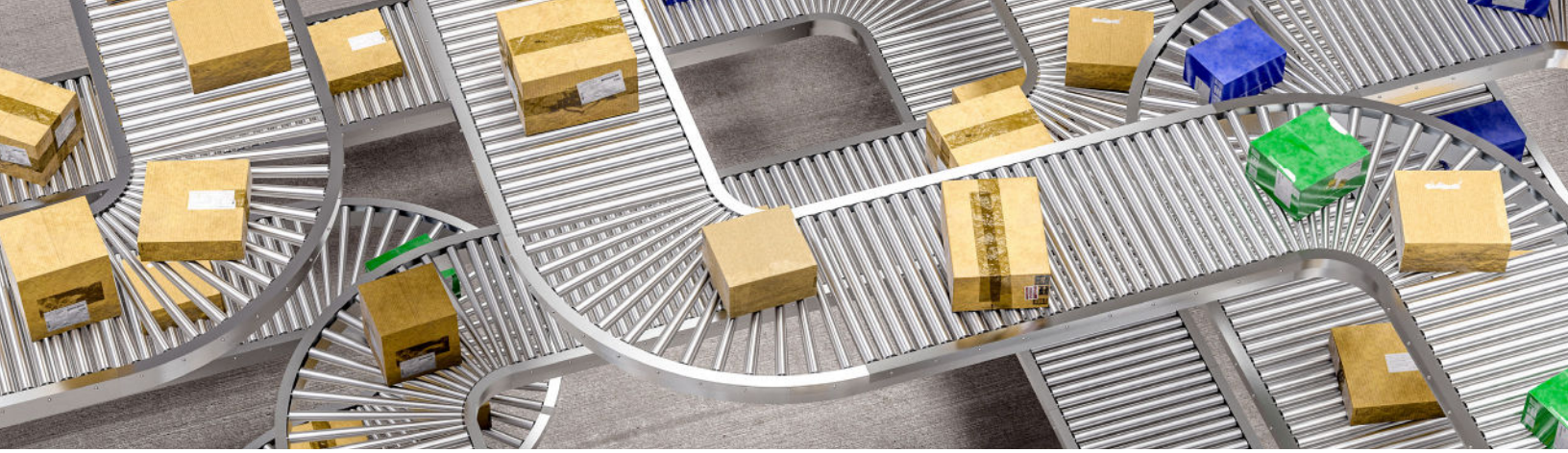
Introduction

When looking into providing warehouses with network coverage, oftentimes, there are multiple key issues most network providers are concerned with. The first issue is the racks of shelving and equipment as well as hallways creating corridors that block wireless connectivity. Frequently, warehouse shelving racks are constructed with metal and filled up with products made or partially made with metal. When planning a network, network designers assume the worst case so that portions of the network will not experience outages. By assuming the worst case, each rack would be filled with boxes or equipment and would completely block wireless signal, similar to a metal wall. These metal corridors are also notorious for causing multipath reflections and due to the constant flux of the product storage, highly unpredictable.

The second issue is mobility, as every warehouse has multiple pieces of mobile equipment. Providing coverage to workers on mobile equipment or the mobile equipment itself requires the ability to roam in and out of cell sizes very quickly. As discussed previously in the first problem, the metal shelving blockages can make this extremely difficult. This quick change in connectivity is constantly happening as the mobile equipment is always moving in and out of various corridors. The need for overlapping and cells and the ability to stay connected at all times is a constantly growing need, as devices and tools used in warehouses are getting smarter and more precise.

This whitepaper explores the challenges of warehouse connectivity and compares a standard traditional Wi-Fi network to a Rajant Kinetic Mesh® network in terms of coverage, capability and stability specifically in a warehouse environment.



What is **Kinetic Mesh?**

Rajant wireless mesh networks are not traditional networks. We call our networks Kinetic Mesh networks, and they are uniquely designed for environments and applications where client devices and even the network itself are in a state of constant change and motion. Rajant Kinetic Mesh networks are built around superior reliability and security. To achieve these goals, Rajant utilizes a multi-frequency, multi-peer mesh connection to give every node in the network the ability to talk to each other using multiple radios simultaneously. Each node, or BreadCrumb®, such as the ES1 pictured below, acts as a smart wireless device, maintaining connections to every other BreadCrumb that can be connected wirelessly or wired. This web of connections gives Rajant unparalleled reliability, ensuring that packets will always have a path home in even the toughest environments.

Coverage **Differences**

There are a couple of factors that give Rajant BreadCrumbs an advantage on radiation cell sizes when compared to traditional Wi-Fi. The first of these factors is the effective isotropic radiated power (EIRP). Rajant BreadCrumbs utilize a more powerful EIRP than traditional Wi-Fi. This means each radio card has more power out, giving each radio greater range. Rajant radios have a max transmit power of 28dBm. Understanding that adding 3dBm doubles transmit power out, in comparison to a Wi-Fi product with a max transmit power level of 22dBm, there is a clear difference in the power levels.

The standard antennas utilized by Rajant are yet another reason that Rajant can provide greater coverage. Rajant standard antennas are 5dBi for 2.4 and 6dBi for 5.8. Compare this to a traditional integrated antenna in standard Wi-Fi access points of 3-4dBi. This 1-3dBi in antenna gain is more effective than raising the transmitted power out in gaining range and still maintaining the highest modulation speeds. In addition, Rajant antennas are standalone for the radio, this allows for greater versatility, separation, and the potential to change the antennas to fit any scenario. With most traditional Wi-Fi APs, the antennas are integrated. This antenna integration allows for zero flexibility as the scenarios change and get tougher, leaving installations with fewer options for coverage.

The effects of a higher EIRP and antenna differences seen below are calculations done using an industry standard Wi-Fi predictive coverage application. The radio model for Rajant is ME4/FE1/ES1 as all units utilize the same radio card specs, power levels and capabilities. The model for traditional Wi-Fi is a standard Wi-Fi AP using values from spec sheets found from vendor's websites. The calculation area is a building size of 150m x 250m.

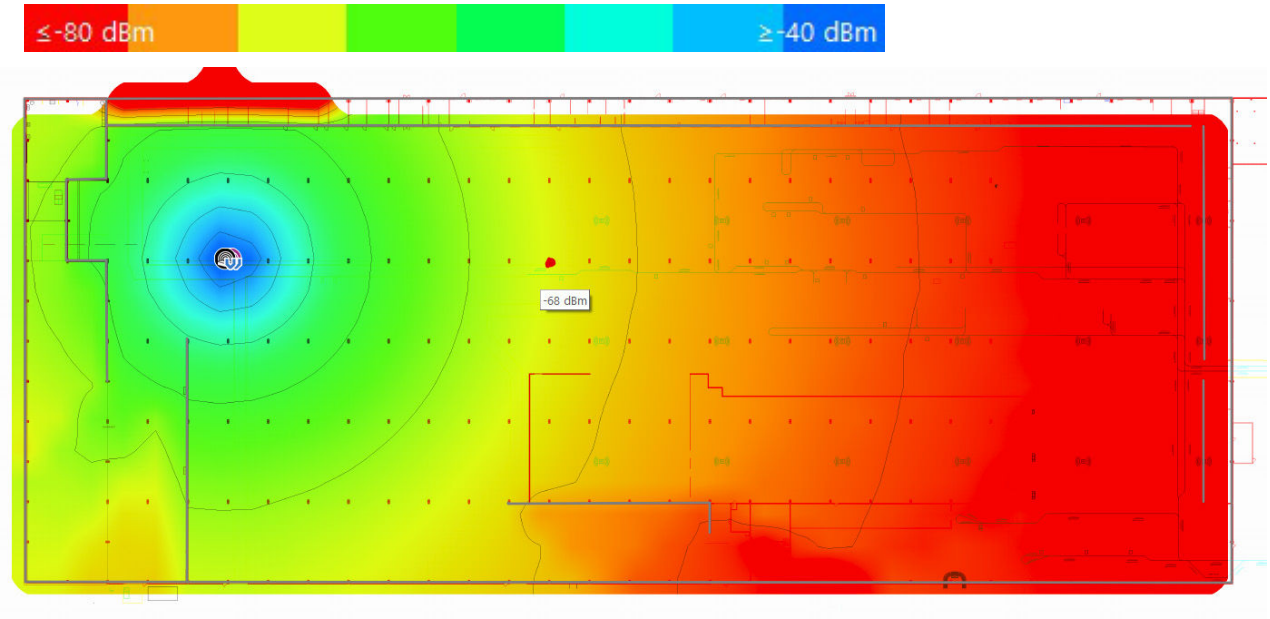


Figure 1. *The image above is a Rajant single node.*

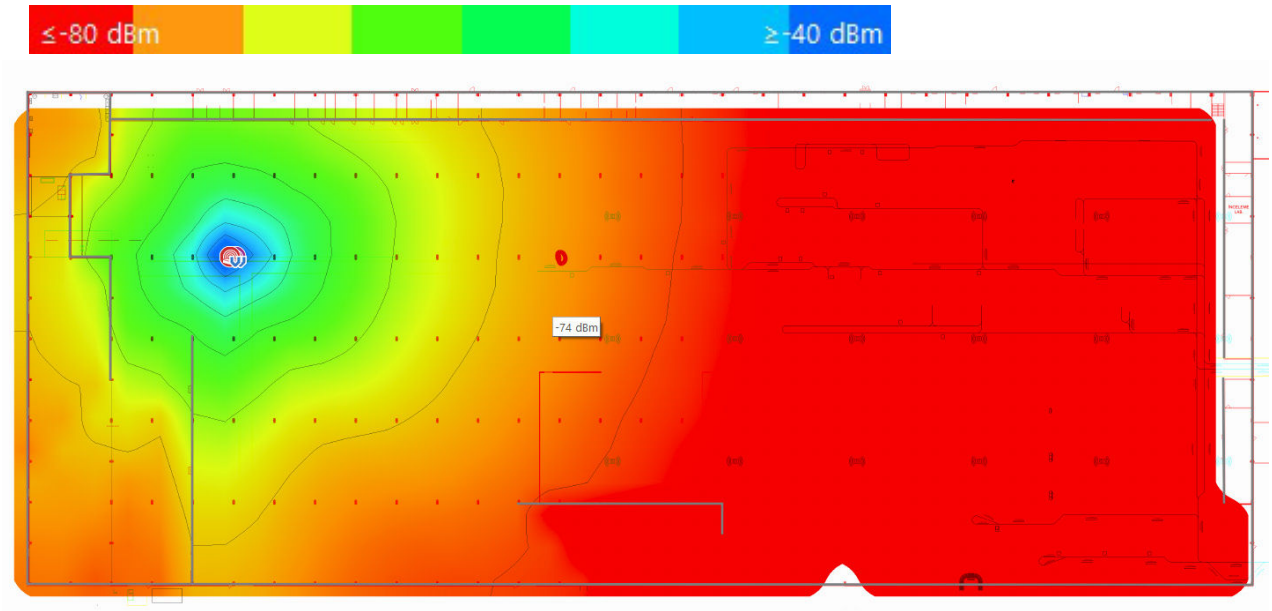


Figure 2. *The image above is a traditional Wi-Fi single node using the max power available.*

Already there are propagation differences seen as two figures show -68dBm and -74dBm respectively. The difference of 6dBm is approximately four times larger or smaller. In this case, the traditional Wi-Fi power level is approximately one-fourth the power level available compared to a Rajant BreadCrumb. This difference in power will affect the speed at which devices can communicate at further ranges, as well as how long clients will remain connected before roaming or simply disconnect and drop off.

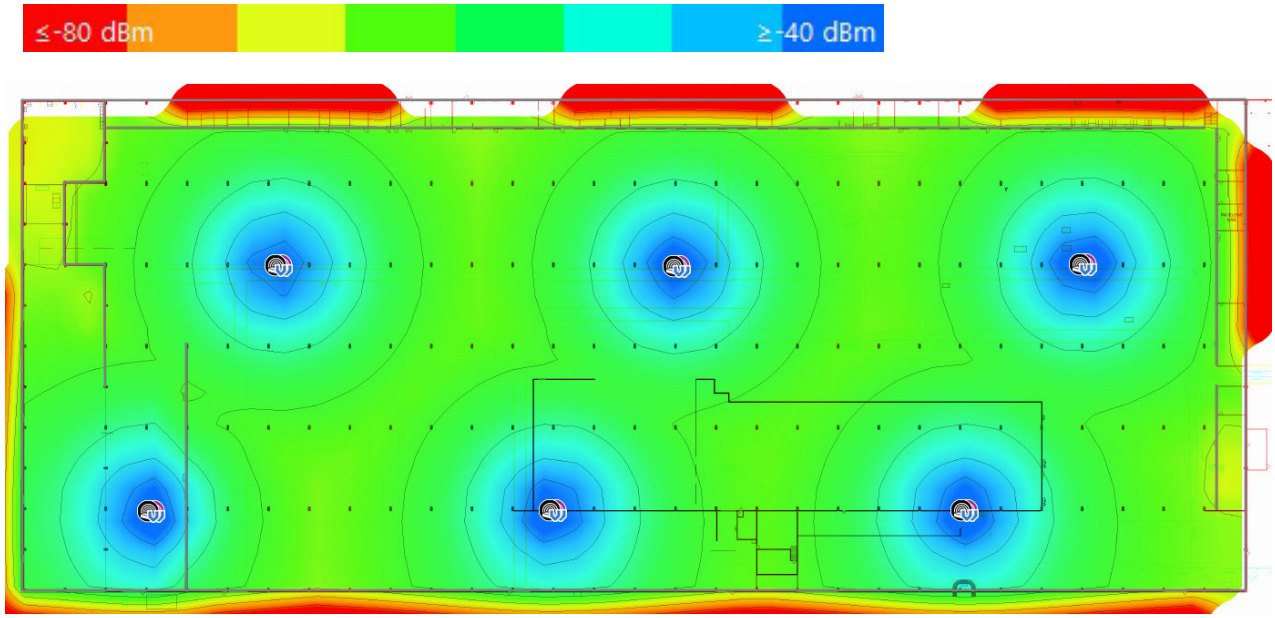


Figure 3. *The image above is a total coverage map of Rajant nodes. Using the spec of -65dBi (VoIP spec) at every floor spot in the room. It takes six Rajant nodes to cover this entire space.*

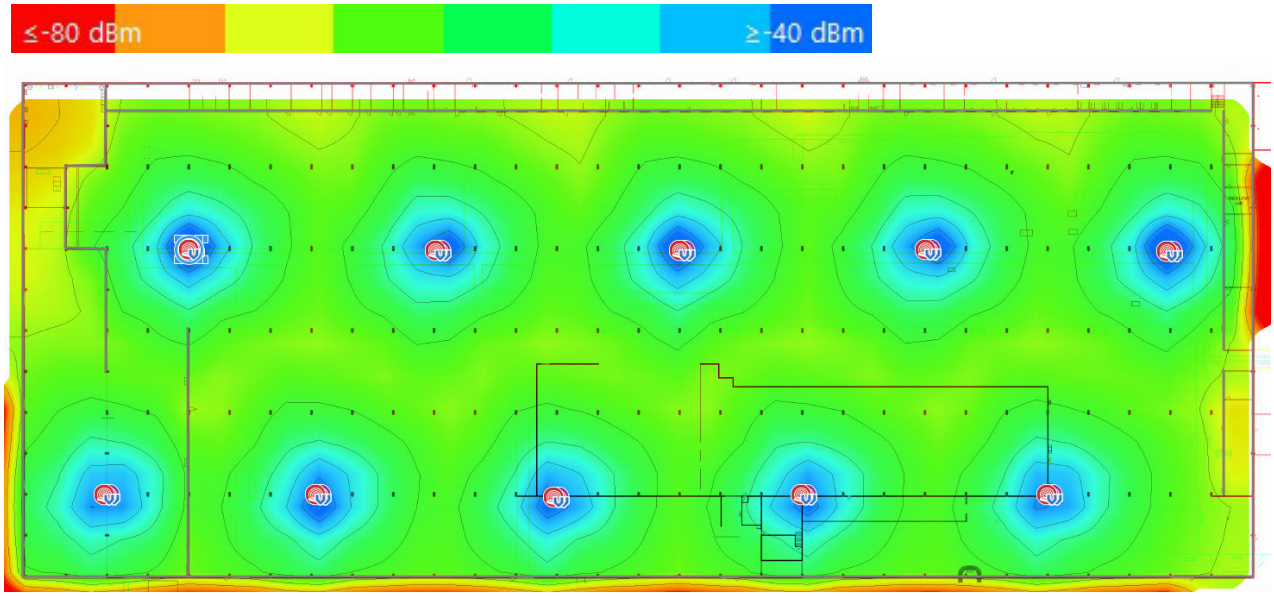


Figure 4. *The image above is a total coverage map using the traditional Wi-Fi node. It takes 10 nodes to provide the same coverage.*

A simplified quantification of six versus ten for the same area or 40% less nodes. This propagation difference seen in the figures above is an empty building.

Capabilities **that Build**

Warehouses are not all open spaces as seen above. Warehouses are full of metal racks and shelves, full of boxes, crates and equipment, all of which cause blockages for potential RF signal. This turns a 10 Wi-Fi node warehouse into a 40 or 50 node warehouse quickly as corridors need coverage for devices like hand scanners or mobile equipment fleet management systems. The traditional Wi-Fi solutions is to add more APs, nothing else. Each of these APs will be hardwired with Ethernet or fiber optic cable, making the deployment of each new node more expensive and time consuming to deploy. In a Rajant Kinetic Mesh, only a few nodes need to be wired into the local area network. By wiring a few nodes, Rajant utilizes its proprietary protocol, Automatic Protocol Tunneling (APT). APT is a wired protocol that allows for multiple nodes to be connected into the same subnet while providing loop prevention and thus allowing for multiple LAN ingress points for information flowing from the warehouse flow to the wired network in the building.

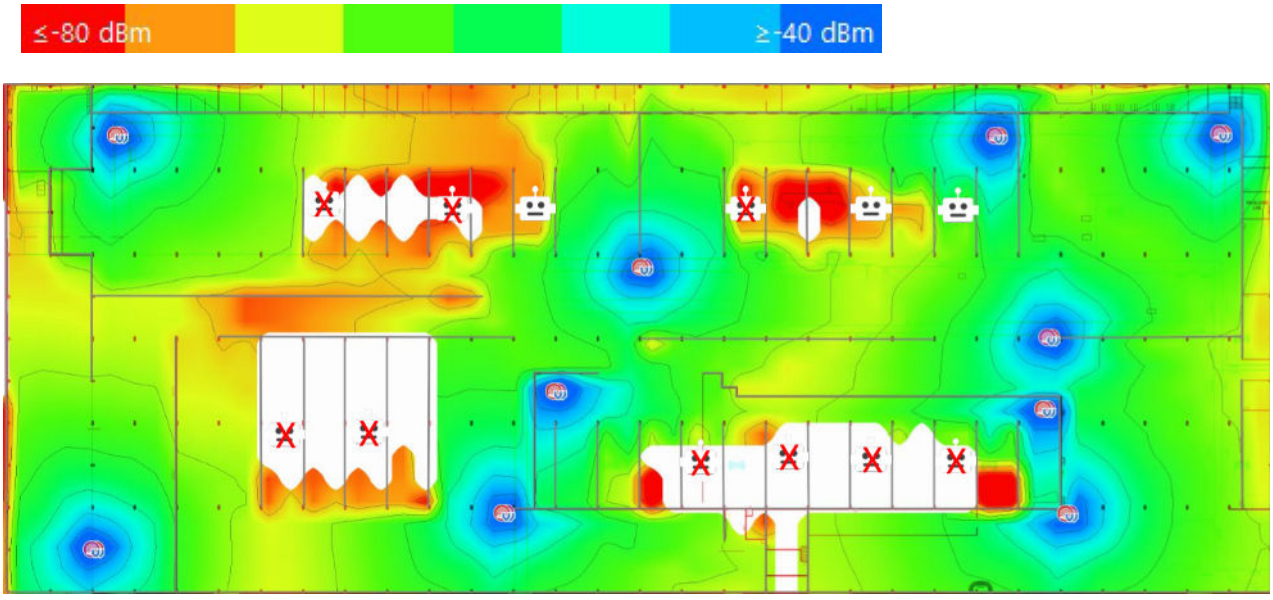


Figure 5. *The image above is using those same 10 nodes in the empty warehouse. A filled warehouse presents a much more challenging environment. The traditional Wi-Fi deployment has trouble covering the corridors with the equipment deployed. Clients on mobile machines are unable to connect and entire corridors are left without coverage.*

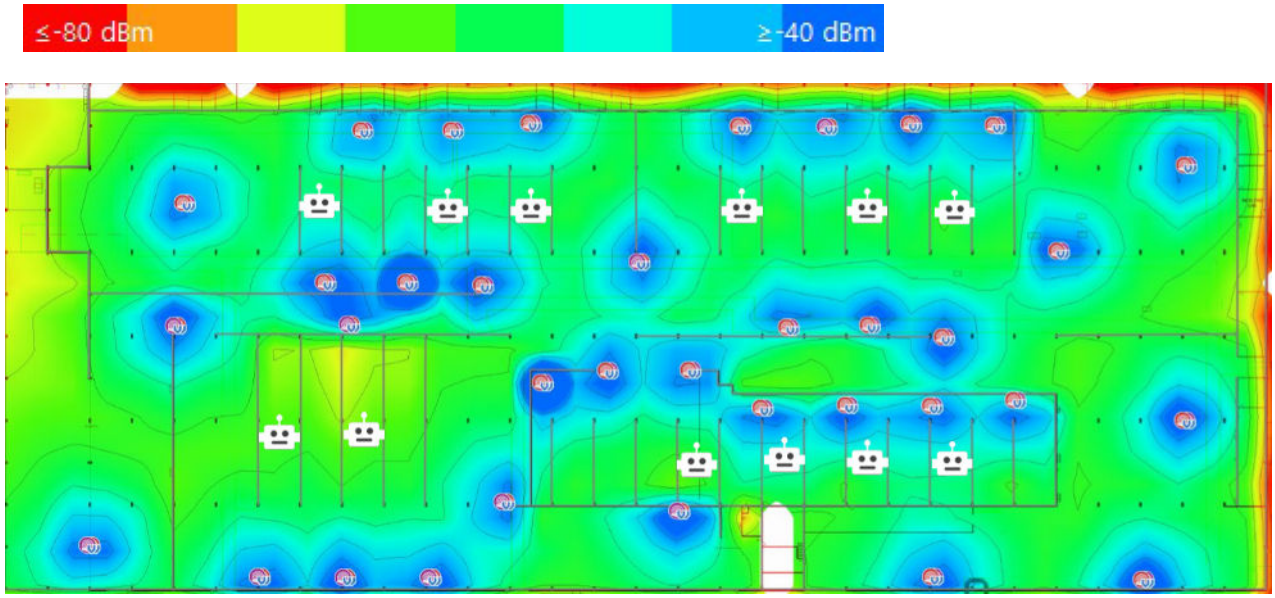


Figure 6. *Traditional Wi-Fi solution is able to over deploy the infrastructure to cover each warehouse corridor. This image above is using 35 nodes to cover the given space with full metal racks. A 150% increase in the amount of nodes required.*

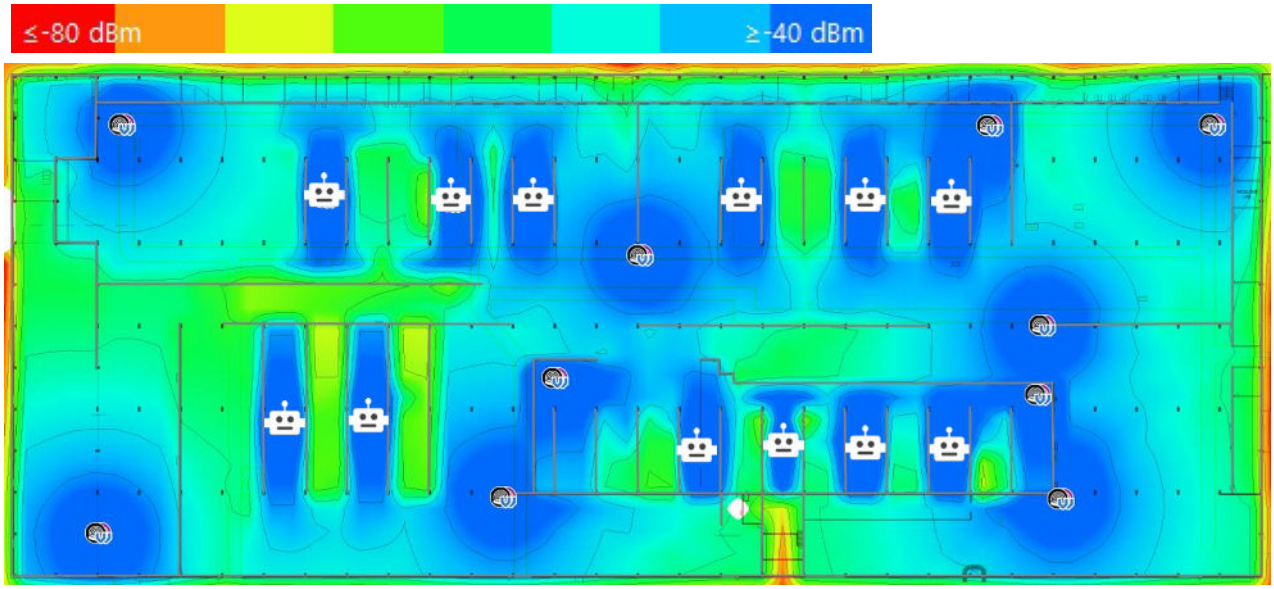


Figure 7. *Placing nodes on mobile assets, as shown the image above, allows extended mobile coverages to cover all areas of the warehouse floor. .*

Using Rajant, the infrastructure of the warehouse is much stronger and of equal number to that of the Wi-Fi deployment in Figure 5; 10 nodes. By placing nodes on mobile assets in FIgure 7, it allows for extended mobile coverage to cover all areas of the warehouse floor. In addition, each vehicle and infrastructure double function as a backhaul device; build an even more robust network in a tough environment. When using Rajant in the warehouse with shelves, using both mobile assets and infrastructure, the total difference is approximately half of the number of nodes when using Rajant versus traditional Wi-Fi.

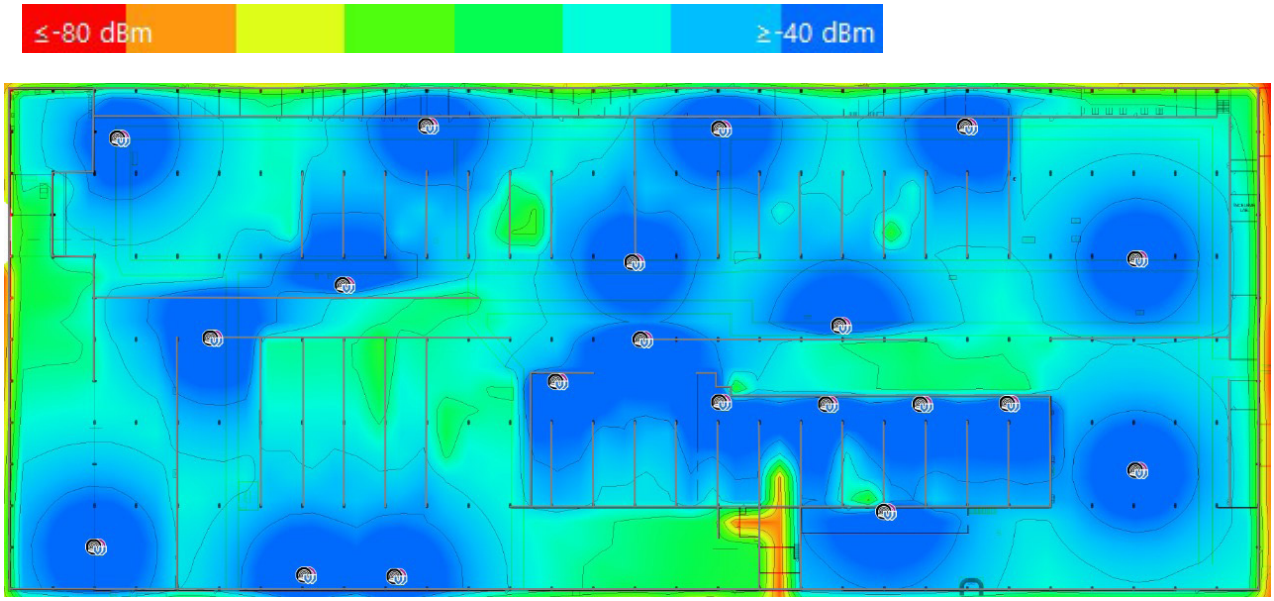


Figure 8. *Without equipping mobile vehicles, the Rajant solution to cover this warehouse example would be 20 nodes. Propagation is strong enough to cover multiple corridors. The number of nodes is equal to that the Rajant solution using mobile vehicles for coverage.*

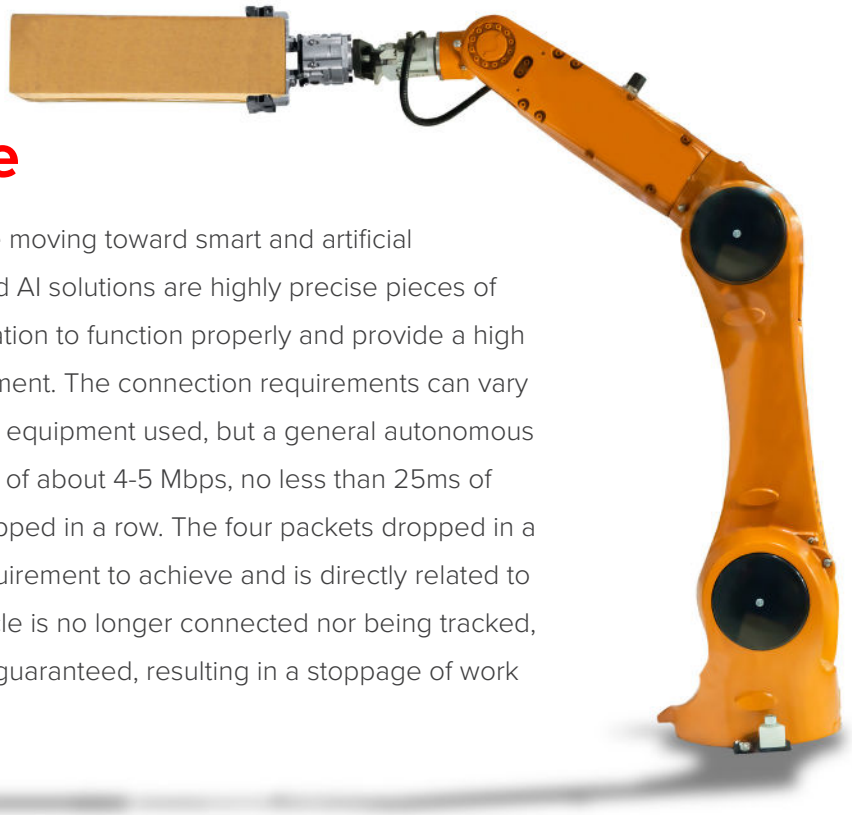
Wired Versus **Wireless**

Traditional Wi-Fi prefers every node wired for a few reasons. The first is because every wireless hop for Wi-Fi costs half of the total bandwidth for that link due to the fact that one radio card serves all wireless clients. Second, most indoor units priced for the warehouse market do not come with the inherent capability to be a Wi-Fi node and a backhaul node. Rajant provides a solution fit for both purposes.

Rajant BreadCrumbs utilize an improved duplex meshing that prevents Rajant Kinetic Mesh networks from losing half of the bandwidth per hop. Rajant's proprietary protocol call InstaMesh® allows packets to be received on one wireless interface and transmitted on another and therefore do not suffer the half-duplex issues other Wi-Fi vendors may experience. This capability allows Rajant to utilize wireless communications in hard to reach places without running any fiber or CAT 5/6 cable and automatically route data through other peers back to a LAN ingress. For wired Rajant connections, Rajant utilizes the APT protocol to allow for multiple ingress nodes to get packets out of the air and onto a wire as fast as possible without causing a broadcast looping. APT allows the Kinetic Mesh network to not only be a wireless mesh network, but also mesh across wired connection and even third party wireless devices. In addition, every Rajant node functions as both an access point, servicing wireless clients as well as a full mesh radio providing multiple functions in the warehouse for automation. Rajant BreadCrumbs are optimized for multicast traffic, allowing for faster throughput speeds, more potential bandwidth and less wireless retries. Standard Wi-Fi networks do not perform the same way with regard to multicast traffic.

Mobility at its **Finest**

With Rajant, the network provided is flexible and reliable in multiple ways. First, Rajant can equip forklifts or mobile vehicles with Rajant BreadCrumbs. By doing so, Rajant can provide a mobile infrastructure in the warehouse that is much more powerful than any client device trying to roam. These mobile infrastructure nodes act as mobile APs and communication bridges/repeaters in areas where communications may be weak or incomplete in coverage. Rajant also utilizes machine-to-machine communications where each forklift or infrastructure node can communicate locally. With InstaMesh's dynamic routing protocol, packets are not required to flow in and out of a wired network or go through a route bridge or "smart node", while also improving coverage with mobile infrastructure.



Built for the **Future**

Everyday more and more warehouses are moving toward smart and artificial intelligence (AI) solutions. These smart and AI solutions are highly precise pieces of equipment that need constant communication to function properly and provide a high level of safety for workers near the equipment. The connection requirements can vary based on the application and the piece of equipment used, but a general autonomous solution will require a network connection of about 4-5 Mbps, no less than 25ms of latency and no less than four packets dropped in a row. The four packets dropped in a row is far and above the most difficult requirement to achieve and is directly related to workplace safety. If the autonomous vehicle is no longer connected nor being tracked, the location of that equipment cannot be guaranteed, resulting in a stoppage of work and a shutdown of other equipment.

Using traditional Wi-Fi, autonomous solutions must roam between many nodes in the warehouse and are always looking to make newconnections. Mobile roaming requires breaking a connection with one AP and establishing a new connection (handoff). The low power client devices are in charge of roaming and if those devices struggle to connect or takes a little longer than normal, packets begin to drop. Four packets lost can happen in less than a second and now operations are grinded to a halt. Utilizing a Rajant Kinetic Mesh solution, autonomous vehicles are fitted with a BreadCrumb, becoming a piece of mobile infrastructure. Instead of a low powered client device like a table handling roaming, the high power Rajant BreadCrumb maintains multiple connections to every other piece of mobile infrastructure piece in range, eliminating the need to roam, and by extension, the chance for packets be dropped or lost. The advantage of turning a high demand autonomous piece of equipment, a networking nightmare, into a mobile piece of infrastructure, is a key reason that the Rajant solution is the preferred worldwide when using smart and autonomous solutions.

Rajant is a reliability-based mesh networking system, using the patented InstaMesh protocol, built around providing wireless service in the toughest areas on the planet. By using the mobile assets, increased range, rapid deployment and the ability to function as a backhaul and access point simultaneously, Rajant is able to achieve a multifunctioning, robust, rapidly deployable, self-healing, Kinetic Mesh network.

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