CSG Technologies

Wireless Networks in A Warehouse Environment

WIRELESS NETWORKS IN COMPLEX ENVIRONMENTS

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INTRODUCTION

Erratic demand, frequent and shorter order-to-shipment times, and stricter customer compliance requirements are the key parameters shaping twenty-first-century business practices. As a result, companies are re-examining their business processes from a business-to-business (B2B) commerce perspective in an effort to be more effective and efficient. Such an evaluation has the potential to transform a company's supply chain practices from a group of unplanned and fragmented processes into an interconnected system capable of delivering value to the customer.

Traditionally, supply chains created value through efficiency and low price. Today, however, supply chains have to create value through their flexibility. Their design must accommodate a customer changing their mind after the order is placed so that the company retains control of the manufacturing and fulfilment processes.

One of the most important trends that impacts supply chains is inventory management in warehouses. Under today's current practices, product information, storage and delivery are handled in warehouses and distribution centres, by using paper-based techniques or in the best of the cases wired hand-held scanners. However, the need for faster and more accurate fulfilment is transforming rapidly supply chain coordination and the way inventory management is organized in a warehouse facility. For that reason, new tools and a new type of inventory/warehouse control is needed. Wireless technology can play a pivotal role in this emerging issue by enabling real-time inventory management systems.

WIRELESS LOCAL AREA NETWORK (W-LAN)

W-LAN is a flexible data communications system implemented as an extension to or as an alternative for cable-based Local Area Network (LAN). The W-LAN infrastructure is similar to cellular systems where the terminal communicates with the base station over an air interface at a certain frequency band. With W-LANs, users can access shared information without looking for a place to plug-in, and network managers can set up or augment networks without installing or moving wires. Wireless LANs offer the following productivity, convenience and cost advantages over traditional wired networks:

- **Mobility**: Wireless LAN systems can provide LAN users with access to real-time information anywhere in their organization. This mobility supports productivity and service opportunities not possible with wired networks.

- **Installation speed and Simplicity**: Installing a wireless LAN system can be fast and easy and can eliminate the need to pull cable through walls and ceilings.

- **Reduced Cost-of-Ownership**: While the initial investment required for wireless LAN hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves and changes.

- **Scalability**: Wireless LAN systems can be configured in a variety of topologies to meet the needs of specific applications and installations. Configurations are easily changed and range from peer-to-peer networks suitable for a small number of users to full infrastructure networks (suitable for inventory management) that enable roaming over a broad area.

Wireless LANs can be simple or complex. At its most basic, two PCs equipped with wireless adapter cards can set up an independent network whenever they are within range of one another. Installing an Access Point (AP) can extend the range of an ad hoc network and effectively doubling the range at which the devices can communicate.

The aim of this paper is to investigate the impact of wireless technology through the perspective of inventory management in a warehouse and yard environment.

LITERATURE OVERVIEW

CURRENT PRACTICES AND LIMITATIONS OF INVENTORY MANAGEMENT IN WAREHOUSES

A typical operation sequence that is followed in a warehouse for processing day-to-day transactions is depicted in figure 1 below. More specifically, the operation starts by the delivered goods (cases or cartons of merchandise), which are unloaded at the receiving docks. Quantities are verified by the warehouse operators by using their bills of landing or manifests (paper-based techniques). At the same time random quality checks are performed on the delivered loads. Then, the loads are quickly calculated in order for the staff to determine the number of pallets needed for transporting the goods to the storage area. Next the goods are palletised, and a label is generated and attached to each load indicating its assigned location. If the storage modules (e.g., pallets, totes or cartons) for internal use differ from the incoming storage modules, then the loads must be reassembled. After this, the loads are transported to a location within the storage area. Some hours later, the operators will have manually to key in the temporary holding location for the pallet data that was entered.

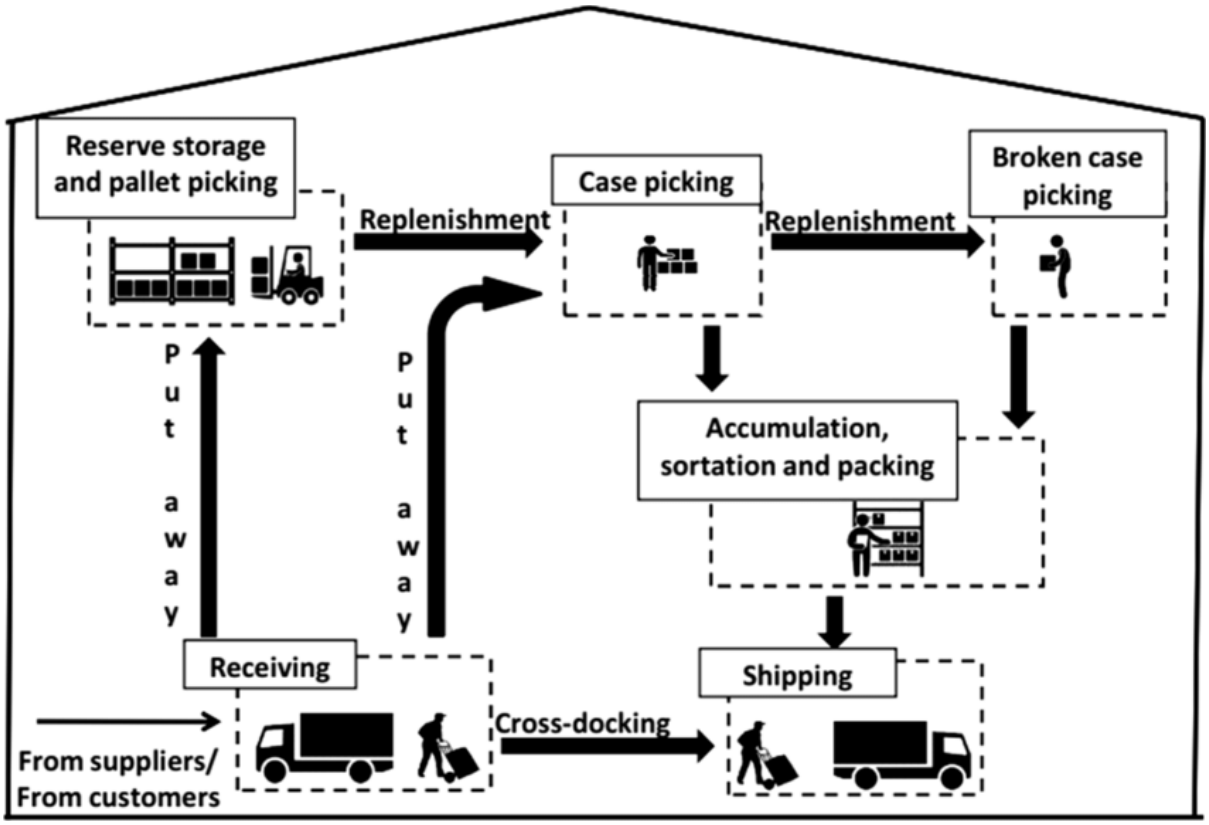

Figure 1: Warehouse Activities

Subsequently, whenever a product is requested, the operator must access the central warehouse database system, and check whether is available or not as well as its exact location. This process is called order picking. An order lists the products and quantities requested by a customer or by a production/assembly workstation, in the case of a distribution centre or a production warehouse, respectively. When an order contains multiple stock keeping units (SKUs), these must be accumulated and sorted before being transported to the shipping area or to the production floor. Accumulation and sorting may either be performed during or after the order-picking processes.

Finally, the products are retrieved from the temporary storage racks and delivered for transport to the shipping area and are shipped.

Although the described process of the warehouse activities seems to be capable of delivering value to the customer/enterprise, the reality is that that it faces many problems as it is costly, inefficient and not effective at all. The basic reason for that is focused basically on the fragmented inventory processes, which are characterised by many unnecessary handoffs or additional process steps, resulting in inefficiency and increased cost. In essence, the problem is a technology issue and in extend can also be an inter-enterprise process issue. The main problems that are faced and which wireless systems could minimise by increasing at the same time warehouse processes velocity (i.e. the fast and accurate collection and manipulation of information) and maximising service levels are:

- The lack of ability to verify (in real-time mode) the quantity of received goods.
- The need for label generation (every time a product arrives) which must be attached to each load indicating its assigned location.
- The "blind" periods where the central database system does not know the actual available locations for pallet assignment.
- The fear for lift drivers to mis-locate pallets due to the lack of real-time verification of the item and its location.
- The "blind" periods, where information about product details/location are not keyed in the system.
- The lack of real-time connectivity between the information system (IS) of the warehouse and the IS of customer or vendor.
- The inability for the warehouse system to always monitor where each product is, inside the warehouse (for the case where some of them must be reallocated in different places).

- The inability of the central warehouse system, to provide accurate, real-time information to the operators about the processes that must be done (e.g. the generation of a put-away list, indicating the warehouse storage location, which can be automatically transmitted it to the appropriate forklift operator) when a product is ready for shipping.

Hence, we may subdivide the activities in a warehouse, where problems can occur, into four categories: receiving, storage, order-picking and shipping. A study in the United Kingdom [1] revealed that order-picking is the costliest among these activities (figure 2). More than 60% of all operating costs in a typical warehouse can be attributed to order-picking.

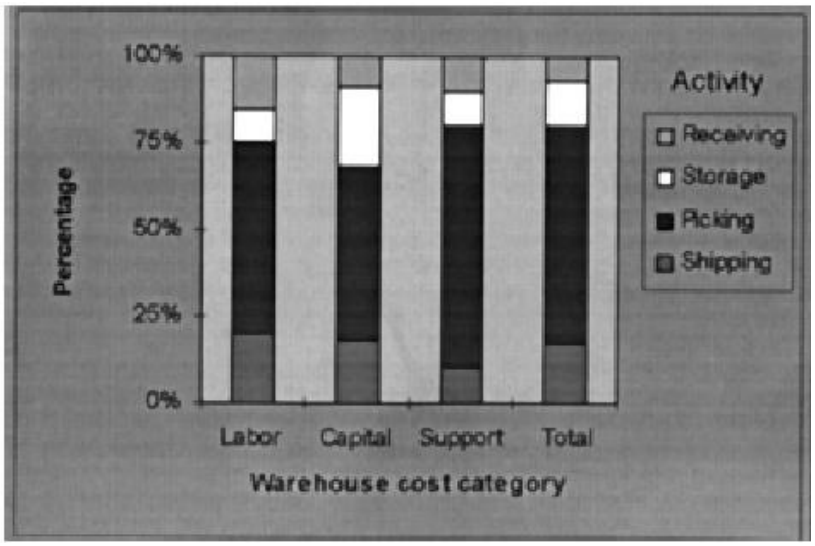

Figure 2: Warehousing Cost by Activity

[1] Source: https://repub.eur.nl/pub/13691/EPS2008139LIS9058921673YU.pdf

WIRELESS SYSTEMS AS AN INVENTORY MANAGEMENT FACILITATOR

Intelligent inventory management through wireless systems may result in a reduction of the warehousing costs. For example, by applying real-time sophisticated production planning and ordering policies the total inventory can be reduced, while guaranteeing a satisfactory service level. The latter specifies the percentage of the orders to be supplied directly from stock. Reduced inventory levels not only reduce inventory costs, but also improve the efficiency of the order-picking operation within the warehouse. Furthermore, an effective wireless storage location policy may reduce the mean travel times for storage/retrieval and order-picking. Also, by distributing wirelessly the activities evenly over the warehouse subsystems, congestion may be reduced and activities may be balanced better among subsystems, thus increasing the throughput capacity. Wireless systems can support all these activities because they provide warehouse operators with:

- **Easy and timely access to product information**: Wireless systems can deliver product information that not only reaches all the warehouse staff instantly, but is also available real-time, wherever and whenever they want it.

- **Ubiquity**: Through wireless devices, warehouse staff is able to reach product information anywhere, any time. On the other hand, inbound or outbound products can transmit automatically their information, such as quantity, part & lot number, supplier wherever they are in the warehouse.

- **Flexibility**: Because wireless devices are inherently portable, warehouse users may be engaged in various activities such as product delivery, storage and so on.

- **Location finding**: By incorporation special RF devices, products can be easily tracked inside a warehouse. This means that we can succeed in having an effective storage location management as well as order picking and thus minimize the costs of distribution centers/warehouses.

- **Dissemination**: Wireless infrastructures support simultaneous delivery of data to all mobile users within a specific geographical region (warehouse). This functionality offers efficient means to disseminate information to a large number of people.

CHALLENGES OF IMPLEMENTING WIRELESS TECHNOLOGY IN A WAREHOUSE ENVIRONMENT

As discussed in the foregoing sections, warehouse businesses can turn to wireless technologies, to solve their operational issues. The key to success is having the proper foundation to support those new initiatives; this is where having a fast, reliable and secure wireless network becomes a critical utility. However, there are some challenges these businesses face when deploying their wireless networks:

- **Infrastructure** – One of the most common challenges that is seen today is that warehouse decision makers and IT management personnel do not possess the in-depth understanding of how wireless technology can be used inside a modern warehouse. Without the complete knowledge of the possibilities wireless networks can afford a warehouse environment, fixing outdated process becomes an impossible task.

- **Wireless Network Design** - Supporting secure mobility and the features warehouses are looking to take advantage of needs the right wireless network design to deliver positive results. Advanced wireless switches and access points are rendered ineffective without the right design. Furthermore, Wireless networks need to be refreshed every 3-5 years.

- **The Physical Environment** - The physical environment in a warehouse plays a pivotal role in the design of wireless network. Everything inside of a warehouse can potentially impact the Wi-Fi performance. From the products or materials being stored inside, the material of the racks, to machines and the warehouse layout, everything has to be taken into consideration and properly planned for to get the WLAN design right.

- **Scaling and Planning for Capacity** – The Wireless network design should incorporate future scaling of the warehouse environment. As new devices are added to the warehouse floor, the wireless network should be able to adapt and grow to continue to properly support everyone and everything.

- **Troubleshooting** - Typically, warehouse networks and the departments they support are disconnected and isolated from one another in silos. When a growing number of mobile and connected devices is added to the mix, problems arise when it comes to troubleshooting things like downtime. By monitoring the wireless network through a single, central dashboard, the source of the problem can be quickly identified and fixed without causing any hiccups in the business's operations.

Deploying wireless inside the modern-day warehouse thus, is as much an art as it is a science, where experience and knowledge will directly impact the results.

WIRELESS WAREHOUSE IMPLEMENTATION

KEY AREAS OF FOCUS

The Wi-Fi engineering process can be difficult and complex to navigate, even for seasoned IT managers. It takes years of experience, the right tools and expertise to guarantee the WLAN design is completed correctly the first time. Whether the project involves updating the existing WLAN or deploying a brand-new wireless network, understanding exactly where to begin is critical to success.

The first step in the process for every school, hospital, warehouse, hotel, retail business, or enterprise is focusing on the RF design and the delivery of Wi-Fi access to end-users. Other than the understanding that commercial or enterprise-grade solutions is required, a proper RF design means focusing the design on three key areas:

- Coverage
- Capacity
- Performance

COVERAGE

Variables such as the physical environment, power levels and antenna gain determine the coverage of wireless networks. It is easier however, to think of coverage in terms of end user access. The areas in which end users can connect using the wireless networks. Coverage is thus given by the number of access points to provide the required signal level in a given area. This can be determined by finding out:

- Where do you need coverage? Where throughout your environment do your end-users need to connect with your wireless network? (This includes both indoors and outdoors)

- What are the minimum throughput levels you need at each different location?
- What areas will need to support large numbers of devices and users (helpful for capacity planning)

CAPACITY

In order to plan and design a WLAN for capacity you need more information than what's typically needed for coverage.

In order to maximize your RF design for capacity you need to know four things:

- Number of devices accessing the network.
- Types of devices
- Device capabilities
- Device applications

It is imperative to remember that by simply adding more access points to a specific high-density area is not a solution, it creates more problems than it solves.

PERFORMANCE

Optimal wireless network performance comes down to how well the design is planned and how much information has been gathered to make that design. The best way to achieve this is through wireless site survey. An RF site survey will help determine the nature of the wireless environment. RF heat maps can provide insights into air saturation and frequency spectrum. A site survey can also help decide the amount of bandwidth based on the number of users, applications and devices.

WIRELESS IMPLEMENTATION

A reliable wireless infrastructure reduces inefficiencies and errors associated with constant disconnections of handhelds, wireless printers, computers, and rugged tablets.

Companies that have successfully implemented an industrial grade wireless infrastructure have positioned themselves with a competitive advantage over those who have not. They have done so by preparing the organization to support more mobility within the warehouse and be ready for upcoming technologies (like the Internet of Things) that will revolutionize the industry.

Here are the 4 critical elements that must be carefully followed to guarantee a successful wireless implementation - and operation.

PLANNING AND DESIGN

The two root causes of poorly implemented wireless warehouse solutions are related to lack of knowledge and the lack of planning.

An example of a warehouse with poor coverage can be seen below. Notice the lack of red. Red represents a strong wireless signal, while blue represents poor coverage. As you can see this warehouse lacks wireless coverage.

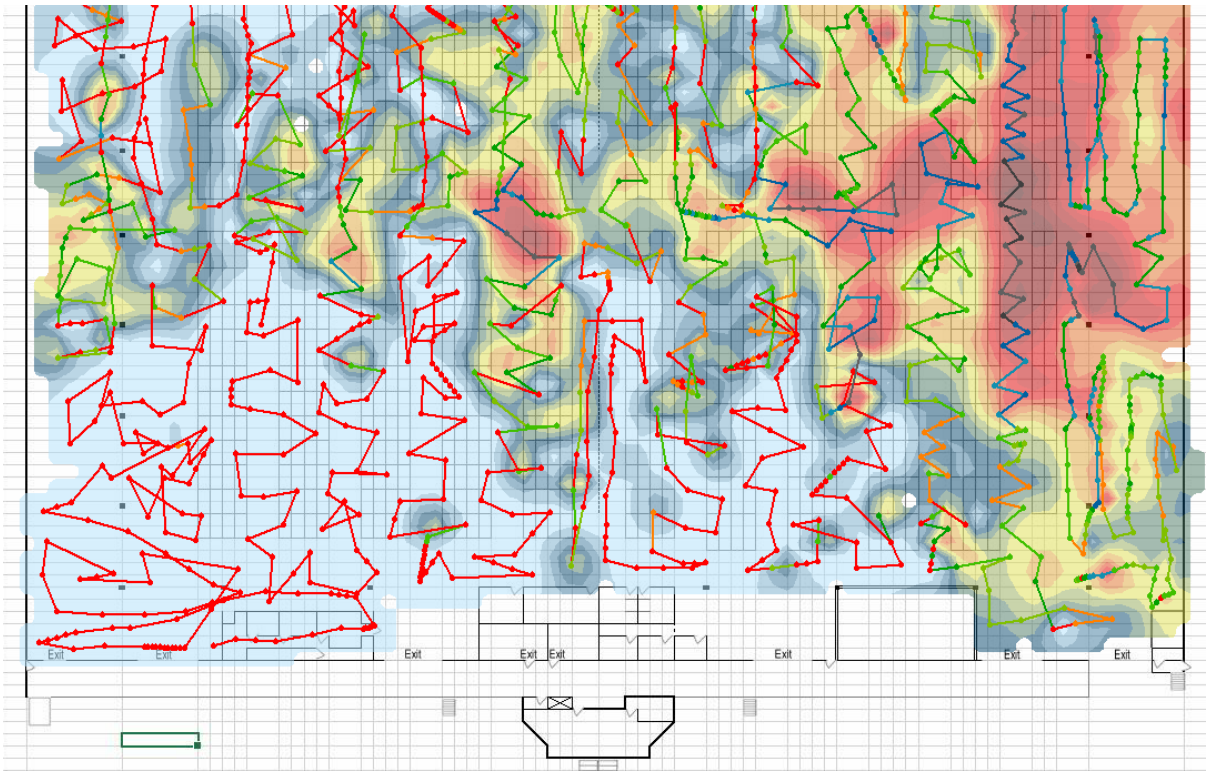

Figure 3: Warehouse Wireless Heatmap

The first step to a solid wireless network implementation is planning. To produce your design for a warehouse wireless network these 5 steps must be taken:

1. A wireless network survey identifying where the antennas (access points) should be installed in order to avoid dead zones.
2. Using the heat map generated from the wireless network survey you can determine what model and number of antennas (access points) you need to install in order to provide sufficient wireless coverage in the warehouse.

3. Determine the type and quantity of wireless devices that are going to be connecting to the wireless network. Not all devices have the same receiving sensitivity so is important to carefully plan what devices are going to be connecting/operating in the wireless network.
4. Carefully consider the environment and obstacles that can result in interferences or poor wireless coverage: high ceilings, racks, shelves, pallets, machinery, power lines and more.
5. Wiring. Although it is a wireless network all access points will be connected to the network backbone. It is important to select the right cable (CAT5e or CAT6), make sure that cable run length remains within the specifications, and that after the installation have been completed the installer certifies each installed cable/run.

WIRELESS PLATFORM AND ARCHITECTURE

Selecting the right platform and architecture is another critical component if you expect a successful wireless warehouse implementation.

The network in a warehouse is far more complex than the one in your home or office, which is why it requires an industrial grade access point that offers interference mitigation and a stronger signal.

Smart industrial antennas can automatically recognize obstacles and adjust wireless channels and power levels to compensate for those obstacles or for when one of the antennas fail – antennas talk to each other and when one fails the remaining antennas augment their power to cover for the failed antenna.

For implementations that require more than one antenna, controllers are a must. Wireless controllers automatically track devices connected to the wireless network and forward credentials as devices roam around the warehouse.

Industrial and smart wireless solutions can also detect the type of traffic transferred (voice, data, video) over the network, and properly adapt to the requirements of the traffic being transmitted. For example, Voice over IP requires network low latency.

Other aspects that must be considered when selecting a wireless warehouse platform includes choosing the appropriate wireless standard (802.11 A/B/G/N/AC, etc) and encryption security protocols.

EQUIPMENT STANDARDIZATION

Another very common and costly mistake is the lack of standardization of the equipment connecting to the wireless network. Here the basic IT best practice of KISS (keep it super simple) is the way to go.

To avoid operation or support related headaches, all wireless devices that are going to be connecting to the wireless network should be of the same model. For example, if using the Honeywell Dolphin 99GX Mobile Computer, then use the same model as the standard handheld solution. If using different models/manufacturers/devices, then you must ensure that wireless devices share the same wireless requirements/characteristics.

Above all else, avoid using consumer products. If you do, you will be wasting your money, frustrating your employees, and taking the risk of losing a customer – this industry has no time to waste and errors are very expensive to fix.

MANAGEMENT AND MONITORING

The most ignored aspect – management and monitoring.

In order to effectively manage something, you need to understand and measure it. In the case of systems, the key to understanding acceptable performance and non-acceptable performance is to collect what is known as a system performance baseline.

Baselines are generated through monitoring systems by collecting performance data for at least one week. Once enough data has been collected, the monitoring system(s) must be configured to alert and take actions when performance deviations occur. This step thus covers;

Network Monitoring - Look at coverage, capacity, and utilization on a monthly basis, and set up alerts on any critical system issue like access points, controllers, or other network components going down. If this is done well, proactive changes can be made before critical problems arise.

User Health – With a set of software tools and sensors, system performance can be monitored from the user's perspective. The user's experience is then measured against industry benchmarks to identify and solve discrepancies.

CONCLUSION

By deploying wireless networks, warehouses will be able not only reduce inventory costs, but also improve the efficiency of the order-picking operation within the warehouse. Furthermore, an effective wireless storage location policy may reduce the mean travel times for storage/retrieval and order-picking.

The need for wireless inventory management clearly indicates that a warehouse environment can benefit significantly from employing wireless technology across all its processes. An in-depth investigation of the impact of new technologies in a warehouse environment can lead to numerous advantages which will affect not only the end customer but the enterprise itself. Facing the future markets trends, in particular the increased use of wireless systems in supply chain management may raise some new research agendas beyond inventory, such as tracking of products, people and machines. The core benefit of wireless technology across all processes, however, remains the same – Increased efficiency, productivity and cost optimization.