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Smart Utility Cart for Improving Wireless Communication in High-Noise Environments

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ABSTRACT

It is common practice in data centers and other industrial environments to place wireless client devices such as laptops on rolling utility carts for transport through the facility. Such wireless client devices are often in close proximity to equipment that generates substantial radio frequency (RF) noise and interferes with wireless connectivity of the client devices. This disclosure describes a smart utility cart with a telescopic mast that hosts a wireless device bridge, e.g., antenna, situated at a height above RF noise sources to improve the received signal (by being in line of sight with access points) and to decrease the received RF noise (by increasing the distance from RF noise sources). The utility cart can also be provisioned with an RF shield to further decrease the received RF noise. The smart utility cart improves signal-to-noise ratio and wireless connectivity in industrial environments that have dense RF noise.

KEYWORDS

- Data center
- Utility cart
- Service cart
- Telescopic mast
- RF shield
- Electromagnetic interference
- Electromagnetic shielding
- Wireless connectivity
- RF noise

BACKGROUND

Reliable wireless connectivity is important in an environment where personnel with wireless client devices (e.g., tablets, laptops, phones, etc.) or mobile machines (automated guided vehicles and other robots) with Internet-of-Things (IoT) devices (e.g., cameras, sensors, etc.) and telemetry operate. Parameters that define wireless communications quality include the signal level (received signal strength indicator, or RSSI) and radio frequency (RF) background noise level, as measured at the wireless client device. Wireless communication improves with higher RSSI and lower RF noise. The ratio between the RSSI and the RF noise is called signal-to-noise ratio (SNR).

Relatively large spaces such as data centers, office buildings, warehouses, etc. are covered by multiple wireless access points (APs). As they move through the space, client devices connect to the strongest AP, handing off from one AP to another as necessary (roaming). Some environments, e.g., data centers, hospitals, etc., have elevated levels of RF noise due to operation of industrial equipment that emit RF energy in the same unlicensed bands (2.4, 5 GHz today, and 6, 7 GHz in the near future) that WiFi operates in. The presence of elevated RF noise makes wireless communication challenging. In particular, client devices suffer from low SNR and roaming problems. The high RF noise can cause client devices to not connect to the AP with the highest RSSI. At the start of roaming, client devices already operate in a very low (or negative-dB) SNR, making the roaming slow and unreliable, to the point of complete halting.

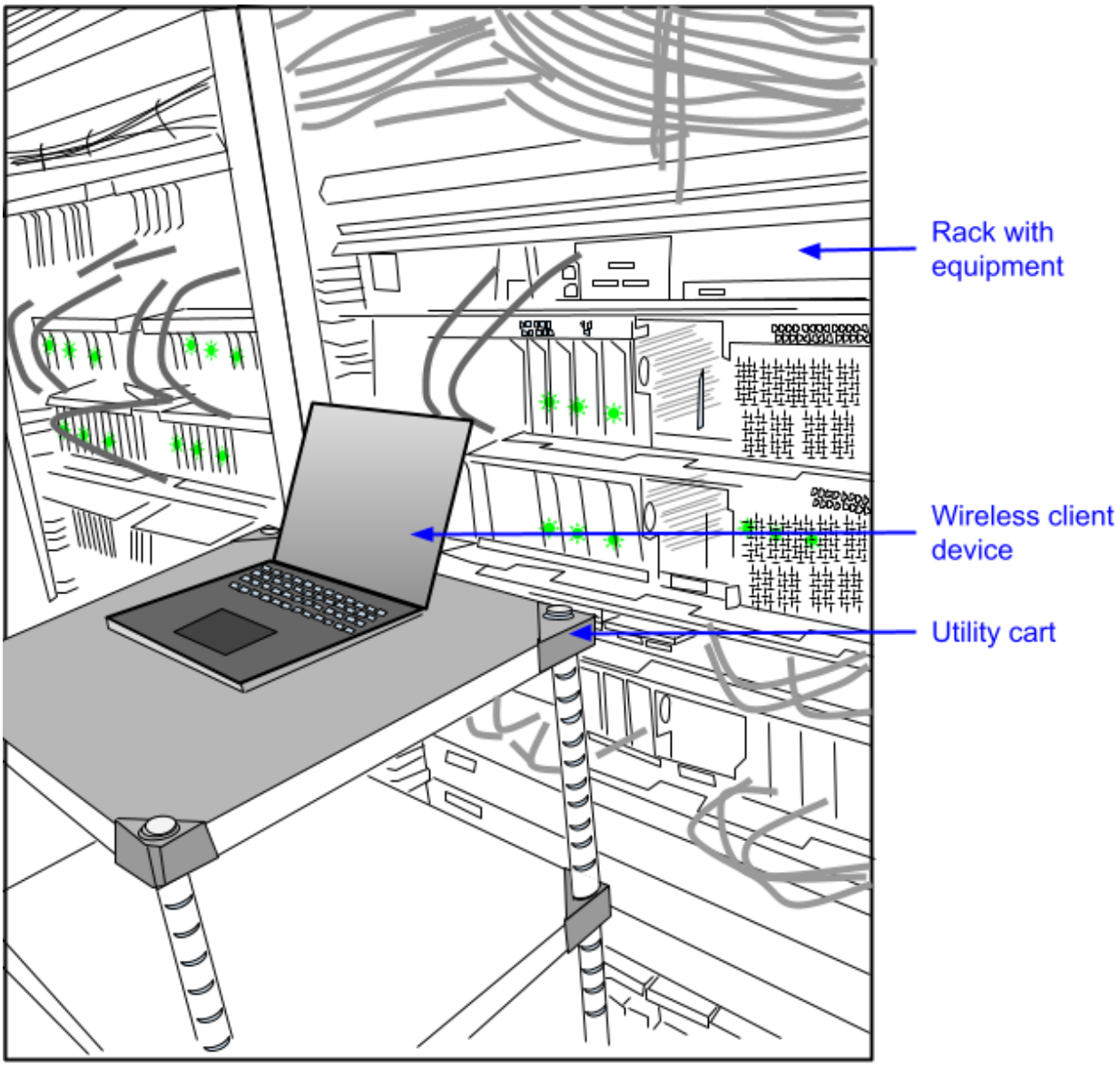

Fig. 1: The use of rolling service (utility) carts to carry IT equipment. When used close to RF noise sources, wireless connectivity of the IT equipment suffers

As illustrated in Fig. 1, it is a common practice in data centers, hospitals, and other industrial environments to place laptops and other wireless client devices (phone, tablets, scanning equipment, etc.) on rolling service or utility carts that are used to transport materials and equipment. No particular provisions are made in the service carts to optimize the RF performance of wireless clients placed on the carts.

In environments where RF noise is generated from equipment located at the same height as the cart, the cart often moves in close proximity to the RF noise sources. As illustrated in Fig. 1, the laptop on the utility cart in a data center aisle is just inches away from a rack that generates RF noise in the frequency bands used by the laptop for WiFi communication. The proximity of RF noise to the wireless antennas of the laptop or any wireless client device placed on the cart can decrease WiFi reliability to the point of being unusable. The RF noise can be unpredictable, e.g., change over time and cannot be easily eliminated since its origins lie in the ordinary operation of industrial equipment. Equipment that generates RF noise cannot easily be retrofitted or replaced. Improving the wireless infrastructure (e.g., increasing AP density) is not cost-effective and may not be helpful.

Wireless cards and roaming algorithms of APs and client devices are designed under the assumption of low-to-moderate noise levels, an assumption that is borne out in most end-customer environments, but not in data centers and other industrial facilities. Client devices also generally do not measure the RF noise levels, and if measured, these are not communicated to APs. As a result, when the RF noise is high (low SNR), comparable to the wireless communication signal strength (RSSI), wireless communication can significantly degrade or stop entirely. Yet the client devices do not search for a different AP unless the RSSI drops below a preset value (usually around -70 dBm). This creates situations where client devices refrain from seeking high-SNR APs and suffer from poor wireless connectivity. Debugging these wireless connectivity issues after design and installation is costly and difficult. Roaming problems reported after AP installation are difficult to fix because the RF environment is uncontrolled and the RF noise is irreducible and unpredictable, such that a reported problem is difficult to reproduce.

External WiFi adapters that purport to boost speed, range, and reliability of a wireless connection are usually connected directly to the laptop USB ports via a short cable. Since these external wireless adapters are located in roughly the same position as the client device, such adapters face similar noise environments and are unlikely to improve wireless performance.

DESCRIPTION

This disclosure describes a smart rolling cart - a utility vehicle suitable for data centers and industrial environments - that decreases the RF noise and increases the RSSI (improves the SNR) received by the wireless client devices carried on the cart.

The described utility cart can operate in environments with elevated RF noise to enable high-quality communication for onboard wireless client devices, even if the RF noise sources are located in close proximity to the cart. For example, in data centers, the RF noise sources are known (rack-deployed devices) and are often located in proximity to the trajectory of the utility cart.

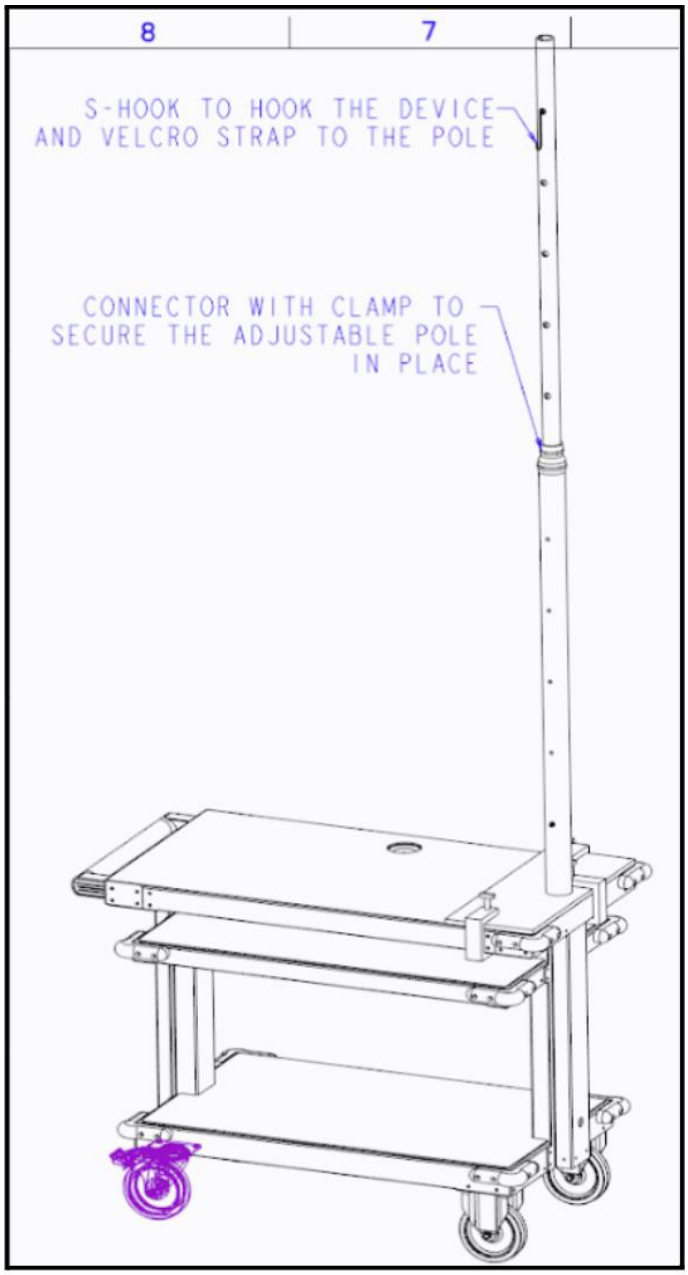

Fig. 2: Utility cart with telescopic mast to improve SNR

As illustrated in Fig. 2, the utility cart has a telescopic mast or a mechanical arm that hosts a wireless device bridge, e.g., antenna, situated at a height above the RF noise sources to improve the received RSSI (by being in line of sight with the APs) and to decrease the received RF noise (by increasing the distance from RF noise sources in the rack). Using the external

wireless bridge situated on the telescopic mast automatically disables the internal wireless card of the client device, effectively increasing the distance between the RF noise sources and the antennas of the client device.

The wireless bridge and the client device can be connected via a shielded USB cable or an ethernet cable. The wireless bridge can also have RF connectors to directional RX/TX antennas such that the antennas can be directed away from the RF noise source and towards the APs.

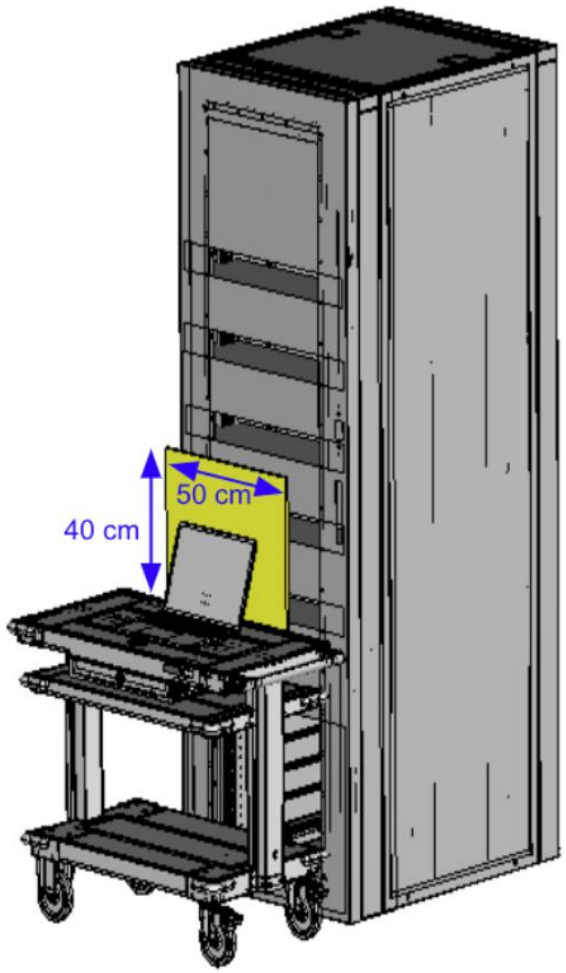

Fig. 3: Utility cart with mounted shield

As illustrated in Fig. 3, the utility cart can also be provisioned with an RF shield (in yellow) to decrease the RF noise received by the wireless client device (e.g., laptop shown in Fig. 3) placed on the cart. The RF shield can be located between the wireless client device and the RF noise sources. The RF shield can be made entirely of metal (e.g., aluminum, copper, steel, etc.), of a plastic substrate with conductive paint on one or both sides, or of a thin metallic sheet. The shield can be made of absorbing RF material or comprise a sandwich of different materials in which one material is a good conductor. At typical WiFi frequencies (1 GHz and above), the thickness of the conductive layer of the shield can be any convenient and cost-compatible value greater than about 0.2 mm. The shield can be mounted on the cart with the help of clamps and/or hinges such that it can be folded on the side or below the cart when not in use.

The wider the shield, the greater the noise reduction at its center, e.g., at the position of the wireless client. For example, a shielding effectiveness of around 10 dB (reduction in noise level by a factor of ten) can be expected for a shield of dimensions approximately 60 cm × 50 cm when the operating frequency is between 5 and 6 GHz.

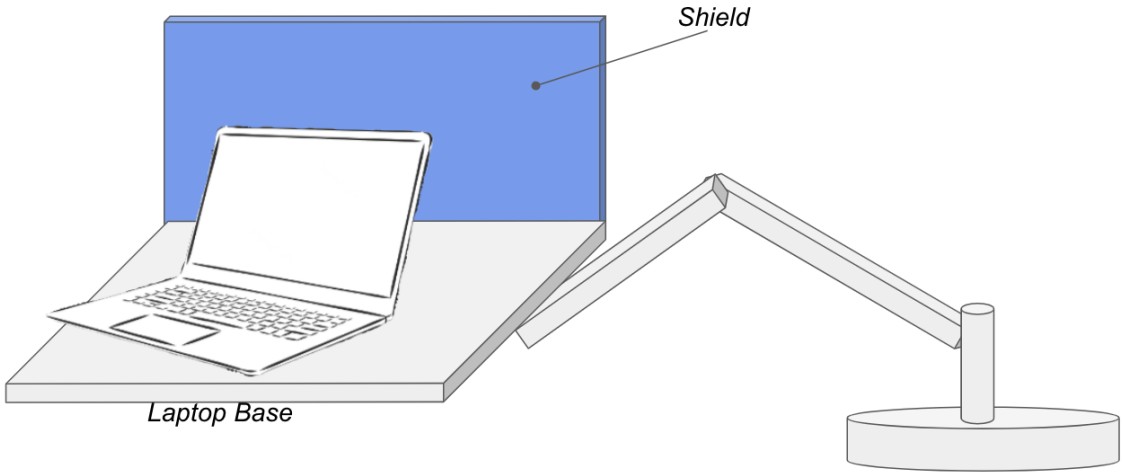

Fig. 4: A mechanical arm with RF shield, for use on a utility cart

Fig. 4 illustrates another technique to improve SNR - a utility-cart mountable mechanical arm with an RF shield. In addition to supporting the laptop or other device, the base on which the laptop sits also provides electromagnetic shielding. The mechanical arm can be mounted on different types of carts using clamps. Alternatively, the mechanical arm can have a base and can be placed on the top of the working surface of the cart.

CONCLUSION

This disclosure describes a smart utility cart with a telescopic mast that hosts a wireless device bridge, e.g., antenna, situated at a height above RF noise sources to improve the received signal (by being in line of sight with access points) and to decrease the received RF noise (by increasing the distance from RF noise sources). The utility cart can also be provisioned with an RF shield to further decrease the received RF noise. The smart utility cart improves signal-to-noise ratio and wireless connectivity in industrial environments that have dense RF noise.

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