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Suitability of 2.4 GHz and 5 GHz wireless communications in production processes

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Abstract. Today, it is increasingly modern to use wireless transmissions in production. It is possible to send information messages, control messages and it is often possible to access the technologies as IoT (the Internet of Things). The aim of this work was to find out which of the selected Wi-Fi frequencies is more suitable for use in syrup processing equipment. The evaluation was performed on the basis of attenuation and download speed at each frequency (2.4 GHz and 5 GHz bandwidth). These frequencies have been chosen due to their massive deployment for wi-fi networks that currently dominate wireless communications. Measurements were made downloading files on different frequency bands. Mean and maximum data throughput and signal strengths were also measured. By measuring, it has been found that when using 2.4 GHz wireless Wi-Fi technology, you can very often encounter strong interference effects. Despite the theoretically worse 5 GHz frequency spread, you can achieve up to 30% better data throughput on average. The results show the suitability of 2.4 and 5 GHz Wi-Fi technology. The main finding is that, despite the worse frequency spread of 5 GHz, it is more appropriate. Not only due to speed but also in the future due to better transmission capacities and future channel expansion.

Key words: wireless communication, wi-fi, production processes, IoT, frequency, data.

INTRODUCTION

Today, it is increasingly modern to use wireless transmissions in production. Many companies are switching to wireless systems with the expectation of helping them save money by eliminating cabling costs. These are companies that have frequent changes in interiors. They may also be companies with flexible workstation locations. As a rule, these are large shops with furniture, warehouses, factories, etc. The most common non-license radio bands are 433, 450, 869, 2,400 and 5,000 MHz (these bands are called ISM). However, ensuring secure and reliable wireless transmission in industrial objects is very complex at these frequencies. (Kamerman & Aben, 2000; Kuchta et al., 2009; Lee, 2017; Zheng et al., 2018)

ISM bands (industrial, scientific and medical) are radio broadcasting bands. They are free, which means that licensed (approved) devices are allowed to operate without license fees, but without any guarantee of interference. These frequencies may collide with another broadcast, so the sent message may not be complete. Another issue is their

real impact and the speed of data transmission in the rugged space (Huang et al., 2005; Kuchta et al., 2009; Lee, 2017; Cena et al., 2018; Zheng et al., 2018).

Wi-fi technologies are currently massively deployed to create LAN networks. These LAN networks serve both industrial and domestic applications. For this reason, the tests focused on the 2.4 GHz and 5 GHz bands. These frequencies were chosen for the applicability of results in the syrup processing facility (Kamerman & Aben, 2000; Hart & Hartová, 2017; Ismaiel et al., 2018; Marčev & Kotek, 2018).

The aim of this work was to find out which of the selected wi-fi frequencies is more suitable for use in syrup processing equipment. The evaluation was performed on the basis of attenuation and download speed at each frequency. Measurements were made at the user's direct request.

MATERIALS AND METHODS

Tests which were performed accurately determined strength of the wireless signal and download speed of wi-fi in production facilities. The equipment used in these tests is as follows:

Testing devices

- **Edimax BR-6288ACL** (Rev. A Firmware 1.12)
  - wi-fi router
  - has technology for transmission at 2.4 and 5 GHz
  - has a 100Mbit transmission rate
  - easy-to-use 2-way wireless router with iQ Setup
  - 5in1 (Router, Access Point, Range Extender, Wi-Fi Bridge and WISP)
  - 802.11ac support, 2.4 or 5 GHz frequency bands
  - 1x 10/100 Mbps WAN / LAN combined port (RJ-45)
- **Lenovo Y700-15ISK (80NV00BKCK)**
  - portable computer
  - has technology for transmission at 2.4 and 5 GHz

Software

- **Scilab 5.5.2**
  - an application for sorting measured data from logs
- **LAN Speed Test 3.5.0**
  - wireless data transfer measurement software
  - measuring tool for output data when measuring data transmissions
- **Wi-fi Analyzer 3.10.5-L**
  - an auxiliary application for measuring the signal strength
- **Plotly**
  - additional data processing
  - creation of heat maps
- **Autodesk Homestyler**
  - Creating a floor plan.

For measuring was syrup processing facility has been selected. This object is owned by Produkty-Vladimír s.r.o. and so far, it has no Ethernet and only 1x WAN cable is

tightened. This is the production facility of the company. A request was made for the possibilities of wi-fi technology with the possibility of its implementation in this production facility. There was a requirement to determine which of the frequencies (2.4 or 5 GHz) would be more suitable for use. Fig. 1 shows the layout of the object where the tests were performed. Measured points were displayed in this object, which were subsequently numbered for clarity.

On this plan the graphical data of measured signal strength and data throughput in the form of a heat map will be shown. All signal strength values are measured in dBm units and data rate values are measured in Mbps. At each selected point, measurement was cyclically repeated 20 times for all types of tests.

The Edimax BR-6288ACL was placed at point 20 for its maximum possible effect (in this case, point 15 could also be used). The router was built on a prepared shelf at a height of 170 cm. Devices to use the new wi-fi network are located at points 28 and 10. The inner walls of the building are made of burnt bricks with a thickness of 10 cm. The door was closed during the measurement, as is the case with the full operation of the syrup processing facility. The height of the measuring instruments from the floor was equal to 120 cm throughout the measurement. It was also measured at 120 cm at points 21 and 22, but below the wooden staircase. The syrup processing facility is 100 meters from the nearest building and no other Wi-Fi network interference has occurred. In the tests, the wi-fi device was used only for tests. She didn't use other devices during wi-fi tests.

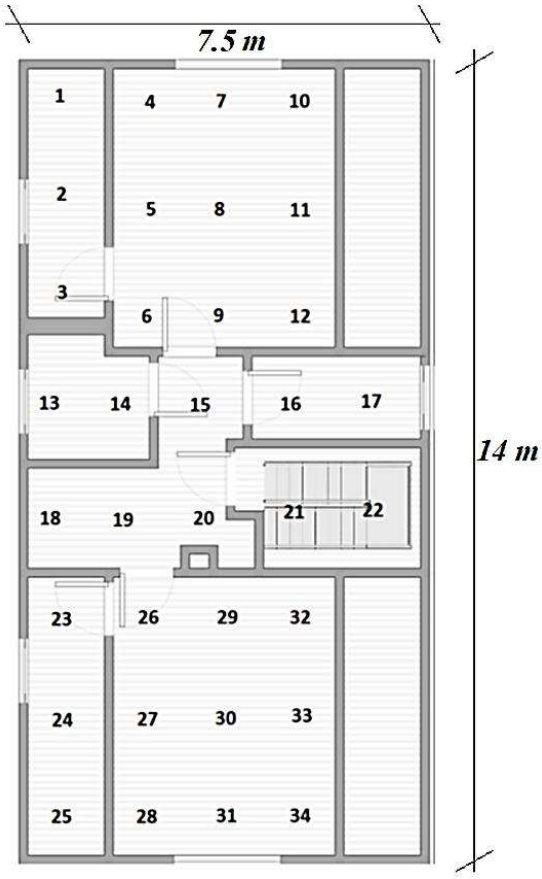

Figure 1. Methodical location of measured points.

RESULTS AND DISCUSSION

Fig. 2 shows the heat map of the signal strength for 2.4 GHz and 5 GHz. By comparison, it is clear that 5 GHz has a stronger signal strength at smaller distances, but 2.4 GHz has better signal propagation in the object.

Fig. 3 shows a heat map of the average download speed for 2.4 GHz and 5 GHz. Compared with the heat map of the signal strength, it is clear that even though 2.4 GHz has overall better signal coverage than 5 GHz, average data downloads do not achieve such good results. The speed / signal ratio is better for 5 GHz (Cena et al., 2018; Kamerman & Aben, 2000).

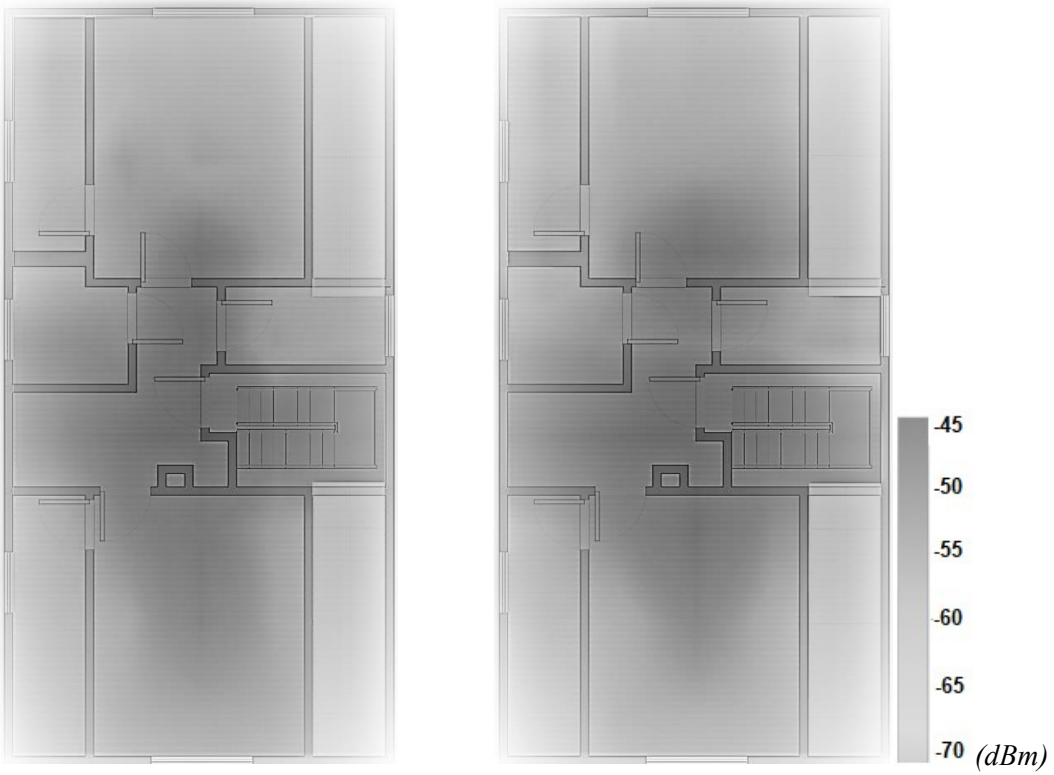

Figure 2. Wireless signal strength at frequencies of 2.4 GHz (left) and 5 GHz (right).

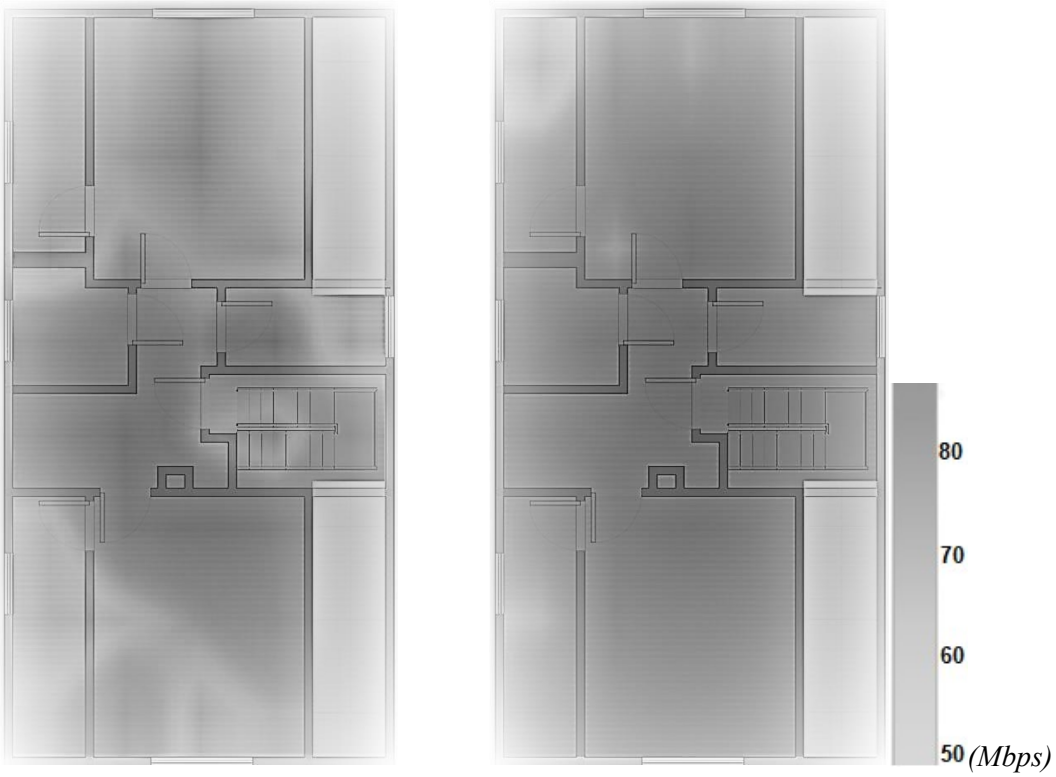

Figure 3. Data download speed on wi-fi 2.4 GHz (left) and 5 GHz (right).

Although it is quite clear at first sight that the 2.4 GHz technology has better signal propagation, this difference is on average only about 1.3 dBm better. However, it is good to say that 2.4GHz technology is at its maximum, and the channel overlay concept is not at all suitable for use in locations where there are multiple wi-fi networks. Based on these results, better 5GHz technology is therefore more appropriate and, thanks to other features, is more suitable. It can be read from the data that 5 GHz technology has an average of about 30% better speed (Kamerman & Aben, 2000; Hart & Hartová, 2018; Cena et al., 2018)

CONCLUSIONS

As is clear from the measurement results, it is more convenient to use 5 GHz technology for normal use in production areas, provided it is used in a small unobstructed space. It is also advisable to use 5 GHz if the areas in the wi-fi area are 2.4 GHz. The 5 GHz wi-fi has a higher speed, but also greater attenuation. Thus, when the connection fails, there may be a larger distance. Although 5 GHz is limited by its reach, it is much more promising in the future, with an average throughput of up to 30 % better than 2.4 GHz, even in larger areas. Recommendations for larger spaces are the use of repeaters that can distribute the signal across the entire building.

For specific use in the syrup processing facility, it is advisable to select the location of the router at centralized (points 20 or 15), which is the center of the building. In this case, it is appropriate to use the 5 GHz band, because its range from this point is sufficient. Because the wi-fi router is centrally located, it is not necessary to use a repeater. It often happens that it is necessary to download the current configuration into the wi-fi devices and to interrupt the current production. This process needs to be implemented as quickly as possible. Although data is not large (hundreds of MB), it is necessary to download it quickly. For these reasons it is better to use the 5 GHz band in this case.

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