Models of information exchange between radio interfaces of Wi-Fi group of standards

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Abstract. This paper offers models of information exchange between radio interfaces of the Wi-Fi group of standards by the example of a real facility management system for the oil and gas industry. Interaction between the MU-MIMO and MIMO technologies is analyzed. An optimal variant of information exchange is proposed.

1. Introduction
This paper addresses a model of a distributed information structure (fig. 1). This study revealed a number of technical issues that prevent further extension of remote inventory and supervisory control systems in the considered terminal access points due to low capacity of the data communication channel.

Figure 1. Distributed information structure of information and communication medium.
2. Methods and materials.

The cause of the low channel capacity in the studied section was the equipment that operated using obsolete radio interface standards.

A solution with minimum labor cost by replacing the obsolete radio interface module is not possible due to the special requirements for the equipment installed on this particular section of the process line.

A section of the structure (fig. 1) was designated to carry out detailed analysis and find possible solutions. Let us represent the selected section as a model (fig. 2.)

Two groups can be distinguished among the existing standards based on Wi-Fi: SISO (Single Input Single Output) and MIMO (Multiple Input Multiple Output). Due to the fundamental differences between these groups, there is the problem of the optimal interaction of the new MIMO standards with the SISO group, which has become the classic conventional model of information exchange.

The conventional model of information exchange through a radio channel implies the presence of one receiver and one transmitter, while the MIMO group transmits information between two nodes using a multitude of receivers and a multitude of transmitters that form information exchange matrices with dimensions M×N, where N is the number of transmitters and M is the number of receivers.

The SISO model shown in fig. 2 was obtained during the analysis of ways of communication peculiar to the Wi-Fi radio interface standard (a-IEEE 802.11 a, b-IEEE 802.11 b, g-IEEE 802.11 g).

A distinctive feature of the SISO technology is the lack capacity to operate in a duplex mode and additional time for the transmit/receive unit to switch between the receive and transmit modes. Currently, the standards based on this technology are considered obsolete because of their low speed of information exchange.

The requirements to the channel capacity of information and communication media keep rising, which leads to the necessity of increasing the speed of information exchange in individual information streams. Increasing the information exchange speed is possible in three ways:

- increasing the channel width and signal carrier frequency;
- increasing the number of simultaneously receive and transmit interfaces to parallelize sent and received information;
- use of hybrid information media that use "last mile" equipment based on wireless technologies as aggregation level equipment and core or trunk level equipment based on wired technologies.

Implementation of the first way is only possible until a certain limit and often conflicts with the requirements to biological protection and electromagnetic compatibility. Hybrid architecture systems, as a rule, are considered cellular access systems and are not considered in this paper. The parallelization method of data stream is used in the MIMO and MU-MIMO technologies.

MIMO and MU-MIMO radio interfaces are identical in information exchange principles but different in terms of interaction with the SISO standards group. A MIMO (Wi-Fi n technology) interface model is show in fig. 3.
3. Results

The current model has several data processing units that are able to both receive and transmit data. Only two transmit/receive units executing a duplex information exchange channel are used when modeling consumer-class systems like this, i.e. one block in the first cycle goes to the transmitting mode, and another one goes to receiving. They remain in these states until the transmission ends or until the receiver unit overheats. In case of the transmitter unit overheating, the units are reconfigured and the roles are changed.

A MU-MIMO (Wi-Fi ac technology) radio interface model is shown in fig. 4. A distinguishing feature of this model is the presence of independent transmit/receive units that allow one to rearrange the information switching structure without any added wait time.

Let us consider a model of a section (fig. 1) based on the MIMO (fig. 5) and MU-MIMO technologies (fig. 6) that uses three transmit/receive units.
Figure 5. Information exchange using the MIMO technology

Figure 6. Information exchange using the MU-MIMO technology

As can be seen, the implementation of information exchange using the MIMO technology completely excludes one transmit/receive unit from the exchange process, which causes a decrease of the information exchange speed by 1/3 of the total speed, i.e. approximately by 150 Mb/s. This solution is acceptable if it is necessary to increase the channel capacity and the decrease of transmission speed in the terminal section of information exchange by 1/3 is not critical.

In case of using the MU-MIMO technology, the advantage of using independent transmitter units allows one to operate in the unbalanced data transmission mode, which allows one to establish one continuous duplex information stream for the second and the third transmit/receive units (fig. 6) and two temporary receiving information streams. Losses of information exchange speed in this case will be minimal and balanced. When exchanging information between the points operating the MU-MIMO and MIMO technologies, one data transmission unit is also excluded from the process, which conditionally decreases the exchange speed by 1/3 of the possible maximum. This is identical to the case of implementing this solution using only the MIMO technology. The reduction of data reception speed will gain lesser values through larger dimensions of the M×N matrix. The information exchange matrix for the MU-MIMO technology will have the 3×2 dimensions (fig. 6), while organizing the same solution using only the MIMO technology will result in a 2×2 matrix (fig. 5).
4. Conclusion.
To conclude, from the considered variants of interaction between the models, it is more rational to use a MU-MIMO group radio interface as a central node because of its significantly larger channel capacity for data reception, which is a priority requirement to data acquisition systems of remote inventory and supervisory control systems. Use of the MIMO group radio interfaces was considered unreasonable due to the lack of the extension capability. In particular, if the number of exchange points is increased by more than one, the total data exchange space formed by a 2×2 matrix will conditionally comprise 300 Mb/s. If an additional information stream is added, the speed will be shared between the streams, and in the third spot it will be 100 Mb/s. When using the MU-MIMO technology with a 3×2 matrix, data reception speed will amount to 600 Mb/s, which will allow splitting the total information medium into a larger number of information streams.

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