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# THE BLUETOOTH™ COMMUNICATION IN STATIONARY ROBOTICS

**Abstract:** Currently, communication via Bluetooth is the standard for mobile devices, such as mobile phones, tablets, computers, multimedia devices, etc. The development of mobile robotics has also contributed to the use of this type of communication in the areas of industrial applications. So far, there are few reports of the use of Bluetooth in the field of stationary robotics. This paper discusses the applicability of this type of communication in the stationary robotics, along with some proposed solutions.

## 1. Introduction

Nowadays, many portable or mobile devices are equipped with the Bluetooth interface. Despite the fact that the first implementation of the standard has many weaknesses, today it is very reliable way for wireless communication between devices. Also products which use Bluetooth interface become more powerful and have more capabilities. For example cellular phones are not the same like a few years back. A modern smartphone is more than voice and sms communication device, having efficient CPU and GPU and then being rather a "microcomputer" with his own operating system and software. Bluetooth devices are also often built in portable computers (notebooks, netbooks etc.).

Bluetooth standard introduced a new way of communication between electronic devices. Due to its flexibility it has been manufactured as a standard interface in cars, home and portable multimedia, sensors and many others. In general, it gives the way to avoid the direct wire connection, where it could be inconvenient.

Bluetooth interface during last few years has become more popular in the mobile robotics [1-3]. The capability of wireless transmission of the data or multimedia (video and sound from a camera) by using only one interface is the far better than using wires. On the other hand, this type of interface is not very popular in the field of stationary robotics [4]. Some manufacturers offer wireless interfaces for its robots, but these are dedicated devices, not the universal ones.

This paper will present some pros and cons of using Bluetooth interface in the stationary robotics. Also the concept of the simple system will be presented.

## 2.  The short characteristic of the Bluetooth standard

From a purely technical point of view, Bluetooth has some in common with the wireless networks (Wi-Fi). First of all they use the same radio frequencies, but the Wi-Fi equipment has higher power, better range and higher speed. Bluetooth was intended mainly for portable/mobile equipment, where the low power consumption is the priority. In the other hand, Wi-Fi requires more effort than Bluetooth to configure in order to work properly.

What Bluetooth has in common with Wi-Fi is the possibility of creating ad-hoc network (Personal Area Network profile). There is also the Dial-Up Networking profile, which allows a device to act as a modem.

Another important difference between Bluetooth and Wi-Fi networks, is the existence of thirteen types, so-called profiles, that since version 1.1 of standard, strictly define how the device could be used. The revision 2.0 of the Bluetooth standard extends profiles by adding another 13. Some of them are dedicated directly for use with the cell phones and multimedia devices, but the others are more universal. Profiles are numbered and named [5,6].

The most important profiles, which could be used in the stationary robotics, are:

- 5 – Serial Port Profile, that emulates serial port connection between Bluetooth devices,
- 12 – File Transfer Profile for managing files and folders (upload, download, delete) on the server device
- 15 – Personal Area Networking Profile, which could be used to establish an ad-hoc network between devices. The same mechanism could be used to access a remote network through the gate device,
- 25 – Human Interface Device Profile that defines protocols and procedures used by HID devices like keyboards, pointing devices etc.

Bluetooth devices are also characterized by the class of transmission power (or range) [5,6]. There are three classes, but the second one is the most common among popular devices. The range/power characteristic of each class is as follows:

- Class 1 devices – 100 meters of range, 100 mW of transmission power,
- Class 2 devices – 10 meters of range, 2,5 mW of transmission power,
- Class 3 devices (rarely used) – 1 meter of range, 1mW of transmission power,

The transmission speed depends on standard version. Nowadays the most common Bluetooth revisions are:

- 2.0 – up to 2,1 Mbps transfer rate,
- 2.0 + EDR (Enhanced Data Rate) – up to 3 Mbps,
- 3.0 + HS (High Speed) – up to 24 Mbps,

Bluetooth devices form a network called piconet. It is based on master-slave model, where one master can handle up to seven slaves. Two or more piconets form so called scatternet. Any device in a given piconet – either the master or slave – could be a slave in the other piconet. This device can then relay the data between the piconets. The relaying must be managed by the software installed on the device, because Bluetooth protocol does not support it. So far, the use of complex Bluetooth-based networks is limited due to the specificity of the standard and method of addressing based on MAC-addresses [5,6]. Some applications of the scatternets are present in the field of mobile robotics – mainly for communication purposes between mobile robots in the swarm.

## 3. Bluetooth versus Wi-Fi networks in the stationary robotics

The following table (Table 1) compares the basic functions of the Bluetooth and Wi-Fi protocols.

*Tab. 1. Comparision of the Bluetooth and Wi-Fi basic functions*

| Function's description | Bluetooth | Wi-Fi |
|---|---|---|
| Connecting to the network / pairing | Easy | Moderately difficult |
| Signal range | Usually up to 10 meters | Local (building, floor) |
| Device addressing | By device name / MAC address | By IP address, DNS name space |
| Connecting to the known device | Automatic | Managed by the user |
| Services management | Protocol built-in service discovery | By third-party software |
| The number of devices in the network | Up to 8 active devices (up to 255 parked) | According to the network type, but no less than up to 255 active devices |
| Safety | Moderate | High |

As it can be seen from the above table, Bluetooth technology has some limitations when compared to Wi-Fi. On the other hand it is easier in everyday use and cheaper (comparing the price of basic Bluetooth module and Wi-Fi card).

Bluetooth limitations should not be significant for applications in stationary robotics. First of all, the user communicates with the exact number of robots that are within range of his eyesight – in this way, the limit of the active devices number and transmission range does not play a fundamental role. Limited range of the Bluetooth device also reduces the influence of safety issues, because the potential attacker would have to be in the same place. Another advantage of the use of the Bluetooth interface is the ability of automatic devices connection, when all of them are in range.

## 4. The examples of configurations using Bluetooth interfaces in stationary robotics

This part of paper will present some examples of the configuration of wireless, Bluetooth based connection, used in the field of stationary robotics.

If there is a need to connect to the robot controller via the serial interface, the application of Bluetooth will allow resigning from the wire connection in the way without having to adjust the previously used software. Such arrangements are shown schematically in Figures 2 and 3. In the case shown in Figure 2, there is an additional computer, which sends the message received from the Bluetooth interface to the serial port, connected to the robot

controller. This "bridge" does not require high computational power and even a single-board computer can fulfil this task. The simplified diagram of the "bridge" computer task is shown in Figure 1
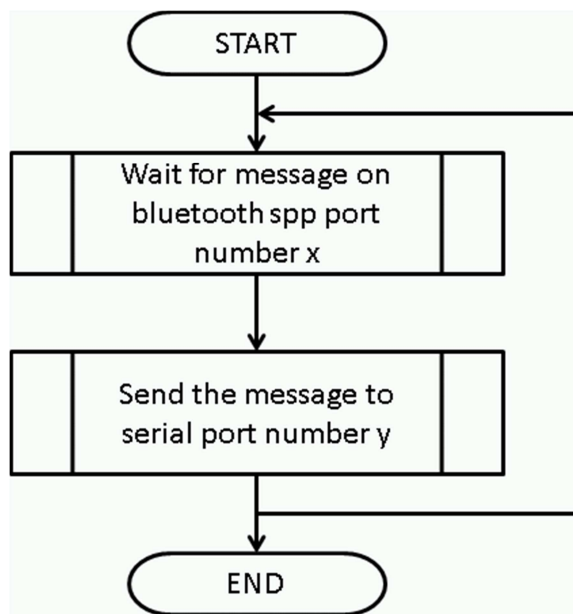


*Fig.1. Simplifed diagram of the "bridge" task*

Another option, shown in Figure 3, is the use of a hardware serial – Bluetooth interface, which is connected directly to the serial port of robot's controller. Such devices are available from some manufacturers.

Both solutions allow using any application, which supports serial ports to connect to the robot's controller. The presented methods have one disadvantage – under MS Windows the special Bluetooth stack software must be installed to enable virtual serial ports via Bluetooth feature. Also, some applications could not handle serial ports with high sequence number.
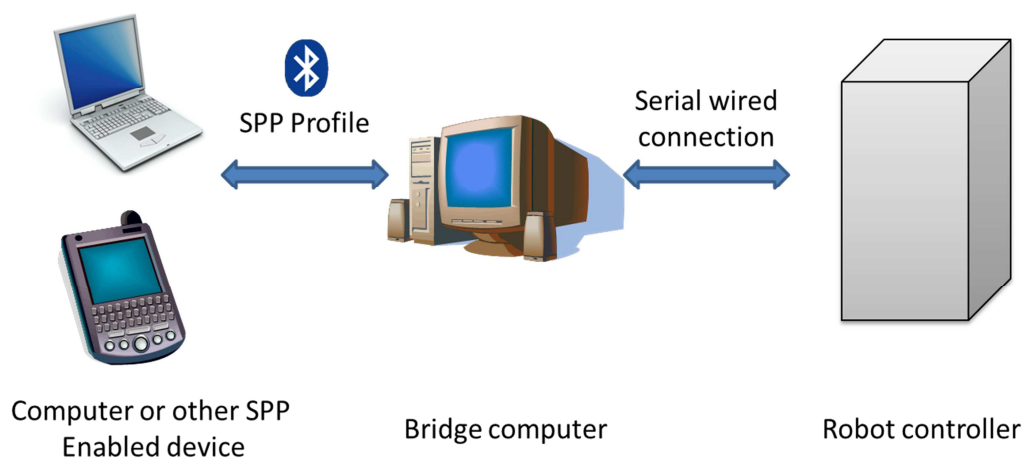


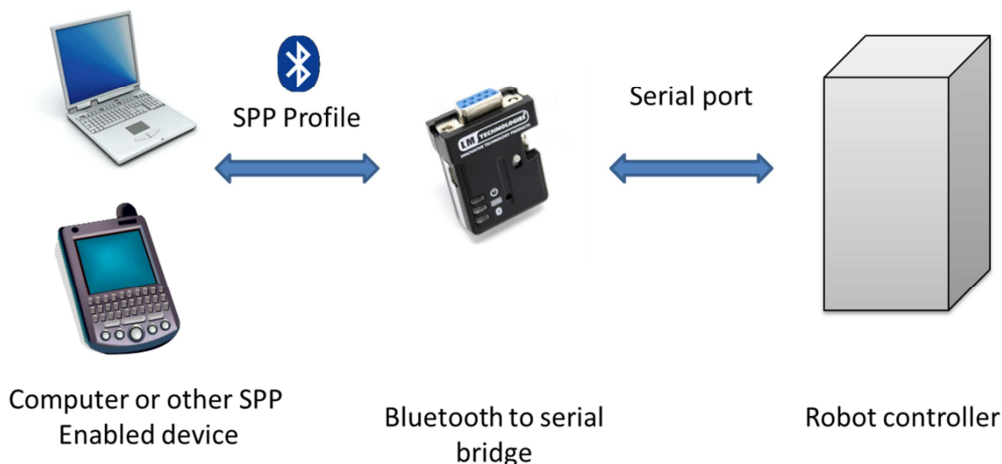*Fig.2. Bluetooth connection through virtual serial port using "bridge" computer*

*Fig.3. Bluetooth connection through virtual serial port using Bluetooth to serial adapter (the pictured device is manufactured by LM Technologies)*

The third, simple option assumes that there will be "bridge" computer near to the robot's controller. It does not matter in which way the bridge will be connected to the robot. The computer is running special software, which could receive messages from network adapters and send it to the controller. The example of this kind of program is the "SERVER" application from the ROBBO package [7]. The Bluetooth standard provides Personal Area Network (PAN) feature. It allows creating ad-hoc network between two devices. In the case of computers running MS Windows, both connected Bluetooth devices receive IP addresses from the 169.254.x.x network. The both devices behave as if they were directly connected. There is no routing function implemented, so – if needed – it must be installed separately. The schematic of use of the PAN method is shown in Figure 4.
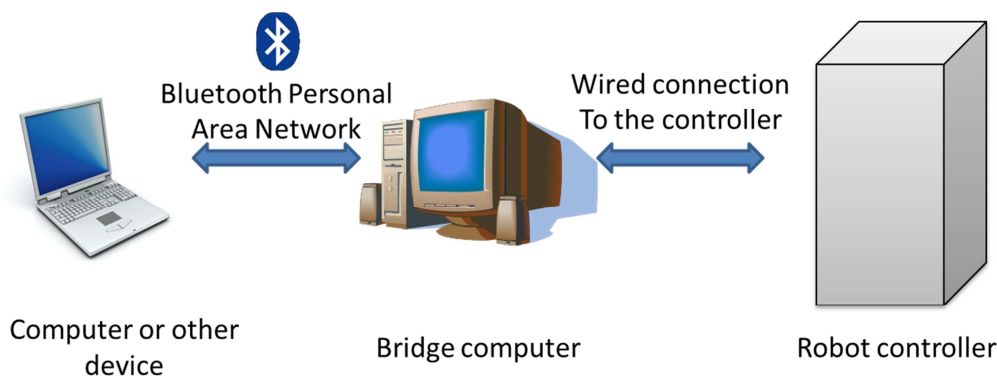


*Fig.4. Bluetooth connection using Personal Area Network profile*

The disadvantage of this method is that the robot programming software must support communication by TCP/IP protocol. There should be also special (dedicated) software installed on the "bridge" computer.

## 5.  Conclusion

The use of the Bluetooth communication in the stationary robotics could give some advantages, like less wiring and easier connection process of the programming device. On the other hand, the main emphasis is on the development of Bluetooth technology for civil applications, rather than industrial ones. Because this standard is widely used in the mobile robotics, it could be seen as the first step towards the wider use in the field of automation.

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