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# Indoor Real-Time Locating System comparison: Polaris vs FIND3

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**Abstract**

**The use of real-time locating systems can be used in several fields, from security and health to building and energy management. However, there is no consensus in what the better solution or technology is to be used in an indoor location system. This paper presents a comparative study between a market real-time locating system and an open source real-time locating system. The systems that will be compared are Polaris and FIND3. The tests were performed in an office building.**

Keywords: indoor location, real-time locating systems

## 1. Introduction

Real-Time Locating Systems (RTLS) are used to locate persons and objects inside an identified zone; usually indoors. They can be used in multiple fields, such as security [1, 2] and health [3-5]. However, the indoor location is not a trivial task and there are not, until now, a known technology that can, with efficiency and effectiveness, provide high-resolution location with minimal delay. Therefore, there are several solutions that use multiple techniques and technology to provide indoor locations.

In this paper, it will be deployed and compared two RTLS indoor solutions: Polaris [6], and FIND3 [7]. Polaris is a market solution that uses Zigbee protocol [8] and is able to identify the location of tags – physical devices that need to be coupled to the person/object that we want to monitor. FIND3 (Framework for Internal Navigation and Discovery 3) is an open source solution that combines Wi-Fi (IEEE 802.11) [9] and Bluetooth [10] and enables the location of persons using the smartphone signal. This paper will present the location results using these two systems.

After this introductory section, is presented in Section 2 the Polaris and FIND3 systems. Section 3 describes how these systems were deployed in an office building. Section 4 shows the results of the two systems in the same office. The main conclusions are presented in Section 5.

## 2. Real-Time Locating Systems

In this section, it will be presented the two RTLS used system: Polaris and FIND3. The two used systems differ from the technology that they use for indoor location but are similar in their operation and use. The biggest operation differentiation is that Polaris provides a geographical location (i.e., with two axes) while FIND3 only provides the identification of the zone where the user is.

### *2.1 Polaris*

Polaris is an RTLS, developed by the Spanish company Nebusens. This RTLS solution uses the n-Core platform, provided by the same company, and it uses Zigbee standard in the communication between system devices. The system uses 3 types of devices that must be used: collector, reader, and tag. The collector device (e.g., n-Core Sirious A) is installed together with an RS-485 to Ethernet converted, it is responsible to collect all Zigbee data, provided by the reader, and sent it to the Polaris server. The reader devices (e.g., n-Core Sirious D) are responsible to read the tag signals and send the signal strength to the collectors. In readers can, it can be added a module for a relay control, this enables Polaris system to control physical resources, such as door lockers and lights. Collectors also provide the reader functionalities and can read tag signals. The tag devices (e.g., N-Core Sirious B or N-Core Sirious Quantum 2.0) are small devices that should be with the person or object that we want to monitor. These tags also have the ability to send custom signals to Polaris, each has two buttons that can be pressed by the user and their actions can be programmed in the Polaris system.

Polaris system provides a web interface for system configuration and location monitor. Fig. 1 shows the browser interface of Polaris. In the interface, an image is presented combining the satellite image of the building, the building's blueprint and the Polaris devices location; activated collectors, readers, and tags. The real-time interface provides the location as well as information regarding the tags (i.e., if a tag button was pressed). Polaris also provides an Application Programming Interface (API) using Simple Object Access Protocol (SOAP). The API enables the use of Polaris by third-parties, that can query Polaris system to check several parameters, such as tag positions.

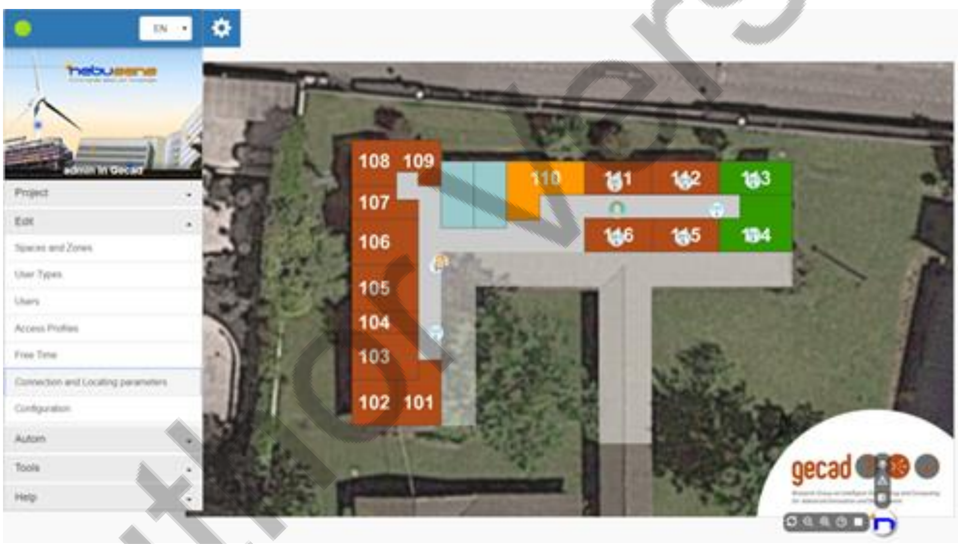


Fig. 1: Polaris web interface.

### *2.2 FIND3*

Framework for Internal Navigation and Discovery 3 (FIND 3) is an open source solution wish allows locating people indoors based on Wi-Fi and Bluetooth technologies. In FIND3 there is no demand for hardware installation, the system is able to work using only one smartphone. However, to improve the location precision is recommended the installation of multiple devices. FIND3 uses the fingerprints of Wi-Fi and Bluetooth wireless networks to identify locations. For this to be possible, the user must create zones and train the system. The training is performed in a Wi-Fi and Bluetooth compatible device – can be a smartphone – where the user must go to each zone and stay there for a while. The mobile application will monitor Wi-Fi and Bluetooth networks signals and store this information in the server. By learning, the system will be able to identify, according to real-time Wi-Fi and Bluetooth readings, the user's location.

FIND3 provides a web interface where the real-time location values can be monitored. Moreover, the system is able to perform accuracy results for each zone. Fig. 2 shows the FIND3 web interface with the accuracy values for each zone created in the system: office N112, office N113, office N114, office N115, and office N116. The server can be installed locally or remotely. Also, FIND3 provides an API for third-parties to access the location data.

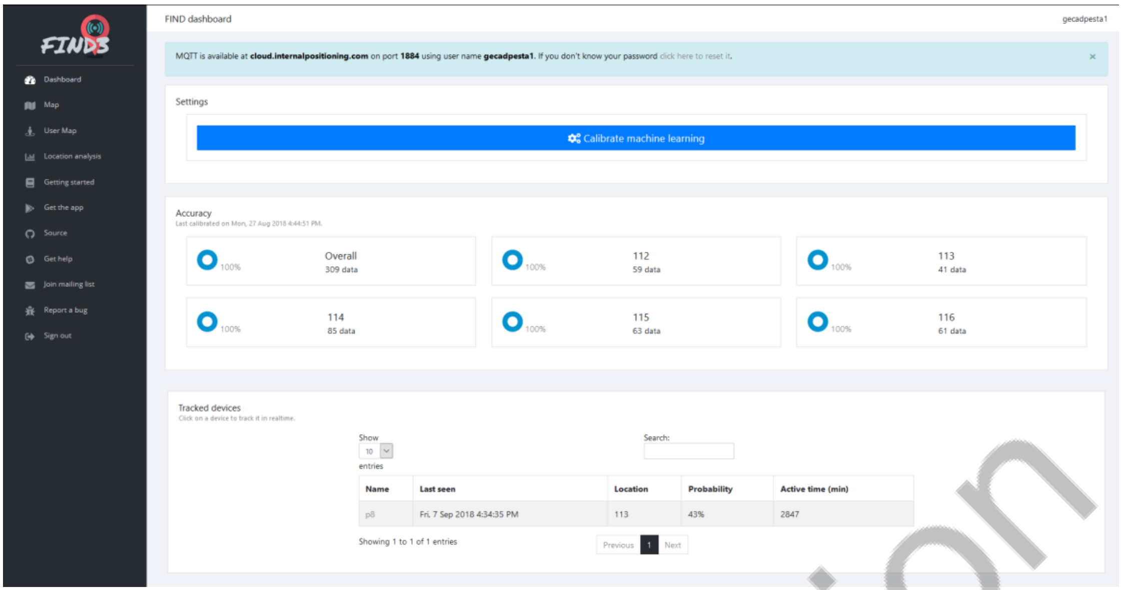


Fig. 2: FIND3 web interface.

## 3. RTLS deployment in an Office Building

Polaris and FIND3 were partially deployed in building N of Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development (GECAD), Polytechnic of Porto (P.PORTO). The offices used to deploy the system were N110, N111, N112, N113, N114, N115, N116 and the respective corridor, as shown in Fig. 3, where these offices are marked with colors. For FIND3, offices N110 and N111 were not considered.


Fig. 3: Offices where Polaris and FIND3 were deployed.

Fig. 4 shows the overall planning of Polaris deployment; where collectors are identified as pink pentagons and readers are identified as yellow stars. However, Polaris was not deployed in the entire building, as seen in Fig. 3. Each office has one reader and the corridor has two readers and one collector.

For FIND3 deployment, it was only used Wi-Fi networks. By default, the building has more than 20 Wi-Fi networks provided by indoor access points and from other building’s access points. To decrease the FIND3 error, new low-range access points were added to each room. It was used the ESP8266 module to provide the new Wi-Fi signals.

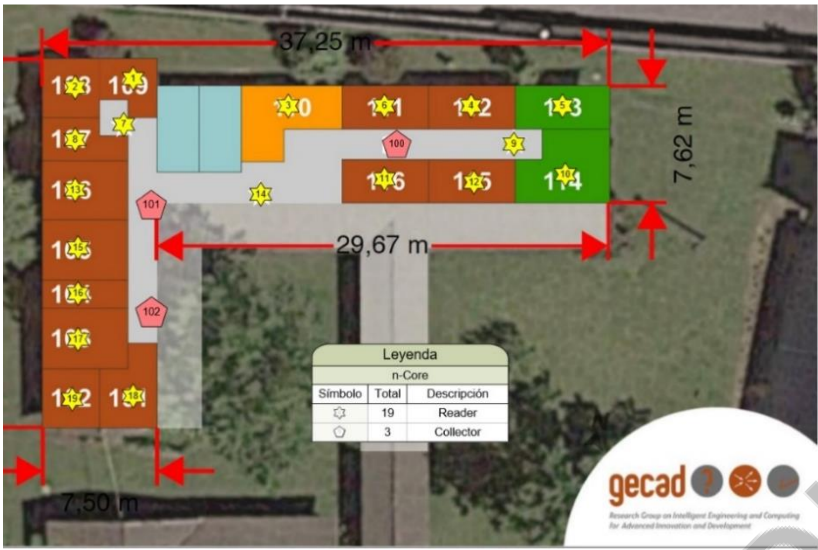


Fig. 4: Designated locations for the different types of Polaris devices.

The ESP8266 module has the ability to work as an access point. However, their wireless range was too expressive; reaching the entire building. To solve this issue, the antennas were cut to decrease the Wi-Fi signal; this enables the ESP8266 signal to stay only in the office and near the installation office. As seen in Fig. 5, some experimental cuts were done.

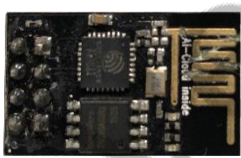


Fig. 5: ESP8266 with antenna cut off.

All the devices, to support Polaris and FIND3, were placed in the locations specified in Fig. 4. There was installed electrical boxes to accommodate each device, as can be seen in Fig. 6. In each installation, box was included a power supply of 5 V/DC and a step-down regulator from 5 V/DC to 3.3 V/DC.

Fig. 6: Installation.

## 4. Location Results of Office N112

Several test positions were specified in office N112 to perform the comparative tests; these positions are identified in Fig. **7**. The central position, B1, is also the location of the Polaris reader and the FIND3 ESP8266. The positions from A1 to A4 are placed near the office's corners. The A1-A2 wall (top of the image) is the division from offices N112 and N111, while the A3-A4 wall (bottom of the image) is the division from offices N112 and N113. All the measures were performed in the identified positions at a 95 centimeters height.

The 95 cm height was used to simulate a person; assuming that the Polaris tag and FIND3 smartphone will be in the user's pocket. The ordered of all the five positions were set clockwise and position A1 is always located in lower left corner; to identify the lower left corner the user must be inside the office facing its center and having his/her back pointing to office's door.

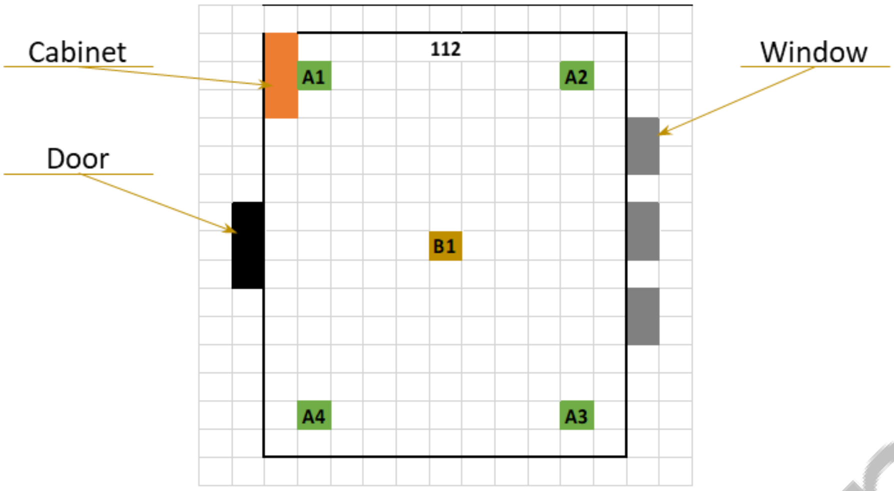


Fig. 7: Office N112 test positions.

The tests were made two times, one with the office's door open and one with the office's door closed. Because Polaris and FIND3 use wireless signals, the interference of a door can affect the results. Therefore, the tests were made with and without the door being open.

The tests were performed in each position during a 5-minute period where measures were taken each minute. The test, as stated before, were executed two times: with the door open, and with the door closed. The 5-minute window starts every time the Polaris tag and FIND3 smartphone are placed in a position. Therefore, is possible to see the reaction of both systems and the delay they have.

The bar chart of Fig. **8** shows the Polaris results for each position while the door stays open. The chart schematizes the distances, in meters, between a real and virtual position in the five samples made for five minutes, with the door open. Each position bar represents the minute measure; from darker blue to lighter blue. The virtual position is the position indicated by Polaris, while the real position is the physical position of the Polaris tag. In all the positions of this test, the distance error remained very similar during the five minutes measured. A1 position is the one that has the biggest error, reaching a 3.5 meters error, while B1 position has the smallest error. During the 5-minutes period, B1 position improved its accuracy, by decreasing its error, but in A2 position the results changed and the error increase alongside the time.


Fig. 8: Chart of Polaris results in room N112 with open door.

Fig. 9 shows the results of the tests using the Polaris system with the office's door closed. Unexpectedly, the errors increased in A3 position. However, all the other positions stayed with the same or lower error. In A1 and A2 positions, the error was constant for the 5-minute window, while the other points have slightly changed.

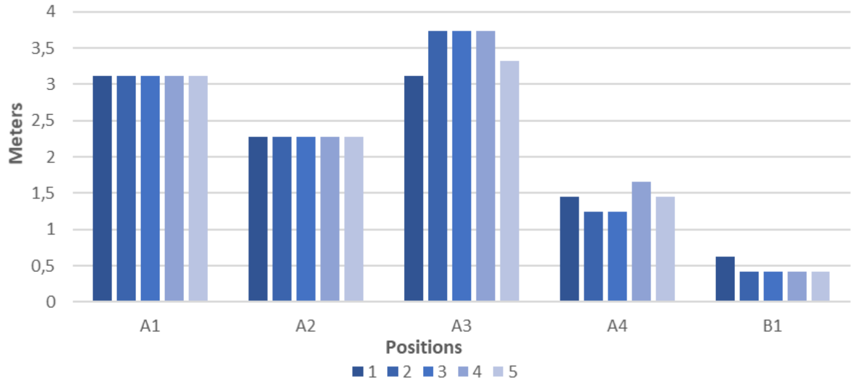


Fig. 9: Chart of Polaris results in room N112 with closed door.

FIND3 did not provide a precise location of the smartphone. Instead, the system identifies, by probability, the zone where the smartphone is. Fig. **10** shows the 5 samples measured for each position when the door was open. The colors identify the probability of the smartphone being in each of the offices/zones. With this representation, it is possible to see that in the 1st and 2nd minutes there is little density of darker colors aligned with 112 (middle of the chart). But from the 3rd minute on, the darker central color zone becomes more stable, even at position A2 (represented in Fig. **7**); which is the one that had the smallest accuracy. This means that initially, the office N112 is not well recognized in some of the positions tested with the door open. However, the accuracy of the system, in this room, began to improve significantly in the final minutes.

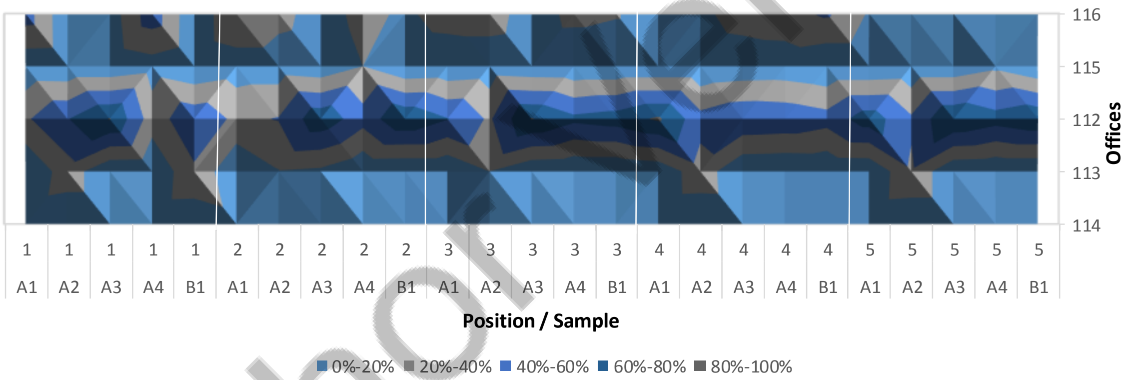


Fig. 10: Chart of FIND3 results in office N112 with open door.

In the closed-door scenario, the tests were also satisfactory as shown in Fig. **11**. With the door closed, the system reacted faster and even from the first minute is visible a darker central color indicating that the system knew the smartphone was in office N112. However, similar to the previous test, the A2 position presents the highest error.

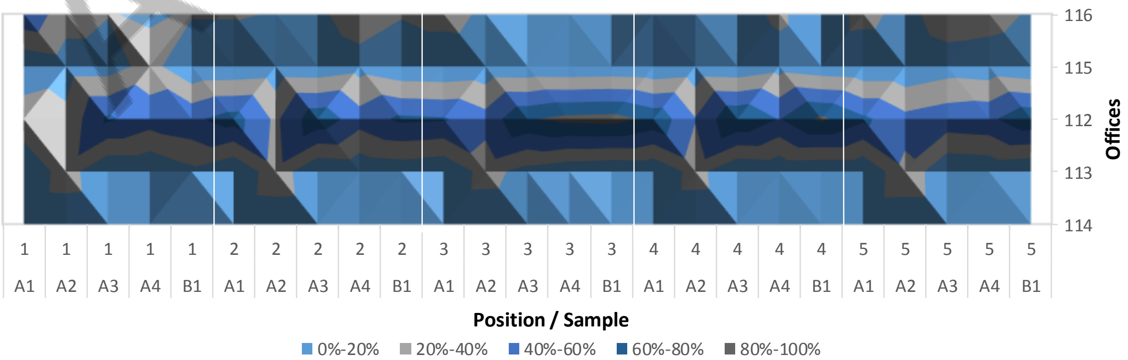


Fig. 11: Chart of FIND3 results in Office N112 with closed door.

## 5. Conclusions

This paper presents the analyses of two real-time locating systems: Polaris and FIND3. To provide indoor location, Polaris uses Zigbee wireless signals while FIN3 uses Wi-Fi and Bluetooth wireless signals. This paper describes the deployment of these two systems and their performance in the same scenario.

Polaris has the advantage ability to perform geographical locations, using two axes, while FIND3 is only able to identify the zone where the person/object is. However, the use of Polaris demands the installation of dedicated hardware and demands that the person/object carries one Polaris tag. Another advantage of FIND3 is the ability to continuously learn; enabling the user to teach the system about new zones or simply retrain existing zones to improve the system location accuracy.

Both systems have advantages and disadvantages, the decision of which one is better should depend on the need and goal of the user. To identify if and who is inside an office, FIND3 should be considered the best option because it does not demand the installation of hardware and uses the users' smartphones. However, if a precise location inside the building is needed, Polaris is the only option; between these two.

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