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MODERN LOCALIZATION APPARATUS IN METALLURGICAL ENTERPRISE

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Abstract

This paper describes the advanced positioning technology - RFID, GPS and GSM focusing on their use in data collection, processing and modification to optimize decision-making processes in logistics in metallurgical conditions. The paper outlines the importance of logistics distribution and logistics processes in terms steelworks with links to other metallurgical processes. The paper explains the information collection system based on position data gathering, either from standard GPS and position data obtained from the GSM operator, which will be sent to the superior system. This system has support for voice communication between the carrier and the supervisor. Visualization of logistical information will enable decision making and analysis for support of control processes.

Keywords: RFID, GSM, GPS, localization, mobile device

1. MAINTENACE TEAMS CONTROL IN LARGE INDUSTRY PREMISES

This paper has its origin in necessity to monitor service maintenance teams in great metallurgical enterprise. The knowledge of maintenance team's positions is a key item to optimize theirs maintenance actions. In a present time, each team has its own daily schedule and make its work until the shift is over. If there is an unexpected issue somewhere in the premise, a backup team has to intervene. This scheme is relatively wide spread in large enterprises, but it is not ideal. To optimize workflow is established department called "Procedural management". The procedural management is continual activity of an enterprise which is lead to implement production lines, development and improvement of procedural organization based on procedural control. This occur when functional oriented organization is turning into procedural type organization. The optimization process need information about active work teams, especially theirs location in time. To gather this type of information, we developed localization device, which is able to send position data to superior database system. The position data can be obtained from GPS system, GSM system or RFID system. [1] [2]

1.1. Options when gathering positioning data

The developed device rely on three position systems sources. The first is GPS (global positioning system) localization system based on standard SIRF Star III standard with NMEA data structure. This data structure is combination of carrier wave, telemetric code and navigation message. The GPS technology is well known and widely used, so it is the primary source of positional data. It is good to remind, that the GPS system is primary intended for military usage. In spite of this, the GPS system is widespread and in present time has hundredth of million users. This is due to relatively high position accuracy, ability to determine time and velocity of the objects, signal availability across the World, it is free of charge, weather independent and the position can be obtained in 3D space (position + height). The main disadvantage of GPS system is loss of signal inside of buildings. This is logical behavior, because the working frequency is about 1500MHz and transmitting power is extremely low in comparison on GSM systems or WiFi hotspots. [3]

1.2. GSM CGI positioning

Because of unavailable GPS signal inside of buildings, the developed device is equipped with GSM communication/positioning system from Quectel. The idea of obtaining positional data from the GSM devices is relatively old. The reason is obvious. The cell topology of GSM network is perfect to implement some kind of localization algorithm based on accessible data provided by GSM provider or GSM mobile device it selves. There are two basic methods, how to determine actual position of GSM device. The oldest one are network based technologies (NB) while the newer ones use GSM mobile device (called Terminal based). Network based technologies use knowledge about network configuration and behavior of radio waves.

Every base station (BTS) has fixed position which is well known and each of them has at least 3 sector antennas so at minimum is known sector, where the mobile GSM device could be. This is called Cell ID or more common CGI – cell global identity and it is most widespread localization technology used in GSM area. The principle is shown in (**Fig. 1**) on the left side. The exact position lies somewhere in circle sector, without possibility to clarify its values. Measurement accuracy is somewhere about 800m ~ 20km. The higher value is probable in poor covered areas like country side. In cities or in huge industrial areas (Arcelor Mittal) are much more BTS, so measurement precise is better.

1.3. GSM CGI + TA positioning

The better option how to measure position using GSM is Time Advance (TA) method (**Fig. 1** in the middle). The method's principle is the same like in CGI, but time of signal travel from the mobile device to the BTS is added. This method is more complex, but significantly more accurate.

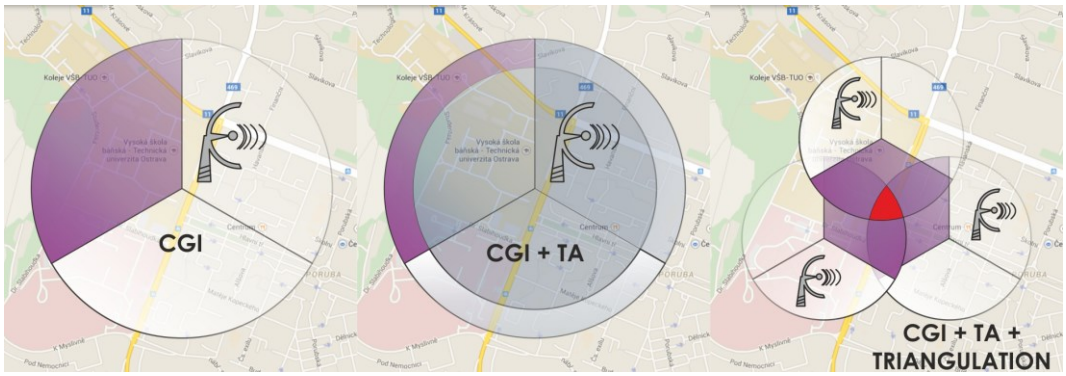

Fig. 1 The GSM network localization options.

Thanks to time, which is need to travel from mobile device to BTS, is possible to determine distance interval between mobile device and BTS, respectively, the location probability.

1.4. GSM triangulation

The most precise location measurement is triangulation method. Technically, this method is based on tracking the mobile device among several surrounding BTS with usage of CGI and TA. In principle the thing is in finding intersection of arches, which determines the point with three most powerful surrounding BTS (**Fig. 1**, right side). This is the most precise measurement method with an accuracy of hundred meters. This method indeed use also a mobile device it selves, respectively its hardware capabilities (E-OTD function). [4]

1.5. RFID identification in industrial environment

These all approaches was take into account when designing our localization device. Our development team also had experience with localization of mold's plates in metallurgy premises from the past. This RFID technique comes out from wireless identification of specialized TAGs on long ranges (up to 10m) with

working frequency 860MHz. RFID identification gates was already installed in testing area (Arcellor Mittal company), so we used these gates to improve localization accuracy. The principle is based on position knowledge of each of RFID gates. If the specialized TAG is detected by RFID wireless transceiver, the supervisory system makes a database entry of its unique ID. If this TAG is a part of localization device we developed, passing the gate will make an echo to supervisor that we are in specific place, independently on GSM or GPS localization information. There is a small drawback, because the RFID system can't determine, if we are passing in or out of the coverage area. It only makes a database entry about passing specific TAG ID through the gate. [5] [6]

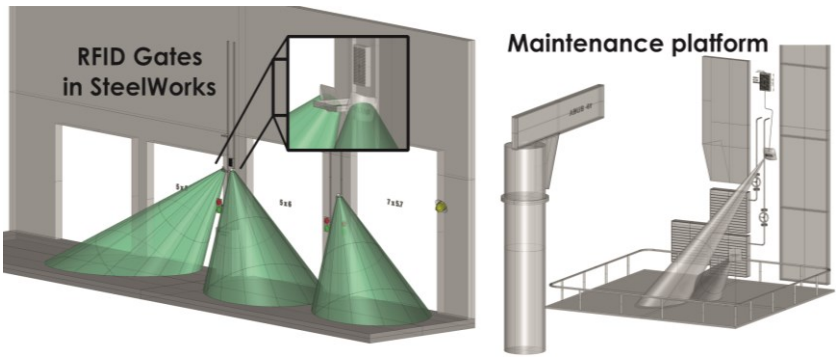

Fig. 2 RFID wireless identification gates on maintenance department and steelworks area

To be able to efficiently control maintenance teams, especially when concerning unexpected operational issues, is a key knowledge very position of the maintenance team. Developed device combine all three technologies, GSM, GPS and RFID, to gather positional data with the best accuracy and reliability as possible. There are two options, one is intended to wearing by maintenance team members as a mobile device with battery power supply and the second option is intended to fitting into vehicles body (cars, train wagon, molds and the like) with battery and DC power supply. [7]

2. Results from operational tests

Developed device can send positional data through the GSM network to the superior database, where can be used by operator to optimize decision making process. The GPS location is sent in simple format, there is no need to send all NMEA word. Concerning GSM data volume limitations only latitude, longitude and altitude are sent. The GSM position is sent only when it change it selves, because refresh rate is in contrast to GPS is very low (order of minutes). Sending data structure is similar to GPS structure. RFID position information is sent by RFID gate. The mobile device has built in TAG with unique ID so it is uniquely determined. Each maintenance team has its own unique ID, so all positional information are correctly assigned to that team. To estimate team's position are used all three positional information. GPS location is very precise, but only in open space, when the team is moving through the plant's locations, or when working in open environment. When the team reaches intended location and enter into the building, the GPS locations disappears. In that case the GSM location information has a turn. This is no so precise like GPS, but the operator knows, that the maintenance team is still inside the building where last GPS location points. If there are RFID gates in the building, the team's position can be further specified so the operator still have exact information about team's position. On (**Fig. 3**) is presented testing outputs from GPS interface. The GPS module it selves is presented on (**Fig. 4**). For testing purposes were chosen two versions. One with passive antenna and one with active antenna. For final realization were chosen active antenna version for its better sensing features. This version is capable to mark actual location even in close proximity to high building and for our purposes is then more suitable. The hardware module is from Quectel and is capable to derived more than 4 localization parameters per second. Main communication module is presented on (**Fig. 5**). It consist of main CPU (central processing unit) from ST – STM417 ARM cortex with working frequency

160MHz and integrated FPU core. This is sufficient power for intended purpose. GSM and data network availability is ensured by Quectel M95 Communicator module with GPRS capability. Used CPU allow many peripheral interfaces like I2C, SPI, USB or UART. [8]

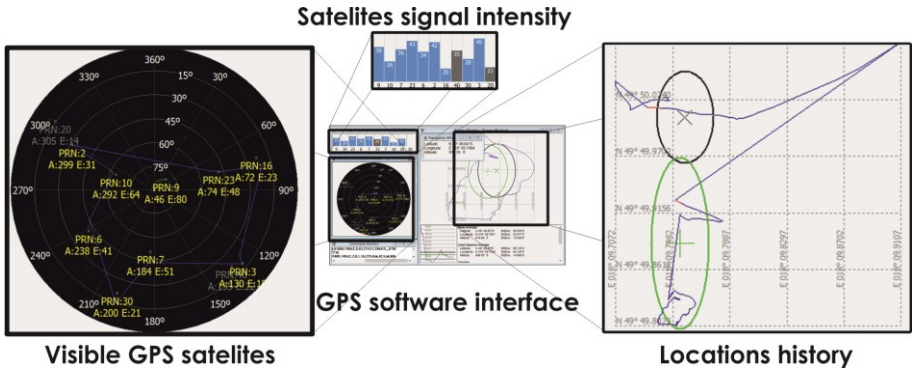

Fig. 3 GPS locations log history and other important data like number of visible satellites or theirs signal intensity

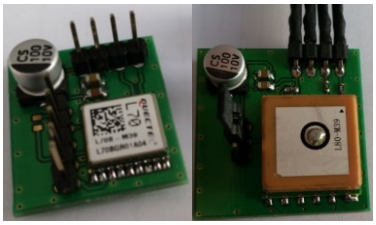

Fig. 4 GPS modules. On the left is passive antenna version and on the right the one with active antenna

Fig. 5 GSM communication device with full duplex voice communication ability

These features allow to communicate the operator with maintenance team in real time on the voice basis. There can also be connect analog or digital signals, which can inform the operator about significant values for example vehicles battery voltage level, humidity in certain area, inner and outer temperature, noise level and so on. These all quantities are automatically sent to superior database in one data package from each mobile communication / localization device. [9]

CONCLUSION

The above described vision to improve maintenance team efficiency can be done by adding one purpose communication / localization devices to operational environment. These devices are able to transfer relevant data to the superior database respectively to the main operator and help him to make the right decision. The software implementation will be ready soon, in this case we were tested localization abilities of present day technologies like GPS, GSM and RFID in hostile industry environment. The results are useable which means that the maintenance team position is known in any time everywhere in the industry premises.

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