

# Summary of available indoor location techniques

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**Abstract:** Outdoor location is currently mostly resolved. Contrary to this, indoor location have not yet been completely resolved. No global solution for complete range of possible applications is developed. Development of new wireless technologies gives developers a lot of possibilities to solve location problems inside buildings. Furthermore, new approaches and algorithms to solve location problems are developed too. In this article we discuss these technologies and their practical applications in indoor location systems.

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## 1. INTRODUCTION

The need for accurate location is currently growing. Outdoor location techniques are commonly used by millions of people and various devices. In contrast to this fact, indoor location is in development and currently not widely used. Compared to the outdoor location, the indoor location have to be more accurate. This need makes great demands on developing new position systems. Inaccuracies and errors in order of meters are not significant in the outdoor location. In case of the indoor location, these inaccuracies are unacceptable - rooms and corridors are very small, compared to the outdoor environment.

Many research groups around the world are engaged in developing accurate indoor location system. The biggest problem in indoor location is fact, that one approach can't be used for all possible cases. It's caused by greater diversity of indoor environment. Therefore, researchers try to find various approaches and implement them to the buildings. Most of these approaches try to be universal for use e.g. as navigation system for people in shopping malls, offices and the other public buildings.

In light of these facts, researchers want to use widespread and cheap wireless technologies. There are several techniques, based on mostly existing infrastructure, e.g. WiFi (Wu and Liu (2013) and Wang et al. (2012)) and FM (Chen et al., 2012). Other technologies needs an additional infrastructure of their own, like a ZigBee, Bluetooth, UWB or RFID.

To estimate location some signal features need to be measured. We can mention e.g. Time of arrival (ToA), Time difference of arrival (TDoA), received signal strength (RSS), etc.

We discuss all these techniques, features and approaches in section 2. In section 3 we describe two different approaches to make an indoor location system, concretely

model-based systems and fingerprint systems. In next section (sec. 4) are listed sensors, usable for improving accuracy of indoor location systems. As location systems are mostly composed from more techniques, combined to increase accuracy (i.e. WiFi and Inertial sensing), we discuss these hybrid systems in section 4. Next section we is conceived as comparison of used techniques and here we introduce some approaches, practically tested in the real-world.

## 2. MEASUREMENT TYPES

Indoor location is field, which can be realised by many technologies and approaches. Every technology suitable for indoor location has some features, which can be used together with various measuring principles. These approaches we discuss in this section.

### 2.1 Used wireless technologies

Variety of wireless tech. can be used to locate inside buildings. Some of these technologies are already frequently used in buildings for communication purposes. In this subsection we discuss this technologies and types of signal and how they can be used for location.

#### WiFi

WiFi is very popular and one of the most used wireless technology. It is often used for wireless Internet connection in a lot of building types, e.g. shopping malls, public spaces and factory buildings. Big advantage is that this technology is implemented in a large range of devices, like mobile phones, notebooks and tablets have implemented this technology and users commonly use it. Every wireless card allows measuring some signal parameters, which can be used for indoor location. It predetermines WiFi for cheap indoor location applications. (Wang et al. (2012), Liu et al. (2012) and Wu and Liu (2013))

WiFi is based on standards IEEE 802.11. Currently, users can use two unlicensed bands on frequencies 2.4 GHz and 5 GHz. It may be important to have large number of APs due to high WiFi signal attenuation, especially in cases where signal passes through the walls. Ideally, there is at least one AP per room. We can use this feature, thus limit distance for received signal from particular AP, for minimizing estimated position errors.

Then, user can walk through the building and his phone or tablet measures parameters describing received signal from every AP in range. Measured parameters are subsequently processed. Most used measured parameter is received signal strength (discussed in 2.2.6), which will be discussed in next section.

### *Bluetooth*

Bluetooth is another very popular wireless technology. Many of consumer electronic devices, such as notebooks, tablets, smartphones, or even smartwatches are equipped with it. Bluetooth uses 2.4 GHz band, as WiFi. Compared to WiFi, Bluetooth has shorter range, smaller bandwidth, but it is much more power efficient.

Currently, there are two major versions of the Bluetooth devices. Devices compliant to older standard, Bluetooth 2 and newer devices, compliant to Bluetooth 4. Although there are systems based on Bluetooth 2 (like ZONITH Bekkelien (2012)), this standard does not fit localization requirements very well. Bluetooth 4 is much more suitable, but still has some shortcomings.

Main disadvantage of Bluetooth 2 is its measurement rate. Localization techniques, which use Bluetooth, are mostly based on RSS (discussed in chapter 2.2.6). Bluetooth 2 uses its Inquiry protocol/command to obtain address of devices in range. This command takes more than 10 seconds to complete. The Inquiry command can be interrupted earlier, but not all devices in range might be discovered in that case. The Inquiry command is the only way to obtain accurate RSS, because during standard communication a Bluetooth transmitter reduces its output power to reduce energy consumption. While Inquiry command, transmitter uses its maximum output power. Another potential complication is that according to standard, Bluetooth stack has to inform user only whether RSS is under, in, or above "Golden Receiver Power Range", which is 0 dBm Bekkelien (2012). Most implementations fortunately offer higher degree of granularity, but there are significant variations between devices, which makes calibration essential.

As mentioned, Bluetooth 4 is more appropriate to localization purposes. Especially its subsection called Bluetooth Low Energy, known as BLE. For purposes of RSS based localization using Bluetooth, it is advisable to have a beacon in every room, in case of office building, or every few meters in case of larger open areas, like a shopping mall. From technical perspective, power source for such a number of devices is a problem (especially in open spaces). WiFi based beacons are too much energy-intensive for battery operation. Bluetooth 2 based devices are capable of operating from battery in matter of days. On the other hand, BLE devices are able to operate from several months to more than year from a single coin cell battery, like

CR2032 Kamath and Lindh (2012). This, together with very low cost (on order of \$), make BLE suitable for RSS based localization. BLE also particularly solves major disadvantage of Bluetooth 2 devices - measurement rate. BLE device can be configured to advertise itself with period down to few milliseconds (according to Faragher and Harle (2014)). The BLE stack on a receiving device then informs user software each time it receives a beacon advertisement packet and also reports the RSS value. Unfortunately, there is a small issue with this. BLE standard defines 3 channels for device advertisement. These channels are relatively far away from each other and advertising device periodically hops over these channels. The BLE stack on a receiving device provides information about the RSS, but not about the channel, at which the packet was captured. This information would be very useful, especially for a fingerprints based localization (see 3.2), because of effects of multipath propagation and fading. While this is not mandatory by standard, some implementations of BLE stack provide this information - for example those, used on an Apple iOS Faragher and Harle (2014).

### *ZigBee*

ZigBee, like a Bluetooth, is short range communication technology, aimed at power efficiency. Where Bluetooth is especially designed for peer-to-peer communication, ZigBee is more suitable for larger mesh networks. It is mainly used in building automation systems. ZigBee operates in one of 3 bands: 868 MHz (Europe), 915 MHz (USA, Canada) and 2.4 GHz (worldwide). These are open ISM bands, which makes it more susceptible to interference from other radios, using same frequencies (especially 868 MHz and 915 MHz bands).

ZigBee PHY and MAC layers are defined in IEEE 802.15.4 standard. There are more RF technologists using this standard. ZigBee standard specifies a communication protocol laying on the top of IEEE 802.15.4. This proprietary protocol is developed and maintained by ZigBee Alliance. XBee is another communication protocol, based on IEEE 802.15.4. It is particularly compatible with ZigBee, but it is free.

Although there may be some solutions using ToA, TDoA or AoA (see chapter 3.1) localization methods, RSS fingerprints, or CoO based approaches are the most common.

### *FM Broadcast signal*

FM Broadcast signal is primarily used as available information channel. FM radio broadcast signal is distributed over long distances, from distant FM towers to the user's FM receiver. FM signal is stronger in comparison with WiFi signals. It means that the signal is available on more places and also probability of receiving the signal in indoor environment.

Range of frequencies, used in Western and Central Europe is from 87.5 MHz to 108 MHz (ECC and CEPT, 2016). Because of used frequencies, signal is only little affected by passing through the walls.

In case of indoor location, FM Broadcasting is used i.e. in mobile phones containing FM receiver or in dedicated chips. For this application we can use some measured

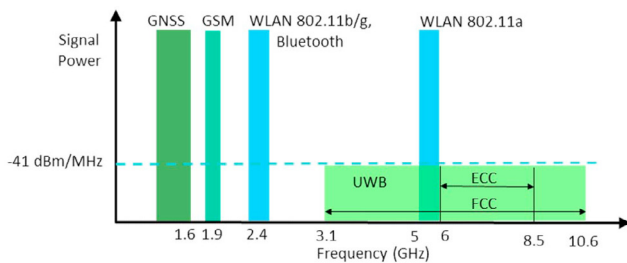


Fig. 1. UWB spectrum and power legal limitations (Mautz, 2012)

signal features. FM-capable devices have received signal strength measuring, but there is more signal features which can be measured. Unfortunately, features as multipath or signal-to-noise ratio (SNR) can be measured by small portion of receivers (according to 2.1.4). These features can improve location accuracy. There is one feature, which can be taken as disadvantage. If we try to compute precise location in indoor environment, we don't have limits of received signal (because of FM broadcast signal range - distances about tens or hundreds of km). It means that for instance WiFi has AP and this AP has limited reach, but in case of FM is impossible to use this limits as points for synchronizing indoor location system and minimizing errors.

### UWB

UWB is an abbreviation for Ultra Wide Band. It is technology for short-range, high-bandwidth communication, designed with an emphasis on multipath fading immunity and better penetrability for building materials. This makes it ideal for indoor communication and localization.

For a radio to be considered as UWB, it must meet certain criteria: its emitted bandwidth exceeds 500 MHz or 20 % of the carrier frequency. Because it occupies a significant portion of the frequency spectrum, avoiding interferences with other narrowband technologies has to be ensured. This is done by limiting carrier frequencies range and maximum transmitting power. As in other radio communications, there are two different standards, one for Europe and one for America. Both of them has the same limit for a maximum equivalent isotropically radiated power density of -41.3 dBm/MHz. Allowed frequency bands are 6.0 GHz - 8.5 GHz and 3.1 GHz - 10.6 GHz for Europe and America respectively. These frequency spectra are illustrated by figure 1.

While UWB operates in microwaves band, whose lower frequencies are able to penetrate building materials, such as concrete, wood, and so on. Because of this, it is possible to measure distance under NLoS (Non Line of Sight) conditions. This leads to reduction of overall system cost, because of less transmitters are needed - one can cover several rooms, instead of one per room. Major disadvantage of this is that signal reflection from outside of the given room might appear. Their recognition and filtration is a major challenge in UWB ranging.

There are three main ways for UWB ranging:

- Continuous waves

In this mode, continuous frequency sweeping over

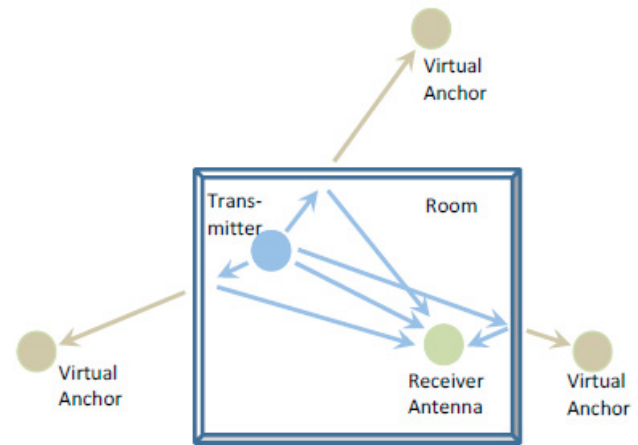


Fig. 2. UWB virtual anchors (Mautz, 2012)

entire band is performed. On the receiver side, signal is processed in frequency domain. It results in low time resolution, making this approach not suitable for dynamic real-time application. Although continuous waves offer precise ranging, it is not suitable for mobile devices, because of large antennas, which are necessary to achieve sufficient antenna efficiency.

- Impulse Radio

This approach is more suitable for ranging. It uses ultra-short pulses, typically in order of nanoseconds, or even less. It is easy to identify the shortest path of signal propagation (most probably LoS), because reflected pulses do not interfere with original pulse, due to their very short length (about 30 cm, assuming 1 ns pulse travelling at the speed of light in free air). But some interferences can still occur, because of multipath mitigation. This approach does not need as large antennas as continuous wave and consumes much less energy, because of very short time when the transmitter is active. The repetition frequency of transmitted pulses is typically between 1 MHz and 100 MHz for ranging purposes, but can be up to 100 GHz for data transmission (Mautz (2012)).

- Pseudo noise modulation

This technique modulates transmitted signal by pseudo-random sequences. It typically uses ToA (see 2.2.1) for distance measurement and localization. This technique is very promising for mobile devices, because it needs the smallest antennas (compared to previously mentioned techniques).

Because of an ability of the UWB to detect the reflected pulses separately, it is possible to perform a localization task by multilateration with only one transmitter and one receiver in known environment. This technique is called "Virtual anchors". The basic principle of this is that signals, reflected from walls, create another virtual transmitters behind these walls, as shown in figure 2.

Another useful application of the UWB is passive detection of moving objects. Several transmitters (at least one) and receivers (at least four for unambiguous localization of object in 3D space) are placed in a room. After their deployment, static reflections from environment objects (like furniture and room walls) are measured and stored. Then every other unknown reflection comes from newly

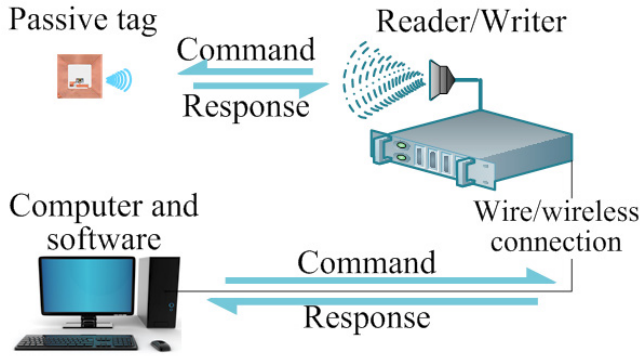


Fig. 3. RFID passive system (Bai et al., 2012)

added object - typically a person who entered the room. His position then can be calculated, while he is moving through the room. It is also possible to detect human activities, like gestures. Even as small movements as breathing can be detected (Mautz (2012)).

#### Radio frequency identification (RFID)

RFID technology was developed for tracking objects or people. According to RFID tags (or we can say transponders) we can divide RFID systems into three categories - passive, semi-passive and active. The RFID system consists of RFID tags, reader and host computer with software. RFID tags implement microchip and antenna to the substrate.

If the tag is passive, then the energy for sending response is accumulated by RF signal from the reader (Figure 3). For this system are given two disadvantages. First disadvantage is power interruption, which may occur in case of the reader is going out of range. Next given disadvantage is short reading range. But in case of indoor location these disadvantages can be taken as benefits. Indoor location systems are influenced by inaccuracies which can accumulate over time. RFID readers can help reduce these errors when used as fixed points with known position. Accuracy of this system can be given mainly by reading range. Passive tags do not need power supply and this feature predetermines these tags for cheap and simple application in buildings.

Semi-passive transponders are provided with battery. This battery is intended for ensuring power supply for microchip. From the perspective of the reader this tag looks like passive tag.

Active tags periodically transmit data with identification (Figure 4). These tags have built-in battery or another power supply. Thanks to power supply and active transmitting these tags have long range.

In general, we can use two types of tag chips - read-only and read-write. Read-only tags are cheaper and easier than read-write tags. For indoor location systems is the read-only type sufficient.

The range of RFID systems differs, depending on frequency used. The features of this technology are summarized in Table. 1.

#### Measuring geomagnetism

In general we can also use geomagnetism for indoor lo-

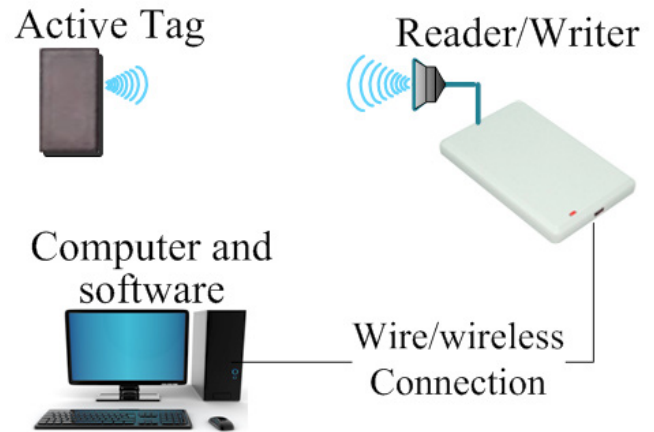


Fig. 4. RFID active system (Bai et al., 2012)

	LF	HF	UHF	SHF
FR [MHz]	<0.135	3 ~ 28	433 - 435, 860 - 930	2400~2454, 5725~5875
RR (P)	≤ 0.5	≤ 3 m	≤ 10 m	≤ 6 m
RR (A)	≤ 40 m	≤ 300 m	≤ 1 km	≤ 300 m
TRR	Slower ⇔ Faster			
ARMW	Better ⇔ Worse			
FR: Frequency Range				
RR (P): Typical Reading Range of Passive Tags				
RR (A): Typical Reading Range of Active Tags				
TRR: Tag Reading Rate				
ARMW: Ability to Read near Metal or Water				

Table 1. Comparing of RFID frequency ranges and parameters (Bai et al., 2012)

cation. The basic principle of this technique is to measure Earth's magnetic field and deformations of this field caused by building elements. This technique can't work without fingerprint database (discussed in 3.2). It's important to make this database big enough to achieve accurate location computing.

To measure magnetic field it is possible to use E-Compass. This sensor can measure direction of geomagnetic field. In buildings, where is this magnetic field deformed, is in each point unique fingerprint which can be used with more information to compute indoor location.

Earth's magnetic field is advantageous because of changes of this field are very slow. This technique has one big advantage. If we want to use other indoor location systems in multi-storey buildings, we must have a lot of APs in every storey. But this technique does not need APs and geomagnetic field is in every point of building different. It means, that we can establish big fingerprint database, which will contain fingerprints for the entire building.

#### 2.2 Most used measuring principles

Wireless signals can be described by many features. The aim is to be able to use these features for location inside the buildings. It means that we have to be able to measure this features and quantify them. Every feature has advantages and disadvantages for using in indoor location. Because of this must be the feature, intended for use in indoor location, chosen with care.



### Time of Arrival (ToA)

is signal parameter, which is defined as measured time required for spreading the RF signal from transmitter to receiver. This time depends on distance between transmitter and receiver and on signal propagation velocity. (Kaňa (2014) and Kaczmarczyk et al. (2015))

One problematic feature of this system is that all nodes of this indoor location system (APs and user devices) need to be time synchronized.

### Time difference of arrival (TDoA)

This parameter is modification of previous parameter - Time of Arrival. In comparison with previous, measurement of this parameter has big advantage. In this process the system doesn't measure the time transmission and reception, instead the differences between times of arrival from every AP is measured. Because of the fact that individual measured Times of Arrival are subtracted, location system doesn't require synchronisation of receiver. Transmitters must be still synchronised. (Kaňa, 2014)

### Symmetrical Double Sided Two Way Ranging (SDS-TWR).

This approach completely eliminates a need for clock synchronization between a transmitter and a receiver. Unlike in ToA, or TDoA, only distance between two nodes can be measured at time. Figure 5 show a schematic diagram of SDS-TWR operation. Simply said, one device sends a message to another and measures time, that takes a reply to arrive. Assuming that the second device has constant and known time of signal processing, the first device can easily compute signal travelling time. Unfortunately, this assumption is not met exactly, because of small variations of devices clock. This inaccuracy can be eliminated by the second measurement, done in an opposite direction (the second device is measuring time of reply from the first device). An average time of both these measurements is then considered as the right one.

### Angle of Arrival (AoA)

The main disadvantage of the previously mentioned methods is a need for very accurate time measurement (at least when they are applied on the very fast propagating signals, like radio waves or light). On the contrary, Angle of Arrival is based on direction, from which received signal arrives, instead of a time which a signal spent by travelling from one device to another. Therefore precise time measurement is not mandatory. On the other hand, angle measurement is not easy at all. Several approaches are used:

- Array of directional antennas  
Several directional antennas, heading to different directions are used. For precise angle measurement there have to be lot of antennas with narrow radiation characteristic. Because of large number of antennas, this solution is quite expensive.
- Rotating directional antenna  
More accurate angle measurement can be achieved by one rotating directional antenna, instead of an array of antennas. However there is a problem with getting signal from a rotating part. Maintain a continuous rotation of an antenna is energy consuming. And it is often not possible to have a moving parts.

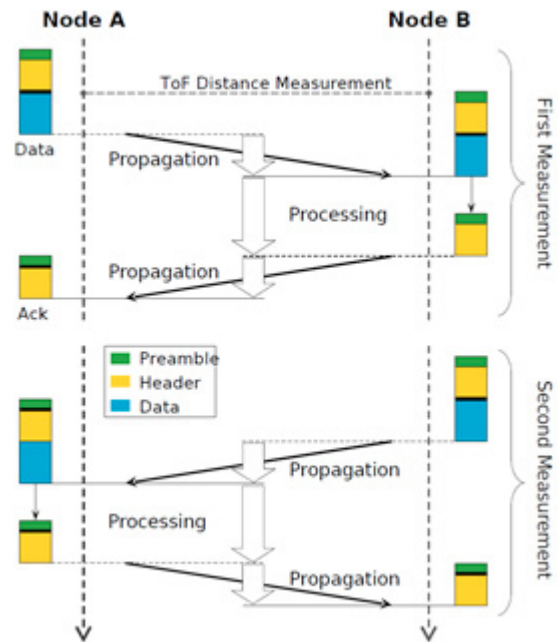


Fig. 5. Symmetrical Double Sided Two Way Ranging schematic diagram (Kaczmarczyk et al., 2015)

- Array of multiplexed omnidirectional antennas This is a relatively new approach to solve this problem. The idea is that several omnidirectional antennas, multiplexed to receiver, with a sophisticated signal post-processing can emulate rotating antenna, with sufficient accuracy.

When angle of arrival of signal from a transmitter is measured by several receivers, triangulation can be used to calculate transmitter position. Accurate angle measurement is mandatory, but hard to reach. Two main problems are a resolution of measurement techniques and that signal could possibly come from different direction, than transmitter is within, because of reflections (under NLoS conditions).

### Cell of origin (CoO)

This principle is used for determining the position of mobile device. It is based on finding the device position in particular area according to limited range of signal. This technique has low accuracy, but it is very simple.

### Received signal strength (RSS)

This is the most common way, used in an indoor localization. Measured parameter is a received signal strength. This depends on distance, between a transmitter and receiver, but it is strongly non-linear. Moreover, assuming fixed positions of both transmitter and receiver, there are variations over time in this parameter, due to changing atmospheric conditions. The great advantage of this method is that almost every radio receiver provides an information about strength of received signal.

There are basically two methods of position determination from RSS measurement: multilateration and fingerprinting. These will be discussed in chapter 3.

### Channel state information (CSI)

CSI is an improvement of a RSS. While RSS provides only

information of overall signal strength, CSI measures signal strength and phase shift of individual signal components. Because of this, it is easier distinguish directly received signal from it's reflections. Or it provides much more informations for fingerprinting.

This technique can only works with advanced modulation techniques, like these used by Wi-Fi or UWB.

### 3. INDOOR LOCATION TECHNIQUES

Two different approaches are commonly used to compute an accurate indoor position. In next subsections we will discuss this approaches and their features and differences.

#### 3.1 Model-based techniques

This is a more direct, we could say a physical approach to the localization problem. We have got an infrastructure of several fixed units (Wi-Fi APs, for example), placed at known locations across the building. And we have got a mobile unit (units), capable of communication with fixed units and, mainly, measurement of some relative position dependent parameters of a signal, such as a time which signal spent by travelling from a mobile unit to a fixed one. This time then can be easily converted to distance between these units. When several distances and position of fixed units are known, multilateration may be used to calculate position of the mobile unit. This method use ToA, TWD, RSS or CSI to measure distances. Special case of this is when only differences between distance to fixed units are known (when TDoA is used). Even in that case a location of the mobile unit can be unambiguously computed (GNSS uses this technique). When AoA is used, triangulation can be used for position calculation.

Problem is, that for unambiguous location in 3D space, four distances or angles have to be measured. We often have more than four measurements. While it may seem that the more data, the better, it complicates position computation. More data then needed leads to a pre-determined system. Because of inaccuracy of measurements, this system has no exact solution in most cases. Some approximation techniques has to be applied, e.g. the least squares method.

#### 3.2 Fingerprint techniques

The second of these techniques is fingerprint technique. Indoor location system that uses this technique have to be equipped with additional infrastructure, which provides computation through fingerprint database, which can alternatively be placed in user device (Liu et al. (2012)).

Fingerprint based systems have two phases of operation. In the first phase the fingerprint database has to be created in the following manner - device with sensors, used for indoor location is placed at known places and values measured by these sensors are collected to the database along with the assigned known location. Second phase is normal mode, where the system computes position of user device according to measured values.

Location is estimated as follows. Current measured values from used sensors or signal features are adapted

to requested form, which is called fingerprint vector. In next step this vector is compared with values saved in fingerprint database. Most similar value is chosen and saved position of this value is returned back to the user.

There are many error sources associated with this approach, which can cause inaccuracies. A lot of problems can be caused by time variance of measured values. This instability causes difference between value on known position and value, which was saved to the fingerprint database in different time. This may cause inaccuracy of the measured position. because of this fact designer of indoor location system has to chose suitable collection of measured values, which are stable over time, or alternatively he can guarantee periodical updates of fingerprint database.

### 4. INERTIAL SENSING

All of previously mentioned methods of localization rely on a radio. But it is useful to have somehow position dependent data obtained by different physical approaches. Methods of combining data from multiple different sources are still challenging. Kalman filter, or some sort of particles filter are hard to implement and needs a lot of computation power, but has superior results.

With advancement of MEMS devices, inertial sensors are logic choice. When speaking about a sensor, 3D sensor is meant in several next subsections. 3D means that there are three independent sensors of given physical quantity, mutually rotated by 90 degree.

#### *Accelerometer*

The are two common ways of using accelerometer. First we can directly compute a position increment by double integration of acceleration. The major disadvantage of this method is integration of measurement error. Because of nature of double integration, overall position error increase rapidly due to even very small measurement error and mainly noise. Precision of present MEMS accelerometers is not enough for measurements longer than only tenths of seconds.

The second way is to recognize some specific patterns and assign them to users movement. The typical example is a pedometer. This device counts user's steps. With combination with previously mentioned direct double integration, user's average step length can be determined. Then from step length and number of steps, total travelled distance can be estimated. Moreover, another specific movement types can be recognized, like a walking upstairs, opening doors and so on. These movements are bounded to specific area in a building. By comparison with a pre-built database, coarse absolute position can be determined.

#### *Gyroscope*

Accelerometer itself is not enough to localization, because it can not handle rotations. Three accelerometers are needed to determine device rotation. This is not practical, especially in small hand-held devices. Instead of this, gyroscope can be used. This device measures an angular velocity, which can be converted to relative orientation by integration. While double integration is needed to convert acceleration to position, which also brings significant error cumulation, only one integration is enough gyroscope.

Because of this, orientation given by gyroscope has less drift, than position computed from accelerometer. But this is still not enough for long-term measurement. This could be improved by combination with accelerometer. While the device is steady, accelerometer can measure its absolute orientation against Earth gravitation field and calibrate the gyroscope drift.

#### E-compass

As we describe in 2.1.7, E-Compass is electronic sensor, designed for measurement of the geomagnetic field. In indoor location system can be used for measurement of the deformations of geomagnetic field in buildings.

## 5. COMPARSION OF LOCATION TECHNIQUES

In the text above we described various approaches to solving indoor location problems. In this section we compare some implemented systems and their parameters. For better clarity we placed data with results of various projects to the table 2. In fact, accuracies listed in table 2 can mislead due to different environment conditions. E.g. geomagnetism sensing is developed for large multi-storey buildings and WILL is tested in small office building.

System	Used Technology	Accuracy
FM Broadcast measuring (Wu and Liu, 2013)	RSS, SNR, Multipath, freq. offset meas. fingerprint database	around 0.3 m
UnLoc (Wang et al., 2012)	WiFi RSS, compass, Accelerometer fingerprint database	1 - 2 m
EZ localization algorithm (Chintalapudi et al., 2010)	WiFi RSS multilateration without APs coordinate knowledge	3 - 10 m
Geomagnetism sensing (Chung et al., 2011)	E-Compass fingerprint database	4.7 m
LIFS (Liu et al., 2012)	WiFi RSS freq. offset fingerprint database	around 5.88 m

Table 2. Indoor location system comparison

## 6. CONCLUSION

Indoor localization is field of interest of growing number of research projects. It has great commercial potential. Some projects are in production phase now, but there is still a lot of space for improvements. On this paper we present summary of techniques currently used for indoor localization. We discussed their advantages and disadvantages. Finally we compare several existing systems for indoor localization - what they are based on and their accuracy.

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