Real Time Location Systems

Clarinox Technologies Pty Ltd

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1 Real Time Location Systems

Real-time location systems (RTLS), are used to track and identify the location of objects in real time using

1. "nodes" or "tags" attached to, or embedded in the objects tracked, and
2. "readers" that receive and process the wireless signals from these tags to determine their locations.

RTLS systems may perform passive or active (automatic) collection of location information. A closely related term is "Intelligent Positioning System (IPS)" which continuously determines the position of an object in real-time in a given physical space [2].

Many wireless technologies are used to establish the communication between tags and readers. Most popular ones include WiFi, GPS, Infrared, Bluetooth, and active and passive RFID systems. Table 1 summarizes the differences of these technologies, their prominent features, and the performance that determine their suitability to different applications. There is no "one size fits all" solution when it comes to the use of wireless technologies.

	RFID-passive	RFID-active	Bluetooth	WiFi	GPS
Power Usage	None	Low to Medium	Medium	High	Medium
Data rate	Low	Low to Medium	Medium to High	High	Not Applicable
Coverage	Low	Medium	High	High	Very High (outdoor)
HW costs	Tags-low Readers-med to high	Medium	Medium	High	High

Security	Limited	Medium	High	High	Not Applicable
Major advantage	Low price of tags, no battery required in tag	Low price of reader	Mainstream technology with high uptake	Mainstream technology with high uptake	Long range coverage
Major disadvantage	Short range (need multiple readers or reference tags required for RTLS)	Tag does require battery (life expected to be up to 1- 3 years)	Power consumption (battery life typically 1-2 weeks)	Low accuracy, very high power consumption (battery life typically 1-2 days)	Does not work inside buildings

Table 1: RTLS algorithm comparison

By positioning the readers at fixed locations in a given environment, the location of the mobile tags is determined by analyzing the various aspects of the communications between readers and tags. Most widely used techniques used for these calculations are, Distance/angle estimation, Position computation and localization algorithms. The choice of a method depends on the application requirements [1].

1.1 Distance/angle computation

With Distance/angle computation, a variety of input data is used, either alone or in combination, in estimating the distance/angle between the tag and the reader.

Angle of Arrival (AoA)

This method uses directive antennae or an array of antennae [1]. The method can be effectively applied in combination with RSSI and TDOA distance estimation techniques to reduce the error in position estimation algorithms

Time (Difference) of Arrival-TDOA

Distance between the tag and the reader is directly proportional to the time taken by the signal to travel between the two. This method is less used due to the precision required with synchronization of clocks of the devices within the system however when implemented correctly is an accurate method.

Received Signal Strength Indicator-RSSI

The received signal strength is inversely proportional to the square of the distance [1]. This is one of the most commonly implemented techniques, due its practicality, low cost and availability [1] [2] [3]

A comparison of these techniques is provided in the following table.

TECHNIQUES	ANGLE OF ARRIVAL	TDOA	RSSI
ANTENNA TYPE	Directional Antenna (Monopole), multimode antenna	Any based on requirement	Monopole, bi-directional, multimode.
ALGORITHMS	Triangulation, along with TDOA applied to array of antenna.	Triangulation / Trilateration. Difference in arrived signal time and transmitted signal time gives estimated distance.	Triangulation. Received signal strength (RSS) inversely proportional to square of distance.
ACCURACY	Potentially high. Determined by the position of the angles, and the robustness of installation.	Potentially very high dependant on clock synchronization.	Variable as received signal strengths changes with changing energy of transmitted signals
ADVANTAGES	When used with TDOA, can be an accurate measurement of the position of asset.	Efficiently used by the GPS satellites, US Federal Communication Commission.	Simplest of all implementation techniques. Low cost.
DISADVANTAGES	Costly depending on size of antenna array. Often used with TDOA which makes cost very high.	Very costly as makes use of expensive electronic quartz clocks to maintain synchronization.	Lower level of accuracy

Table 2: RTLS parameter

1.2 Clarinox location tools

Clarinox has developed tools for faster algorithm development. These tools record and map input information available from readers and present in graphical view.

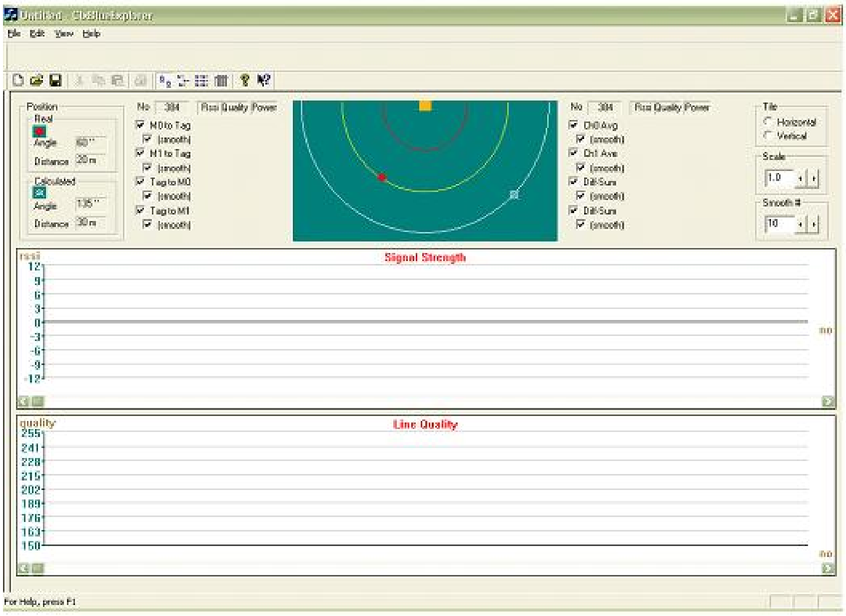

Figure 1: Signal capture tool

A mixture of input data can be selected. The below is a sample set of data looking at signal strength and line quality obtained from a solution using Bluetooth.

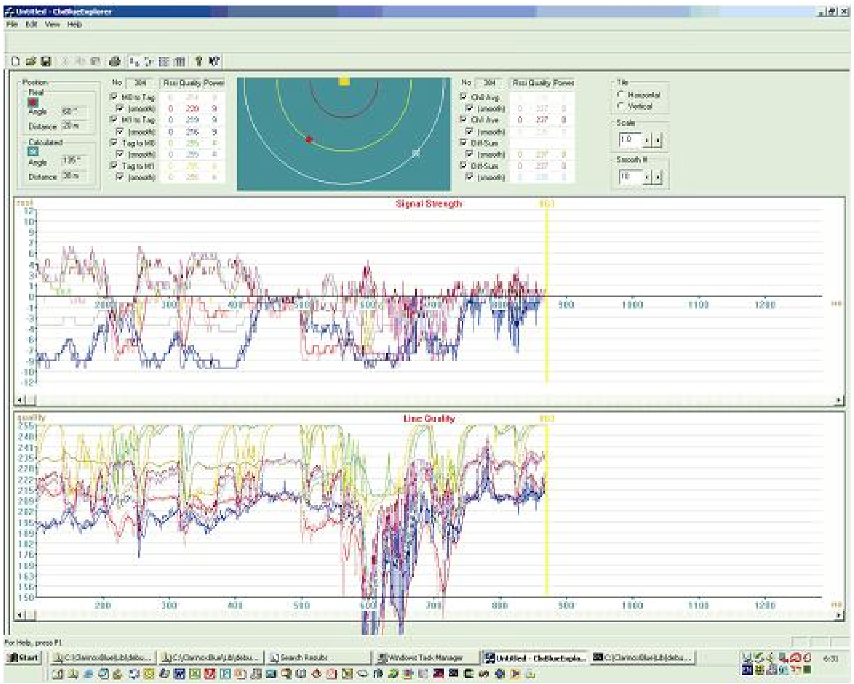

Figure 2: Sample captured signal view

1.3 Position Computation

Once the readers have individually derived the distance between them and the tag, the next step is to compute the position of the tag within in the area. Again several computation methods are available though the most used include:

Trilateration/Multi-Trilateration

The tag distance from each reader has been calculated using one or a mix of the methods discussed. A circle is drawn from each reader with the radius equal to the distance of the tag from the respective reader. If there are three readers, then the three imaginary circles drawn will meet at one or more points. The locality in which there are the most intersections provides the location of the tag.

Triangulation-with the use of Angle of Arrival

Each reader in the network knows the angle between the reader and the tag. The distance between readers is predefined. Hence using trigonometric identities, the other readers reference their angles to the respective readers, to calculate the position of the tag.

Probabilistic Approaches-with Trilateration

This method is based upon the use of readers and reference tags and creates a matrix of possible locations which is refined as more data is acquired from other readers about the tag. This method has high computational requirements.

For a large range of applications Trilateration using the RSSI algorithm provides sufficient accuracy and provides lowest total cost of ownership. For applications requiring greater accuracy additional techniques can be applied.

1.4 Visual representation

For the end user this is the most important part of the RTLS as this is the part of the system that displays the location of the tag on a map (2D or 3D). Clarinox currently present as 2D visuals however the software has been designed to cater for, and calculate 3D information hence the system can be used for 3D application by the addition of a 3D top map view easily.

2 About Clarinox Technologies

Clarinox provides a flexible, robust software solution that can be rapidly adapted to multiple technologies and hardware to meet the needs of the application. The software solution encompasses middleware, API, XML and web based user interface. Clarinox software is award winning: finalist for 2007ATS patrons award, 2009 AIIA Victorian Merit Award, and winner 2009 EDN Best Application of Design Software Award.

The Clarinox solution:

- Is based upon proven robust code
- Has a display system that is easy to understand
- Is simple to administrate
- Contains an internet enabled / web based user interface
- Is based on years of experience with wireless technologies
- Uses intelligent data handling and data filtering to remove repetitive data
- Readily customized to provide best cost and performance blend
- Provides a practical solution to meet real world scenarios
- Provides flexibility in the overall integrated solution as software and algorithm is separate from hardware

Clarinox has implemented RTLS with a variety of wireless technologies including active and passive RFID, Bluetooth and proprietary low power wireless. This experience has been developed over 8 years since the inception of the company. The software infrastructure has grown from both strong theoretical knowledge as well as practical experience placing Clarinox in an ideal position to provide innovative and custom RTLS solutions.

For many reasons such as relatively low cost as well as low power requirements, RFID technologies are evolving as the technology of choice for RTLS. Clarinox has used UHF, HF and active/passive 433MHz/2.4GHz technologies and can combine these together into an overall system to provide higher accuracy and solution flexibility (e.g. personnel building access and security function and major item tracking in production line). With the Clarinox solution a specific vendor's active or passive reader can be integrated into the system within an average of 1-3 days. This provides a large degree of flexibility in overall system setup as the software and algorithm is not tied to a single hardware item.

Clarinox focuses on ease of use and simple installation hence only uses complex installations such as the use of reference tags and large number of readers if extreme accuracy is the requirement. This approach saves on costs and avoids difficult and time consuming installations.

Current demonstration system of RTLS is based upon active RFID technology and is available to demonstrate at any time. Demonstration of RTLS using alternative technologies can be demonstrated via simulation.

The WayPoint software consists of three separate software components:

- Web Service
- Data Base Interface

- RFID interface

Each component can be used independent of the others and the communication between components follows international standards.

The Web Service requires a web server running to support users and administrators to remotely login to the system via password protection and view and/or access the system resources. Web Service can be deployed within a private network or via the internet. System information and settings are kept on a SQL data base.

Data Base Interface is a Java application to provide communications between the RFID Interface components and the SQL Data Base. The interface between the RFID Interface and the Data Base Interface components is using XML over HTTP or TCP connections. Data Base Interface application can communicate with an unlimited number of RFID Interface clients. Depending on the size of the system, multiple copies of Data Base Interface can be run in parallel to balance the load sharing.

RFID Interface provides the interface to the physical active or passive RFID readers. This module runs the real-time location system algorithms and reports the tag location and other details to the Data Base Interface. This software utilizes award winning Clarinox SoftFrame software as the architecture hence it could run on tiny electronic boards or more powerful desktop computers. The following diagram shows the Clarinox SoftFrame architecture.

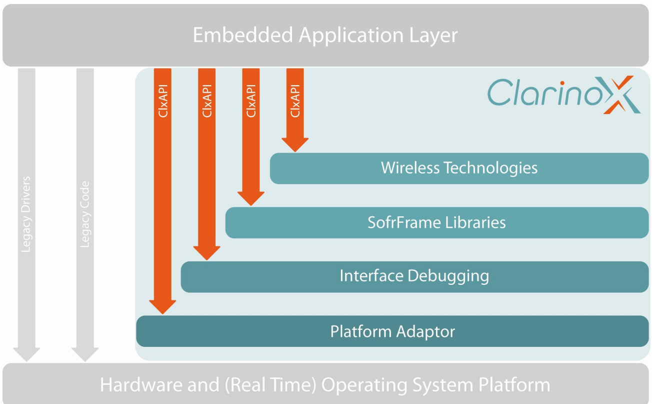

Figure 3: SoftFrame

The Clarinox solution is scalable to unlimited number of tags, readers. All of these software components mentioned above can run on a single desktop computer for a small system. For a very large scale system, multiple Data Base Interface and RFID Reader Interface components could be deployed to serve hundreds of thousands of tags and thousands of readers. Such a system could run the web server on a separate computer and a data base on another computer. Clarinox software architecture is designed to distribute the system geographically and computationally.

The following block diagram depicts the overall architecture.

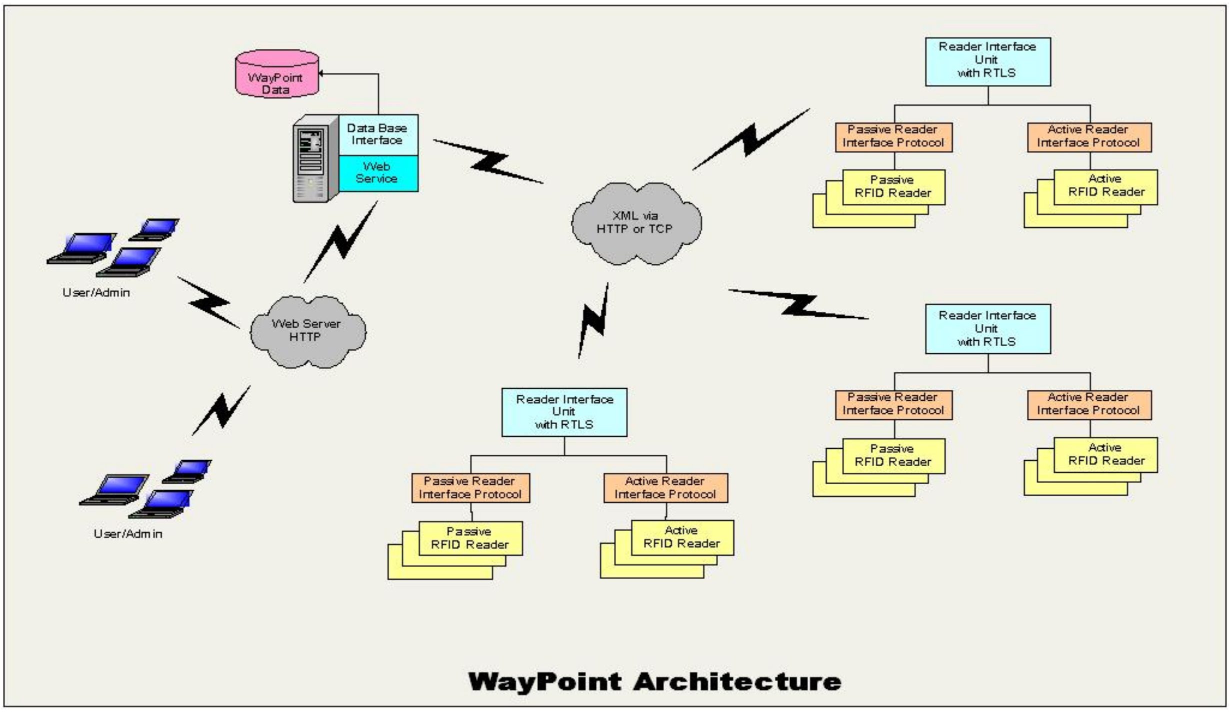

Figure 4: WayPoint block diagram

3 References

[1] Boukerche, A. Oliveira, H.A.B. Nakamura, E.F. Loureiro, A.A.F;

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[3] Ni, L.M.; Yunhao Liu; Yiu Cho Lau; Patil, A.P.; "LANDMARC: indoor location sensing Using active RFID", Proceedings of the First IEEE International Conference, 23rd March 2003