

METHODS AND APPARATUS FOR IMPROVING ACCURACY OF WIRELESS LAN LOCATION TRACKING SYSTEM

BACKGROUND OF THE INVENTION

Field of Invention:

The present invention relates to wireless LAN client location tracking system and more specifically to methods and apparatus for improving the accuracy of the location tracking system.

In particular, the apparatus, a customized wireless LAN device, that sends out transmitted power information in several power level and the method for improving location accuracy is described.

Description of the Prior Art:

All existing wireless LAN based location tracking system use received signal strength to compute the location of wireless client in a Wireless LAN system. Most of them use the received signal strength in the following way.

- Closest AP

In the simplest form, a wireless LAN client's location could be identified by the associated wireless LAN Access Point. The accuracy is limited to the coverage of Access Point. Normally the accuracy level is around 50 meters.

- Trilateration and Triangulation

In the trilateration and triangulation solution, the relationship between received signal's strength and distance is used to improve the accuracy. Based on each surrounding Access Point's RSSI(Received Signal Strength Indicator) or Time arrival information, the distance between the wireless client to each AP could be calculated. Thus the intersection line will identify the location of client.

Multipath effect and other blockage inside building makes the mapping between RSSI to distance varies a lot in different building and location. A practical system needs to be calibrated before it can produce reasonable result.

- RF fingerprint

In RF fingerprint solution, instead of the mapping between distance and signal strength, the mapping between location to signal strength is used. It is the most computation and calibration intensive solution. During calibration stage, all location's received signal strength from different Access Point is logged in database. Later when a wireless client



reports its received signal strength, the location computation engine will find the closest match.

The changing environment will affect the accuracy of location computation severely. The need for intensive calibration makes the deployment for this solution a difficult task .

The invention has been carried out in view of existing location tracking system's challenges and limitation. One major limitation for prior art system is that the transmitted power is inferred from Access Point Model, data rate etc. And the assumption that there is a fixed transmit power corresponding to each type of received frame limits prior art system to achieve both high resolution and big coverage. Take closest AP location tracking system for example, bigger coverage requires a higher transmit power. While a lower transmit power indicates a lower coverage radius thus a higher resolution. So a fixed transmit power scheme in prior art system doesn't work well for location tracking system.

SUMMARY OF THE INVENTION

In the present invention, an apparatus called PAP(Positioning Access Point) is described. A normal wireless LAN Access Point or Client could take the role of PAP if they implement the specified Power Information Element(a information element that contains transmit power information) processing. A method for making use of the PAP power information is also described.

Each PAP added to the Wireless LAN system will improve the computed location accuracy of the installed location to be within 1 meter or below, depending on the minimum power level setting

The present invention solves the problem of unstable mapping between received signal strength to location or distance by introducing the following three key method:

1. A data structure of Power Information Element contains the current transmitting power is added to PAP. The PAP transmits out Power Information Element in beacon or other dedicated data frame. Using transmitted power information from the PAP instead of the received signal strength eliminates the inaccurate changing map between signal strength and distance or location.
2. The PAP transmits out the Power Information Element by a set of predefined different power level. Different level of power corresponds to different level of location accuracy and coverage. The higher the power, the bigger the coverage. The smaller the power, the more accurate the location estimation. By transmitting the power information at different power level, the new tracking system now can increase accuracy without sacrifice the coverage.
3. The wireless client collects all received Power Information Element from all PAP in the same location tracking system. The minimum power level it receives will give the most accurate reference to its current location. The wireless client then can make a decision of its location on its own. Or it can report its received power information to a Location Computation Server for a better estimation combined with existing solution .

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

A preferred form of the present invention is illustrated in the accompanying drawings in which:

Fig. 1 illustrates the typical setup diagram where PAP could be used.

Fig. 2 illustrates the information contained inside a Power Information Element

Fig. 3 illustrates the flow chart of the PAP to send out Power Information Element.

Fig. 4 illustrates the algorithm of deriving more accurate location information from Power Information Element.

Fig. 5 illustrate the difference of location accuracy between existing system and the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description, the preferable embodiment will be explained based on the accompanying drawings . It shall be apparent to one skilled in the art, however, the invention may be practiced without such details.

As shown in figure 1, A typical Location Tracking System contains

- Location Computation Server 1,
- Network connection 2
- Access Point 3,
- PAP 4,
- Wireless Client 5

Access Point is used to provide data link to PAP, wireless client as in the normal Wireless LAN system.

PAP is used to provide position information to Wireless Client. It could be a light weight Access Point, Wireless Client, or existing Access Point with software enhancement. The PAP will transmit Power Information Element periodically. And it will also connect to

Access Point by switching to client mode periodically to report its own status to Location Computation Server.

Location Computation Server is used to calculate the location of Wireless Client 5 and report all PAP's status inside the Location Tracking System. It has the exact location information about each Access Point, PAP. In the present invention, the distance to Power Level mapping could use Free Space Path Loss. So calibration is not really necessary.

Wireless Client refers to any Wireless LAN enabled notebook, WIFI tag etc that understands Power Information Element and its processing flow.

As shown in figure 2, a example of Power Information Element contains:

- LTS_ID
- PAP_ID
- POWER_LEVEL
- Checksum

LTS_ID refers to Location Tracking System ID. This will be the unique identification code for the particular Location Tracking System. If multiple Location Tracking System is installed in one place, this could be used to differentiate between each system.

PAP_ID refers to Positioning Access Point ID. Each Location Tracking System may have multiple PAP installed to improve the accuracy. Each installed PAP will be assigned a unique PAP_ID. In Location Computation Server(1), it will associate each PAP_ID to a reference location.

POWER_LEVEL refers to the transmitted RF power level for this Power Information Element. Each time PAP transmits out a Power Information Element with different power level, this field will also be updated.

Checksum refers to a secured check sum for validity check of this Power Information Element. Since Power Information Element is sent out in clear text, for a secure system, it may be preferred to use SHA or other secured hash function with hidden secret to compute a check sum for validity check. Only those Power Information Element with correct check sum will be processed.

Figure 3 illustrates the processing flow of Power Information Element inside a PAP. It can be run as a separate software process in a Wireless LAN Device.

At Step 6, A Power Information Element Array for the particular PAP is initialized with the correct LTS_ID, PAP_ID, POWER_LEVEL, Checksum. The array contains a set of predefined POWER_LEVEL that PAP is supposed to transmit out. The number of POWER_LEVEL is determined by the system accuracy requirement and also how fine the Wireless LAN device could adjust its transmit power level. This array only needs to initialize once.

From Step 7 to 10, the PAP loops through the Power Information Element Array one by one. It will get one Power Information Element at a time(Step 7). Then it will set the transmit power to the POWER_LEVEL specified in the Power Information Element(Step 8). At step 9, it will transmit the Power Information Element out. At step 10, it will check whether all Power Information Element in the array has been processed. Once all the Power Information Element in the array is processed, it will wait for next time slot to transmit the whole Power Information Element Array(Step 11). If the implementation use a modified beacon to carry the Power Information Element, the time slot will be each original beacon time slot. If instead a dedicated data frame is used, the time slot could be decided based on how fast the Wireless Client wants to update its location and the capacity of the Location Tracking System. For general system, 1 second per time slot could be used.

Figure 4 illustrates the processing flow of Power Information Element inside Wireless Client or Location Computation Server.

At Step 12, the Wireless Client will collect all Power Information Element from all surrounding PAP. It can do so by listening for modified beacons or those dedicated data frames containing Power Information Element.

At Step 13, it will filter out those Power Information Element with wrong LTS_ID or Checksum.

At Step 14, it will group all the received Power Information Element by their PAP_ID. Each group contains all the Power Information Element from a specific PAP with the unique PAP_ID.

At Step 15, for each group, the Power Information Element with minimum POWER_LEVEL is retained while others are removed.

At Step 16, from the minimum transmitted POWER_LEVEL, and the PAP's location we've 100% certainty that the Wireless Client is within a most accurate coverage of the PAP based on the predefined Distance to Signal Strength Mapping. With multiple PAP's minimum transmitted POWER_LEVEL, we can use other existing method like trilateration or triangulation to compute the exact location of the Wireless Client.

Figure 5 illustrates why in Step 16 we can derive a more accurate location of Wireless Client, while the existing prior arts can not arrive at the same level of accuracy.

As an example, when wireless frame is received from both PAP and AP with a weak RSSI(10), the possible location of Wireless Client in the present invention and prior art system are illustrated in Figure 5a and 5b.

In Figure 5a, a POWER_LEVEL will give us extra information. As the POWER_LEVEL corresponds to 1 meter, we're sure it should be within 1 meter of coverage of this PAP. But in Figure 5b, based on the received RSSI(10), we can't make the same conclusion, it could be the following two scenario:

- There is blockage in the environment, the weak signal is due to environment. Wireless Client's position could actually be around circle 19
- There is no blockage, the weak signal is due to Free Space Path Loss, the Wireless Client's position could be actually be around circle 18.

So it is obvious that based on the present invention, we can remove the some of the ambiguity associated with environment and increase the location accuracy to 1 meter or more.

What is claimed is:

1. A method to improve the accuracy of location tracking system that comprising:
a data structure of Power Information Element that contains explicitly defined transmit power level, location tracking system information and check sum, and
an apparatus that can send out the Power Information Element through wireless interface, and
a software task running on Wireless LAN Client that can receive validated Power Information Element and
an algorithm for utilizing the Power Information Element data structure.
2. A data structure as claimed in claim 1, wherein the said Power Information Element contains transmitted Power Level.
3. A data structure as claimed in claim 2, wherein the said Power Information Element contains Location Tracking System ID, Apparatus ID, and Check Sum.
4. A data structure as claimed in claim 3, wherein the said Check Sum could be calculated by a secured hash algorithm.
5. An apparatus as claimed in claim 1, wherein the said power Information Element is transmitted using a set of predefined Power Level.
6. An apparatus as claimed in claim 5, wherein the said Power Information Element is transmitted periodically.
7. An apparatus as claimed in claim 6, wherein the apparatus will connect to Access Point periodically by switching to Wireless Client mode to report its status.
8. A software task as claimed in claim 1 will collect all Power Information Element from the surrounding apparatuses by tune to the apparatus's channel periodically.
9. An algorithm as claimed in claim 1, wherein the algorithm will remove Power Information Element with wrong Location Tracking System ID and Check Sum.
10. An algorithm as claimed in claim 9, wherein the algorithm will group all Power Information Element by Apparatus ID and search for the minimum transmitted power level for each Apparatus ID.
11. An algorithm as claimed in claim 1, wherein the algorithm use the minimum transmitted power level instead of the received signal strength for location calculation.