

SYSTEM AND METHOD FOR LOCATING AND TRACKING OF NEIGHBOURING MOBILE NODES IN A WIRELESS NETWORK

Field of the Invention

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[0001] The present invention relates to network tracking. In particular, the invention relates to a system and method for locating and tracking of neighbouring mobile nodes in a wireless network.

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Background

[0002] The popularity of wireless networking has grown exponentially over the past few years. With greater flexibility, broader range, and increased mobility, wireless networks let us live and work more conveniently, especially with the rapid emergence
15 of small portable devices such as PDAs (personal digital assistants), smart phones, and etc. With the increasing demand, wide selection of affordable enterprise and small office/home office wireless networking products and services are offered in the market. There are also noticeable increase in public and private wireless network access hot-spots.

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[0003] Under coverage of wireless networks, our work force is no longer bound onto desks to perform work. Workers can perform their duties anywhere, anytime with flexibility. It would be more productive if locations of users using the wireless devices can be traced and monitored for the support of planning, management and optimization
25 of work flow and job assignments.

[0004] Triangulation is one of the most commonly known methods to determine the location of wireless network users. The triangulation method uses at least three base stations or access points to identify the location of the wireless network
30 nodes. With this method, more base stations or access points are required to refine the accuracy of the location determined. Further, it is preferred that the base stations'

equipment are made by the same developer or manufacturer for compatibility issues. In addition, the location detection system is generally a dedicated system which is costly and involves elaborate effort to implement.

5 **[0005]** In the applications of contact tracing, RFID technology are commonly used. In particular, an area to be monitored is bounded by gantries equipped with RFID reader. Each subject to be traced is attached with an RFID tag and they are required to be scanned upon entry and exit from the area. In the event of a disease outbreak, the contact list is determined by generating the list of users who have entered
10 into the area of outbreak. Such contact tracing requires the setup of separate RFID enabled system to enclose the area to be traced.

[0006] Singapore Patent No. 120957 discloses a system and method for tracking mobile devices. The system establishes a reference set of performance
15 parameter characteristics in the form of islands or spots and subsequently matching the pattern of performance characteristics obtained from a device to locate its position in real time. For this method, more performance parameters are required per set to refine the accuracy of the islands determined.

20 **[0007]** It can thus be seen that there exists a need for a simple and robust way for a method and system for locating and tracking wireless devices that can overcome the disadvantages of the existing prior art.

Summary

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[0008] In accordance with one aspect of the present invention, there is provided a system for locating and tracking wireless devices within a wireless network, the system comprises at least two agent programs, each for deploying in one of the wireless devices respectively, wherein the agent programs operable to acquire performance
30 characteristics data of a wireless device to be located for locating a location of the wireless device to be located, and a positioning model for processing the performance

characteristics data acquired by the at least two agent programs for determining the location of the wireless device to be located.

5 **[0009]** In one embodiment of the above aspect, the positioning model may determine the location of the wireless device to be located based on a respective distance between the two wireless devices having the agent programs and the wireless device to be located and subsequently tracked, wherein the respective distances may be obtained based on the acquired performance characteristics data.

10 **[0010]** In another embodiment, the wireless devices deploying with the agent program may be registered users for the wireless network. Further, the positioning model may be incorporated in the agent programs.

15 **[0011]** In yet another embodiment, the system may further comprise a server having the positioning model installed therein, wherein the server operable to receive the performance characteristics data acquired by the at least two agent programs to determine the location of the wireless device to be located. The system may also comprise a databases subsystem for storing users registration details and recording wireless performances and traffic's activities. In the present embodiment, the at least
20 one of the agent programs may comprise the databases subsystem. It is possible that the positions of wireless device to be located are tracked and stored in the databases subsystem.

25 **[0012]** In a further embodiment, the system may further comprise a spatial performance model for mapping out wireless performance characteristics within the wireless network; wherein the wireless performance characteristics may be mapped in various spots or regions based on similarities of the performance characteristics. It is possible that the spots or regions are divided into grids or islands. It is also possible that the system further comprises a ranking algorithm operable to matching the
30 performance characteristics data of the wireless device to be located with the spatial

performance model for identifying the spot or region at which the wireless device to be located is locating.

5 **[0013]** In yet a further embodiment, the system further comprises a compensation model for processing and providing average values for the performance characteristics data within a period for compensating irregularities due to background noise and radio interferences.

10 **[0014]** It is possible that the average values provided by the compensation is based on a pre-determined threshold value that is determined based on filed measurements and simulation results. When a difference between the average values of a period and its succeeding period exceed the threshold value, the average values of a current period may be used if the difference does not exceed the threshold value. When a difference between the average values of the current period and a previous
15 period does not exceed the threshold value, the average values of the current period may be provided. It is also possible that when a difference between the average values of the current period and a next period exceeds the threshold value, the average values of the previous value is provided.

20 **[0015]** In another aspect of the present invention, there is provided a method for locating and tracking wireless devices within a wireless network having a plurality of wireless devices, the method comprises deploying an agent program in at least two wireless devices; acquiring performance characteristics data of a wireless device to be located for locating a location of the wireless device to be located; processing the
25 performance characteristics data acquired by the at least two agent programs; and determining the location of the wireless device to be located.

30 **[0016]** In one embodiment, the step of determining the location of the wireless device to be located may be based on a respective distance between the two wireless devices having the agent programs and the wireless device to be located, wherein the distances may be obtained based on the acquired performance characteristics data. It is

possible that the wireless devices deploying with the agent program are registered users for the wireless network.

5 **[0017]** In another embodiment, the step of processing the performance characteristics data acquired by the at least two agent programs and the step of determining the location of the wireless device to be located is performed by one of the agent programs.

10 **[0018]** In yet another embodiment, the method may further comprise processing the performance characteristics data acquired by the at least two agent programs at a server and determining the location of the wireless device to be located by the server. The method may also comprise storing users registration details and recording wireless performances and traffic's activities at a databases subsystem. It is possible that the at least one of the agent programs comprises the databases subsystem.

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[0019] In a further embodiment, the method may further comprise mapping out wireless performance characteristics within the wireless network, wherein the wireless performance characteristics are mapped in various spots or regions based on similarities of the performance characteristics. It is possible that the method further divides the spots or regions into grids or islands. It is also possible that the method further comprises matching the performance characteristics data of the wireless device to be located with the wireless performance characteristics of the wireless network; and identifying the spot or region at which the wireless device to be located is locating.

25 **[0020]** In yet a further embodiment, the method may further comprise tracking and storing the positions of the wireless device to be located in the databases subsystem. Yet, the method may also comprise processing average values for the performance characteristics data for a period; and compensating irregularities due to background noise and radio interferences based on a threshold value.

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[0021] It is possible that the method further comprises comparing a difference of the average values of a current period with that of its succeeding period with the threshold value, wherein, the average values of the current period is provided if it does not exceed the threshold value. When a difference between the current period and the previous period does not exceed the threshold value, the average values of the current period may be provided. When a difference between the average values of the current period and a next period exceeds the threshold value, the average values of the previous value may be provided.

Brief Description of the Drawings

[0022] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0023] FIG. 1 illustrates a floor plan having a wireless network with wireless devices locating and tracking capabilities in accordance with one embodiment of the present invention;

[0024] FIG. 2 illustrates a block diagram of a system for locating and tracking wireless devices in accordance with another embodiment of the present invention;

[0025] FIG. 3 illustrates a block diagram of a databases subsystem in accordance with yet another embodiment of the present invention;

[0026] FIG. 4 illustrates a flow chart showing a process for tracking location of a wireless device in accordance with yet another embodiment of the present invention;

[0027] FIG. 5 illustrates a flow chart showing a process performed by a compensation model in accordance with one embodiment of the present invention;

[0028] FIG. 6 illustrates a flow chart showing a process performed under an positioning model in accordance with one embodiment of the present invention; and

[0029] FIGs. 7a and 7b show two screen shots of a neighbour model in
5 accordance with one embodiment of the present invention.

Detailed Description

[0030] In line with the above summary, the following description of a number of specific and alternative embodiments are provided to understand the inventive features of the present invention. It shall be apparent to one skilled in the art, however that this invention may be practiced without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0031] The present invention provides a system and method for locating and tracking neighbouring mobile nodes within a wireless network. The neighbouring mobile nodes include any wireless devices, such as laptop, smart phone, PDA, etc. The system and method provides agent programs for deploying in at least two of the wireless devices within the wireless network, wherein the agent programs acquire performance characteristics data of a wireless device to be located and determine the location of the wireless device to be located based on the performance characteristics data. There is also provided with a database for storing the locations of the wireless devices to be located for contact tracking and tracing.

[0032] FIG. 1 illustrates a floor plan **100** having a wireless network with wireless devices locating and tracking capabilities in accordance with one embodiment of the present invention. The wireless network comprises a wireless access point (WAP) **110** for providing wireless connections to wireless devices within its coverage. The coverage of the WAP **110** covers substantially the entire floor plan **100**. The WAP **110** connects to a wired network **120** that includes servers **150** for providing services to the wireless devices. The wireless devices includes laptop devices **111**, smart phones **112**, personal computer (PC) **113**, tablet PC **114** and other wireless enabled devices (not shown). The wireless devices are able to communicate with each other via peer-to-peer or ac-hoc connections with appropriate configurations and applications provided therein. The wireless network may be a secured network. The wireless

devices accessing the wireless network are required to register with the wireless network as a valid user and an agent program is deployed on the registered wireless device. The agent program deployed in each wireless device is used as monitoring tools for collecting relevant performance characteristics data for other nearby wireless devices (including valid and invalid users) and the collected data is pushed to the servers **150** for processing. Upon receiving the relevant performance characteristics data from the agents, the servers **150** are able to identify the locations of all detected wireless devices.

10 **[0033]** Still referring to FIG. 1, a spatial performance model **190** mapping out wireless signal performance characteristics within the wireless network at various spots or regions reference to the WAP **110** is provided for the wireless network on the floor plan **100**. The spatial performance model **190** is pre-constructed through a wireless site surveying among the floor plan **100**. Based on the similarities of the acquired performance characteristics data, the spatial performance model **190** is tabulated according to the respective position indices represent by rectangular grids **180**. The measurement of the performance characteristics are commonly affected by number of factors including indoor or outdoor placement, nearby obstructions, other electronic devices actively interfere with the signal, and etc. For easy reference, each column of the rectangular grids **180**, from left to right, is denoted by capital letters **A, B, C, D, E,** and **F** respectively, and each row, from top to bottom, is denoted by capital letters **V, W, X, Y** and **Z** respectively. A position of each rectangular grid **180** can accordingly be identified by a two letters code representing its corresponding column and row; for example, the grid **FV** represents a grid at the most top right corner of the floor plan **100**. Once the spatial performance model **190** is established, the relevant performance data are stored and updated periodically in the servers **150**.

30 **[0034]** When a wireless device is within the coverage of the wireless network, performance characteristics of the wireless device are acquired by the server **150** via the WAP **110** to determine a grid **180** that corresponds to the location of the wireless device. The servers **150** further identify whether the wireless device is a valid user. In

FIG. 1, the laptop **111a** (at grid **CV**), **111b** (at grid **BZ**) and **111c** (at grid **FV**), the PC **113** (at grid **EZ**), the smart phone **112b** (at grid **FX**) and the tablet PC **114** (at grid **FY**) are valid users with agent program deployed, whilst the smart phone **112a** (at grid **AW**) is an invalid user. The respective position on the grids **180** of the wireless devices may be identified by a system and method disclosed in Singapore patent no. 120957 entitled “System and Method for Detection and Location of Rogue Wireless Access Users in a Computer Network” (SG120957). The system and method of SG120957 proximate a location range **140** for the location of each wireless devices. In SG120957, the location range **140** is an area having same or similar performance characteristics that can be detected by the WAP **110**. It is thereto referred as “the islands” or the like, and it has a same or similar meaning as the grid **180**.

[0035] Still referring to FIG. 1, when the smart phone **112a** enters the coverage of the wireless network, at least two of the valid users’ wireless devices having the agent program installed therein acquire the performance characteristics of the smart phone **112a** to determine a distance therebetween respectively. For easy reference, the wireless devices having the agent program deployed thereon may also herein after referred to as “the agent device”. In the present case, laptop **111a** and laptop **111b**, being the nearest two agent devices to the smart phone **112a**, acquire the performance characteristics data of the smart phone **112a** and send to the servers **150** via the WAP **110** for processing. Based on the acquired data, the servers **150** determine a distance, **D1**, between the laptop **111a** and the smart phone **112a**, and a distance, **D2**, between the laptop **111b** and the smart phone **112a**. With reference to the two distances **D1** and **D2**, the location of the smart phone **112a** can be identified by finding an intersection based on the distances.

[0036] In the above embodiment, the positions of the wireless devices are assumed static for simplicity. It is understood that the present invention is capable of detecting and tracking positions of moving wireless devices in real-time.

[0037] It is understood that the servers **150** incorporated with the WAP **110** can be treated as a wireless device for the purpose of the present invention.

5 [0038] For simplicity, only a two dimensional spatial performance model **190** is provided herewith. In accordance with an alternative embodiment, the spatial performance model **190** can be constructed in a three dimensional model for locating and tracking wireless devices at different heights, for example, different floors of building.

10 [0039] In accordance with yet another embodiment, the wireless network include a plurality of wireless access points and/or repeaters or reflectors for extending the coverage that ordinarily would go un-received for a larger floor plan.

15 [0040] In accordance with yet another embodiment, it is possible that the wireless network deploys an agent program automatically to a wireless device for performing location tracking.

[0041] FIG. 2 illustrates a system **200** for locating and tracking wireless devices in accordance with one embodiment of the present invention. The system **200** comprises a databases subsystem **201**, a performance reference profiles generator **202**,
20 a user registration administrator **203**, agent programs **204**, a network performance monitor **205**, a compensation model **206**, a ranking algorithm processor **207**, an positioning model **208**, a neighbours model **209** and a layout generator **210**. The system **200** is hosted by the servers **150**. The databases subsystem **201** manages data
25 for the system **200**. It comprises a plurality of databases that will be described in details later. In an alternative embodiment, the system **200** may be hosted at a wireless device, such as the desktop computer **113** for locating and tracking wireless devices accessing to the wireless network.

30 [0042] Still referring to FIG. 2, the performance reference profiles generator **202** constructs the spatial performance model **190** as a reference of performance

characteristics data for locating and tracking wireless devices based on the detected performance characteristics of the wireless devices. The spatial performance model **190** requires updating systematically and/or on an ad-hoc basis. The user registration administrator **203** handles registrations of new users for the system **200**. When a
 5 wireless device is connected to the wireless network via the WAP **110**, the user registration administrator **203** determines whether the wireless device is a valid user (or registered user) in a user register stored at the databases subsystem **201**. When the wireless device is identified as a valid user, the location of the wireless device is recorded and tracked as it moves among the wireless network. When the wireless
 10 device is identified as an invalid user, the user registration administrator **203** may request the wireless device to register as a new valid user. After the registration, the user registration administrator **203** deploys the agent program **204** in the wireless device. If the wireless device is not an authorized user, the user registration administrator **203** may deny access of that wireless device. The user registration
 15 administrator **203** may further record the wireless device identity, such as Media Access Control (MAC) address, as well as its locations for future references. The agent program **204** is deployed in the wireless device for performing background tasks, often known as “daemon”. The agent program **204** is configured to scan the existence of other nearby active wireless devices, collect data of performance characteristics of the
 20 active wireless devices, send the collected data to the server **150** for processing, and etc. The network performance monitor **205** monitors the wireless network’s traffic and records the traffic activities in the databases subsystem **201**.

[0043] Still referring to FIG. 2, the compensation model **206** provides
 25 algorithms for compensating irregularities due to background noise and radio interferences in performance measurement by using differential values. The ranking algorithm **207** compares the performance characteristics of the detected wireless device **112a** with an average of the historical reference performance characteristics pertinent to the time of the day of detection, and the algorithm **207** normalizes, ranks and yields a
 30 performance index, representing the performance characteristics of each area covered by the WAP **110**, with that of the detected wireless device **112a**. The positioning

model **208** acquires data from at least two agent devices and processes the data for determine a location of another wireless device. The neighbours model **209** generates a list of neighboring nodes within a specified vicinity for the wireless device to be tracked and the graphical interface for presenting the wireless devices locations and the relevant user data. The layout generator **210** comprises a floor plan generator **211** and an access point/base station generator **212**. The floor plan generator **211** generates a floor plan layout for graphically presenting on a computer screen. The access point/base station generator **212** provides exact locations of all WAPs and repeater or reflector, if any, and the layout is overlaid with the floor plan layout. With the generated floor plan layout, the neighbour model **209** establishes an overlay grid on the floor plan as a reference for identifying the location of wireless devices. It is understood that the grid may be in any matrix form or coordinate system for identifying location of wireless devices within the wireless network. The computer screen shows not only the device to be located, but all the active neighbouring nodes within the wireless network.

[0044] FIG. 3 illustrates a block diagram of the databases subsystem **201** of FIG. 2 in accordance with one embodiment of the present invention. The databases subsystem **201** is divided into two main modules; a dynamic updating module **301** and an admin module **302**. The dynamic updating module **301** requires real time updating of the wireless network performances and traffics. The admin module **302** stores users registration data and reference data for the system **200** processing. Each of the modules comprises sub-databases for handling data of different categories. The dynamic updating module **301** is further divided into a client subsystem **310** and a server subsystem **320**. The client subsystem **310** stores data of devices' particulars as feature of the agent program **204**. The data includes client particulars **311**, client performance **312**, client location **313** and client neighbour **314** and these data are correlated to each other by a unique client identity. The client particulars **311** include device type (such as laptop, PDA, etc), client description, identity number, MAC address, operating system type, and etc. The client performance **312** include date and time of which the performance characteristics data is measured and the relevant

performance characteristics include signal strength, signal-to-noise ratio, round-trip-response-time, and etc. The client location **313** includes a location of the wireless devices at a particular date and time, and the corresponding date and time. The client neighbour **314** includes client identity of other nearby devices, and the relevant date and time. The server subsystem **320** includes a site client **321**, site reference performance **322**, client capture performance **323**, client island **324**, client location **325** and client neighbour **326**. The site client **321** includes the client identity of all the wireless devices accessing to the wireless network and the time and date of access. The site reference performance **322** includes respective island identities and their performance characteristics include signal strength, signal-to-noise ratio, round-trip-response-time for the corresponding island. The client-captured performance **323** includes respective client identities and their performance characteristics such as signal strength, signal-to-noise ratio, round-trip-response-time, etc. The client location **325** includes the client identities and their location, time and date that computes by the system **200**. The client neighbour **326** records client identity of nearby devices at a particular time and date. The admin module **302** comprises a site island data **331**, a site location data **332**, a client register **333**, an access point location data **334** and a floor plan data **335**. The site island data **331** include island identities, island X-Y coordinates, island range radius/boundary, performance characteristics data and etc. The site location **332** includes location identity, location X-Y coordinates and etc which are identified by the positioning model **208**. The client register **333** contains all the registered users' particulars including client identity, client description, identity number, MAC address, operating system type, and etc. The access point location data **334** stores the access point/base station particulars, which include access point identity, access point description, access point model number, brand name, and location identity. The floor plan data **335** stores floor plan identity, floor plan description, floor plan file name, and etc.

[0045] FIG. 4 is a flow chart showing a process for tracking location of a wireless device in accordance with one embodiment of the present invention. The process comprises detecting of active user or system in step **410**; processing under the

compensation model **206** in step **420**; processing under the ranking algorithm **207** in step **430**; processing under the positioning model **440**; and presenting outcome in the neighbours model **209** in step **450**. In step **410**, the system **200** detects all the wireless devices (valid and invalid users) within the coverage of WAP **110** and identifies their validity status. The performance characteristics data for each of the devices are also acquired and stored in the databases subsystem **201**. For invalid users, the system **200** may prompt for registration as described above. In step **420**, the compensation model **206** provides an average value for the performance characteristics data for compensating the irregularities due to background noise and radio interferences. In step **430**, the ranking algorithm **207** first obtains performance characteristics data that are provided in the spatial performance model **190** and the acquired performance characteristics data of the wireless device and calculates differences between the performance characteristics data. A rank number can then be obtained by normalizing the differences with a minimum value of that difference. A performance index can then be derived by summing the rank number at each position, and the location of that wireless device can be identified from the performance index. In step **440**, the positioning model **208** further refines the location of the wireless devices via at least two nearby wireless devices having agent program deployed therein.

[0046] Taking an example shown in FIG. 1, the laptops **111a** and **111b** can be used for refining the position of the smart phone **112a**. The agent programs of the laptops **111a** and **111b** collect the performance characteristics data from the smart phone **112a**. Based on the performance characteristics data, a distance from **112a** to **111a** and **111b** respectively is determined and the refined location of the smart phone **112a** can accordingly be identified. Likewise, the location of the smart phone **112b** can also be refined by the positioning model **208** with tablet PC **114** and PC **113**. It is to be understood that the positioning model **208** is performed regardless of the user validity status. Further, by cross-referencing the location information obtained by each of the wireless devices, the accuracy improves. Yet, the nearer the agent devices to the device to be detected, the better the accuracy. In step **450**, the neighbour model **209** acquires the relevant data and information from the databases subsystem **201** for constructing a

floor plan graphically and for outputting the wireless devices' locations therein based on the processed results.

[0047] In step **430**, the ranking algorithm **207** suggests process for locating a wireless device based on the spatial performance model **190**. It is to be appreciated to the skilled person that the other method or algorithm, such as the algorithms suggested in SG120957, may be utilized.

[0048] FIG. 5 is a flow chart showing the processing under the compensation model **206** in accordance with one embodiment of the present invention. The compensation model **206** processes and provides a suitable average value for each of the performance characteristics at a particular spot in a period T in order to determine the location of the wireless device to be located. It is understood that RF signals (and the performance characteristics) in a wireless network fluctuates in ordinary environment. Depending on the performance parameter and environment, a threshold value is pre-determined based on field measurements and simulation results. When there is a temporarily change in the environment, for example a moving object passed by, the RF signal is interfered and the fluctuation may have a sudden change in the average value within that period T which may give a difference from the average values of it succeeding period that exceed the threshold. The difference exceeding the threshold affects the accuracy of the location determination. Accordingly, only the difference below the threshold value are provided. Therefore, the compensation is adapted to identify such changes and provides suitable average values. Performance characteristics and the threshold at key locations, such as corridors, that are prone to RF interferences may require frequent updates and refinements for better accuracy.

[0049] Still referring to FIG. 5, in step **510**, the compensation model **206** collects the performance characteristics data of the wireless devices for a period T. The period T can be any reasonable period, such as 30 seconds, set by the system administrator. In step **520**, an average value, A_T , for the performance characteristics data within the period T is computed. In the process, A_T changes as the time passed.

For each performance parameter, a difference between the currently obtained average, A_T , and the previously obtained average, A_{T-1} in previous period is calculated at step 530. The compensation model 206 determines if the difference is within the threshold at step 540. If the difference is within than the threshold, the compensation model 206 saves the current average value, A_T , at step 545 for further processing. If the difference exceeds the threshold, the compensation model 206, further computes a difference of the next average value, A_{T+1} , with the current average value, A_T , at step 550. The compensation model 206 then determines if the difference is smaller than the threshold at step 560. If the difference is smaller than the threshold, the compensation model 206 saves the next average value, A_{T+1} , at step 570 for further processing. If the difference is bigger than the threshold, the compensation model 206 saves the previous average value, A_{T-1} , at step 570 for further processing. In any event, the compensation model 206 provides a suitable average value of the performance characteristics for processing the location of the wireless device to be located.

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[0050] FIG. 6 is a flow chart showing the processing under the positioning model 208 in accordance with one embodiment of the present invention. At step 610, the ranking algorithm 207 is processed as described above. At step 620, the detected performance characteristics data of the wireless device to be located are mapped with an island or grid that best match the performance characteristics data. At step 640, the positioning model 208 obtains the performance characteristics data of the wireless device to be located from two of agent devices to determine the distance and direction from the respective two agent devices to the device to be located. The positioning model 208 then finds the intersections based on the detected distances and directions to determine the location of the device to be located. At step 640, the location of the device to be located is stored at the databases subsystem 201.

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[0051] FIGs. 7a and 7b show two screen shots provided by the neighbour model 209 in accordance with one embodiment of the present invention. The neighbour model 209 retrieves data from the databases subsystem 201, determines the set of neighbouring nodes based on a specified vicinity from the wireless device to be

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tracked and presenting the neighbour nodes and data in a graphical interface. FIG. 7a is a screen shot for a layout tab **710**. The layout tab **710** shows a floor plan **711** of floor of a building with the system **200** for locating and tracking provided therein. The floor plan **711** is divided by grid lines forming a coordinate system. On the floor plan **711**,
 5 six laptops are detected and their locations on the floor are shown in real time. Each of the laptops is bound by a dashed circle **715** indicating that the laptop could be in anywhere within the dashed circle **715**. FIG. 7b is a screen shot for a neighbour list tab **720**. The neighbour list tab **720** shows the list of neighbouring nodes within the vicinity of the wireless device to be tracked as well as some details of the neighbouring
 10 wireless devices. From the list, the six laptops are all valid users for the wireless network.

[0052] Depending on the resources that are available on the agent devices, it is possible that the agent program **204** is adapted to perform a local distance and location
 15 computation based on the received performance characteristics in accordance with a further embodiment of the present invention. The agent program **204** may further push the location information to the servers **150**.

[0053] As the present invention is able to locate wireless devices within the
 20 network and recorded the traffic and activities, it is understood that such system may be useful for identifying neighbouring nodes to enable various location-based application to be developed such as contact tracing and asset checking. The nodes/devices include any electronic devices that are wireless enabled such as PDA, handsets and other mobile devices.

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[0054] The proposed methods and systems address the challenges in identifying, locating and tracking both valid and invalid mobile/wireless nodes (users or/and systems) in a wireless network environment in real time.

30 [0055] The commercial enterprise which might be interested in pursuing commercialization of this invention includes wireless network system integrators or

solution providers which require location based applications to enable contact tracing, systems identification, route optimization, cost saving and enhance productivity

[0056] The above methodology may be incorporated into existing wireless location based system to further enhance its accuracy as well as to generate a set of neighbouring nodes for application in advanced military tactical deployment and training for urban warfare, home security, health care and retails industries for location tracking and contact tracing of fixed and mobile objects, users and systems.

[0057] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For example, wireless devices location and tracking system may be adapted for generating a list of neighbouring mobile nodes can be used for disease control in the event of an outbreak of contagious disease.

Claims

1. A system for locating and tracking wireless devices within a wireless network, the system comprising:
 - 5 a spatial performance model for pre-mapping out wireless performance characteristics within the wireless network;
an agent program for deploying on at least one of the wireless devices, the agent program operable to acquire performance characteristics data of neighboring wireless devices; and
 - 10 a positioning model operable to approximate a location range of each wireless device based on the wireless performance characteristics thereof, and subsequently further identify a location of the wireless device based on the performance characteristics data acquired by the agent program.
- 15 2. The system according to claim 1, wherein the positioning model determines the location of the wireless device based on a distance between the wireless device having the agent program and the wireless device to be located, wherein the distance is determined based on the performance characteristics data acquired by the agent program.
- 20 3. The system according to claim 1, wherein the wireless devices deploying with the agent program are registered users for the wireless network.
4. The system according to claim 1, wherein the positioning model is incorporated
- 25 in the agent programs.
5. The system according to claim 1, further comprising a server having the positioning model installed therein, wherein the server operable to receive the performance characteristics data acquired by the at least two agent programs to
- 30 determine the location of the wireless device to be located.

6. The system according to claim 1, further comprising a databases subsystem for storing users registration details and recording wireless performances and traffic activities.
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7. The system according to claim 6, wherein the agent programs comprises the databases subsystem.
8. The system according to claim 1, wherein the wireless performance characteristics are mapped in various spots or regions based on similarities of the performance characteristics.
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9. The system according to claim 8, wherein the spots or regions are divided into grids or islands.
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10. The system according to claim 8, further comprising a ranking algorithm operable to matching the performance characteristics data of the wireless device to be located with the spatial performance model for identifying the spot or region at which the wireless device to be located is locating.
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11. The system according to claim 6, wherein positions of the wireless device to be located are tracked and stored in the databases subsystem.
12. The system according to claim 1, further comprising a compensation model for processing and providing average values for the performance characteristics data within a period for compensating irregularities due to background noise and radio interferences.
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13. The system according to claim 12, wherein the average values provided by the compensation model is based on a pre-determined threshold value that is determined based on field measurements and simulation results.

5 14. The system according to claim 13, wherein when a difference between the average values of a period and its succeeding period exceed the threshold value, the average values of a current period is used if the difference does not exceed the threshold value.

10 15. The system according to claim 14, wherein when a difference between the average values of the current period and a previous period does not exceed the threshold value, the average values of the current period is provided.

15 16. The system according to claim 15, wherein when a difference between the average values of the current period and a next period exceeds the threshold value, the average values of the previous value is provided.

17. A method for locating and tracking wireless devices within a wireless network having a plurality of wireless devices, the method comprising:
20 pre-mapping a spatial performance model of wireless performance characteristics within the wireless network;
deploying an agent program in at least one wireless device;
acquiring performance characteristics data of neighboring wireless devices;
approximating a location range of each wireless device based on the wireless
25 performance characteristics thereof;
identifying a location of the wireless device based on the performance characteristics data acquired by the agent program.

18. The method according to claim 17, wherein determining the location of the
30 wireless device is based on a distance between the wireless device having the agent

program and the wireless device to be located, wherein the distance is determined based on the performance characteristics data acquired by the agent program.

19. The method according to claim 17, wherein the wireless devices deploying with
5 the agent program are registered users for the wireless network.

20. The method according to claim 17, wherein the step of processing the
performance characteristics data acquired by the at least two agent programs and the
step of determining the location of the wireless device to be located is performed by
10 one of the agent programs.

21. The method according to claim 17, further comprising processing the
performance characteristics data acquired by the at least two agent programs at a server
and determining the location of the wireless device to be located by the server.
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22. The method according to claim 17, further comprising storing users registration
details and recording wireless traffic activities at a databases subsystem.

23. The method according to claim 22, wherein at least one of the agent programs
20 comprises the databases subsystem.

24. The method according to claim 17, wherein the wireless performance
characteristics are mapped in various spots or regions based on similarities of the
performance characteristics.
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25. The method according to claim 24, further comprising dividing the spots or
regions into grids or islands.

26. The method according to claim 24, further comprising:

matching the performance characteristics data of the wireless device to be located with the wireless performance characteristics of the wireless network; and

5 identifying the spot or region at which the wireless device to be located is locating.

27. The method according to claim 22, further comprising tracking and storing the positions of the wireless device to be located in the databases subsystem.

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28. The method according to claim 17, further comprising:

processing average values for the performance characteristics data for a period; and

15 compensating irregularities due to background noise and radio interferences based on a threshold value.

29. The method according to claim 28, further comprising comparing a difference of the average values of a current period with that of its succeeding period with the threshold value, wherein, the average values of the current period is provided if it does
20 not exceed the threshold value.

30. The method according to claim 29, wherein when a difference between the current period and the previous period does not exceed the threshold value, the average values of the current period is provided.

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31. The method according to claim 30, wherein when a difference between the average values of the current period and a next period exceeds the threshold value, the average values of the previous value is provided.

SYSTEM AND METHOD FOR LOCATING AND TRACKING OF
NEIGHBOURING MOBILE NODES IN A WIRELESS NETWORK

ABSTRACT

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[0058] The present invention provides a system and method for locating and tracking neighbouring mobile nodes within a wireless network. The neighbouring mobile nodes include any wireless devices, such as laptop, smart phone, PDA, etc. The system and method provide agent programs for deploying in at least two of the wireless devices within the wireless network, wherein the agent programs acquires performance characteristics data of a wireless device to be located and determines the location of the wireless device to be located based on the performance characteristics data. There is also provided with a database for storing the locations of the wireless devices to be located for contact tracking and tracing.

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[0059] FIG. 1 for publication.