

PETITIONER'S DEMONSTRATIVES FOR ORAL ARGUMENT

Google LLC v. Geoscope Technologies Pte. Ltd.

Case No. IPR2023-01212

U.S. Patent No. 8,406,753

GOOGLE EXHIBIT 1033

Google v. Geoscope

IPR2023-01212

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE



US008406753B2

(12) **United States Patent**
Alles et al.
(10) **Patent No.:** **US 8,406,753 B2**
(45) **Date of Patent:** **Mar. 26, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING A LOCATION ESTIMATE USING UNIFORM AND NON-UNIFORM GRID POINTS**
(75) Inventors: **Martin Alles**, Vienna, VA (US); **John Carlson**, Dulles, VA (US); **George Maher**, Herndon, VA (US); **Selcuk Mazlum**, Leesburg, VA (US)
6,108,558 A 8/2000 Vanderspool, II
6,115,605 A 9/2000 Siccardo et al.
6,269,246 B1 7/2001 Rao et al.
6,281,834 B1 8/2001 Sulp
6,393,294 B1 5/2002 Perez-Breva et al.
6,449,486 B1 9/2002 Rao
6,564,065 B1 * 5/2003 Chang et al. 455/457
6,591,112 B1 7/2003 Siccardo et al.
(Continued)

(73) Assignee: **Andrew LLC**, Hickory, NC (US) FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1135 days.
EP 1471688 A2 10/2004
WO 0034799 A1 6/2000
(Continued)

(21) Appl. No.: **12/026,480** OTHER PUBLICATIONS

(22) Filed: **Feb. 5, 2008**
Rick Roberts, "Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANS)," Harris Corporation, Melbourne Florida, Oct. 4, 2004, pp. 1-11.

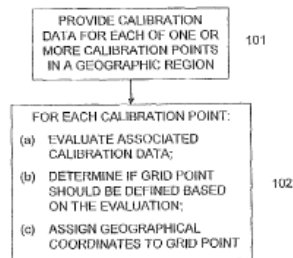
(65) **Prior Publication Data**
US 2008/0188237 A1 Aug. 7, 2008
(Continued)

Related U.S. Application Data
(60) Provisional application No. 60/899,379, filed on Feb. 5, 2007.
Primary Examiner — Melody Mehrpour
Assistant Examiner — Emmet Stephen
(74) *Attorney, Agent, or Firm* — Duane Morris LLP

(51) **Int. Cl.** **H04W 4/00** (2009.01)
H04W 24/00 (2009.01)
(52) **U.S. Cl.** **455/422.1**; 455/425
(58) **Field of Classification Search** 455/422.1, 455/423, 425, 433, 404.2, 456.1-456.3, 435.1-435.5, 340/870.04-870.05, 988-989, 991, 995.18, 340/995.25, 423.19; 342/357.2-357.25, 342/357.62; 702/85, 94-95, 150
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
5,960,341 A 9/1999 LeBlanc
6,097,709 A 8/2000 Kuwabara
57 Claims, 72 Drawing Sheets

(57) **ABSTRACT**
The location of a wireless mobile device may be estimated using, at least in part, one or more pre-existing Network Measurement Reports ("NMRs") which include calibration data for a number of locations within a geographic region. The calibration data for these locations is gathered and analyzed so that particular grid points within the geographic region can be determined and associated with a particular set or sets of calibration data from, for example, one or more NMRs. Sets of grid points may be evaluated as a function of parameters of the calibration data, and a set of grid points may be selected as a function of a predetermined criteria. The location of a mobile device in the geographic region may then be determined as a function of the predetermined criteria.



GOOGLE EXHIBIT 1001
Google v. Geoscope

U.S. PATENT NO. 8,406,753 (EX1001)

CHALLENGED CLAIMS

Proceeding	Claims challenged in Petition	Claims disclaimed by Patent Owner	Remaining claims
IPR2023-01212 (‘753 Patent)	1, 7, 9, 32, 38, 40	None	1, 7, 9, 32, 38, 40

1

SYSTEM AND METHOD FOR GENERATING A LOCATION ESTIMATE USING UNIFORM AND NON-UNIFORM GRID POINTS

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority benefit to and hereby incorporates by reference in its entirety co-pending U.S. Provisional Patent Application Ser. No. 60/899,379 filed on 5 Feb. 2007.

BACKGROUND

The present subject matter is directed generally towards a system and method for estimating the location of a wireless mobile device that is in communication with a wireless communications network. More specifically, the present subject matter relates to the problem of estimating the location of a wireless mobile device using information from one or more Network Measurement Reports ("NMRs") which may be generated by a wireless communications network or the mobile device.

As is well known in the art, the use of wireless communication devices such as telephones, pagers, personal digital assistants, laptop computers, anti-theft devices, etc., herein-after referred to collectively as "mobile devices", has become prevalent in today's society. Along with the proliferation of these mobile devices is the safety concern associated with the need to locate the mobile device, for example in an emergency situation. For example, the Federal Communication Commission ("FCC") has issued a geolocation mandate for providers of wireless telephone communication services that puts in place a schedule and an accuracy standard under which the providers of wireless communications must implement geolocation technology for wireless telephones when used to make a 911 emergency telephone call (FCC 94-102 E911). In addition to E911 emergency related issues, there has been increased interest in technology which can determine the geographic position, or "geolocate" a mobile device. For example, wireless telecommunications providers are developing location-enabled services for their subscribers including roadside assistance, turn-by-turn driving directions, concierge services, location-specific billing rates and location-specific advertising.

Currently in the art, there are a number of different ways to geolocate a mobile device. For example, providers of wireless communication services have installed mobile device location capabilities into their networks. In operation, these network overlay location systems take measurements on radio frequency ("RF") transmissions from mobile devices at base station locations surrounding the mobile device and estimate the location of the mobile device with respect to the base stations. Because the geographic location of the base stations is known, the determination of the location of the mobile device with respect to the base station permits the geographic location of the mobile device to be determined. The RF measurements of the transmitted signal at the base stations can include the time of arrival, the angle of arrival, the signal power, or the unique/repeatable radio propagation path (radio fingerprinting) derivable features. In addition, the geolocation systems can also use collateral information, e.g., information other than that derived for the RF measurement to assist in the geolocation of the mobile device, i.e., location of roads, dead-reckoning, topography, map matching, etc.

In a network-based geolocation system, the mobile device to be located is typically identified and radio channel assign-

2

ments determined by (a) monitoring the control information transmitted on radio channel for telephone calls being placed by the mobile device or on a wireline interface to detect calls of interest, i.e., 911, (b) a location request provided by a non-mobile device source, i.e., an enhanced services provider. Once a mobile device to be located has been identified and radio channel assignments determined, the location determining system is first tasked to determine the geolocation of the mobile device and then directed to report the determined position to the requesting entity or enhanced services provider.

The monitoring of the RF transmissions from the mobile device or wireline interfaces to identify calls of interest is known as "tipping", and generally involves recognizing a call of interest being made from a mobile device and collecting the call setup information. Once the mobile device is identified and the call setup information is collected, the location determining system can be tasked to geolocate the mobile device.

While the above-described systems are useful in certain situations, there is a need to streamline the process in order to efficiently and effectively handle the vast amount of data being sent between the wireless communications network and the large number of mobile devices for which locations are to be determined. In this regard, the present subject matter overcomes the limitations of the prior art by estimating the location of a wireless mobile device using, at least in part, one or more pre-existing Network Measurement Reports ("NMRs") which include calibration data for a number of locations within a geographic region. The calibration data for these locations must be gathered and analyzed so that particular points (e.g., "grid points") within the geographic region can be determined and associated with a particular set or sets of calibration data from, for example, one or more NMRs. Then, the received signal level measurements reported by the mobile device to be geolocated may be compared with the data associated with the various grid points to estimate the location of the mobile device. The performance of a grid-based pattern matching system such as that disclosed herein is typically dependent on stored received signal level measurements that accurately reflect the levels that are likely to be reported by the mobile device to be located. These grid points do not necessarily have to be part of a uniform grid and usually will not be uniformly distributed throughout the geographic region. These non-uniform grid points ("NUGs"), once determined, can be assigned geographic coordinates so that the NUGs may be used in determining the location of a mobile device exhibiting certain attributes as discussed in more detail below.

Accordingly, an embodiment of the present subject matter provides a method for assigning geographical coordinates to a grid point located in a geographic region for the location of a mobile device where the method provides calibration data for each of one or more calibration points in the geographic region and where for each of the calibration points the associated calibration data is evaluated and based on that evaluation a determination is made as to whether at least one grid point should be defined, and if so, geographical coordinates are assigned to the grid point.

An additional embodiment of the present subject matter further includes in the above method a determination of geographical coordinates for each of a plurality of nodes of a uniform grid spanning the geographic region and for each of the grid points determining a closest node from the plurality of nodes and assigning characteristic data associated with the grid point to the closest node.

THE '753 "PROBLEM"

The '753 Patent discloses "there is a need to *streamline the process* in order to efficiently and effectively *handle the vast amount of data* being sent between the wireless communications network and the large number of mobile devices for which locations are to be determined." EX1001, 2:21-26 (emphasis added); Pet. at 8-9.

The problem identified in the '753 Patent is a significant volume of data that needs to be searched during geolocation, and the need to perform such searching efficiently. EX1008, ¶26; Pet. at 8-9.

THE '753 “SOLUTION”

The '753 Patent's proffered solution is to: (1) **provide “calibration data” for each of one or more “calibration points” in a geographic region**, as known in the art, (2) **generate one or more sets of “grid points” for the “calibration data”**, (3) **evaluate “network measurement report” “calibration data” received from a mobile device at an unknown location with the generated “sets of grid points”**, (4) **to select “a set of grid points” using a predetermined criteria**, and lastly (5) **to determine the mobile device location as a function of the selected “set of grid points”** – all with a

grid-based pattern matching system. *See, e.g.*, EX1001, 2:26-50; Claim 1. EX1008,

¶27.

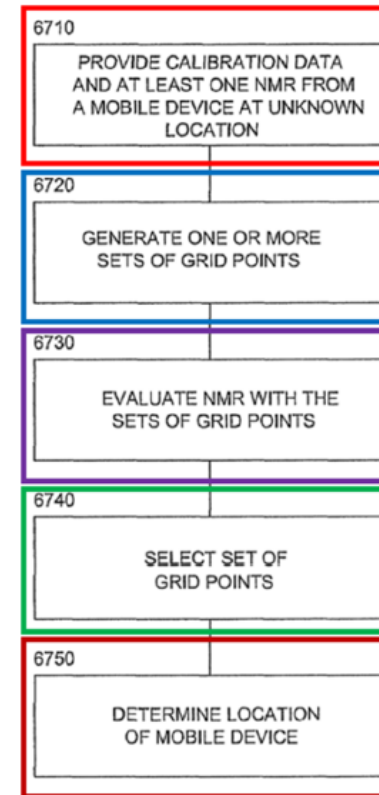


FIG. 67

CHALLENGED HIGHLIGHT CLAIMS RECITE METHOD/SYSTEM OF DETERMINING THE LOCATION OF A MOBILE DEVICE

1. A method of determining the location of a mobile device in a geographic region comprising the steps of:

- (a) providing calibration data for each of one or more calibration points in a geographic region, said calibration data having one or more characterizing parameters;
- (b) generating one or more sets of grid points for said calibration data;
- (c) receiving at least one network measurement report from a mobile device at an unknown location in said geographic region;
- (d) evaluating said at least one network measurement report with each of said sets of grid points as a function of select ones of said characterizing parameters;
- (e) selecting a set of grid points as a function of a predetermined criteria; and
- (f) determining the location of a mobile device in said geographic region as a function of said selected set of grid points.

7. The method of claim 1 wherein said calibration data comprises information from a network measurement report.

9. The method of claim 1 wherein said characterizing parameter is selected from the group consisting of: signal strength for a signal transmitted by a transmitter having a known location as received by a receiver at said grid point; signal strength of a signal transmitted by a transmitter located at said grid point as received by a receiver at a known location; round trip time for a signal traveling between said grid point and a known location; timing advance of a signal received by said mobile device at said grid point; time difference of arrival of plural signals at said grid point with respect to a pair of known locations as measured by a receiver at said grid point or at said known locations; the identification of a serving cell or serving sector of said mobile device located at said grid point; a state of a wireless network serving said mobile device, and combinations thereof.

CHALLENGED CLAIMS (continued)

32. A system for determining the location of a mobile device in a geographic region comprising:

- (a) a database; and
- (b) a processor for receiving calibration data for each of one or more calibration points in a geographic region and receiving at least one network measurement report from a mobile device at an unknown location in said geographic region, said calibration data and network measurement report having at least one characterizing parameter and said processor is programmed to:
 - (i) generate one or more sets of grid points for said calibration data,
 - (ii) evaluate said at least one network measurement report with each of said sets of grid points as a function of select ones of said characterizing parameters,
 - (iii) select a set of grid points as a function of a predetermined criteria, and
 - (iv) determine the location of a mobile device in said geographic region as a function of said selected set.

38. The system of claim 32 wherein said calibration data comprises information from a network measurement report.

40. The system of claim 32 wherein said characterizing parameter is selected from the group consisting of: signal strength for a signal transmitted by a transmitter having a known location as received by a receiver at said grid point; signal strength of a signal transmitted by a transmitter located at said grid point as received by a receiver at a known location; round trip time for a signal traveling between said grid point and a known location; timing advance of a signal received by said mobile device at said grid point; time difference of arrival of plural signals at said grid point with respect to a pair of known locations as measured by a receiver at said grid point or at said known locations; the identification of a serving cell or serving sector of said mobile device located at said grid point; a state of a wireless network serving said mobile device, and combinations thereof.

Final Construction of “Grid Point”

“a point associated with representative calibration data for an area”

“But the italicized language from which Plaintiff’s construction is drawn is directed more toward what *must be done* to arrive at a grid point or set of grid points rather than what a grid point *is*. ”

Case 1:22-cv-01331-MSN-JFA Document 105 Filed 07/19/23 Page 19 of 34 PageID# 2016

Plaintiff's Construction	Defendants' Construction
"locations or areas that are determined and associated with a particular set or sets of calibration data"	"a point associated with representative calibration data for an area"

Plaintiff argues that the Abstract of the '753 Patent provides a "near-definitional statement" of this disputed claim term, and that its construction is derived from that text. Pl. Br. at 14. Defendants argue that the specifications of the '753 Patent and related '104 Patent Family contemplate a grid point to be a single point that is representative of the calibration data for an area. See Defs. Br. at 15–17. Under the proposed constructions, the parties agree that a grid point encompasses an area. But there are two core disagreements: (1) whether the term can refer to a *location*, and (2) whether a grid point is "representative" of or "associated with" calibration data.

Plaintiff argues that its proposed construction is "near-definitional" language taken from the Abstract of the '753 Patent, which states, in relevant part:

The location of a wireless mobile device may be estimated using, at least in part, one or more pre-existing Network Measurement Reports ("NMRs") which include calibration data for a number of locations within a geographic region. *The calibration data for these locations is gathered and analyzed so that particular grid points within the geographic region can be determined and associated with a particular set or sets of calibration data from, for example, one or more NMRs.*

Ex. E at Abstract (emphasis added). But the italicized language from which Plaintiff's construction is drawn is directed more toward what *must be done* to arrive at a grid point or set of grid points rather than what a grid point *is*. The specification of the '104 Patent, sibling to the '753 Patent, provides a clear indication of the meaning of "grid point"—or a Non-uniform grid point (NUG)—as "NUGs represent an area of collected calibration data." Ex. B at 3:56–60; see *Andersen v. Fiber Composites, LLC*, 474 F.3d 1361, 1375 (Fed. Cir. 2007) (considering specification of sibling patent where the claims had same scope). The specification also describes NUGs as present[ing] the signal characteristics and/or calibration data over a given region." Ex. B at 3:19–20.

19

Google, referenced herein as "*Geoscope v. Google*," is case number 22-cv-1331. For the purposes of claim construction, however, Google and Apple have submitted identical claim construction briefs in this action and made a joint presentation at the *Markman* hearing.

³ The parties claim construction briefing addressed eleven disputed claim terms, but the parties subsequently reached an agreement on one of the disputed claim terms. See (*Geoscope v. Google*, Dkt. No. 100) (*Geoscope v. Apple*, Dkt. No. 89).

GOOGLE EXHIBIT 1028
Google v. Geoscope

PETITIONER'S EXPERT



Planet Depos
We Make It Happen™

Transcript of David Hilliard Williams

Transcript of David Hilliard Williams
Conducted on April 23, 2024

37

1 number of different areas so that you have a set of
2 calibration data, is it possible that some subset of
3 that calibration data would be representative of one
4 of those areas where you collected calibration data,
5 but not another?

6 MR. LEE: Objection. Form. Asked
7 answered.

8 THE WITNESS: It

9 BY MR. DESAI:

10 Q To determine which of that calibration data
11 is representative of an area would require analyzing
12 that set of collected calibration data, right?

13 MR. LEE: Objection. Form. Scope.
14 Relevance.

15 THE WITNESS: It would not require
16 analysis. It could be just the actual measurements,
17 and I believe that is an issue as part of the
18 calibration data construction, it being as:
19 "modified or unmodified network measurement data
20 associated with a geographical [sic] location."

21 So analysis could be part of it, but it
22 doesn't have to be.

PLANET DEPOS
888.433.3767 | WWW.PLANETDEPOS.COM Geoscope Exhibit 2023
Google v. Geoscope
IPR2023-01212, Page 38 of 148

Mr. Williams:

Q To determine which of that calibration data is representative of an area would require analyzing that set of collected calibration data, right?

...

THE WITNESS: It would not require analysis. It could be just the actual measurements....

PO Sur-Reply at 5: “there is no relevant difference in ‘evaluation’ and ‘analysis’ for purposes of this IPR”

Mr. Sturza: “I don’t recall if the district court construed ‘evaluating’ or ‘evaluation’ but I don’t recall it being in that section.” (EX1032, 68:15-25)

GRID POINT: GEOGRAPHICAL COORDINATES AND NETWORK MEASUREMENT REPORT DATA (FINGERPRINT)

US008406753B2

(12) **United States Patent**
Alles et al.

(10) **Patent No.:** **US 8,406,753 B2**
(45) **Date of Patent:** **Mar. 26, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING A LOCATION ESTIMATE USING UNIFORM AND NON-UNIFORM GRID POINTS**

(75) Inventors: **Martin Alles**, Vienna, VA (US); **John Carlson**, Dulles, VA (US); **George Maher**, Herndon, VA (US); **Selcuk Mazlum**, Leesburg, VA (US)

(73) Assignee: **Andrew LLC**, Hickory, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1135 days.

(21) Appl. No.: **12/026,480**

(22) Filed: **Feb. 5, 2008**

(65) **Primary Publication Data**
US 2008/0188237 A1 Aug. 7, 2008

Related U.S. Application Data

(60) Provisional application No. 60/899,379, filed on Feb. 5, 2007.

(51) **Int. Cl.**
H04W 4/00 (2009.01)
H04W 24/00 (2009.01)
(52) **U.S. Cl.** **455/422.1; 455/425.1**
(58) **Field of Classification Search** **455/422.1, 455/423, 425, 433, 404.2, 456.1-456.3, 435.1-435.5, 340/870.04-870.05, 988-989, 991, 995.18, 340/995.25, 423.19; 342/357.2-357.25, 342/357.62; 702/85, 94-95, 150**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,960,341 A 9/1999 LeBlanc
6,097,709 A 8/2000 Kuwahara

6,108,558 A 8/2000 Vanderpool, II
6,115,605 A 9/2000 Siccardi et al.
6,269,246 B1 7/2001 Rao et al.
6,281,834 B1 8/2001 Stulp
6,393,294 B1 5/2002 Perez-Breva et al.
6,449,486 B1 9/2002 Rao
6,564,065 B1* 5/2003 Chang et al. 455/457
6,591,112 B1 7/2003 Siccardi et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1471688 A2 10/2004
WO 0034799 A1 6/2000

(Continued)

OTHER PUBLICATIONS

Rick Roberts, "Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)," Harris Corporation, Melbourne Florida, Oct. 4, 2004, pp. 1-11.

(Continued)

Primary Examiner — Melody Mehrpour
Assistant Examiner — Emmet Stephen
(74) *Attorney, Agent, or Firm* — Duane Morris LLP

(57) **ABSTRACT**

The location of a wireless mobile device may be estimated using, at least in part, one or more pre-existing Network Measurement Reports ("NMRs") which include calibration data for a number of locations within a geographic region. The calibration data for these locations is gathered and analyzed so that particular grid points within the geographic region can be determined and associated with a particular set or sets of calibration data from, for example, one or more NMRs. Sets of grid points may be evaluated as a function of parameters of the calibration data, and a set of grid points may be selected as a function of a predetermined criteria. The location of a mobile device in the geographic region may then be determined as a function of the predetermined criteria.

57 Claims, 72 Drawing Sheets

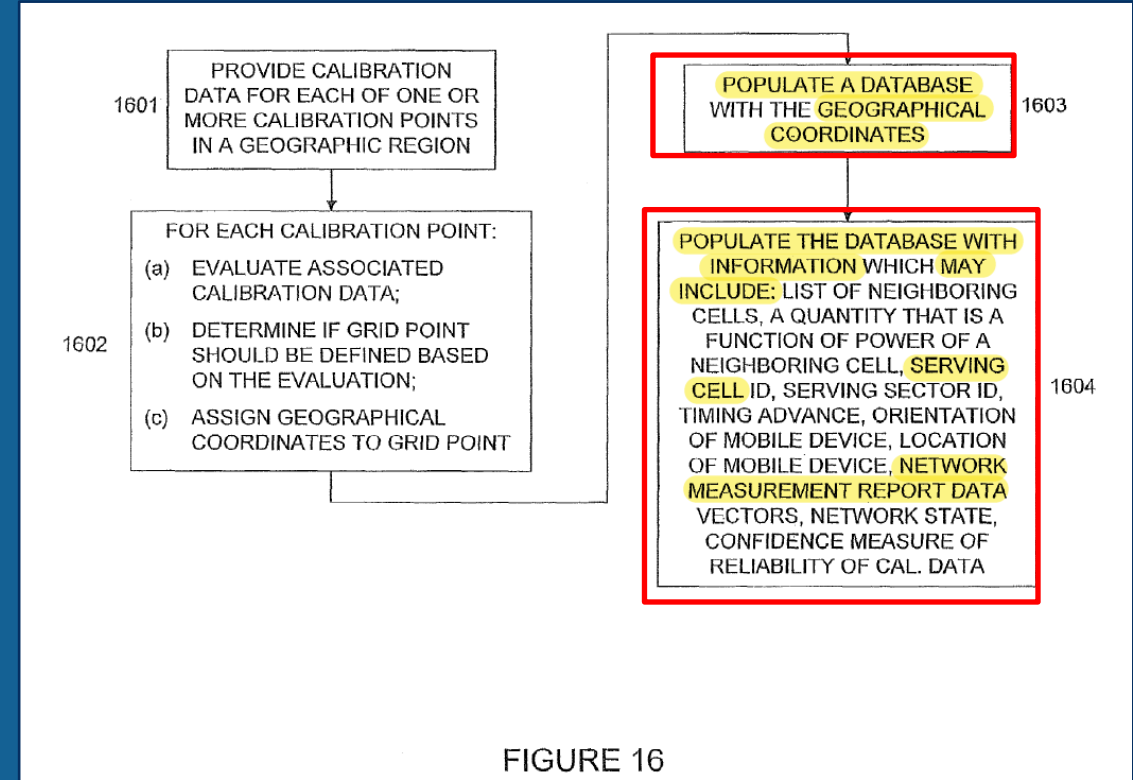
```

    graph TD
      A[PROVIDE CALIBRATION DATA FOR EACH OF ONE OR MORE CALIBRATION POINTS IN A GEOGRAPHIC REGION] --> B[FOR EACH CALIBRATION POINT:  
(a) EVALUATE ASSOCIATED CALIBRATION DATA  
(b) DETERMINE IF GRID POINT SHOULD BE DEFINED BASED ON THE EVALUATION  
(c) ASSIGN GEOGRAPHICAL COORDINATES TO GRID POINT]
  
```

101

102

GOOGLE EXHIBIT 1001
Google v. Geoscope



EX1001, Fig. 16.

“EVALUATION” IS NOT REQUIRED FOR A GRID POINT

An “evaluation” of calibration data is an example of *what can be done to arrive at a grid point* rather than *properties* of the grid point. Patent Owner’s expert Mr. Sturza acknowledged that the District Court’s final claim construction of “grid point” makes no mention of any “evaluation.” Reply at 4-5.

8/27/2024
Deposition of Mark Sturza
Page: 68

1 A. Okay.
2 Q. No trick questions, okay?
3 Pages 18 through 20 of the district court
4 Claim Construction talks about grid point.
5 Is that correct?
6 A. Yes.
7 Q. And on page 20 of the district court Claim
8 Construction there's a box that says Final Construction.
9 A. Yes.
10 Q. Correct?
11 A. Correct.
12 Q. And that's the final construction of "grid
13 point." Correct?
14 A. That's correct.
15 Q. Okay. My question to you is, in this
16 discussion on page -- starting on page 18 as it relates
17 to the construction of grid point that goes all the way
18 to page 20, is there any discussion of evaluation or
19 evaluating? Please let me know where that is mentioned
20 in the district court's Claim Construction.
21 ATTORNEY McBRIDE: Object.
22 A. Yeah, I -- I don't recall seeing that in those
23 pages. I don't recall if the district court construed
24 "evaluating" or "evaluation," but I don't recall it
25 being in that section.

BlueBear Reporting LLC

GOOGLE EXHIBIT 1032
Google v. Geoscope
IPR2023-01212

Reported by: Mary Ann Payonk
Job No. 1578

BlueBear Reporting LLC

“starting on page 18 as it relates to the construction of grid point ... is there any discussion of evaluation or evaluating?”

“I don’t recall seeing that in those pages. I don’t recall if the district court construed ‘evaluating’ or ‘evaluation’ but I don’t recall it being in that section.”

EX1032, p. 68, ll. 15-25.

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

THE '753 PATENT EXPRESSLY DISCLOSES MANY WAYS FOR GENERATING A GRID POINT ASSOCIATED WITH REPRESENTATIVE CALIBRATION DATA FOR AN AREA, INCLUDING MEASUREMENT OF A SINGLE SIGNAL STRENGTH.

8/27/2024
Deposition of Mark Sturza IPR2023-01209, IPR-01210, IPR-01211 & IPR-01212
Page: 1

1 UNITED STATES PATENT AND TRADEMARK OFFICE
2 BEFORE THE PATENT TRIAL AND APPEAL BOARD
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

GOOGLE LLC,
Petitioner
v.
GEOSCOPE TECHNOLOGIES PTE. LTD.
Patent Owner

Case No. IPR2023-01209
Patent 7,561,104
Case No. IPR2023-01210
Patent 8,400,358
Case No. IPR2023-01211
Patent 8,786,494

DEPOSITION OF MARK A. STURZA
TAKEN REMOTELY BY VIDEOCONFERENCE
August 27, 2024

Reported by: Mary Ann Payonk
Job No. 1578

GOOGLE EXHIBIT 1031
Google v. Geoscope
IPR2023-01212

BlueBear Reporting LLC

8/27/2024
Deposition of Mark Sturza IPR2023-01209, IPR-01210, IPR-01211 & IPR-01212
Page: 56

1 area whose boundaries are determined from evaluation of
2 the calibration data.
3
4 So when you're asking if the nonuniform grid
5 point can be signal strength, I don't understand how
6 that could be, how that would work.
7
8 Are you asking if -- can the signal strength
9 be the calibration data?
10
11 Q. Well, let's start with that.
12
13 Can the signal strength be the data that
14 constitutes the representative calibration data?
15
16 A. Well, that was, you know, as we saw, an
17 example in one point in the '104 patent.
18
19 Q. Is that a yes or a no?
20
21 A. That signal strength could be a calibration
22 data? Again, it's, you know, not something that I've
23 provided an opinion on here.
24
25 Q. So you do not have an opinion as to whether a
signal strength can constitute calibration data.
Is that correct?
A. Well, you know, just in the, you know, what we
looked at in the '104 patent, you know, it's talking
about calibration data and providing an example of the
signal strength. I agree that could be an example of
calibration data as well as the time of arrival and the
other things mentioned there.

BlueBear Reporting LLC

PATENT OWNER PROPOSES NEW CONSTRUCTION: NON-UNIFORM

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GOOGLE LLC,

Petitioner

v.

GEOSCOPE TECHNOLOGIES PTE. LTD.,

Patent Owner.

CASE: IPR2023-01212

U.S. Patent No. 8,406,753

PATENT OWNER'S SUR-REPLY

Case IPR2023-01212
Patent 8,406,753

I. INTRODUCTION

Patent Owner ("PO") proposes a construction of "[non-uniform] grid point" that further articulates the district court's construction to better address issues raised by the specific prior art used in the Petition. PO's construction is based on the intrinsic record, as well as the district court's construction and related analysis and the arguments advanced by Petitioner in its claim construction brief.

Petitioner's Reply opposes PO's construction, contradicting not only the Markman order, but also Petitioner's own representations to the court to obtain its construction. Petitioner told the district court one thing to obtain its construction, now Petitioner disavows those statements in its representations to the Board. Petitioner's arguments against PO's construction also fail because they avoid addressing PO's construction and mischaracterize the intrinsic and extrinsic evidence.

Spain does not teach NUGs under the appropriate construction because the prior art only teaches generating calibration data. That is, the prior art employs interpolation or extrapolation to estimate signal strength measurements—calibration data—against a pre-laid grid, not generate NUGs that define the grid. Accordingly, the challenged claims are patentable.

"[non-uniform] grid point"

PATENT OWNER'S FLAWED CLAIM CONSTRUCTION OF "NUG"

8/27/2024
Deposition of Mark Sturza IPR2023-01212
Page: 61

1 quoted section anywhere else, if you can help me
2 understand.
3
4 A. Sure, let me try and
5 of page 36, Spain does not teach
6 regarding generating one or more
7 Okay. So Spain is all about filling in
8 interpolating fingerprint database
9 know, filling in for sample locations
10 built -- taking fingerprint measurements at
11 predetermined locations --
12 (Reporter clarification)
13 THE WITNESS: Paragraph
14 fingerprint measurements at pre
15 using --
16 BY ATTORNEY FEDOWITZ:
17 Q. I -- I'm wondering about
18 not talking about that. I'm --
19 do you say that this does not t
20 A. Well, starting at the
21 particular, Spain does not teach
22 in the challenged claims require
23 one or more sets of grid points
24 Q. So, but why? Like, I
25 understand why, like --
26 A. Well, that's what I w

8/27/2024
Deposition of Mark Sturza IPR2023-01212
Page: 62

1 paragraphs 93 through -7 is why.
2 Q. Okay. Explain it to me, because it doesn't --
3 I don't understand.
4 A. Okay, so --
5 Q. Explain why it does not teach the quoted
6 section. Don't read.
7 ATTORNEY McBRIDE: Objection. Form.
8 A. Well, so the claims require generating or
9 generate one or more sets of grid points for said
10 calibration. And Spain talks about, you know,
11 fingerprint measurements at predefined locations and
12 interpolating fingerprints at locations between sample
13 locations, and that's not the grid points that are
14 claimed in the '753 patent.
15 BY ATTORNEY FEDOWITZ:
16 Q. Why? Why not?
17 ATTORNEY McBRIDE: Object to form.
18 A. Well, the '753 patent, the claimed grid points
19 are associated with representative calibration for an
20 area whose boundaries are determined from evaluation of
21 the calibration data.
22 BY ATTORNEY FEDOWITZ:
23 Q. I don't understand what you're talking about.
24 Can you explain that? It doesn't make sense.
25 ATTORNEY McBRIDE: Objection. Form.

8/27/2024
Deposition of Mark Sturza IPR2023-01212
Page: 61

1 UNITED STATES PATENT AND
2 BEFORE THE PATENT TRIAL
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

GOOGLE LLC
Petitioner
v.
GEOSCOPE TECHNOLOGIES
Patent Owner

Case No. IPR2023-01212
Patent 8,406,103

DEPOSITION OF MARK STURZA
TAKEN REMOTELY BY VIDEO
August 27, 2024

Reported by: Mary Ann Payonk
Job No. 1578

BlueBear Reporting LLC

BlueBear Reporting LLC

BlueBear Reporting LLC

Patent Owner's expert's testimony demonstrates reliance upon their flawed claim construction of a "[non-uniform] grid point" as requiring association with "representative calibration [data] for an area whose boundaries are determined from evaluation of the calibration data."

PATENT OWNER'S EXPERT WAS UNABLE TO CONFIRM DETAILS OF HOW "BOUNDARIES" ARE DETERMINED OR STORED FOR THE UNCLAIMED "NUGS"

8/27/2024
Deposition of Mark Sturza IPR2023-01209, IPR-01210, IPR-01211 & IPR-01212
Page: 1

1 UNITED STATES PATENT AND TRADEMARK OFFICE
2 BEFORE THE PATENT TRIAL AND APPEAL BOARD
3
4
5
6 GOOGLE LLC,
7 Petitioner
8 v.
9 GEOSCOPE TECHNOLOGIES PTE. LTD.
10 Patent Owner
11
12 Case No. IPR2023-01209
13 Patent 7,561,104
14 Case No. IPR2023-01210
15 Patent 8,400,358
16 Case No. IPR2023-01211
17 Patent 8,786,494
18
19 DEPOSITION OF MARK A. STURZA
20 TAKEN REMOTELY BY VIDEOCONFERENCE
21 August 27, 2024
22
23
24 Reported by: Mary Ann Payonk
25 Job No. 1578

GOOGLE EXHIBIT 1031
Google v. Geoscope
IPR2023-01212

BlueBear Reporting LLC

8/27/2024
Deposition of Mark Sturza IPR2023-01209, IPR-01210, IPR-01211 & IPR-01212
Page: 57

1 Q. Let's get back to the idea of the boundaries.
2 You mentioned boundaries in the construction.
3 Do you recall that?
4 A. Yes, I do.
5 Q. How are the boundaries determined?
6 A. Well --
7 ATTORNEY McBRIDE: Objection. Form.
8 A. -- they're determined from evaluation of the
9 calibration data.
10 BY ATTORNEY LEE:
11 Q. And after the boundaries are determined, are
12 they stored?
13 A. Well, you know, I think that's getting into
14 embodiments, which is something I haven't opined on.
15 Q. So the boundaries are not required to be
16 stored. Is that correct?
17 A. I -- you know, again, I haven't provided an
18 opinion on that. I don't recall if there's something in
19 the claim that goes one way or another on that. But,
20 you know, it's not something I've thought about, not
21 something I've provided an opinion on.
22 Q. Have you ever been a named inventor in a
23 US Patent?
24 A. Yes, I have. I have been a named inventor on
25 several patents.

BlueBear Reporting LLC

EX1031, p. 57, ll. 11-14; Reply at 9.

PATENT OWNER'S EXPERT CONCEDES THAT HE DID NOT PROVIDE ANY EXPLANATION OF THE DEGREE OF "SIMILARITY" THAT IS REQUIRED FOR A "NUG" OR THE "STATISTIC" EVEN CONSIDERED WHEN DETERMINING WHETHER DATA IS "STATISTICALLY" SIMILAR

8/27/2024
Deposition of Mark Stuebs 1980223-01209, 198-01210, 198-01211 & 198-01212
Page: 81

1 Q. In the first sentence of paragraph 69 you say
2 that: This evaluation involves determining which data
3 are statistically very similar.
4 Do you see that?
5 A. Yes, I do.
6 Q. How similar does the data have to be to
7 qualify as statistically very similar?
8 A. Well, you know, not something I've
9 opined upon here. It's -- you know, very -- "very
10 similar" is not a defined value, if you will.
11 Q. You then say: Using increasingly stringent
12 tests of statistical sufficiency.
13 Do you see that?
14 A. Yes, I do.
15 Q. What are increasingly stringent tests of
16 statistical sufficiency?
17 A. Just to be clear, these are, you know,
18 excerpts from various intrinsic evidence in the matter,
19 and it's not something, you know, that I've provided an
20 opinion on.
21 Q. Does the evaluation in your construction
22 require multiple stringent tests of statistical
23 sufficiency?
24 ATTORNEY McBRIDE: Objection. Scope.
25 A. Well, you know, not something that I provide

BlueBear Reporting LLC

"What statistic is considered when determining whether data is statistically similar?"

8/27/2024
Deposition of Mark Stuebs 1980223-01209, 198-01210, 198-01211 & 198-01212
Page: 82

1 an opinion on here. It's, you know, it's something
2 that, yeah, I would need to think about and, you know,
3 evidence, not something, you know, I've opined upon here.
4 I've opined upon here. It's -- you know, very -- "very
5 similar" is not a defined value, if you will.
6 Q. You then say: Using increasingly stringent
7 tests of statistical sufficiency.
8 Do you see that?
9 A. Yes, I do.
10 Q. What are increasingly stringent tests of
11 statistical sufficiency?
12 A. Just to be clear, these are, you know,
13 excerpts from various intrinsic evidence in the matter,
14 and it's not something, you know, that I've provided an
15 opinion on.
16 Q. Does the evaluation in your construction
17 require multiple stringent tests of statistical
18 sufficiency?
19 ATTORNEY McBRIDE: Objection. Scope.
20 A. Well, you know, not something that I provide
21 an opinion on here. It's, you know, it's something
22 that, yeah, I would need to think about and, you know,
23 evidence, not something, you know, I've opined upon here.
24 I've opined upon here. It's -- you know, very -- "very
25 similar" is not a defined value, if you will.

BlueBear Reporting LLC

"Again, not something I specifically opined upon."

GROUND 1: THE CHALLENGED CLAIMS ARE ANTICIPATED OR RENDERED OBVIOUS OVER SPAIN

ID at 36-37: “The above discussion related to anticipation also equally applies to the obviousness challenges presented by Petitioner, which support the reasonable likelihood of Petitioner prevailing in showing that claims 1, 7, 9, 32, 38, and 40 are obvious over Spain.”



US 2003/0064735 A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0064735 A1**
Spain et al. (43) **Pub. Date: Apr. 3, 2003**

(54) **LOCATION DETERMINATION USING RF FINGERPRINTING**

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/158,296, filed on Sep. 22, 1998, now Pat. No. 6,269,246.

Publication Classification

(51) **Int. CL⁷** **H04Q 7/20**
(52) **U.S. CL.** **455/456; 455/457**

(57) **ABSTRACT**
A method for determining the location of a mobile unit (mobile unit) in a wireless communication system is disclosed. The illustrative embodiment provides a computationally-efficient technique for reducing the number of possible positions that have to be analyzed. In particular, the illustrative embodiment eliminates possible positions for the mobile unit from consideration by considering which signals the mobile unit can—and cannot—receive and the knowledge of where those signals can and cannot be received.

Correspondence Address:
DEMONT & BREYER, LLC
PO BOX 7490
SHREWSBURY, NJ 07702 (US)

(21) Appl. No.: **10/299,398**

(22) Filed: **Nov. 18, 2002**



GOOGLE EXHIBIT 1006
Google v. Geoscope

U.S. PATENT PUB. NO. 2003/0064735 (“SPAIN”) (EX1006): SPAIN SOLVES THE “PROBLEM”

SPAIN GRID POINT IN LOCATION SERVER DATABASE

[illegible]

United States Patent
 (12) **Alles et al.**
 (10) **Patent No.: US 8,406,753 B2**
 (45) **Date of Patent: Mar. 26, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING A LOCATION ESTIMATE USING UNIFORM AND NON-UNIFORM GRID POINTS**

6,108,558 A 8/2000 Vanderspool, II
 6,115,605 A 9/2000 Siscario et al.
 6,269,246 B1 7/2001 Rao et al.
 6,281,834 B1 8/2001 Stulp

```

graph TD
    1601[PROVIDE CALIBRATION DATA FOR EACH OF ONE OR MORE CALIBRATION POINTS IN A GEOGRAPHIC REGION] --> 1602[FOR EACH CALIBRATION POINT:  
(a) EVALUATE ASSOCIATED CALIBRATION DATA;  
(b) DETERMINE IF GRID POINT SHOULD BE DEFINED BASED ON THE EVALUATION;  
(c) ASSIGN GEOGRAPHICAL COORDINATES TO GRID POINT]
    1602 --> 1603[POPULATE A DATABASE WITH THE GEOGRAPHICAL COORDINATES]
    1603 --> 1604[POPULATE THE DATABASE WITH INFORMATION WHICH MAY INCLUDE: LIST OF NEIGHBORING CELLS, A QUANTITY THAT IS A FUNCTION OF POWER OF A NEIGHBORING CELL, SERVING CELL ID, SERVING SECTOR ID, TIMING ADVANCE, ORIENTATION OF MOBILE DEVICE, LOCATION OF MOBILE DEVICE, NETWORK MEASUREMENT REPORT DATA VECTORS, NETWORK STATE, CONFIDENCE MEASURE OF RELIABILITY OF CAL. DATA]
  
```

FIGURE 16

COORDINATES TO GRID POINT

GOOGLE EXHIBIT 1001
 Google v. Geoscope

SPAIN DISCLOSES THE CHALLENGED CLAIMS

'753 Patent

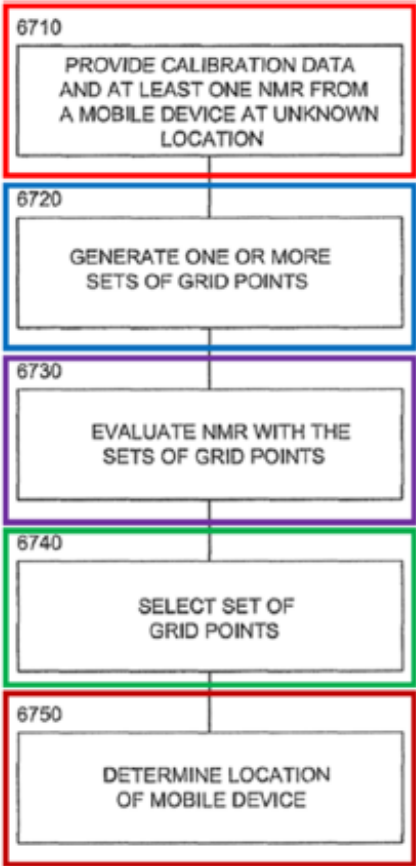


FIG. 67

Spain

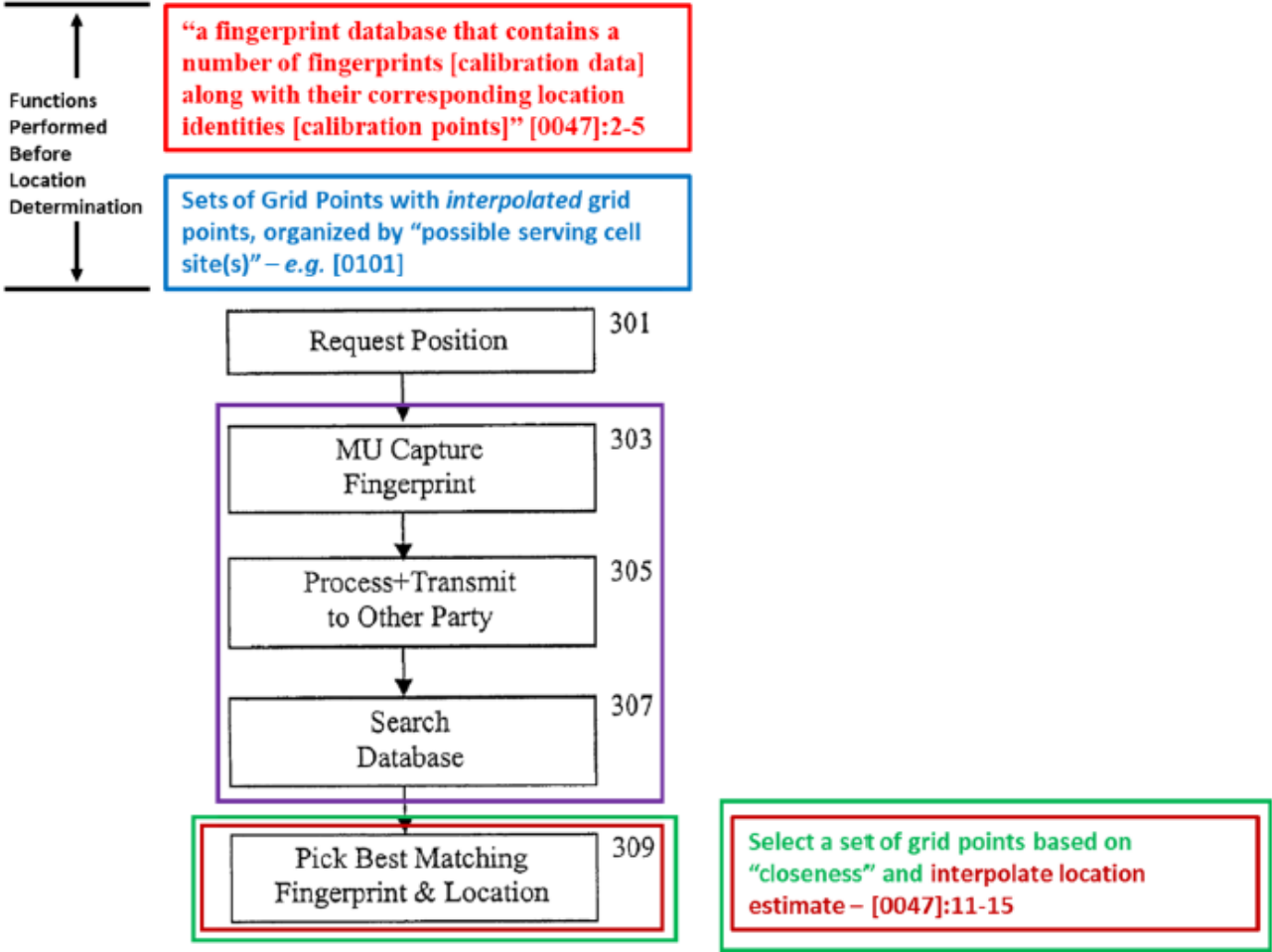


FIG. 67 DESCRIPTION OF THE '753 PATENT REGARDING CLAIM 1 REFERENCES "A PRE-DETERMINED FIXED UNIFORM GRID"

US008406753B2

(12) **United States Patent**
Alles et al.

(10) **Patent No.:** **US 8,406,753 B2**
(45) **Date of Patent:** **Mar. 26, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING A LOCATION ESTIMATE USING UNIFORM AND NON-UNIFORM GRID POINTS**

6,108,558 A	8/2000	Vanderspool, II
6,115,605 A	9/2000	Siccardi et al.
6,269,246 B1	7/2001	Rao et al.
6,281,834 B1	8/2001	Slip
6,393,294 B1	5/2002	Perez-Breva et al.
6,449,486 B1	9/2002	Rao
6,564,065 B1 *	5/2003	Chang et al.
6,591,112 B1	7/2003	Siccardi et al.

(Continued) 455/457

(75) Inventors: **Martin Alles**, Vienna, VA (US); **John Carlson**, Dulles, VA (US); **George Maher**, Herndon, VA (US); **Selcuk Mazlum**, Leesburg, VA (US)

(73) Assignee: **Andrew LLC**, Hickory, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1135 days.

FOREIGN PATENT DOCUMENTS

EP	1471688 A2	10/2004
WO	0034799 A1	6/2000

(Continued)

(21) Appl. No.: **12/026,480**

(22) Filed: **Feb. 5, 2008**

(65) **Priority Publication Data**
US 2008/0188237 A1 Aug. 7, 2008

Related U.S. Application Data

(60) Provisional application No. 60/899,379, filed on Feb. 5, 2007.

(51) **Int. Cl.**
H04W 4/00 (2009.01)
H04W 24/00 (2009.01)

(52) **U.S. Cl.** **455/422.1**; **455/425**

(58) **Field of Classification Search** **455/422.1**, **455/423**, **425**, **433**, **404.2**, **456.1**, **456.3**, **435.1**, **435.5**, **340/870.04**, **870.05**, **988**, **989**, **991**, **995.18**, **340/995.25**, **423.19**, **342/357.2**, **357.25**, **342/357.62**, **702/855**, **94**, **95**, **150**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,960,341 A	9/1999	LeBlanc
6,097,709 A	8/2000	Kuwabara

Rick Roberts, "Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANS)," Harris Corporation, Melbourne Florida, Oct. 4, 2004, pp. 1-11.

OTHER PUBLICATIONS

(Continued)

Primary Examiner — Melody Mehrpour

Assistant Examiner — Emem Stephen

(74) Attorney, Agent, or Firm — Duane Morris LLP

(57)

ABSTRACT

The location of a wireless mobile device may be estimated using, at least in part, one or more pre-existing Network Measurement Reports ("NMRs") which include calibration data for a number of locations within a geographic region. The calibration data for these locations is gathered and analyzed so that particular grid points within the geographic region can be determined and associated with a particular set or sets of calibration data from, for example, one or more NMRs. Sets of grid points may be evaluated as a function of parameters of the calibration data, and a set of grid points may be selected as a function of a predetermined criteria. The location of a mobile device in the geographic region may then be determined as a function of the predetermined criteria.

57 Claims, 72 Drawing Sheets

PROVIDE CALIBRATION
DATA FOR EACH OF ONE OR
MORE CALIBRATION POINTS
IN A GEOGRAPHIC REGION

101

FOR EACH CALIBRATION POINT:

- (a) EVALUATE ASSOCIATED CALIBRATION DATA;
- (b) DETERMINE IF GRID POINT SHOULD BE DEFINED BASED ON THE EVALUATION;
- (c) ASSIGN GEOGRAPHICAL COORDINATES TO GRID POINT

102

GOOGLE EXHIBIT 1001
Google v. Geoscope

US 8,406,753 B2

51

52

the geographic region or randomly located within said geographic region. The calibration data may also comprise information from at least one NMR, may be obtained from one or more mobile devices located in close proximity to the one calibration point, and/or may be obtained from a signal transmitted from a mobile device in close proximity to the one calibration point and received at a receiver in or in proximity to the geographic region. In one embodiment of the present subject matter for each of select ones of the calibration points, the calibration data may include plural data vectors and the evaluating of the calibration data may comprise a determination of clustering of the plural data vectors.

FIG. 67 is a flow chart for a method of determining the location of a mobile device in a geographic region according to one embodiment of the present subject matter. With reference to **FIG. 67**, at block **6710**, the method may comprise providing calibration data for each of one or more calibration points in a geographic region where the calibration data includes one or more characterizing parameters. At block **6710**, at least one NMR from a mobile device at an unknown location may be received. Of course, a set of NMRs may also be received in another embodiment of the present subject matter. At block **6720**, one or more sets of grid points for the calibration data may be generated, and at block **6730**, the at least one network measurement report may be evaluated with each of the sets of grid points as a function of select ones of the characterizing parameters. A set of grid points may be selected as a function of a predetermined criteria at block **6740**, and at block **6750**, the location of a mobile device may be determined in the geographic region as a function of the selected set of grid points. Exemplary predetermined criteria may be, but are not limited to, total probability, cluster radius, Euclidean norm, joint probability, and Mahalanobis distance. **Of course, any one or plural grid points may be located on a predetermined fixed uniform grid defined over the geographic region or randomly located within the geographic region.** The calibration data may also comprise information from at least one NMR. In one embodiment of the present subject matter for each of select ones of the grid points, the calibration data may include plural data vectors and the evaluating of the calibration data may comprise a determination of clustering of the plural data vectors. An exemplary characterizing parameter (which may have been extracted from the calibration points that were assigned to the corresponding grid point) may be, but is not limited to, signal strength for a signal transmitted by a transmitter having a known location as received by a receiver at the grid point, signal strength of a signal transmitted by a transmitter located at the grid point as received by a receiver at a known location, round trip time for a signal traveling between the grid point and a known location, timing advance of a signal received by the mobile device at the grid point, time difference of arrival of plural signals at the grid point with respect to a pair of known locations as measured by a receiver at the grid point or at the known locations, the identification of a serving cell or serving sector of the mobile device located at the grid point, a state of a wireless network serving the mobile device, and combinations thereof.

FIG. 68 is a flow chart for a method of determining the location of a mobile device in a geographic region according to another embodiment of the present subject matter. With reference to **FIG. 68**, blocks **6810**, **6820**, **6830**, **6840**, and **6850** are similar to blocks **6710**, **6720**, **6730**, **6740**, and **6750**, respectively. At block **6831**, in one embodiment of the present subject matter the evaluation of the at least one NMR may include (i) comparing select ones of the sets of grid points to at least one characterizing parameter of the at least one NMR,

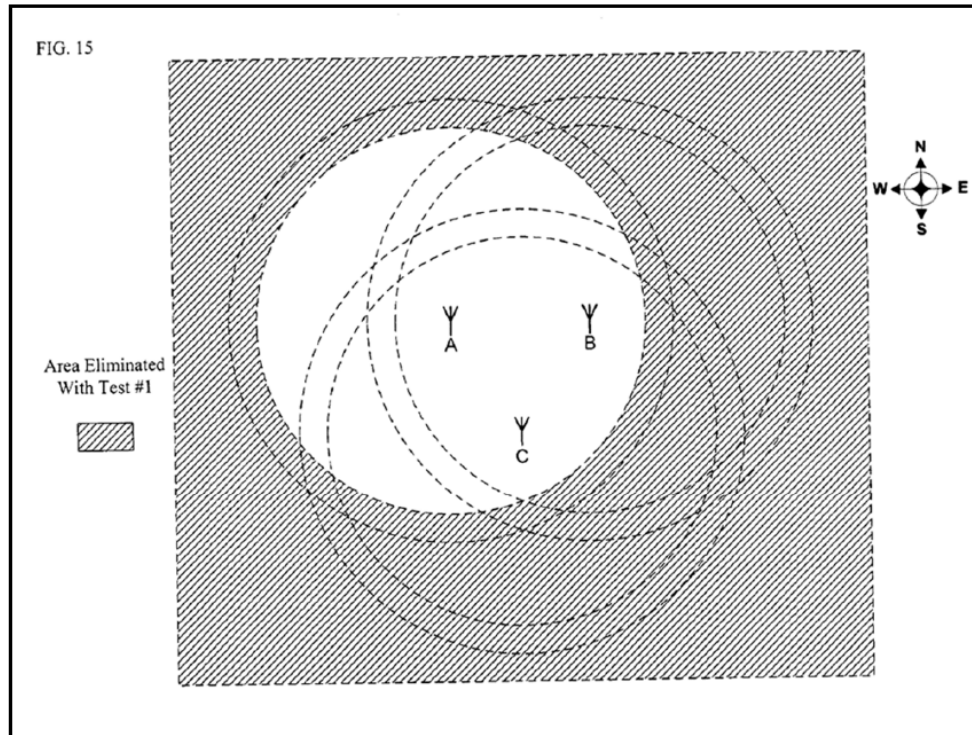
(ii) generating a first location estimate of the mobile device for each parameter of the NMR, and (iii) determining a second location estimate of the mobile device as a function of at least one of the generated first location estimates. At block **6832**, another embodiment of the present subject matter may further comprise the step of identifying and omitting outlier first location estimates by (i) determining a Mahalanobis distance from each first location estimate to the second location estimate, (ii) determining a distance threshold from a median of the Mahalanobis distances multiplied by a predetermined factor, and (iii) determining a third location estimate by averaging two or more of the first location estimates. First location estimates having a Mahalanobis distance to the second location estimate greater than the distance threshold may be omitted from the determined third location estimate.

At block **6833**, embodiments of the present subject matter may determine a second location estimate by averaging two or more first location estimates, or omit a first location estimate having an error greater than a predetermined threshold, at block **6834**. At block **6835**, embodiments of the present subject matter may also determine a second location estimate by employing a weighted averaging of ones of the first location estimates, or at block **6836**, determine a second location estimate by weighting a first location estimate by an inverse of a distance metric. At block **6837**, embodiments of the present subject matter may also determine a second location estimate by normalizing a first location estimate by a sum of an inverse of a distance metric, or at block **6838**, determine a second location estimate by weighting a first location estimate as a function of the number of reporting neighboring cells to a serving cell serving the mobile device.

FIG. 69 is a flow chart for a method of determining the location of a mobile device in a geographic region according to a further embodiment of the present subject matter. With reference to **FIG. 69**, blocks **6910**, **6920**, **6930**, **6940** and **6950** are similar to blocks **6710**, **6720**, **6730**, **6740**, and **6750**, respectively. At block **6931**, in one embodiment of the present subject matter the evaluation of the at least one NMR may include (i) comparing an ordered list of cells neighboring a cell serving the mobile device in the NMR to an ordered list of neighboring cells in each grid point of the geographic region where the ordering may be a function of any parameter of the NMR; and (ii) generating an estimated location of the mobile device. The estimated location may be, but is not limited to, a centroid of a cluster of matching grid points in the geographic region, a highest joint probability matching grid point in the geographic region, a weighted sum of the locations of a set of matching grid points in the geographic region (exemplary weights may be defined by any number of means such as, but not limited to, a joint probability derived from individual pdfs, etc.), a weighted sum of clustered locations of a set of matching grid points in the geographic region (i.e., cluster the locations of the matching grid points and then apply a cumulative probability for all contained grid points in a cluster as a weight for the respective cluster), as a function of locations determined from subsets of the calibration data, and any combination thereof.

At block **6932** in another embodiment of the present subject matter, the evaluation of the at least one NMR may include (i) comparing an ordered list of cells neighboring a cell serving the mobile device in the NMR to an ordered list of neighboring cells in each grid point of the geographic region where the ordering may be a function of any parameter of the NMR, (ii) if no exact match is made between the ordered list of neighboring cells of the NMR and any grid point in the geographic region then forming a largest subset of the ordered list of neighboring cells in the grid points that provide a

Spain's "Test #1" "[e]liminates all locations outside the serving area of the cell that is reported as the serving cell." EX1006, [0082] (emphasis added).



EX1006, Fig. 15; EX1008, ¶92.

SPAIN DISCLOSES: GENERATING A SET OF GRID POINTS ASSOCIATED WITH REPRESENTATIVE CALIBRATION DATA FOR AN AREA, AND HAVING A CHARACTERIZING PARAMETER (E.G., SIGNAL STRENGTHS, SERVING CELL)

SPAIN DISCLOSES FINGERPRINT DATABASE FOR “VARIOUS LOCATIONS”



US 20030064735A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.:** US 20
Spain et al. (43) **Pub. Date:**

(54) LOCATION DETERMINATION USING RF FINGERPRINTING

Related U.S. Applications

(76) Inventors: **David Stevenson Spain**, Portola Valley, CA (US); **Robert Lewis Martín**, Antioch, CA (US); **Luis Perez-Breva**, Barcelona (ES)

(63) Continuation-in-part of appl
filed on Sep. 22, 1998, now

Publication Classi

Correspondence Address:
DEMONT & BREYER, LLC
PO BOX 7490
SHREWSBURY, NJ 07702 (US)

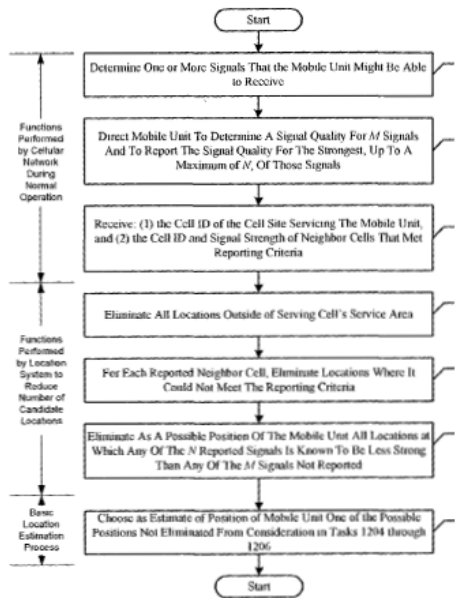
(21) Appl. No.: 10/299,398

(22) Filed: Nov. 18, 2002

(51) Int. Cl.⁷

(52) U.S. Cl.

(57) ABSTRACT
A method for determining the location of a mobile unit in a wireless communication system. The illustrative embodiment is a directionally-efficient technique for reducing the number of possible positions that have to be analyzed. The illustrative embodiment eliminates the need to consider a mobile unit from consideration by only considering the edge of where those signals can be received.



US 2003/0064735 A1

8

Apr. 3, 2003

latitude and longitude of the location to which the fingerprint corresponds. In one instance the fingerprint corresponds not to one exact spot on the surface of the earth, but instead to a small area. The Lat and Long fields in this embodiment indicate a position inside the area, preferably the center point. The Time column indicates the time at which the fingerprint was captured. In one embodiment the UTC time format is used to indicate this time. The Fingerprint column contains the actual fingerprint data. In one embodiment the structure depicted in **FIG. 9** is used to store the fingerprint data. Finally, the Description column contains a short description of the location corresponding to the fingerprint. For example, it may indicate a street address, or an intersection. This field is optional.

[0100] **Embodiment** the database built has relatively fine snapshots of fingerprints. The fingerprint information along with the coordinates of the location are entered into the database. The more the locations, the richer the database. The resolution of location determination is also controlled by how far apart the fingerprint samples are taken. The closer they are, the higher the resolution. Of course, a person skilled in the art can appreciate that the resolution of the database is limited by the sensitivity of the fingerprint measuring device. In one embodiment the fingerprints are taken using very sensitive signal measuring devices that enable locations that are very close to each other to have distinct fingerprints.

[0101] In another embodiment, the database is built by taking fingerprint measurements at predetermined locations and using intelligent algorithms that interpolate the fingerprints at all locations in between the sampled locations. This method has the advantage of not requiring a great many physical measurements to be made, however, it does suffer from some loss in accuracy. This is because, however clever, the interpolating algorithms will not be as accurate as making the actual measurements.

[1012] In yet another embodiment, the database is generated on-line using smart algorithms that can predict the fingerprints in a local area. This scheme is effective in instances where an approximate idea of the mobile unit location is already available. For example, this could be the cell in which the mobile unit is located.

[1013] Location estimation procedures using a predicted fingerprint model and fingerprint measurements from the mobile unit are subject to several sources of error, including errors in measuring the fingerprints and mismatches between the fingerprint model and the real world. If the predicted fingerprints in two locations are similar, either of these error sources may cause the measured fingerprint to more closely match the fingerprint model for the incorrect location than for the correct location. This situation leads to the possibility of fingerprint ambiguities.

[0104] For this embodiment of the invention, when a fingerprint model is produced for a particular region, it can be subjected to statistical analysis to assess both the location

accuracy that may be expected in that region and to identify specific areas that can have potential ambiguity problems. For each point in the fingerprint model, the probability distribution of ambiguous locations may be calculated, as a function of the level of errors expected, by computing the likelihood that each pair of location points will be confused at that error level. The characteristics of this distribution

provide information about the accuracy and confidence of location estimates. If the distribution at a particular point is tight (low statistical variance), location estimates of mobile unit's at that location should be quite accurate. If the distribution at a particular point is very broad (high statistical variance), location estimates of mobile unit's at that location are likely to be inaccurate. Conversely, if the calculated location estimate is at a point known to have high ambiguity (high statistical variance), the confidence attributed to that estimate should be low.

[0105] The following references are incorporated by reference in their entirety for all purposes:

[0106] 1. T. Suzuki, et al., The Moving-body Position Detection Method; Patent Application (Showa

work, IEEE Trans. on Systems, Man, and Cybernetics, 46, No. 1, pp. 65-71, February 1997.

[0108] 3. I. Gaspard, et al., Position Assignment in Digital Cellular Mobile Radio Networks (e.g. GSM) Derived from Measurements at the Protocol Interface, IEEE Journal, pp. 592-596, March 1997.

[0109] 4. J. Jimenez, et al., Mobile Location Using Coverage Information: Theoretical Analysis and Results, COST 259 TD (98), April 1999.

CONCLUSION

[0110] In conclusion, it can be seen that this invention has one or more of the following significant improvements over prior art for mobile unit location techniques: (1) it can be implemented without requiring any modifications to the existing wireless network infrastructure, (2) only minor software changes in the mobile unit (typically a cellular phone) are required, and (3) it can be utilized in areas where GPS coverage is either not available or not reliable. This follows because the fingerprints are generated by using portions of the RF spectrum that typically have superior coverage and in-building penetration than GPS signals.

[0111] While the above is a complete description of specific embodiments of the invention, various modifications, alternative constructions, and equivalents may be used. Therefore, the above description should not be taken as limiting the scope of the invention as defined by the claims.

What is claimed is:

1. A method for estimating the location of a mobile unit from a plurality of possible positions, said method comprising:

receiving an indication from said mobile unit that said mobile unit does not receive a first signal from a first transmitter;

eliminating some of said plurality of possible positions from consideration based on the fact that said mobile unit did not receive said first signal from said first transmitter; and

choosing as an estimate of said position of said mobile unit one of said plurality of possible positions not

[0100] In one embodiment, the database is built by taking off-line snapshots of fingerprints at various locations. The fingerprint information along with the coordinates of the location are entered into the database. The more the locations, the richer the database. The resolution of location determination is also controlled by how far apart the fingerprint samples are taken. The closer they are, the higher the resolution.

EX1006, at 8; Pet at 34, 36.

GOOGLE EXHIBIT 1006
Google v. Geoscope

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE 23

LOCATOR - Location Estimation System For Wireless LANs

Ankur Agiwal^{*}
ankur@iitd.ernet.in

Parakram Khandpur[†]
parakram@iitd.ernet.in

Huzur Saran
saran@cse.iitd.ernet.in

ABSTRACT

With the wide spread of wireless LANs and local area wireless networks, users have started to target location estimation based on the users' location awareness and user tracking. This becomes an increasingly important issue, we have developed a system for location estimation in wireless networks. Our system works at the network site, which involves various points in the radio map, the system estimates the location from the value of signal strength. Although the use of signal strength for location estimation is not new, but it builds and manages a database of signal strength queries. Moreover, in order to model the problem, we use a clustering based algorithm for location estimation. We use a wireless network testbed to evaluate the accuracy of location estimation with 90% accuracy.

Categories and Subject Descriptors: C.2.1 [COMPUTER-COMMUNICATIONS] Network Operations - Management

General Terms: Algorithms, Performance, Experimentation

^{*}Now a graduate student, Science, UNC, Chapel Hill
[†]Now a graduate student, Science, Stanford University

Permission to make digital or hard copies of this work for personal or classroom use is granted by ACM, provided that the fee of \$5.00 is paid directly to ACM. Copyright 2004 ACM 1-58113-XXXX-X/04/0010\$5.00

Thus, with the use of location-based clustering in the radio map building phase, the computation cost greatly reduces and makes LOCATOR scalable to larger wireless networks and also allows a finer granularity of the radio map. Till now, an assumption that there are only 3 wireless base stations in the wireless network has been made. In case there are more than 3 base stations then a first level clustering based on strongest signal base station can be done as described in [12]. After the first level clustering, location-based clustering can be used without any modification.

3.2 Location Estimation Phase

In the location estimation phase, the users periodically query the radio map database with their observed signal strengths (q_1, q_2, q_3) from the 3 base stations. To estimate a user's location, LOCATOR works as follows:

1. Performs a k -best search in the 3-dimensional signal space using the previous estimate of the user's location and (q_1, q_2, q_3)
2. Clusters the k points based on their physical closeness
3. For each cluster, estimates the most probable location of the user and its likelihood
4. Chooses the location with the highest likelihood as the current estimate of the user's location

The above steps are described below in greater detail.

3.2.1 K -best search

To reduce the computation cost, the k -best search is performed only on a portion of the radio map database. If the user's previously estimated location lies in some cluster (i, j) then the search space comprises of the cluster (i, j) and its neighboring clusters only as depicted in figure 2. For k -best search, a k -nearest neighbor search in the signal space is performed using the average values of the signal strengths stored in the radio map. Two points are considered to be the closest in the signal space if their Euclidean distance is the least i.e. (q_1, q_2, q_3) and (s_1, s_2, s_3) are the closest in signal space if the $(q_1 - s_1)^2 + (q_2 - s_2)^2 + (q_3 - s_3)^2$ is minimum. Algorithms exist that perform k -best search in $O(k \log n)$ time where n is the size of the sample to be searched.

3.2.2 Clustering based on physical closeness

The k candidate points $\{u_i\}_{i=1}^k$ obtained from the k -best search described in subsection 3.2.1, are now grouped into clusters based on their physical closeness.

Definition 1. The diameter of a cluster is the maximum distance between any two nodes in the cluster.

Clustering of nodes is done in a manner that each cluster has its diameter less than the maximum diameter, D . The optimum value of D is obtained empirically as discussed in section 4.4.2. Thus, if $d(u, v)$ denotes the distance between nodes u and v , then the clustering algorithm partitions the k points into m disjoint clusters $\{C_i\}_{i=1}^m$, such that

$$d(u, v) \leq D \quad \forall u, v \in C_i, 1 \leq i \leq m \quad (2)$$

Definition 2. The distance between two clusters C_i and C_j is denoted by $d(C_i, C_j)$ and is defined as:

$$d(C_i, C_j) = \max \{d(u, v) : u \in C_i, v \in C_j\} \quad (3)$$

Claim 1. If diameter of each of C_i and C_j is less than D and $d(C_i, C_j) < D$ then diameter of $C_i \cup C_j$ is less than D .

PROOF. Consider any edge $(u, v) \in C_i \cup C_j$
Case I: u and v belongs to same cluster. Say, $u \in C_i, v \in C_i$, then by definition of diameter $d(u, v) < D$.
Case II: u and v belongs to different clusters. Say, $u \in C_i, v \in C_j$ then by definition of distance $d(u, v) < D$. $\square$

Algorithm for clustering:

```

1   $C_i = \{u_i\}$  for all  $1 \leq i \leq k$ 
2   $S = \{C_1, C_2, \dots, C_k\}$ 
3   $i = k$ 
4  while  $(i > 1)$  do
5    begin
6      find  $i, j$  s.t.  $\Delta = \min\{d(C_i, C_j)\} \forall C_i, C_j \in S$ 
7      if  $(\Delta < D)$ 
8        begin
9           $C_{new} \leftarrow C_i \cup C_j$ 
10          $S = S - \{C_i, C_j\} + \{C_{new}\}$ 
11          $d(C_{new}, C) = \max\{d(C_i, C), d(C_j, C)\} \forall C \in S$ 
12          $S = S + \{C_{new}\}$ 
13       end
14     else stop
15      $i \leftarrow i - 1$ 
16   end
```

The above clustering algorithm terminates either when all the clusters have been merged into one single cluster or when no two clusters exist such that the distance between them is less than the maximum diameter D .

Steps 1, 2 and 3 take constant time and the while loop in step 4 can loop at most k times. Step 5 is $O(k^2)$ operation while steps 6, 8, 10, 11 and 12 are constant time operations. Steps 7 and 9 each take $O(k)$ time. Thus, the overall time complexity of the clustering algorithm is $O(k^3)$. But, k is small so number of operations are less.

3.2.3 Estimation of most probable location and its likelihood for each cluster

For each cluster, the most probable location and the likelihood of the user being at that location is calculated. For a cluster consisting of n points, Lagrange multipliers l_{1i}, l_{2i} , and l_{3i} corresponding to each of the n points are calculated as described below, where (q_1, q_2, q_3) is the signal strength tuple that the user has provided in his query request.

$$l_{1i} = \prod_{1 \leq j \leq n, j \neq i} \frac{(q_1 - s_{1j}^i)}{(s_{1i}^i - s_{1j}^i)} \quad \forall 1 \leq i \leq n \quad (4)$$

$$l_{2i} = \prod_{1 \leq j \leq n, j \neq i} \frac{(q_2 - s_{2j}^i)}{(s_{2i}^i - s_{2j}^i)} \quad \forall 1 \leq i \leq n \quad (5)$$

$$l_{3i} = \prod_{1 \leq j \leq n, j \neq i} \frac{(q_3 - s_{3j}^i)}{(s_{3i}^i - s_{3j}^i)} \quad \forall 1 \leq i \leq n \quad (6)$$

The effective multiplier at each point is calculated as average of these three multipliers.

$$\lambda_i = \frac{l_{1i} + l_{2i} + l_{3i}}{3} \quad \forall 1 \leq i \leq n \quad (7)$$

Agiwal (EX1005) provides further evidence of a way a POSITA would consider calculating “closeness” between signal strength fingerprints in the selection of multiple fingerprints in the same two-tiered searching context as Spain. Pet. at 32, citing EX1005, p. 105, Section 3.2.1.