

(19) World Intellectual Property Organization
International Bureau



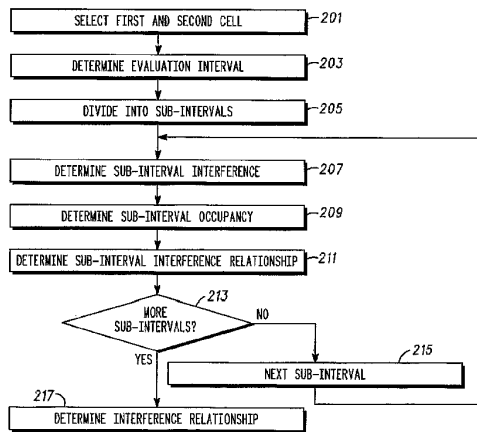
(43) International Publication Date
1 July 2004 (01.07.2004)

PCT

(10) International Publication Number
WO 2004/056145 A2

- (51) International Patent Classification⁷: **H04Q 7/36**
 - (21) International Application Number: PCT/EP2003/050950
 - (22) International Filing Date: 5 December 2003 (05.12.2003)
 - (25) Filing Language: English
 - (26) Publication Language: English
 - (30) Priority Data:
0229390.0 18 December 2002 (18.12.2002) GB
 - (71) Applicant (for all designated States except US): **MOTOROLA INC** [US/US]; 1303 E. Algonquin Road, Schaumburg, IL 60196 (US).
 - (72) Inventors; and
 - (75) Inventors/Applicants (for US only): **RATFORD, Michael** [GB/GB]; Ground Floor Flat, 10 Pulteney Street, Bath, Somerset BA2 4BR (GB). **BRUSCH, Simon** [GB/GB]; 1 Sandview, Faringdon, Oxfordshire SN7 7UT (GB). **WILLIAMS, Olatunde** [GB/GB]; Flat B, Avon House, Tithe Barn Crescent, Swindon SN1 4NP (GB).
 - (74) Agent: **LITCHFIELD, Laura**; Motorola European Intellectual Property Operations, Midpoint, Alencon Link, Basingstoke, Hampshire RG21 7PL (GB).
 - (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
 - (84) Designated States (regional): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— without international search report and to be republished upon receipt of that report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR DETERMINING AN INTERFERENCE RELATIONSHIP BETWEEN CELLS OF A CELLULAR COMMUNICATION SYSTEM



(57) Abstract: The invention relates to a system for determining an interference relationship between cells of a cellular communication system comprising at least a first cell and a second cell. A method comprises the step of dividing (205) an evaluation interval into a plurality of sub-intervals. For each sub interval, the method proceeds to determine (209) a sub-interval simultaneous occupancy related to the correlation between communication in the first and second cell. The sub-interval simultaneous occupancy is determined from an occupancy of each of the first cell and the second cell. A sub-interval potential interference is then determined (209) in response to the interference characteristics in each sub-interval. An interference relationship is subsequently determined from the sub-interval potential interferences and the sub-interval simultaneous occupancies. The interference relationship provides a measure of the impact of interference between the first and second cell suitable for frequency planning.

WO 2004/056145 A2

METHOD AND APPARATUS FOR DETERMINING AN INTERFERENCE
RELATIONSHIP BETWEEN CELLS OF A CELLULAR COMMUNICATION
SYSTEM

5

Field of the invention

The invention relates to a method and apparatus for determining an
interference relationship between cells of a cellular communication system and
10 in particular for determining an interference relationship suitable for
frequency planning.

Background of the Invention

15

FIG. 1 illustrates the principle of a conventional cellular communication
system 100 in accordance with prior art. A geographical region is divided into
a number of cells 101, 103, 105, 107 each of which is served by base station
109, 111, 113, 115. The base stations are interconnected by a fixed network
20 which can communicate data between the base stations 109, 111, 113, 115. A
mobile station is served via a radio communication link by the base station of
the cell within which the mobile station is situated. In the example of FIG. 1,
mobile station 117 is served by base station 109 over radio link 119, mobile
station 121 is served by base station 111 over radio link 123 and so on.

25

As a mobile station moves, it may move from the coverage of one base station
to the coverage of another, i.e. from one cell to another. For example mobile
station 125 is initially served by base station 113 over radio link 127. As it
moves towards base station 115 it enters a region of overlapping coverage of
30 the two base stations 113 and 115 and within this overlap region it changes to
be supported by base station 115 over radio link 129. As the mobile station 125

moves further into cell 107, it continues to be supported by base station 115. This is known as a handover or handoff of a mobile station between cells.

A typical cellular communication system extends coverage over typically an
5 entire country and comprises hundreds or even thousands of cells supporting thousands or even millions of mobile stations. Communication from a mobile station to a base station is known as uplink, and communication from a base station to a mobile station is known as downlink.

10 The fixed network interconnecting the base stations is operable to route data between any two base stations, thereby enabling a mobile station in a cell to communicate with a mobile station in any other cell. In addition the fixed network comprises gateway functions for interconnecting to external networks such as the Public Switched Telephone Network (PSTN), thereby allowing
15 mobile stations to communicate with landline telephones and other communication terminals connected by a landline. Furthermore, the fixed network comprises much of the functionality required for managing a conventional cellular communication network including functionality for routing data, admission control, resource allocation, subscriber billing, mobile
20 station authentication etc.

Currently, the most ubiquitous cellular communication system is the 2nd generation communication system known as the Global System for Mobile communication (GSM). GSM uses a technology known as Time Division
25 Multiple Access (TDMA) wherein user separation is achieved by dividing frequency carriers into 8 discrete time slots, which individually can be allocated to a user. A base station may be allocated a single carrier or a multiple of carriers. One carrier is used for a pilot signal which further contains broadcast information. This carrier is used by mobile stations for
30 measuring of the signal level of transmissions from different base stations, and the obtained information is used for determining a suitable serving cell during

initial access or handovers. Further description of the GSM TDMA communication system can be found in 'The GSM System for Mobile Communications' by Michel Mouly and Marie Bernadette Pautet, Bay Foreign Language Books, 1992, ISBN 2950719007.

5

Currently, 3rd generation systems are being rolled out to further enhance the communication services provided to mobile users. The most widely adopted 3rd generation communication systems are based on Code Division Multiple Access (CDMA) wherein user separation is obtained by allocating different
10 spreading and scrambling codes to different users on the same carrier frequency. The transmissions are spread by multiplication with the allocated codes thereby causing the signal to be spread over a wide bandwidth. At the receiver, the codes are used to de-spread the received signal thereby regenerating the original signal. Each base station has a code dedicated for a
15 pilot and broadcast signal, and as for GSM this is used for measurements of multiple cells in order to determine a serving cell. An example of a communication system using this principle is the Universal Mobile Telecommunication System (UMTS), which is currently being deployed. Further description of CDMA and specifically of the Wideband CDMA
20 (WCDMA) mode of UMTS can be found in 'WCDMA for UMTS', Harri Holma (editor), Antti Toskala (Editor), Wiley & Sons, 2001, ISBN 0471486876.

In order to optimise the capacity of a cellular communication system, it is important to minimise the impact of interference caused by or to other mobile
25 stations. Thus, it is important to minimise the interference caused by the communication to or from a mobile station, and consequently it is important to use the lowest possible transmit power. As the required transmit power depends on the instantaneous propagation conditions, it is necessary to dynamically control transmit powers to closely match the conditions. For this
30 purpose, the base stations and mobile stations operate power control loops, where the receiving end reports information on the receive quality back to the

transmitting end, which in response adjusts its transmit power. This ensures that the minimum transmit power necessary to ensure a given quality is used, and thus that interference caused by communication with each mobile station is minimised.

5

An important advantage of cellular communication systems is that, due to the radio signal attenuation with distance, the interference caused by communication within one cell is negligible in a cell sufficiently far removed, and therefore the resource can be reused in this cell. In GSM systems, carrier
10 frequencies are therefore reused in other cells in accordance with a frequency plan. Frequency planning is one of the most important optimisation operations for a cellular communication system in order to maximise the communication capacity of the system. The frequency planning typically considers a vast number of parameters including propagation characteristics, traffic profiles
15 and communication equipment capabilities.

Specifically, known frequency planning methods rely heavily on interference estimations between different cells. Automatic frequency planning methods have been developed wherein potential cross-interference and resulting carrier
20 to interference ratios are determined for different possible frequency allocations. Typically, an interference level is determined as the interference caused to a communication between a mobile station and a base station in one cell by a potential communication between a mobile station and base station in a different cell. Conventionally, the interference is determined from
25 propagation predictions based on calculated and measured propagation characteristics.

However, these interference values and carrier to interference ratios do not reflect the true impact on the performance of the communication system as
30 they do not consider the relationship between the caused interference and the quality of service parameters provided by the communication system.

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.