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(54) Titre : PROCEDE DE TRANSMISSION DE DONNEES D'EMPLACEMENT DE MATERIEL MOBILE DE TELEPHONIE CELLULAIRE

(54) Title: TRANSMISSION METHOD FOR CELLULAR TELEPHONY MOBILE EQUIPMENT'S LOCATION DATA

RXLEV-FULL-SERVING-CELL (6-bit)	Changed Tag (2-bit)
MCC High Byte	
MCC Low Byte	
MNC	
LAC High Byte	
LAC Low Byte	
Serving cell ID (High Byte)	
Serving cell ID (Low Byte)	
Number of monitored neighbouring cells	

(57) Abrégé/Abstract:

Method for cellular telephony mobile equipment location data transmission, in which an application, preferably installed on the SIM card, measures the Base Transceiver Stations in the serving cell and the neighbouring cells, detecting, storing and transmitting respective information to a remote Service Centre by means of SMS messages, where a processing system, applying an appropriate algorithm and a Base Transceiver Stations geographic position database, computes the geographical position of the mobile equipment. Transmission is made using a compressed format which requires a very low number of SMS messages.

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TRANSMISSION METHOD FOR CELLULAR TELEPHONY MOBILE EQUIPMENT'S LOCATION DATA

5 **Description**

This invention relates to personal communication systems, such as, for example, GSM operating standard communication systems, and specifically relates to a method for transmitting cellular mobile telephone location data.

10

As known, one of the possibilities offered by personal communication systems, such as the aforesaid GSM system, is the provision of location-based services, i.e. based on determination of the position of a mobile cellular telephone owner in an area served by one or more Base Transceiver Stations (BTS).

This is possible because modern GSM mobile equipment is capable of measuring Base Transceiver Stations in its own cell and neighbouring cells, detecting, storing and transmitting the respective information.

5

This information comprises:

1. National code (Mobile Country Code = MCC) pertaining to the serving cell;
2. Network code (Mobile Network Code = MNC) pertaining to the serving
10 cell;
3. Local area code (Local Area Code = LAC) pertaining to the serving cell;
4. Serving cell identification (Cell ID);
5. Control channel signal intensity of serving cell (RxLev);
6. Control channel signal intensity of neighbouring cells detected by the
15 telephone (RxLev);
7. Frequency indexes (BCCH-FREQ = Broad Control CHannel-Frequency)
univocally corresponding to channel numbers (ARFCN = Absolute Radio
Frequency Channel Number) and identification codes (BSIC = Base
transceiver Station Identity Code) related to neighbouring cell base
20 stations.

25

This information, consisting of numeric data, combined with the geographic positions of the Base Transceiver Stations, contained in a database generally provided by the mobile telephone operator, can be used by an appropriate calculation procedure to estimate the position of the GSM mobile equipment.

30

The described information is normally tracked by the mobile equipment via a SIM Toolkit type application, installed on the SIM card ("Subscriber Identity Module"), and compressed to be sent by means of SMS (Short Message System) messages to a remote Service Centre.

Firstly, the received messages are decompressed and then fed into a processing system, called "Location Engine", which, by applying an appropriate algorithm, computes the geographical position of the mobile equipment. If required, the system either informs the mobile equipment of its position or utilises it for a location-based service.

The need to reduce the number of SMS messages transmitted for each location request arises during the data exchange phase between mobile equipment and Service Centre. This corresponds to the precise needs of all mobile telephone operators, who cannot afford excessive traffic on their network for a single application, and of users, who require cost-effectiveness.

Additionally, reducing the number of transmitted SMS text messages means significantly reducing the response time of each location-based service, thus providing a significant contribution to service quality.

The cellular telephony mobile equipment location data transmission method which is the object of this invention overcomes said shortcomings and solves the described technical problems by implementing a compressed format for GSM mobile equipment location data suitable to be sent in the form of an SMS message.

Specifically, object of the invention is a method for transmitting cellular telephony mobile equipment location data, as described in the characterising part of claim 1.

Additional characteristics and advantages of the invention will now be described, by way of example only, with reference to the accompanying drawings wherein:

- Fig. 1 is the network and serving cell data format according to GSM standard;
- Fig. 2 is the signal intensity of all monitored cells, frequencies and identification codes of neighbouring cells;
- 5 - Fig. 3 is the channel number format of the neighbouring cell links;
- Fig. 4 is the first byte in the message according to the invention;
- Fig. 5 is the service data and measurement number format, where relevant;
- Fig. 6 is the data format of each measurement;
- Fig. 7 is the data format of each neighbouring cell.

10 The Base Transceiver Stations data format measured by the mobile equipment and supplied to its SIM card is described in GSM specifications and essentially concerns three different types of data:

- Data on the network and serving cell currently in use, indicated as MCC,
15 MNC, LAC and Cell ID in the description above. Numeric representation is illustrated in Fig. 1.
- Data on signal intensity in monitored cells, frequency index and neighbouring cell identification codes, indicated as RxLev, BCCH-FREQ and BSIC
20 in the description above. Numeric representation, defined in GSM 04.08 specifications, is illustrated in Fig. 2.
- List of neighbouring cell link channel number, indicated as ARFCN in the description above. Numeric representation, defined in GSM 11.14, specifications, is illustrated in Fig. 3.

25 As shown in Fig. 1, MCC, LAC and Cell ID are each represented by two bytes, High Byte and Low Byte, while MNC only requires one.

Fig. 2 shows data on signal intensity, frequencies, codes, etc., pertaining to neighbouring cells, distributed on 17 octets (or bytes), for up to eight monitored cells.

30

Specifically, the fields have the following meaning in GSM context:

- Measurement Results IEI (7 bits): identifier of the information that follows (IEI = Information Element Identifier), i.e. measurement results in this case;
- 5 - BA-USED (1 bit): BCCH coding type;
- DTX-USED (1 bit): indicating whether the mobile equipment uses DTX (DTX = Discontinuous transmission [mechanism]) or not, i.e. a power level transmission which is not continuous in the previous measurement period;
- 10 - RXLEV-FULL-SERVING-CELL (6 bits): intensity of the signal received from the serving cell, measured on all slots;
- MEAS-VALID (1 bit): indicating validity of measurements on the dedicated channel;
- 15 - RXLEV-SUB-SERVING-CELL (6 bits): intensity of the signal received from the serving cell, measured on a subset of slots;
- RXQUAL-FULL-SERVING-CELL (3 bits): quality of the signal received from the serving cell measured on all slots;
- RXQUAL-SUB-SERVING-CELL (3 bits): quality of the signal received from the serving cell measured on a subset of slots;
- 20 - NO-NCCELL-M (3 bits): number of measurements of neighbouring cells;
- RXLEV-NCCELL i (6 bits): intensity of signal received from the i-th neighbouring cell ($i = 1 \dots 6$);
- BCCH-FREQ-NCCELL i (5 bits): frequency index related to the BCCH channel of the i-th neighbouring cell;
- 25 - BSIC-NCCELL i (6 bits): identification code of the i-th neighbouring cell base station.

Fig. 3 illustrates the link frequency format, identified as the absolute number of the m-th radio-frequency channel (ARFCN#m). Each is formed by ten consecutive bits, subdivided into "high part" and "low part", and identified by

said frequency index BCCH-FREQ-NCELL i.

Sending all this information in standard GSM format would be rather costly in terms of the number of SMS messages required. This is because the mobile equipment must provide a certain number of consecutive measurements for sufficiently accurate and reliable location to filter detected signal frequency peaks (positive and negative).

According to the invention, the transmission of location data detected by the GSM equipment is made using a compressed format which requires a very reduced number of SMS messages. Naturally the number of SMS messages will be effected, since accuracy and reliability of location depends on the number of measurements made.

Generation of said format must be as simple as possible because it is processed by a SIM card application and, as known, the SIM card performance and computing capacity are poor if compared to those of a personal computer. Furthermore, a complex application would occupy a great deal of memory space, consequently penalising optional location-based services, which are interesting from a commercial point of view.

The application installed on the SIM card generates SMS messages containing location data in compressed format, comprising specific data on each single message, specific data on the message set, specific data on measurements and specific data on the serving cell and the neighbouring cells monitored by the mobile equipment. The dimensions of some data depend on the results of the measurements made at the current instant and those obtained at an earlier time.

The format description refers to Fig. 4, 5, 6 and 7 which illustrate tables in

which each line corresponds to a byte in the SMS message.

Considering that the aforesaid information can occupy more than one SMS message, the first byte of each message must contain the data shown in Fig. 4, i.e. the current SMS message number and the total number of messages dedicated to location data transmission.

The subsequent bytes in the body of the message contain information described in Fig. 5. Specifically, some bytes are dedicated to "possible service-specific data", i.e. data dedicated to a specific service. This is because the mobile equipment location process could be linked to high number of location-based services installed on the user's SIM card. In these cases, numerous other data may need to be communicated to the Service Centre. For example, transmission may include the selection the user made in a telephone menu (SAT application). Such data must be included in the transmitted SMS messages and integrated with pure location information.

An additional byte is used to indicate the number of measurements.

Fig. 6 lists the data transmitted for each measurements, particularly:

- RXLEV-FULL-SERVING-CELL (6 bits), i.e. the intensity of the serving cell signal;
- "Changed Tag" (2 bits), whose meaning is explained below;
- MCC (2 bytes, High byte and Low byte), present if the "Changed Tag" is higher than 2;
- MNC (1 byte), present if "Changed Tag" is higher than 2;
- LAC (2 bytes, High byte and Low byte), present if "Changed Tag" is higher than 1;
- Serving Cell ID (2 bytes, High byte and Low byte), present if "Changed Tag" is higher than 0;

- the number of monitored neighbouring cells (1 byte).

"Changed Tag" is useful when several consecutive measurements are required by the mobile equipment. This condition is necessary to obtain reliable locations. "Changed Tag" indicates which of the four cell data (Cell ID, LAC, MCC or MNC), related to the serving cell, have changed with respect to the previous measurement. When a new measurement is made, the procedure checks what has changed with respect to the previous data stored by the SIM card and sets the Changed Tag value consequently. Finally, only the data which have changed are added to the SMS message body.

The data listed Fig. 7 are measured and transmitted for each neighbouring cell, specifically:

- the relative intensity of the neighbouring cell signal (5 bits), computed on the previous measurements as explained below;
- "ARFCN-BSIC cache index" (3 bits), whose meaning will be explained below;
- ARFCN (10 bits), subdivided into two parts, one consisting of one byte and one by two bits. Present if "ARFCN-BSIC cache index" has binary value "111";
- BSIC (6 bits), also present if "ARFCN-BSIC cache index" has binary value "111";
- absolute intensity of neighbouring cell signal (8 bits), present if the relative intensity of the neighbouring cell" has binary value "11111".

The application residing on the SIM card uses a 6-byte memory table to compute the relative intensity of the neighbouring cell signal, one for each monitored neighbouring cell. During SMS message coding, each element of the table is initialised to binary value "11110". Subsequently, the following operations are carried out each time the neighbouring cell signal is detected:

- if the intensity of the current neighbouring cell is included in the binary range $\pm$ "01111" with respect to the intensity of the previous measurement related to the neighbouring cell in the same position, only the difference in intensity is transmitted (therefore only 5 bits in the SMS message are required) and the table is updated with the absolute value of the current intensity;
- otherwise the binary value "11111" is assigned to the relative intensity, the absolute current intensity value is sent in the subsequent byte and the table is updated with the same absolute value.

A similar reversed procedure is carried out on Service Centre side for decoding.

"ARFCN-BSIC cache index" is the index of the ARFCN-BSIC pair in a specific memory table (cache). The pair is used to determine the Cell ID which univocally identifies the neighbouring cell.

It is very likely for the set of monitored neighbouring cells to change significantly during multiple consecutive measurements required for correct location. Consequently, a specific table is used to reduce the space required to store the ARFCN-BSIC pairs related to monitored neighbouring cells. This table has a capacity of seven value pairs and is filled progressively as new ARFCN-BSIC pair values are found.

If a value present in the table is encountered, the row number, or index, containing the encountered value is used instead of the value itself. A considerable amount of space is saved since the index only occupies 3 bits, while the ARFCN-BSIC pair occupies 16 bits.

If an ARFCN-BSIC value which is not present in the table is encountered and the table is full, the new value will be written over the oldest, according to FIFO

mode. This mechanism ensures high simplicity in management and good efficiency. "ARFCN-BSIC cache index" is set to binary "111" and the real value is added in the subsequent bytes as shown in the format specifications when an ARFCN-BSIC pair value which is not present in the table is encountered. The
5 new value is thus added to the table.

A similar reversed procedure is carried out on Service Centre side for decoding.

Naturally, numerous changes can be implemented to the construction and
10 embodiments of the invention herein envisaged without departing from the scope of the present invention, as defined by the following claims.

AMENDED CLAIMS

1. Method for cellular telephony mobile equipment location-based services data transmission, in which an application, installed on a Subscriber Identity Module card, acquires information on Base Transceiver Stations in a cell serving a mobile equipment housing said Subscriber Identity Module card and in the related neighbouring cells, said application being configured for:

acquiring said information by said mobile equipment;

storing and transmitting said information to a remote Service Centre by means of messages, said remote Service Centre including a processing system applying calculation procedures and a Base Transceiver Stations geographic position database computing data associated to said location based services; and

generating at least one message containing a set of data in compressed format, said set of data comprising data of each single message, data on a message set, data on measurements and data on the serving cell and the neighbouring cells monitored by the mobile equipment.

2. Method according to claim 1 wherein said application is configured for:

- checking what data of the set have changed in results obtained at a current instant with respect to results obtained at an earlier instant, and

- adding to said at least one generated message only the data that have changed.

3. Method according to any of claims 1 or 2, wherein said set of data in compressed format comprise, for each message:

- a current message order number; and

- a total number of messages dedicated to location based services data transmission.

4. Method according to claim 3, wherein said set of data in compressed format comprise, in the message body:

- 5 - data dedicated to specific services; and/or
- a number of said measurements.

5. Method according to claim 4, wherein said set of data in compressed format comprise, for each measurement:

- 10 - data representing an intensity of a signal of the serving cell associated with said mobile equipment;
- a label indicating which data pertaining to the serving cell, among a serving cell identifier, a local area code, a mobile country code and a mobile network code, have changed with respect to a previous measurement;
- 15 - the mobile country code and the mobile network code if the label is higher than a first value;
- the local area code, if the label is higher than a second value;
- 20 - the serving cell identifier if the label is higher than a third value; and
- a number of monitored neighbouring cells associated with the mobile equipment.

6. Method according to claim 5, wherein said set of data in compressed format comprise for each neighbouring cell:

- 25 - a relative intensity of the neighbouring cell signal computed on the basis of the previous measurement;

- a cache index of a channel order number-identification code pair in a memory table;
- the channel order number and the identification code, if the cache index has a first binary value; and
- 5 - an absolute intensity of the neighbouring cell signal, if the neighbouring cell relative signal intensity has a second binary value.

7. Method according to claim 5, wherein whenever a new measurement is made, said application checks which data of
10 the serving cell among the serving cell identifier, the local area code, the mobile country code and the mobile network code have changed with respect to the previous measurement and consequently sets the label, adding only the data that have changed to the body of the message.

15 8. Method according to claim 1 wherein said at least one message containing a set of data in compressed format is a Short Message Service type message.

9. Method according to claims 1 wherein said processing system informs the mobile equipment of said geographical
20 position, if required.

10. Method according to claims 1 wherein said data in compressed format comprises service specific data dedicated to a specific service.

MCC High Byte
MCC Low Byte
MNC
LAC High Byte
LAC Low Byte
Cell ID High Byte
Cell ID Low Byte

PRIOR ART

Fig. 1

	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
Byte 1	ARFCN#1 (high part)							
Byte 2	ARFCN#1 (low part)			ARFCN#2 (high part)				
Byte 3	ARFCN#2 (low part)				ARFCN#3 (high part)			
...	...							
Byte X-1	ARFCN#m-1 (low part)				ARFCN#m (high part)			
Byte X	ARFCN#m (low part)					Spare bit (0)	Spare bit (0)	

PRIOR ART

Fig. 3

2/3

8	7	6	5	4	3	2	1	
Measurement Results IE1								octet 1
RA- USED	DTX USED	RXLEV-FULL-SERVING-CELL						octet 2
0 spare	MEAS- VALID	RXLEV-SUB-SERVING-CELL						octet 3
0 spare	RXQUAL-FULL SERVING-CELL				RXQUAL-SUB SERVING-CELL		NO- NCELL M (high part)	octet 4
NO-NCELL-M (low part)		RXLEV-NCELL 1						octet 5
BCCH-FREQ-NCELL 1					BSIC-NCELL 1 (high part)			octet 6
BSIC-NCELL 1 (low part)			RXLEV-NCELL 2 (high part)				octet 7	
RXLEV NCELL 2 (low part)	BCCH-FREQ-NCELL 2					BSIC-NCELL 2 (high part)		octet 8
BSIC-NCELL 2 (low part)			RXLEV-NCELL 3 (high part)				octet 9	
RXLEV- NCELL 3 (low part)	BCCH-FREQ-NCELL 3					BSIC- NCELL 3 (high part)		octet 10
BSIC-NCELL 3 (low part)				RXLEV-NCELL 4 (high part)				octet 11
RXLEV-NCELL 4 (low part)			BCCH-FREQ-NCELL 4					octet 12
BSIC-NCELL 4						RXLEV-NCELL 5 (high part)		octet 13
RXLEV-NCELL 5 (low part)				BCCH-FREQ-NCELL 5 (high part)				octet 14
BCCH- FREQ- NCELL 5 (low part)	BSIC-NCELL 5					RXLEV NCELL 6 (high part)		octet 15
RXLEV-NCELL 6 (low part)				BCCH-FREQ-NCELL 6 (high part)				octet 16
BCCH-FREQ- NCELL 6 (low part)		BSIC-NCELL 6						octet 17

PRIOR ART

Fig. 2

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Current SMS number (4-bit)	Total SMS number (4-bit)
----------------------------	--------------------------

Fig. 4

[Possible service-specific data]
...
Number of measurements

Fig. 5

RXLEV-FULL-SERVING-CELL (6-bit)	Changed Tag (2-bit)
MCC High Byte	
MCC Low Byte	
MNC	
LAC High Byte	
LAC Low Byte	
Serving cell ID (High Byte)	
Serving cell ID (Low Byte)	
Number of monitored neighbouring cells	

Fig. 6

Relative intensity of the neighbouring cell signal (5 bit)	ARFCN-BSIC cache index (3 bit)
ARFCN (bit 9, 8, 7...2)	
ARFCN (bit 1, 0)	BSIC (6 bit)
Absolute intensity of the neighbouring cell signal	

Fig. 7

RXLEV-FULL-SERVING-CELL (6-bit)	Changed Tag (2-bit)
MCC High Byte	
MCC Low Byte	
MNC	
LAC High Byte	
LAC Low Byte	
Serving cell ID (High Byte)	
Serving cell ID (Low Byte)	
Number of monitored neighbouring cells	