Agenda Item:

Source: **Lucent Technologies**

Title: **A flexible method for defining RF channels for UMTS**

Document for: **Information**

1   Introduction

This document proposes a flexible technique for defining the set of frequencies to be used a mobile for searching for a network, and for handover messages. The proposal can be extended to include handover to other systems, including (but not restricted to) GSM. This would effectively be an implementation of the logical global pilot channel, which has been proposed in ITU/R TG8/1. It will also support TDD (both in paired and unpaired frequency bands) and different duplex spacings.

The raster of possible carrier frequencies has already been defined to be 200kHz. However, it is obvious that only a small proportion can be used simultaneously. Previous contributions to TSG RAN WG4 [1] [2], have shown the benefits of reducing the number of defined RF channels, in terms of reduced search time (and hence battery consumption) and handover messages. On the other hand, a liaison statement from ERC TG1 [3] states that more flexibility may be required than provided by the fixed subset proposed in this contribution. This paper achieves both objectives.

There are three main parts to the proposal:

1)   A "default" list of frequencies, which would be programmed into the terminal on manufacture.

2)   A method of modifying the list if frequencies, both to add or remove frequencies from the list and to assign different priorities to different frequencies, to speed up the search process. The data could be either stored in the SIM, or downloaded over the radio interface from the home network, or both.

3)   A temporary list which can be broadcast by a network, and would (for example) take precedence over the other lists until the terminal attaches to a different network.

1.1   The default list

The default list of frequencies would be programmed into the phone during manufacture. It could be used by networks which did not wish to implement the modified list, or in circumstances in which the phone could not use it (e.g. if the modified list is stored on the SIM, and the user wants to make an emergency call on a phone without a SIM).

The channel raster proposed in previous contributions [1] [2] is suitable for use as the default list, and it is proposed that this is adopted.

1.2   The modified list

The modified list of frequencies is based on the default list, but with modifications made by the home network operator. These modifications could include:
-        addition of new entries to the list

- assigning different priorities to the list.
- "removing" entries from the list, by assigning them a priority such that they are never searched.

This would enable an operator to optimise the list used by phones which subscribe to his network, to speed up the search time for the networks which the terminal is most likely to use.

1.3 The temporary list

When a terminal is roaming, there may be occasions where it would be useful for the terminal to use a list which is specific to an individual roamed network. This could be achieved using a temporary list, which would take precedence over the default list and the modified list under specified conditions (defined by the home network operator). This list could be broadcast by the roamed network, and would be valid until the terminal connects to a different network.

One example where this could be useful is where indoor coverage is provided by TDD in some areas. If a terminal was switched on indoors where FDD coverage was not available, the speed at which the TDD carrier could be identified would be greatly increased.

2 The default list

The carrier raster of 200kHz is obviously not needed for such a dense carrier allocation but for fine-tuning of a carrier raster of basically 5MHz. It is therefore suggested to mirror these requirements in the carrier definition formula for the default frequency list:

$Fc = F_0 + 5$ MHz $* n + 200$ kHz $* k$; $F_0 = 1922.4$ MHz (for FDD band);

F_0 is the first (nominal) carrier center frequency (the spectrum used by the first carrier would then extend down to about 1920 MHz i.e. the IMT paired band); n is an integer running from 0 to 12 for the paired band and describes the channel, as if a regular 5MHz allocation was used, k is used to express a deviation from this regular scheme in steps of 200kHz. k can be positive or negative, but will only cover a small range. For the default frequency list the range $-2 \leq k \leq 2$ is proposed. This seems to be sufficient to perform carrier raster fine-tuning in most cases. It is then possible to shift two intra layer carriers as close as 4.2 MHz in order to get more separation to inter layer and inter operator carriers (up to 5.8 MHz).

Note that the carrier allocation is slightly unsymmetrical to the middle of a 5 MHz band because the latter is not a multiple of the 200 kHz synthesiser spacing. The value of 1922.4 has been chosen because this will give an extra 200 kHz separation to the satellite band which could be more vulnerable to intersystem interference. Of course, if need be, the uppermost carrier can still be placed closer, e.g. setting k=1.

3 The modified list

The parameters of entries in the default frequency list can be modified, and new entries can be added. This can either be performed over the air, or using data pre-programmed in the SIM.

The frequency list would contain the following fields:
- UTRA RF channel number (effectively, the number of the row in the table)
- Information relating to the transmit and receive frequency (eg uplink and downlink frequencies, uplink frequency and duplex separation).
- Whether the channel is FDD or TDD (if that is not obvious from the frequency information)
- A priority for each channel number (used to optimise searching for networks)
- Information about other options needed to decode the broadcast channel.

However, it is not the information stored in the terminal which will be standardised, but the messages which are sent over the air to change it. The following table contains the proposed elements for the messages to update the frequency table in the terminal. The first two elements extend the messages to allow handover between systems. For handover related messages, an RF channel can be fully described by the first three elements.

Element number	Information element	Number of bits	
1	Same/different system	1	Identifies whether the message relates to same or different system
2	Identification of system	8	Used for different systems only
3	UTRA RF channel number	10	A unique number for each raster position which is used, together with its associated parameters
4	Raster position	10	The complete set of permitted carrier frequencies
5	Priority	2 – 3	Enables an operator to assign different priorities to RF channels
6	RF channel type	2	Identifies TDD / FDD / uplink only / downlink only
7	Options	TBD	Identifies other options necessary to decode broadcast information

The following sections describe the use of these information elements in more detail (note that the elements are described in a different order, to simplify the explanation). Annex 2 contains some examples of messages and their effect on the frequency list.

3.1   The raster position for UTRA

The channel raster defines the complete set of all frequencies which are available for use, and must therefore (as far as possible) allow for all possible applications of UTRA. The channel raster defined for UTRA should be sufficiently flexible for all deployments within the IMT 2000 frequency bands, both in the initial deployment and in the longer term. It is proposed that the raster should be defined as:

		Permitted range	Expected range for initial deployment[1]
Uplink	$F (MHz) = 1885.2 + N_{raster} * 0.2$	0 – 698 (1885.2 - 2024.8MHz)	186 - 461 (1922.4 - 1977.4MHz)
Downlink	$F (MHz) = 2075.2 + N_{raster} * 0.2$	186 – 612 (2112.4 - 2197.6MHz)	187 – 460 (2112.6 – 2167.2MHz)
TDD	$F (MHz) = 1885.2 + N_{raster} * 0.2$	0 – 698; 1885.2 - 2024.8MHz	84 - 462 (1902.0 – 1977.6MHz) 638 - 685 (2012.8 – 2022.2MHz)

This raster extends closer to the edge of the IMT2000 bands than can be used with the current state of technology. However, these frequencies are included in the raster to allow for possible advances in the technology of UTRA or in frequency co-ordination techniques. The proposed channel raster information element uses 10 bits.

3.2   UTRA RF Channel number

The UTRA RF channel number identifies frequencies to be used by a terminal (eg in messages relating to neighbour lists and handover). It identifies the channel raster number and any other parameters necessary for a terminal to decode the broadcast information (such as whether the channel is TDD or FDD).

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[1]   These ranges are based on the Draft ERC Decision on Utilisation of spectrum for Terrestrial UMTS. It may be possible to extend this range slightly when the chip rate is reduced to 3.84Mchip/s

The default list of RF channels and any further RF channels and any further UMTS RF channel numbers which are defined together form the set of UTRA RF Channel Numbers.

3.3 Assigning Priorities to RF channels

The default list of frequencies must assign an equal priority to all frequencies within it, because the list is programmed during manufacture, and must be applicable to all customer. However, when a terminal is used on a particular network, the frequencies which are used most often will be those of the home network. Next most commonly used will be the frequencies used in preferred roaming networks. There may be some frequencies in the default list which are not used in any network with which roaming is permitted; the terminal can be prevented from wasting time searching for signals on these frequencies (except, perhaps, when performing a manual full network search).

It is therefore proposed that there should be four levels of priority:

- First priority; normally the home network
- Second priority; normally preferred roaming network.
- Third priority; normally a frequency used in any network with which there is a roaming relationship
- Zero priority; a frequency which is not used in any valid network.

(Input from operators is welcome as to whether four levels of priority is sufficient for all applications).

3.4 Handover between systems

The first information element in the message is a flag which indicates whether the remainder of the message relates to UTRA or to a different system such as GSM. The second information element identifies which other system the remainder of the message relates to; this need only be sent if the message relates to a system other than UTRA. The contents of the remainder of the message would be specific to each system, but it would be beneficial if the structure of the message is kept consistent.

Some examples of systems to which dual mode phones may be manufacturers, for which handover and/or roaming may be needed, include:

- UTRA in the PCS band.
- GSM in the GSM 900, GSM 1800 and GSM 1900 bands
- EDGE in the IMT 2000 band.
- Multicarrier in the PCS band
- Multicarrier in the IMT 2000 band (if it has a raster other than 200kHz)
- Satellite mobile systems

The number of systems for which handover will need to be supported (either immediately or in the future) is almost certain to be less than 256; therefore 8 bits should be sufficient for this element.

This proposal is effectively an implementation of the concept of the "Global Logical Pilot Channel", which has been proposed in ITU TG 8/1.

3.4.1 Handover to GSM

For handover to GSM, the format could be very similar to that proposed for UTRA. The UTRA RF channel number could be replaced by the GSM ARFCN; in this case the information element for raster position would not also be needed. Currently in GSM, ARFCNs are not assigned different priorities. However this could be beneficial for multi-mode phones to reduce the search time, which could otherwise be very lengthy for a phone supporting several modes.

3.5   Support of TDD

It is necessary to support the option of TDD within the paired band, and it is therefore not possible to distinguish TDD from FDD by the raster position. Element 6 is therefore used to indicate if the UTRA RF channel is TDD or FDD. This is illustrated in Annex B.

3.6   Support of different duplex spacing

The normal message format assumes that FDD channels use the default duplex spacing of 190MHz. However, it is possible to define an UTRA RF channel with a different duplex spacing by sending two messages, one for the uplink only and a second for the downlink only. This is illustrated in Annex B.

3.7   Support for IMT 2000 extension bands

The IMT 2000 extension bands can be supported either by using the raster positions which are currently not defined, or by defining a "new system".

If the channel raster information element uses 10 bits, there would be sufficient undefined positions for an additional 65MHz to be included.

If an extra "system" was defined for use of UTRA in the IMT 2000 extension bands, one "system" would allow for 204.8 MHz of extension spectrum.

3.8   Support for future enhancements

The message includes a field for options, which can include options which are not yet defined. Only those options which are necessary to decode the broadcast channel need be included. One example of an option which may need to be signalled in this way is different chip rates such as 8.192Mchip/s.

3.9   Handover messages

For handover, all that is needed is a "pointer" to the correct entry in the table in the terminal; for this, the only information elements which need to be included in the handover message are:

Element 1	Same/different system
Element 2 (for handover to different systems)	Identity of system
Element 3	UTRA RF channel number (or equivalent, for different systems).

4   Downloading frequency information to the terminal

This paper does not address in detail the mechanisms which might be used to signal the messages which update the frequency table. This section describes one possibility.

Default frequency list

-        Programmed into the terminal on manufacture.

Modified frequency list

-        Latest information programmed into the SIM when it is sent to the subscriber.
-        Messages sent from the home network to the SIM using SIM toolkit.
-        Data transferred from the SIM to the terminal whenever it is switched on, or whenever a message is received.

Temporary frequency list

-	transmitted by SMS cell broadcast and stored by terminals when roaming.

# 5	References

[1]	TSGR4#3 (99) 100; Definition of Channel Raster; Siemens

[2]	TSGR4#4 (99) 202; Suitability of Channel Raster for various Scenarios; Siemens

[3]	TSGR4#4 (99) 188; Response to 3GPP TSG RAN LS on Carrier Frequency Raster; ERC TG1.

Annex A: Proposed message content and format

Element number	Information element	Number of bits	Used for updating frequency table	Used for handover	Comments
1	Same/different system	1	**X**	**X**	0 = message relates to the same system 1 = message relates to a different system
2	Identification of system	8	**X**		This information element is only sent if the content of the previous element is 1. See note 1
3	Assigned RF channel number	10	**X**	**X**	This is the number of the row in a table of RF channels which are defined for use. See Note 2
4	Raster position	10	**X**		This is the complete set of possible channels. The number of bits for this element must be greater than or equal to the previous field. See Note 3.
5	Priority	2 - 3	**X**		This assigns a priority for searching assigned channel numbers when searching for a network See Note 4
6	RF channel type	2	**X**		0 = FDD 1 = TDD 2 = Downlink only For variable duplex spacing. See Note 5 3 = uplink only ditto
7	Options	TBD	**X**		This element is only used to identify options needed to decode the broadcast control channel. One possible option is chiprate.

Note 1: The content of this information element is a number which defines the standard, with its associated channel raster. If a standard has several associated channel rasters, these could be identified separately in this information element, or the rasters could be combined or identified as a single system in this element.

Information elements 1 and 2 would need to be defined consistently for all systems (eg by ITU).

Note 2: The set of these numbers describes the complete set of RF channels which are defined for use in one system.

Note 3: The raster need not be continuous. For instance, GSM defines the possible channels for all three bands (GSM 900, 1800 and 1900) using a single 10 bit number sequence.

Note 4: One possible use of this is:

Priority: 0 (top priority)   Channels used by the home network (the one to whom the user pays his subscription)

1   Channels used by networks preferred for roaming

2   Channels used by any network

3   Channels not used by any network (but which may have been programmed in the terminal as defaults)

Note 5: If it is necessary to signal the uplink and downlink frequencies separately, the information for the uplink and downlink for one channel can be sent separately.

Annex B: Examples of signalling messages

B.1 Default Frequency list

UTRA RF Channel No	Freq TX, MHz (Raster Number in brackets)	Freq RX, MHz (Raster Number in brackets)	Priority	Options
0	1922.0 (184)	2112.0 (184)	1	
1	1922.2 (185)	2112.2 (185)	1	
2	1922.4 (186)	2112.4 (186)	1	
3	1922.6 (187)	2112.6 (187)	1	
4	1922.8 (188)	2112.8 (188)	1	
55	1977.0 (459)	2167.0 (459)	1	
56	1977.2 (460)	2167.2 (460)	1	
57	1977.4 (461)	2167.4 (461)	1	
58	1977.6 (462)	2167.6 (462)	1	
59	1977.8 (463)	2167.8 (463)	1	

B.2 Changing priorities and adding new UTRA RF Channel Numbers

The following messages would result in the changes to the default frequency list shown in the following table (changes in bold):

1	3	4	5	6	7
	UTRA RF channel number	Raster position	Priority	RF channel type	Options
0	95	189	0 (top priority)	0 (FDD)	
0	96	464	0	0	
0	0	184	3 (never used)	0	
0	59	463	0	0	

Modified Frequency list (changes in bold):

UTRA RF Channel No	Freq TX, MHz (Raster Number in brackets)	Freq RX, MHz (Raster Number in brackets)	Priority	Options
0	1922.0 (184)	2112.0 (184)	**3**	
1	1922.2 (185)	2112.2 (185)	1	
2	1922.4 (186)	2112.4 (186)	1	
3	1922.6 (187)	2112.6 (187)	1	
4	1922.8 (188)	2112.8 (188)	1	
55	1977.0 (459)	2167.0 (459)	1	
56	1977.2 (460)	2167.2 (460)	1	
57	1977.4 (461)	2167.4 (461)	1	
58	1977.6 (462)	2167.6 (462)	1	
59	1977.8 (463)	2167.8 (463)	**0**	
95	**1923.0 (189)**	**2113.0 (189)**	**0**	
96	**1978.0 (464)**	**2168.0 (464)**	**0**	

B.4 An example default frequency list, including TDD

UTRA RF Channel No	Freq TX, MHz (Raster Number in brackets)	Freq RX, MHz (Raster Number in brackets)	Priority	Options
0	1922.0 (184)	2112.0 (184)	1	
1	1922.2 (185)	2112.2 (185)	1	
2	1922.4 (186)	2112.4 (186)	1	
3	1922.6 (187)	2112.6 (187)	1	
4	1922.8 (188)	2112.8 (188)	1	
55	1977.0 (459)	2167.0 (459)	1	
56	1977.2 (460)	2167.2 (460)	1	
57	1977.4 (461)	2167.4 (461)	1	
58	1977.6 (462)	2167.6 (462)	1	
59	1977.8 (463)	2167.8 (463)	1	
60	1902.2 (85)	N/A (TDD)	1	
61	1902.4 (86)	N/A (TDD)	1	
62	1902.6 (87)	N/A (TDD)	1	
63	1902.8 (88)	N/A (TDD)	1	
64	1903.0 (89)	N/A (TDD)	1	
75	1917.2 (160)	N/A (TDD)	1	
76	1917.4 (161)	N/A (TDD)	1	
77	1917.6 (162)	N/A (TDD)	1	
78	1917.8 (163)	N/A (TDD)	1	
79	1918.0 (164)	N/A (TDD)	1	
80	2012.0 (634)	N/A (TDD)	1	
81	2012.2 (635)	N/A (TDD)	1	
82	2012.4 (636)	N/A (TDD)	1	
83	2012.6 (637)	N/A (TDD)	1	
84	2012.8 (638)	N/A (TDD)	1	
90	2022.0 (684)	N/A (TDD)	1	
91	2022.2 (685)	N/A (TDD)	1	
92	2022.4 (686)	N/A (TDD)	1	
93	2022.6 (687)	N/A (TDD)	1	
94	2022.8 (688)	N/A (TDD)	1	

B.5 Paired, TDD and variable duplex spacing channels

B.5.1 Changing priorities and adding new UTRA RF Channel Numbers (as B.2)

1	3	4	5	6	7
	UTRA RF channel number	Raster position	Priority	RF channel type	Options
0	95	189	0 (top priority)	0 (FDD)	
0	96	464	0	0	
0	0	184	3 (never used)	0	
0	59	463	0	0	

B.5.2 Adding TDD channels in the paired frequency band

1	3	4	5	6	7
	UTRA RF channel number	Raster position	Priority	RF channel type	Options
0	97	286	0 (top priority)	1 (TDD)	
0	98	311	0	1	

B.5.3 Adding a FDD channel with a different duplex spacing

1	3	4	5	6	7
	UTRA RF channel number	Raster position	Priority	RF channel type	Options
0	99	188	0 (top priority)	2 (downlink)	
0	99	213	0	3 (uplink)	

These messages would result in the following changes to the default list in section B.4.

UTRA RF Channel No	Freq TX, MHz (Raster Number in brackets)	Freq RX, MHz (Raster Number in brackets)	Priority	Options
0	1922.0 (184)	2112.0 (184)	**3**	
1	1922.2 (185)	2112.2 (185)	1	
2	1922.4 (186)	2112.4 (186)	1	
3	1922.6 (187)	2112.6 (187)	1	
4	1922.8 (188)	2112.8 (188)	1	
...	...	...	...	
55	1977.0 (459)	2167.0 (459)	1	
56	1977.2 (460)	2167.2 (460)	1	
57	1977.4 (461)	2167.4 (461)	1	
58	1977.6 (462)	2167.6 (462)	1	
59	1977.8 (463)	2167.8 (463)	**0**	
60	1902.2 (85)	N/A (TDD)	1	
61	1902.4 (86)	N/A (TDD)	1	
62	1902.6 (87)	N/A (TDD)	1	
63	1902.8 (88)	N/A (TDD)	1	
64	1903.0 (89)	N/A (TDD)	1	
...	...	...	...	
90	2022.0 (684)	N/A (TDD)	1	
91	2022.2 (685)	N/A (TDD)	1	
92	2022.4 (686)	N/A (TDD)	1	
93	2022.6 (687)	N/A (TDD)	1	
94	2022.8 (688)	N/A (TDD)	1	
95	**1923.0 (189)**	**2113.0 (189)**	**0**	
96	**1978.0 (464)**	**2168.0 (464)**	**0**	
97	**1942.4 (286)**	**N/A (TDD)**		
98	**1947.4 (311)**	**N/A (TDD)**		
99	**1922.4 (213)**	**2112.8 (188)**	**0**	