IBM Japan Ltd.
1623-14, Shimotsuruma, Yamato-shi
Kanagawa-ken 242-8502, Japan
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To whom this may concern

TCB Requested Information

FCC ID : ANO20040700HER
Applicant : International Business Machines Corporation
Correspondence Reference Number : 241201A.ANO
731 Confirmation Number : 4378
Original Requested Date : December 1, 2004

Subject 1) Please confirm that the EUT complies with the following requirements, listed in Section 15.247(a)(1):

(a) the hopping sequence in pseudo random.
(b) the channels are used equally on average
(c) the receive input bandwidth (at either RF or IF) is approximately equal to the transmission bandwidth (1 MHz)
(d) the receiver is capable of hopping in sequence with the transmitted signal

Subject 2) Please confirm that EUT complies with the requirements of Section 15.247(g) (the EUT is capable of full compliance with the rules if it is presented with a continuous data stream).

Subject 3) Please confirm that EUT complies with the requirements of Section 15.247(h) (the EUT is not capable of coordinating its hopping sequence with that of other systems for the express purpose of avoiding the simultaneous occupancy of one channel by multiple systems).

Answer) Please refer to the submittal exhibit, "Bluetooth_Attestation.pdf".
Also the following page shows a summary of the original exhibit in corresponding to the above subject numbers. The description indicates the case of full hopping mode representatively, but AHF (Advanced Frequency Hopping) mode employs the same logic.

Sincerely, December 2, 2004

Signature: T. Murota

Toshiya Murota,
Staff Engineer, EMC Engineering,
Yamato Laboratory, IBM Japan Ltd.

Prepared by T. Murota.

Summary of "Bluetooth_Attestation.pdf" exhibit

1-a) Pseudo random Frequency Hopping Sequence (FCC 15.247(a), RSS 6.2.2(o))

The following is an example of a 79 pseudo random hopping sequence in data mode:
40, 21, 44, 23, 42, 53, 46, 55, 48, 33, 52, 35, 50, 65, 54, 67,
56, 37, 60, 39, 58, 69, 62, 71, 64, 25, 68, 27, 66, 57, 70, 59,
72, 29, 76, 31, 74, 61, 78, 63, 01, 41, 05, 43, 03, 73, 07, 75,
09, 45, 13, 47, 11, 77, 15, 00, 64, 49, 66, 53, 68, 02, 70, 06,
01, 51, 03, 55, 05, 04

1-b) and 2 Equally average use of frequencies in data mode(15.247(a), 6.2.2(o)), and behavior for short transmissions (15.247(g), 6.2.2(o)):

The generation of the hopping sequence in connection mode depends essentially on two input values:
1. LAP/UAP of the master of the connection
2. Internal master clock

The LAP (lower address part) are the 24 LSB's of the 48 BD_ADDRESS. The BD_ADDRESS is an unambiguous number of every Bluetooth unit. The UAP (upper address part) are the 24 MSB's of the 48 BD_ADDRESS.
The internal clock of a Bluetooth unit is derived from a free running clock which is never adjusted and is never turned off. For synchronization with other units only offset are used. It has no relation to the time of the day. Its resolution is at least half the RX/TX slot length of 312.5 µs. The clock has a cycle of about one day (23h30). In most case it is implemented as 28 bit counter. For the deriving of the hopping sequence the entire LAP (24 bits), 4 LSB's (4 bits) (Input 1) and the 27 MSB's of the clock (Input 2) are used. With this input values different mathematical procedures (permutations, additions, XOR-operations) are performed to generate the sequence. This will be done at the beginning of every new transmission.

Regarding short transmissions the Bluetooth system has the following behavior:
The first connection between the two devices is established, a hopping sequence was generated. For transmitting the wanted data the complete hopping sequence was not used. The connection ended. The second connection will be established. A new hopping sequence is generated. Due to the fact that the Bluetooth clock has a different value, because the period between the two transmission is longer (and it cannot be shorter) than the minimum resolution of the clock (312.5 µs). The hopping sequence will always differ from the first one.

1-c) Receiver input bandwidth (15.247(a), 6.2.2(o)):

The input bandwidth of the receiver is 1 MHz.
In every connection one Bluetooth device is the master and the other one is the slave. The master determines the hopping sequence (see chapter 5). The slave follows this sequence. Both devices shift between RX and TX time slot according to the clock of the master.
Additionally the type of connection (e.g. single or multislot packet) is set up at the beginning of the connection. The master adapts its hopping frequency and its TX/RX timing according to the packet type of the connection. Also the slave of the connection will use these settings.
Repeating of a packet has no influence on the hopping sequence. The hopping sequence generated by the master of the connection will be followed in any case. That means, a repeated packet will not be send on the same frequency, it is send on the next frequency of the hopping sequence.

1-d) Receiver capability of hopping in sequence with the transmitted signal (15.247(a), 6.2.2(o)):

Bluetooth units which want to communicate with other units must be organized in a structure called PICONET. This PICONET consist of maximum 8 Bluetooth units. One unit is the master the other seven are the slaves. The master co-ordinates frequency occupation in this piconet for all units.
As the master hop sequence is derived from it's BD address which is unique for every Bluetooth device, additional masters intending to establish new PICONET will always use different hop sequences.

Comment by IBM: This means that a unique hop sequence is exchanged between master and slave devices in advance, then the hopping frequency for both Tx/Rx is shifted at the same time to the same frequency according to the hop sequence.

2. Hopping sequence in hybrid mode (15.247(g), 6.2.2(o))

For the generation of the inquiry and page hop sequences the same procedures as described for the data mode are used (see the item 1), but this time with different input vectors:
· For the inquiry hop sequence, a predefined fixed address is always used. This results in the same 32 frequencies used by all devices doing an inquiry but every time with a different start frequency and phase in this sequence.
· For the page hop sequence, the device address of the paged unit is used as input vector. This results in the use of a subset of 32 frequencies which is specific for that initial state of the connection establishment between the two units. A page to different devices would result in a different subset of 32 frequencies.

So it is ensured that <u>also in hybrid mode the frequency use equally averaged.</u>

Example of a hopping sequence in inquiry mode:
48, 50, 09, 13, 52, 54,41, 45, 56, 58, 11, 15, 60, 62, 43, 47,
00, 02, 64, 68, 04, 06, 17, 21, 08, 10, 66, 70, 12, 14, 19, 23

Example of a hopping sequence in paging mode:
08, 57, 68, 70, 51, 02, 42, 40, 04, 61, 44, 46, 63, 14, 50, 48,
16, 65, 52, 54, 67, 18, 58, 56, 20, 53, 60, 62, 55, 06, 66, 64

Receiver input bandwidth in hybrid mode (15.247(g), 6.2.2(o))

The receiver input bandwidth is the same as in the data mode (1 MHz). When two Bluetooth devices establish contact for the first time, one device sends an inquiry access code, the other device is scanning for this inquiry access code. If two devices have been connected previously and want to start a new transmission, a similar procedure takes place. The only difference is, instead of the inquiry access code, an special access code, derived from the BD_ADDRESS of the paged device will be, will be sent by the master of this connection.
Due to the fact that both units have been connected before (in the inquiry procedure) the paging unit has timing and frequency information about the page scan of the paged unit.
For this reason the time to establish the connection is reduced considerable.

3. Co-ordination of the hopping sequence in data mode to avoid simultaneous occupancy by multiple transmitters (15.247(h), 6.2.2(o))

Bluetooth units which want to communicate with other units must be organised in a structure called PICONET. This PICONET consist of maximum 8 Bluetooth units. One unit is the master the other seven are the slaves. The master co-ordinates frequency occupation in this piconet for all units.
As the master hop sequence is derived from it's BD address which is unique for every Bluetooth device, additional masters intending to establish new PICONET will always use different hop sequences.