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(54) Wireless hearing system and method

(57) The present invention is concerned a flexible and easily extendible wireless hearing system for transmitting audio information to individual users. According to the invention, a Wireless Local Area Network (WLAN) is used to transmit the audio information, in particular comprising excerpts of human voice or speech signals, from a base station to a hearing device. In other words, both the base station and the hearing device arc part of a packet-based data network and as such assigned individual network addresses. Wireless data networks for mobile computing devices being devised for selectively communicating different contents to different participants, hearing systems based there upon hence allow providing audio information on demand to a large number of independent users without having to arrange for dedicated channels in each case. In addition, heavy infrastructural investments are avoided, as WLAN networks already exist in many places or can be created at comparably low costs.

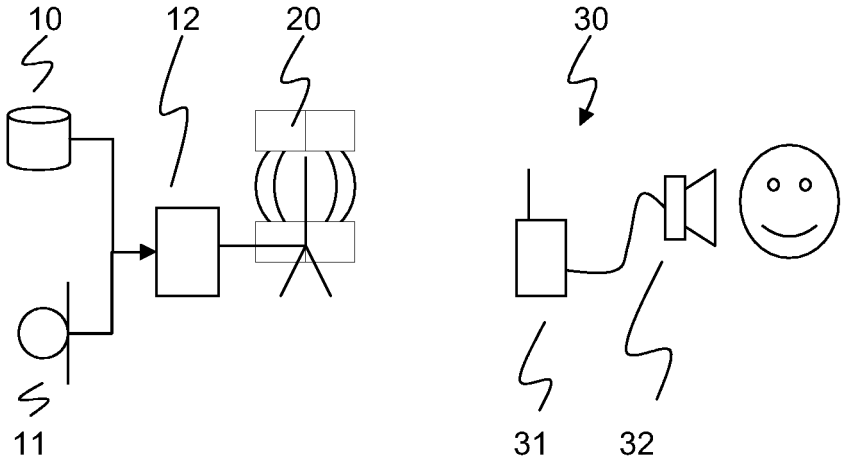

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of wireless communication to or from a hearing device. It departs from a wireless hearing system as described in the preamble of claim 1.

BACKGROUND OF THE INVENTION

[0002] Hearing devices or hearing instruments assist individual persons in perceiving audio information where direct propagation of sound waves from a speaker to the person is not adequate or sufficient, e.g. due to environmental noise, due to a long distance between the speaker and the hearer, or due to an impaired hearing capability of the latter.

[0003] The patent application publication US 20050100182 discloses a wireless base unit, e.g. as a hand held device, including a microphone for receiving an audio signal from a nearby talker and communications circuitry for wirelessly transmitting the audio signal to a single hearing instrument or to a plurality of hearing instruments. The hearing instrument includes communications circuitry for receiving the audio signal from the base unit, a processing device operable to process the audio signal, including digital to analogue conversion and compensation for a hearing impairment of a hearing instrument user and a speaker for transmitting the processed audio signal into an ear canal of the hearing instrument user. The wireless hearing instrument system automatically selects a communication channel from a range of available frequencies in a UHF or ISM frequency band for transmitting the audio signal from the base unit to the hearing instrument.

[0004] The base unit converts received acoustic signals into the digital domain, process the digital signals, modulate the processed signals to an RF carrier and transmit the signals to the hearing instrument. The hearing instrument comprises a magnetic loop antenna and a matching network, wherein the antenna may be attached to the inner or outer surface of the shell of the hearing aid worn behind the ear of the user, with the shape of the loop antenna being matched to the irregular shape of the hearing aid shell. The base unit may function as a wireless link to an external device or network, such as a computer network, and may receive an input (wired or wireless) from the external device or network and function as a wireless gateway between the device or network and the hearing instrument.

[0005] If a stereo audio signal is to be transmitted, two frequency channels are required for transmitting a respective portion of the stereo audio signal to a hearing instrument at the left or right ear of the person, respectively. This hearing system was designed for teaching hearing impaired students in a classroom, and is of limited flexibility and extendibility when it comes to transmit selectively a broader range of information, e.g. content and language wise, to a number of individual and independent users.

DESCRIPTION OF THE INVENTION

[0006] It is therefore an objective of the invention to create a wireless hearing system for transmitting audio information to individual users which is flexible and easily extendible. This objective is achieved by a wireless hearing system and a method of non-delayed transmission of audio information according to patent claims 1 and 6. Further preferred embodiments are evident from the dependent patent claims.

[0007] According to the invention, a Wireless Local Area Network (WLAN) is used to transmit audio information, in particular comprising excerpts of human voice or speech signals, from a base station to a hearing device. In other words, both the base station and the hearing device are part of a packet-based data network and as such assigned individual network addresses. Wireless data networks for mobile computing devices being devised for selectively communicating different contents to different participants, hearing systems based there upon hence allow providing audio information on demand to a large number of independent users without having to arrange for dedicated channels in each case. In addition, heavy infrastructural investments are avoided, as WLAN networks already exist in many places or can be created at comparably low costs.

[0008] In a first preferred variant of the invention, an encoder is provided including means for suitably compressing an incoming stream of audio data in view of a non-delayed transmission of the audio information contained in the stream. In the context of the present invention, non-delayed, or real-time, transmission of audio information refers to the user of the information and his/her capability of perceiving the information as (not) being delayed. The latter is the case if the user has a visual or other non-audio reference indicating the presence of audio information, e.g. because he can see people speak in a movie / on a stage, or because a light signals a message being broadcast in a public space, or because the user expects an instantaneous answer to a question previously submitted. It is presently believed that a delay of 40 ms, and preferably a delay of less than 20 ms corresponding to a distance of the order of 10 m traveled by sound waves, between the above-mentioned non-audio reference and the perception of the acoustic signal by the user is acceptable. Hence, non-delay, real-time and/or instantaneous transmission all revert to the physiology of the user, but for the purpose of this application, may be substituted for by the above exemplary delay times.

[0009] For the intended latency-sensitive application in hearing systems, an occasional loss of data may be acceptable, resulting in a temporal interruption or suppression of a few syllables that the user is nevertheless

capable to reconstruct himself e.g. by contextual reference. On the other hand, and basically for reasons of quality, wireless streaming of music and video relies on comparably large buffers at the receiver and includes a wider range of acoustic frequencies as compared to human voice or speech signals. Large buffers help avoid unwanted skipping or artifacts during playback, but generate long delays of several seconds before any actual replay resumes.

[0010] In a second preferred variant of the invention, the hearing device comprises two separate parts, i.e. a portable receiver that may be carried in a pocket of the user's clothes, and headphones including a loudspeaker to be worn close to the ear of the user. This separation releases the stringent restrictions concerning constructional space in hearing devices related to antenna arrangements and power supplies (batteries). As a preferred receiver, a WI-FI capable Personal Digital Assistant (PDA) or personal Smartphone of the user may be employed following installation of suitable client software. In this case, there is no need for the user to acquire a dedicated hearing device, and he may benefit from the fact that extra power supplies or batteries are readily available for increasing the autonomy of the PDA or Smartphone beyond a present 4-5 hours.

[0011] According to a further advantageous embodiment of the invention, the WLAN is concurrently used for transmission of audio information and non-audio data. Bandwidth or a maximum bit rate required for the hearing system's audio information, or for an individual stream of audio data, is then permanently reserved in order to guarantee a minimum Quality of Service (QoS) of the hearing system without one having to establish a dedicated WLAN for the audio information alone.

[0012] In summary, the present invention represents a low cost wireless hearing system that relies on standard components from popular telecommunication systems. Useful information is selectively amplified and transmitted at constantly high quality and low noise. The wireless hearing system according to the invention is particularly suited as a hearing aid for hearing impaired persons, capable of providing on-demand and real-time audio information and greatly improving their communication possibilities.

[0013] All or part of the steps required for non-delayed transmission of audio information by means of a wireless hearing system may be implemented as programmed software modules or procedures, i.e. as computer program code means for controlling one or more processors of a wireless enabled stationary or mobile device, wherein the modules or procedures may be stored in a computer readable medium, either in a memory integrated in said device or on a data carrier that can be inserted into said device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The subject matter of the invention will be explained in more detail in the following text with reference to preferred exemplary embodiments which are illustrated in the attached drawings, in which:

Fig.1 shows a wireless hearing system,
Fig.2 is a sequence of audio information processing steps, and
Fig.3 depicts an exemplary audio data packet.

[0015] The reference symbols used in the drawings, and their meanings, are listed in summary form in the list of designations.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Fig.1 depicts a system for providing non-delayed audio information to a user. The audio information is previously identified and stored on a server 10 or produced in real time by a speaker and processed via recorder 11 including a microphone and suitable AD conversion means. The server 10 and/or recorder 11 are feeding a stream of digital audio data to an encoder 12 with adequate processing means for modifying the representation or format of the audio data. The encoder 12 is connected to a base station 20 of a WLAN network for transmitting the audio information to a hearing device 30. The hearing device 30 comprises two parts, a receiver 31 for receiving the digital audio information and converting it to an analog signal, and a headphone or earphone 32 including loudspeaker means for generating an acoustic signal there from at or near the ear of the user.

[0017] A WLAN network is a wireless local area data network linking, in a limited area of some hundred square meters called a hot spot, two or more mobile computing devices without using wires. A WLAN network utilizes single carrier direct-sequence spread spectrum radio technology and multi-carrier OFDM (Orthogonal Frequency Division Multiplexing) radio technology as defined in a number of standards collectively denoted IEEE 802.11. A WLAN operates in the unlicensed 2.4 and 5 GHz radio bands, with date rates of up to 54 Mbps. Access Points (AP) are base stations for the wireless network, transmitting and receiving radio frequencies for wireless enabled mobile devices and occasionally serving as a bridge to a wired network infrastructure.

[0018] The encoder 12 may be embedded in a base device comprising, in addition to the encoder, the server 10, one or more audio inputs for analog audio sources 11, and the base station 20 executing the WLAN AP common tasks such as DHCP Server, access security, and Quality of Service (QoS) reservation. This base device may be proposed for use in a 19" rack case, i.e. suitable for an audio rack implementation in a professional audio sound system, or for mobile purposes, i.e. as a little portable embedded device with all components needed to build a WLAN network and enable the proposed hearing services. Alternatively, the functionality of the encoder

12 may be added to any new or existing server connected to a WLAN network by means of a wireless access card, thus enabling the present invention to be added to any existing WLAN network.

[0019] Exemplary headphones 32 include T-coil compliant inductive ear hooks that comprise a 3.5 mm Audio Jack - Induction adapter generating an inductive signal covering an ultimate distance of a few cm to a T-coil (telecoil) enabled hearing aid device worn by the user.

[0020] Fig.2 schematically depicts a sequential processing of the audio information generated by a human speaking into the microphone of recorder 11. At the recorder, blocks or frames of digitized data of 20 ms are defined and forwarded to the encoder. The encoder processes, during 14 ms, the incoming block of audio data by suitably compressing it. The compressed data is subsequently transmitted and received over the wireless network, and decoded at the receiver. The original audio data of a block is then played back some 20 ms after the block has finished recording, resulting in a total delay of 40 ms.

[0021] At the recorder 11, the step of recording as well as a step of playing audio data may be implemented by reverting to ALSA (Advanced Linux Sound Architecture), an open source driver / library for sound cards. Correctly initialized and programmed, ALSA callback functionality manages the asynchronous capture and playback operations of the audio frames in a stable and reliable manner.

[0022] At the encoder 12, the audio data compression and decompression may be implemented by reverting to Speex, a speech specific open source codec / library that can adjust the gain of the sound, detect silence and stop the transmission in order to save bandwidth and reduce packet loss effects. Speex provides multiple bitrates using narrowband, wideband and ultra-wideband modes. In the latter mode, the PCM (Pulse Code Modulation) sound flow, at 32 KHz sampling rate, produces 512 kbit/s of uncompressed audio data traffic which, as tests have shown, can easily be handled by any laptop client of an ordinary WLAN network. However, the high bit rate of an uncompressed stream appears to put a heavy burden on the receiver buffer of a Personal Digital Assistant (PDA) or personal Smartphone, increasing packet loss and unexpected behaviour at the receiver. Hence, data compression by Speex is preferably enabled, reducing typical bitrates to below 100 kbit/s. The latter is a perfect Quality of Service (QoS) scenario when sharing the WLAN with non-audio data traffic or dividing the available bandwidth among multiple streams for multilingual, multi content, and on demand - time delay purposes.

[0023] Fig.3 shows an exemplary audio data packet to be used in the proposed wireless hearing system. The packet header provides general or specific information about the audio stream that is being transmitted. The structure of the packet header is as follows, read from top left to bottom right, each square denoting a single byte. The first five bytes denote the service (e.g. "WAPHI"), followed by a byte for the service type (e.g. "real time"), a byte for the data type (e.g. "Speex UWB, WB, NB"), and a byte for the parameter quantity (e.g. "3 parameters"). Next, on the second line in Fig.3, follow these parameters (e.g. appropriate values for "ID", "Complexity", "Quantity"), as well as a number of further parameters as indicated by the arrow. Ultimately, starting on the third line in Fig.3, a byte for the data length (e.g. "90" for UWB complexity 5, quality 9) and the actual data with a number of bytes as indicated in the previous field conclude the packet.

[0024] The wireless hearing system uses two transportation layer protocols to stream information on the wireless data network. The User Datagram Protocol (UDP) is employed for the audio data stream because of its "one-way" and/or "connectionless" property, i.e. because of the fact that an established connection between the source and all of the potentially many destination clients or receivers is not required. This helps reducing the network traffic and transmission delays, as a receipt of the data packets is not acknowledged by the destination clients and an eventual packet loss is thus accepted in exchange for an increased transmission speed. On the other hand, the Transmission Control Protocol (TCP) is employed for the transmission of audio content information, requests and specific on-demand audio streams (for audio commentary in museums for example).

[0025] Wireless hearing systems as described herein are most beneficially used in public places or institutions on behalf of, without limitation, the participants to a multilingual conference requiring interpreting services, public transport (train, airplane) passengers seeking information about correspondences upon arrival at a platform or gate, visitors to a museum expecting complementary audio information, movie spectators with a hearing impairment requiring additional amplification of sound, or a mixed audience hearing audio information from a DVD in different languages. In all these cases, an audio data server generates and broadcasts an initialization message or packet approximately once per second, comprising the IP address of the server and a name indicative of the place or institution the server is associated with. The initialization message is then received by any hearing device entering the zone of its diffusion. The hearing device subscribes to the service as a client and starts demanding the services offered by the audio data server. The hearing device is then included in a multicast distribution list or information group for which the audio data server has to send just one data stream, independently of the actual number of listeners or subscribers.

[0026] A final aspect is concerned with the provision of continuously updated lists of places or institutions that are equipped with a wireless hearing system as described herein. Such lists may be updated and made public via dedicated web-sites.

LIST OF DESIGNATIONS

[0027]

10 audio data server
11 recorder
12 encoder
20 base station
30 hearing device
31 receiver
32 headphone

Claims

1. A wireless hearing system with a base station (20) for transmitting audio information and a hearing device (30) for receiving the audio information and converting the audio information into an acoustic signal, **characterized in that** the base station (20) and the hearing device (30) are part of a Wireless Local Area Network (WLAN).

2. The system according to claim 1, **characterized in that** an encoder (12) comprises means for compressing audio information in a stream of audio data provided to the encoder (12) and means for providing the compressed audio information to the base station (20) for subsequent non-delay transmission to the hearing device (30).

3. The system according to claim 1, **characterized in that** the hearing device (30) comprises a receiver (31) for receiving the audio information over the WLAN and a detachable headphone (32) for generating the acoustic signal.

4. The system according to claim 1, **characterized in that** the WLAN is concurrently used for transmission of the audio information and non-audio data.

5. The system according to claim 1, **characterized in that** the audio information is associated with a public place or institution and stored on an audio data server (10), and **in that** the base station (20) sends out broadcast initialization messages.

6. A method of non-delayed transmission of audio information by means of a wireless hearing system, comprising

   - transmitting audio information, by a base station (20) of a Wireless Local Area Network (WLAN), to a hearing device (30) via the WLAN, and
   - converting the audio information received by the hearing device (30) into an acoustic signal.

7. The method according to claim 6, wherein the audio information is associated with a public place or institution and stored on an audio data server (10), comprising

   - broadcasting, by the base station (12), initialization messages.

8. The method according to claim 7, comprising, by the hearing device (30) and upon receipt of the initialization message,

   - subscribing to a multicast list for the audio information.

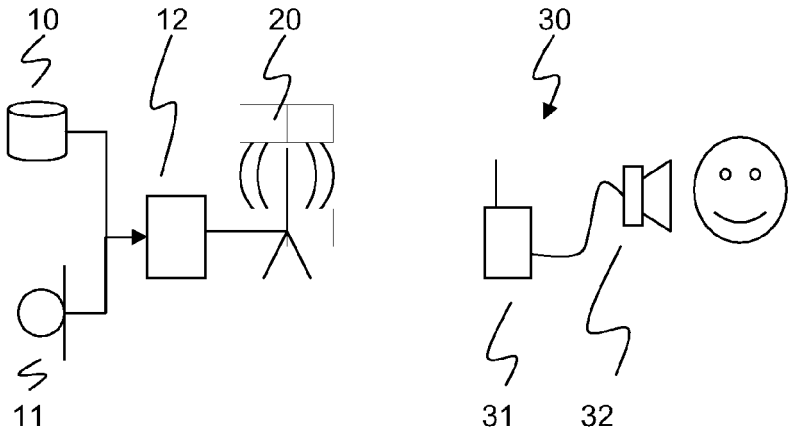

Fig. 1

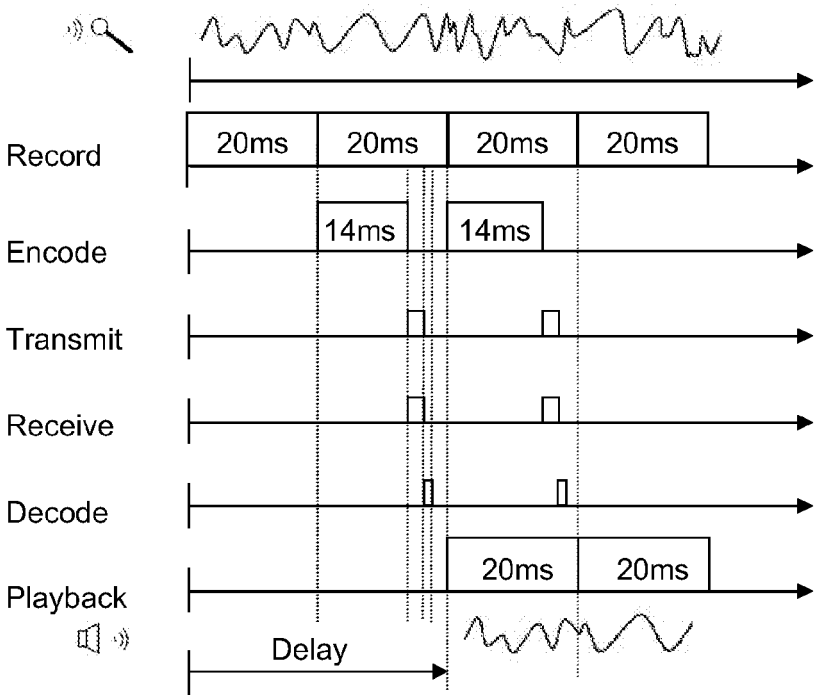

Fig. 2

W	A	P	H	I	S_Type	D_Type	Param_QT
ID	Complexity	Quantity	.....	.....	.....	.....	.....
Data_len	.D.	.A.	.T.	.A.	...	...	...>

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 11 0229

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2006/166716 A1 (SESHADRI NAMBIRAJAN [US] ET AL) 27 July 2006 (2006-07-27) * page 2, paragraph 24 - page 6, paragraph 50 * -----	1-8	INV. H04R1/10 H04R5/033
X	EP 1 335 544 A (BROADCOM CORP [US]) 13 August 2003 (2003-08-13) * column 1, line 44 - column 2, line 33 * * column 5, line 43 - column 8, line 5 * * column 12, line 37 - column 13, line 36 * * figures 1,2,6 * -----	1-3,6	
X	DE 20 2005 020531 U1 (AKG ACOUSTICS GMBH [AT]) 14 June 2006 (2006-06-14) * page 3, paragraph 18 - page 5, paragraph 30 * * page 8, paragraph 56 - paragraph 61 * -----	1,3,6	
			TECHNICAL FIELDS SEARCHED (IPC) H04R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 September 2007	Coda, Ruggero

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 11 0229

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12-09-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006166716 A1	27-07-2006	NONE	
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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