(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 962 436 B9

(12) # CORRECTED EUROPEAN PATENT SPECIFICATION

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Description Paragraph(s) 3, 15, 19
Claims FR 1

(48) Corrigendum issued on:
22.12.2010 Bulletin 2010/51

(45) Date of publication and mention of the grant of the patent:
08.09.2010 Bulletin 2010/36

(21) Application number: **06753115.2**

(22) Date of filing: **06.07.2006**

(51) Int Cl.:
H04B 3/23 *(2006.01)* ***H04M 3/00*** *(2006.01)*
H04M 7/00 *(2006.01)*

(86) International application number:
PCT/CN2006/001592

(87) International publication number:
WO 2007/068166 (21.06.2007 Gazette 2007/25)

(54) **ELECTRICITY ECHO ELIMINATION DEVICE AND METHOD**

EINRICHTUNG UND VERFAHREN ZUR ELEKTRIZITÄTSECHOBESEITIGUNG

DISPOSITIF ET PROCEDE D'ELIMINATION D'ECHO D'ELECTRICITE

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **13.12.2005 CN 200510134638**

(43) Date of publication of application:
27.08.2008 Bulletin 2008/35

(73) Proprietor: **Huawei Technologies Co., Ltd.**
Longgang District, Shenzhen
Guangdong 518129 (CN)

(72) Inventor: **WANG, Wei**
Guangdong 518129 (CN)

(74) Representative: **Casalonga, Axel**
Casalonga & Partners
Bayerstrasse 73
80335 München (DE)

(56) References cited:
EP-A- 0 986 190 **WO-A-01/45291**
CN-A- 1 691 716 **US-A1- 2002 114 445**
US-B1- 6 590 975 **US-B1- 6 724 736**
US-B1- 6 792 106

- **MELVIN H ET AL: "An integrated ntp-rtcp solution to audio skew detection and compensation for voip applications" MULTIMEDIA AND EXPO, 2003. PROCEEDINGS. 2003 INTERNATIONAL CONFERENCE ON 6-9 JULY 2003, PISCATAWAY, NJ, USA,IEEE, vol. 2, 6 July 2003 (2003-07-06), pages 537-540, XP010650611 ISBN: 978-0-7803-7965-7**

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of echo cancellation, and more particularly to an electricity echo cancellation device and method applied in a terminal.

BACKGROUND

[0002] With the continuous development of the Internet and telecommunication technologies, telecommunication applications over the Internet become more numerous. Recently, great development of the Voice over IP (VOIP) technology has been achieved. However, compared with the conventional telephone technologies, the VOIP technology has disadvantage in its voice quality for a main reason of echoes.

[0003] According to the generation principles, echoes are classified into acoustic echo and electricity echo. As shown in Fig.1, S_{in} represents a near-end input signal, S_{out} represents a near-end output signal, R_{in} represents a far-end input signal, and R_{out} represents a far-end output signal. Taking the near-end as an example, the generation principle of electricity echoes is as follows. When the near-end input signal S_{in} is transmitted in the Public Switched Telephone Network (PSTN), a mixing converter is needed to convert the two-line at the user end to the four-line in an exchanger. During the conversion, a part of signals are leaked from a near-end transmitting path to a near-end receiving path. This part of "leaked" signals is retransmitted to the near-end, and thereby a near-end user hears his/her own voices. This is electricity echo. Also taking the near-end as an example, the generation principle of acoustic echoes is as follows. The acoustic echo is caused by voice coupling between a voice playback device and a voice collection device. The far-end input voice signal R_{in}, after transmitted to the near-end, becomes the far-end output voice signal R_{out}. After the signal R_{out} is received by the near-end voice playback device, such as a speaker, and picked up by the near-end voice collection device, such as a microphone, via various reflecting paths or without any reflection, the signal R_{out} is retransmitted to the far-end, and thereby a far-end user hears his/her own voices. This is acoustic echo.

[0004] Generally, typical echoes with a delay of 16~20ms are called sidetone, which are even desired by a user because the user may feel comfortable when hearing it in a talking. However, echoes with a delay of more than 32ms would seriously influence the quality of a talking. With the development of communication technologies, talking distance supported by the VOIP technology is becoming longer and thus voice delay increases greatly, so that echo phenomenon is becoming much more serious. Therefore, echo cancellation becomes a problem to be overcome for the VOIP technology.

[0005] Presently, electricity echo cancellation is realized by an electricity echo canceller deployed on network. Taking the near-end in Fig.1 as an example, the operation principle of an electricity echo canceller is as follows. Because an electricity echo signal r in the near-end is generated from the near-end input signal S_{in} with certain delay and returned to the near-end together with the far-end input signal R_{in} through the far-end output signal R_{out}, when no voice signal is inputted in the far-end, that is, R_{in} is not a voice signal, an electricity echo delay M might be estimated according to the correlation of the far-end output signals R_{out} and S_{in}. Then a near-end input signal S_{in}(n-M) at the time earlier than the current time n byM, i.e. the time(n-M), is selected as an input signal of an adaptive filter, and an estimated electricity echo signal r' is derived through filtering computation. Then the estimated electricity echo signal r' is subtracted from the far-end input signal R_{in}, and thus the purpose of eliminating the electricity echo in the far-end output signal is achieved. During the above process, the far-end output signal R_{out} should be used as a correction signal in order to continuously update coefficients of the adaptive filter, so that the estimated electricity echo signal could approach an actual electricity echo signal more exactly.

[0006] The principle of acoustic echo cancellation is similar to that of electricity echo cancellation except that an acoustic echo canceller (AEC) is generally deployed in a terminal.

[0007] European patent application EP 0 986 190 A2 discloses estimation of the round-trip user-to-user delay in telephone connections. Patent application WO 01/45291 A1 discloses a method of echo removing using delay information. US patent 6,724,736 B1 discloses a method of remote echo cancellation in a packet telephony system. US patent 6,792,106 B1 disclosed an echo canceller and a method of echo cancellation using an NLMS algorithm.

[0008] The related art might bring about the following problems.

[0009] 1. It is difficult for the conventional electricity echo canceller to ensure the electricity echo cancellation effect at the final user end on the whole. An electricity echo canceller could only eliminate electricity echo signals on the network where it is deployed. However, because an actual network is constructed by interconnecting sub-networks based on various network technology, an electricity echo canceller deployed in a certain sub-network could only eliminate electricity echo signals on this sub-network, and could not ensure the electricity echo cancellation effect on the whole network.

[0010] 2. Influences of network transmission performance on the electricity echo cancellation effect are not considered. For a voice transmission network, its transmission performance may vary at different times due to various reasons, and thereby imposing influences on echo signals, for example, distorting echo signals. The conventional electricity echo cancellation method estimates an echo delay according to the correlation of media signals only in terms of media transmission, with no concern of the problem of inaccurate estimations on echo delay caused by influences of network transmission performance on echo signals, and thereby the echo cancellation effect could not be ensured. Further, because to estimate an electricity echo delay according to the correlation of media signals incurs a large amount of calculations, an electricity echo canceller usually needs to be realized with specific chips, and it is needed to deploy electricity echo cancellers on network in a multi-point manner, and the cost is high.

[0011] 3. The electricity echo cancellation effect is restricted by hardware memory. During eliminating electricity echoes, terminal input signals in a previous time period need to be saved so as to serve as reference signals for estimating electricity echo signals. Because of limited hardware memory, when transmission delay is long, a terminal input signal corresponding to the current electricity echo signal might have been discarded by the hardware memory, and thereby the electricity echo cancellation effect could not be ensured.

SUMMARY

[0012] The present invention provides an electricity echo cancellation device and method for ensuring the electricity echo cancellation effect on the whole and improving the effectiveness of electricity echo cancellation.

[0013] Technical solutions of the present invention are implemented as follows.

[0014] An electricity echo cancellation device includes a network echo delay computation module, an input buffer memory module and an adaptive filtering module. The electricity echo cancellation device is applied at the terminal, The network echo delay computation module configured to calculate a network echo delay according to a Real Time Control Protocol (RTCP) packet transmitted from the network. The input buffer memory module is configured to determine a terminal input signal to be adaptively filtered according to information of the network echo delay most recently outputted from the network echo delay computation module, and output the terminal input signal to the adaptive filtering module. The adaptive filtering module is configured to calculate an electricity echo signal and a network output signal. The adaptive filtering module includes: an adaptive filter, configured to calculate the electricity echo signal according to the terminal input signal outputted from the input buffer memory module and a filtering coefficient maintained in the adaptive filter, output the electricity echo signal to a subtracter, adjust the current filtering coefficient according to a network output signal outputted from the subtracter.

The subtracter is configured to subtract the electricity echo signal outputted from the adaptive filter from a network input signal from the network, and output the network output signal derived through the subtraction to the terminal and the adaptive filter.

[0015] The current filtering coefficient is adjusted as $e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K)$, where n is the current time, μ=0.5, K is the current network echo delay, e(n) is the current filtering coefficient, e(n+1) is the adjusted filtering coefficient, $\Delta(n)$ is the network output signal, x(n-K) is the terminal input signal at the time (n-K), and $P(n-K)=X^T(n-K)*X(n-K)$ where $X^T(n-K)$ is the transposed vector of X(n-K).

[0016] The adaptive filtering module may further include a dual-ended voice detection module which is configured to detect whether the current time is a dual-ended voice time according to the network input signal from the network and the terminal input signal from the input buffer memory module, and if the current time is a dual-ended voice time, output a signal for interrupting coefficient adjustment to the adaptive filter. The adaptive filter is further configured to interrupt the adjustment of the current filtering coefficient after receiving a signal for interrupting coefficient adjustment from the dual-ended voice detection module.

[0017] In accordance with an electricity echo cancellation method, a network echo delay is calculated according to an RTCP packet when the RTCP packet arrives and the current network echo delay is updated with the network echo delay. The method includes: determining a terminal input signal to be adaptively filtered according to the current network echo delay and an adaptive filtering algorithm; calculating an electricity echo signal by performing adaptive filtering on the terminal input signal; and calculating the difference between a network input signal and the electricity echo signal to obtain a network output signal. The adaptive filtering algorithm includes: adjusting the current filtering coefficient as $e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K)$, where n is the current time, μ=0.5, K is the current network echo delay, e(n) is the current filtering coefficient, e(n + 1) is the adjusted filtering coefficient, $\Delta(n)$ is the network output signal, x(n-K) is the terminal input signal at the time (n-K), and $P(n-K)=X^T(n-K)*X(n-K)$ where $X^T(n-K)$ is the transposed vector of X(n-K).

[0018] Calculating the network echo delay according to the RTCP packet includes: subtracting, from a Network Time

Protocol (NTP) time at which the RTCP packet arrives, a time, carried by the RTCP packet, at which a transmitted packet is most recently received, and further subtracting a time interval between the time at which a transmitted packet is most recently received and the time at which the RTCP packet is transmitted; and dividing the resulting difference derived through the two subtractions by a sampling time interval to obtain the network echo delay.

[0019] The electricity echo signal is calculated as $r(n) = \sum_{m=0}^{M-1} e(n)_m \cdot X(n-K-m)$, where n is the current time, M is the total order of adaptive filtering, K is the current network echo delay updated in step B, r(n) is the current electricity echo signal, $e(n)_m$ is the current filtering coefficient of the m^{th} order, and x(n-K-m) is the terminal input signal at the time (n-K-m).

[0020] The method further includes determining whether the current time is a dual-ended voice time; and if the current time is a dual-ended voice time, maintaining the current filtering coefficient unchanged, and if the current time is not a dual-ended voice time, adjusting the current filtering coefficient according to the adaptive filtering algorithm.

[0021] Determining whether the current time is a dual-ended voice time includes determining whether the condition $|Y_{out}(n)|-C^*|\max(|X(n)|,|X(n-1)|,...,|X(n-L+1)|) > 0$ is met; and if the condition is met, determining the current time is a dual-ended voice time, and if the condition is not met, determining the current time is not a dual-ended voice time; where n is the current time, C and L are constants determined experientially, Y_{out} (n) is the network output signal in step C, x (n) is the terminal input signal at the current time, x(n-1) is the terminal input signal at the time (n-1), and x(n-L +1) is the terminal input signal at the time (n-L+1).

[0022] Compared with the related art, the electricity echo cancellation device according to the present invention is deployed at the terminal, thus ensuring the electricity echo cancellation effect at the final user end on the whole, and improving the effectiveness of electricity echo cancellation through adjusting a terminal input signal outputted to an adaptive filtering module according to a network echo delay outputted from a network echo delay computation module. The electricity echo cancellation method according to the present invention includes calculating a network echo delay according to relevant information of an RTCP packet transmitted from the network and dynamically adjusting a terminal input signal to be adaptively filtered according to the network echo delay, thus improving the effectiveness of echo cancellation. Meanwhile, method of the present invention can be realized with software, thus avoiding influences of hardware memory restricts on the echo cancellation effect. In addition, the present invention only needs a single-point deployment, and thus the cost is saved.

BRIEF DESCRIPTION OF THE DRAWING(S)

[0023] Fig.1 is a conceptual graph of echo generation;

[0024] Fig.2 is a block diagram of the configuration of an electricity echo cancellation device according to an embodiment of the present invention; and

[0025] Fig.3 is a flow chart of an electricity echo cancellation method according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0026] The present invention is further explained below by reference to the accompanying drawings and detailed embodiments.

[0027] Fig.2 is a block diagram of the configuration of an electricity echo cancellation device according to an embodiment of the present invention, which is deployed at the terminal. As shown in Fig.2, the device mainly includes: an input buffer memory module 21, a network echo delay computation module 22 and an adaptive filtering module 23.

[0028] The input buffer memory module 21 is configured to: receive and save a terminal input signal X(n); determine a terminal input signal to be adaptively filtered according to a network echo delay K most recently outputted from the network echo delay computation module 22; and output the terminal input signal to be adaptively filtered to the adaptive filtering module 23.

[0029] Herein, n represents the current time.

[0030] Particularly, X(n-K) is used as a terminal input signal corresponding to the current network input signal Y(n), and the terminal input signal to be adaptively filtered is outputted to the adaptive filtering module 23 according to an adaptive filtering algorithm's requirements. For example, if the Normalized Least Mean Square (NLMS) algorithm is employed as the adaptive filtering algorithm, X(n-K), X(n-K-1), X(n-K-2) ,..., X(n-K-M+1) are outputted to the adaptive filtering module 23 as terminal input signals to be adaptively filtered, where M is the filtering order of the adaptive filtering module 23.

[0031] The network echo delay computation module 22 is configured to: receive a Real Time Control Protocol (RTCP) packet from the network; calculate a network echo delay K according to a Network Time Protocol (NTP) time A at which the RTCP packet arrives, the time (LSR), carried by the RTCP packet, at which a transmitted packet (SR) is most recently received, a time interval (DLSR) between the time at which SR is most recently received and the transmitting time of the RTCP packet, and a sampling time interval t; and output the network echo delay K to the input buffer memory module 21.

[0032] The adaptive filtering module 23 is configured to: calculate an electricity echo signal r(n) according to the terminal input signal to be adaptively filtered, outputted from the input buffer memory module 21 and the current filtering coefficient e(n) maintained in the adaptive filtering module 23; subtract the electricity echo signal r(n) from the network input signal Y(n) from the network and output a network output signal $Y_{out}(n)$ derived through the subtraction to the outside; and when the current time is not a dual-ended voice time, adjust the current filtering coefficient e(n) according to the network output signal Y_{out} (n) and the terminal input signal X(n).

[0033] Further, as shown in Fig.2, the adaptive filtering module 23 includes: an adaptive filter 231, a subtracter 232 and a dual-ended voice detection module 233.

[0034] The adaptive filter 231 is configured to: calculate the electricity echo signal r(n) according to the terminal input signal to be adaptively filtered, outputted from the input buffer memory module 21 and the current filtering coefficient e (n) maintained in the adaptive filter 231; output the electricity echo signal r(n) to the subtracter 232; adjust the current filtering coefficient e(n) according to the network output signal $Y_{out}(n)$ outputted from the subtracter 232 and the terminal input signal X(n); and interrupt the adjustment of the current filtering coefficient e(n) after receiving a signal for interrupting coefficient adjustment transmitted from the dual-ended voice detection module 233.

[0035] The subtracter 232 is configured to: subtract the electricity echo signal r(n) outputted from the adaptive filter 231 from the network input signal Y(n) from the network; and output the network output signal $Y_{out}(n)$ derived through the subtraction to the outside and the adaptive filter 231.

[0036] The dual-ended voice detection module 233 is configured to: detect whether the current time is a dual-ended voice time according to the network input signal Y(n) from the network and the terminal input signal from the input buffer memory module 21; and if the current time is a dual-ended voice time, output a signal for interrupting coefficient adjustment to the adaptive filter 231.

[0037] The terminal input signal outputted from the input buffer memory module 21 to the dual-ended voice detection module 233 is determined according to the employed dual-ended voice detection algorithm. For example, if the Geigel dual-ended voice detection algorithm is employed, X(n), X(n-1),..., X(n-L+1) are needed to be outputted to the dual-ended voice detection module 233, where L is a constant and might be determined experientially.

[0038] Fig.3 is a flow chart of an electricity echo cancellation method according to an embodiment of the present invention. As shown in Fig.3, the method includes the following steps.

[0039] Step 301: An RTCP packet is received.

[0040] Step 302: A network transmission delay De is calculated as De = A-LSR-DLSR according to an NTP time A at which the RTCP packet arrives and LSR and DLSR carried by the RTCP packet.

[0041] Step 303: A network echo delay k is calculated as k=De/t, and the current network echo delay K is updated with k, i.e. K = k , where t is a sampling time interval.

[0042] Step 304: An electricity echo signal r(n) is calculated according to a filtering coefficient e(n) at the current time and terminal input signals at the time (n-K) and the time a certain period before the time (n-K).

[0043] Particularly, $r(n) = \sum_{m=0}^{M-1} e(n)_m \cdot X(n - K - m)$ if the NLMS algorithm is employed, where n is the current time and n ≥ K + m, $e(n)_m$ is the m^{th} order coefficient of the vector $e(n)_m$, M is the total order of adaptive filtering, and X (n-K-m) is the terminal input signal at the time (n-K-m).

[0044] Step 305: The difference between a network input signal Y(n) and the electricity echo signal r(n) is calculated to obtain a network output signal $Y_{out}(n)$.

[0045] Step 306: It is determined whether the current time is a dual-ended voice time. If the current time is a dual-ended voice time, step 307 is performed; and if the current time is not a dual-ended voice time, step 308 is performed.

[0046] According to the Geigel dual-ended voice detection algorithm, if the condition $|Y_{out}(n)|- C*\max(|X(n)|,|X(n-1)|,...,|X(n-L+1)|)> 0$ is met, the current time is determined a dual-ended voice time; and if the condition is not met, the current time is not determined a dual-ended voice time. C is a constant and usually C= 0.5, and L is a constant and may be determined experimentally.

[0047] Step 307: The current filtering coefficient e(n) is maintained unchanged, i.e. e(n+1) = e(n), and the process ends.

[0048] Step 308: The current filtering coefficient e(n) is adjusted as an adjusted filtering coefficient e(n+1) according to an adaptive filtering algorithm.

[0049] Particularly, if the NLMS algorithm is employed, then $e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K)$, where, μ is a step factor, satisfying $0 < \mu < 2$ and usually $\mu = 0.5$; $\Delta(n)$ is an error signal and $\Delta(n)=Y(n)-r(n)=Y_{out}(n)$; and P(n-K) is a short-time average power of X(n-K) and $P(n-K)=X^T(n-K)*X(n-K)$ where $X^T(n-K)$ is the transposed vector of X(n-K).

[0050] Alternatively, r(n) and e(n+1) can also be calculated through the Least Mean Square (LMS) algorithm, or the Recursive Least Square (RLS) algorithm, and so on.

The above steps 301~303 could be performed before or after the steps 304~308. The steps 301~303 would be performed if only an RTCP packet is received, and the steps 304~308 would be performed if only a terminal input signal is received.

Claims

1. An electricity echo cancellation device, comprising a network echo delay computation module (22), an input buffer memory module (21) and an adaptive filtering module (23), wherein:

   the network echo delay computation module (22) is configured to calculate a network echo delay according to a Real Time Control Protocol, RTCP, packet transmitted from the network;
   the input buffer memory module (21) is configured to determine a terminal input signal to be adaptively filtered according to the network echo delay most recently outputted from the network echo delay computation module (22), and output the terminal input signal to the adaptive filtering module (23); and
   the adaptive filtering module (23) is configured to calculate an electricity echo signal and a network output signal, **characterized in that** the adaptive filtering module (23) comprises:

   an adaptive filter (231), configured to calculate the electricity echo signal according to the terminal input signal outputted from the input buffer memory module (21) and a filtering coefficient maintained in the adaptive filter (231), output the electricity echo signal to a subtracter (232), adjust the current filtering coefficient according to a network output signal outputted from the subtracter (232); and
   the subtracter (232) is configured to subtract the electricity echo signal outputted from the adaptive filter (231) from a network input signal from the network, and output the network output signal derived through the subtraction to the terminal and the adaptive filter (231),
   wherein the current filtering coefficient is adjusted as

$$e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K),$$

   where n is the current time, $\mu=0.5$, K is the current network echo delay, e(n) is the current filtering coefficient, e(n+1) is the adjusted filtering coefficient, $\Delta(n)$ is the network output signal, x(n-K) is the terminal input signal at the time (n-K), and $P(n-K)=X^T(n-K)*X(n-K)$ where $X^T(n-K)$ is the transposed vector of X(n - K).

2. The device according to claim 1, wherein the adaptive filtering module (23) further comprises:

   a dual-ended voice detection module (233), configured to detect whether the current time is a dual-ended voice time according to the network input signal from the network and the terminal input signal from the input buffer memory module (21), and if the current time is a dual-ended voice time, output the signal for interrupting coefficient adjustment to the adaptive filter (231), and
   wherein the adaptive filter (231) is further configured to interrupt the adjustment of the current filtering coefficient after receiving a signal for interrupting coefficient adjustment from the dual-ended voice detection module (233).

3. The device according to claim 2, wherein the terminal input signal outputted from the input buffer memory module (21) to the dual-ended voice detection module (233) is determined according to an employed dual-ended voice detection algorithm.

4. A terminal, comprising the electricity echo cancellation device according to any one of the claims 1 to 3.

5. An electricity echo cancellation method, comprising:

calculating a network echo delay according to a Real Time Control Protocol, RTCP, packet when the RTCP packet arrives;
updating the current network echo delay with the network echo delay;
determining a terminal input signal to be adaptively filtered according to the current network echo delay and an adaptive filtering algorithm;
calculating an electricity echo signal by performing adaptive filtering on the terminal input signal; and
calculating the difference between a network input signal and the electricity echo signal to obtain a network output signal,
characterized in that the adaptive filtering algorithm comprises:

adjusting the current filtering coefficient as

$$e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K),$$

where n is the current time, μ=0.5, K is the current network echo delay, e(n) is the current filtering coefficient, e(n+1) is the adjusted filtering coefficient, Δ(n) is the network output signal, x(n-K) is the terminal input signal at the time (n-K), and $P(n-K)=X^T(n-K)*X(n-K)$ where $X^T(n-K)$ is the transposed vector of X(n-K).

6. The method according to claim 5, wherein calculating the network echo delay according to the RTCP packet comprises:

subtracting, from a Network Time Protocol, NTP, time at which the RTCP packet arrives, a time, carried by the RTCP packet, at which a transmitted packet is most recently received, and further subtracting a time interval between the time at which a transmitted packet is most recently received and the time at which the RTCP packet is transmitted; and
dividing the resulting difference derived through the two subtractions by a sampling time interval to obtain the network echo delay.

7. The method according to claim 5, wherein the electricity echo signal is calculated as

$$r(n) = \sum_{m=0}^{M-1} e(n)_m \cdot X(n-K-m),$$

where n is the current time, M is the total order of adaptive filtering, K is the updated current network echo delay, r (n) is the current electricity echo signal, $e(n)_m$ is the current filtering coefficient of the m^{th} order, and x(n-K-m) is the terminal input signal at the time (n-K-m).

8. The method according to claim 5, wherein the method further comprises:

determining whether the current time is a dual-ended voice time; and
if the current time is a dual-ended voice time, maintaining the current filtering coefficient unchanged, and
if the current time is not a dual-ended voice time, adjusting the current filtering coefficient according to the adaptive filtering algorithm.

9. The method according to claim 8, wherein determining whether the current time is a dual-ended voice time comprises:

determining whether the condition $|Y_{out}(n)|-C*\max(|X(n)|,|X(n-1)|....,|X(n-L+1)|)>0$ is met; and
if the condition is met, determining the current time is a dual-ended voice time, and
if the condition is not met, determining the current time is not a dual-ended voice time;
where n is the current time, C and L are constants determined experientially, $Y_{out}(n)$ is the network output signal, x(n) is the terminal input signal at the current time, x(n-1) is the terminal input signal at the time (n-1), and x(n-

L+1) is the terminal input signal at the time (n-L+1).

Patentansprüche

1. Elektrizitätsecho-Löscheinrichtung, umfassend ein Netzechoverzögerungs-Berechnungsmodul (22), ein Eingangspuffer-Speichermodul (21) und ein adaptives Filterungsmodul (23), wobei
das Netzechoverzögerungs-Berechnungsmodul (22) dafür ausgelegt ist, eine Netzechoverzögerung gemäß einem von dem Netz gesendeten Paket des Real Time Control Protocol RTCP zu berechnen;
das Eingangspuffer-Speichermodul (21) dafür ausgelegt ist, ein adaptiv zu filterndes Endgeräteeingangssignal gemäß der zuletzt von dem Netzechoverzögerungs-Berechnungsmodul (22) ausgegebenen Netzechoverzögerung zu bestimmen und das Endgeräteeingangssignal an das adaptive Filterungsmodul (23) auszugeben; und
das adaptive Filterungsmodul (23) dafür ausgelegt ist, ein Elektrizitätsechosignal und ein Netzausgangssignal zu berechnen,
dadurch gekennzeichnet, dass das adaptive Filterungsmodul (23) Folgendes umfasst:

   ein adaptives Filter (231), das dafür ausgelegt ist, das Elektrizitätsechosignal gemäß dem von dem Eingangspuffer-Speichermodul (21) ausgegebenen Endgeräteeingangssignal und einen in dem adaptiven Filter (231) geführten Filterungskoeffizienten zu berechnen, das Elektrizitätsechosignal an einen Subtrahierer (232) auszugeben, den aktuellen Filterungskoeffizienten gemäß einem von dem Subtrahierer (232) ausgegebenen Netzausgangssignal zu justieren; und
   der Subtrahierer (232) dafür ausgelegt ist, das von dem adaptiven Filter (231) ausgegebene Elektrizitätsechosignal von einem Netzeingangssignal von dem Netz zu subtrahieren und das durch die Subtraktion abgeleitete Netzausgangssignal an das Endgerät und das adaptive Filter (231) auszugeben,
   wobei der aktuelle Filterungskoeffizient folgendermaßen justiert wird:

$$e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K),$$

   wobei n die aktuelle Zeit, μ=0,5, K die aktuelle Netzechoverzögerung, e(n) der aktuelle Filterungskoeffizient, e (n+1) der justierte Filterungskoeffizient, Δ(n) das Netzausgangssignal, x(n-K) das Endgeräteeingangssignal zur Zeit (n-K) und $P(n-K)=X^T(n-K)*X(n-K)$ wobei $X^T(n-K)$ der transponierte Vektor von X(n-K) ist.

2. Einrichtung nach Anspruch 1, wobei das adaptive Filterungsmodul (23) ferner Folgendes umfasst:

   ein Dual-Ended-Sprachdetektionsmodul (233), das dafür ausgelegt ist, gemäß dem Netzeingangssignal von dem Netz und dem Endgeräteeingangssignal von dem Eingangspuffer-Speichermodul (21) zu detektieren, ob die aktuelle Zeit eine Dual-Ended-Sprachzeit ist, und das Signal zur Unterbrechung der Koeffizientenjustierung an das adaptive Filter (231) auszugeben, wenn die aktuelle Zeit eine Dual-Ended-Sprachzeit ist, und

   wobei das adaptive Filter (231) ferner dafür ausgelegt ist, die Justierung des aktuellen Filterungskoeffizienten nach dem Empfang eines Signals zur Unterbrechung der Koeffizientenjustierung von dem Dual-Ended-Sprachdetektionsmodul (233) zu unterbrechen.

3. Einrichtung nach Anspruch 2, wobei das von dem Eingangspuffer-Speichermodul (21) an das Dual-Ended-Sprachdetektionsmodul (233) ausgegebene Endgeräteeingangssignal gemäß einem verwendeten Dual-Ended-Sprachdetektionsalgorithmus bestimmt wird.

4. Endgerät, das die Elektrizitätsecho-Löscheinrichtung nach einem der Ansprüche 1 bis 3 umfasst.

5. Elektrizitätsecho-Löschverfahren mit den folgenden Schritten:

   Berechnen einer Netzechoverzögerung gemäß einem Paket des Real Time Control Protocol RTCP, wenn das RTCP- Paket ankommt;
   Aktualisieren der aktuellen Netzechoverzögerung mit der Netzechoverzögerung;

Bestimmen eines adaptiv zu filternden Endgeräteeingangssignals gemäß der aktuellen Netzechoverzögerung und einem Algorithmus der adaptiven Filterung;
Berechnen eines Elektrizitätsechosignals durch Ausführen von adaptiver Filterung an dem Endgeräteeingangssignal; und
Berechnen der Differenz zwischen einem Netzeingangssignal und dem Elektrizitätsechosignal, um ein Netzausgangssignal zu erhalten,

dadurch gekennzeichnet, dass der Algorithmus der adaptiven Filterung Folgendes umfasst:

Justieren des aktuellen Filterungskoeffizienten als

$$e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K),$$

wobei n die aktuelle Zeit, μ=0,5, K die aktuelle Netzechoverzögerung, e(n) der aktuelle Filterungskoeffizient, e (n+1) der justierte Filterungskoeffizient, Δ(n) das Netzausgangssignal, x(n-K) das Endgeräteeingangssignal zur Zeit (n-K) und P(n-K)=XT(n-K)*X(n-K), wobei X^T(n-K) der transponierte Vektor von X(n-K) ist.

6. Verfahren nach Anspruch 5, wobei das Berechnen der Netzechoverzögerung gemäß dem RTCP-Paket Folgendes umfasst:

   Subtrahieren einer durch das RTCP-Paket geführten Zeit, zu der ein gesendetes Paket zuletzt empfangen wird, von einer Zeit des Network Time Protocol NTP, zu der das RTCP-Paket ankommt, und ferner Subtrahieren eines Zeitintervalls zwischen der Zeit, zu der das gesendete Paket zuletzt empfangen wird, und der Zeit, zu der das RTCP-Paket gesendet wird; und
   Dividieren der durch die beiden Subtraktionen abgeleiteten resultierenden Differenz durch ein Abtastzeitintervall, um die Netzechoverzögerung zu erhalten.

7. Verfahren nach Anspruch 5, wobei das Elektrizitätsechosignal als

$$r(n) = \sum_{m=0}^{M-1} e(n)_m \cdot X(n-K-m)$$

berechnet wird,
wobei n die aktuelle Zeit, M die Gesamtordnung der adaptiven Filterung, K die aktualisierte aktuelle Netzechoverzögerung, r(n) das aktuelle Elektrizitätsechosignal, $e(n)_m$ der aktuelle Filterungskoeffizient der m^{ten} Ordnung und x (n-K-m) das Endgeräteeingangssignal zur Zeit (n-K-m) ist.

8. Verfahren nach Anspruch 5, wobei das Verfahren ferner die folgenden Schritte umfasst:

   Bestimmen, ob die aktuelle Zeit eine Dual-Ended-Sprachzeit ist; und
   wenn die aktuelle Zeit eine Dual-Ended-Sprachzeit ist, Unveränderthalten des aktuellen Filterungskoeffizienten und
   wenn die aktuelle Zeit keine Dual-Ended-Sprachzeit ist, Justieren des aktuellen Filterungskoeffizienten gemäß dem Algorithmus der adaptiven Filterung.

9. Verfahren nach Anspruch 8, wobei das Bestimmen, ob die aktuelle Zeit eine Dual-Ended-Sprachzeit ist, Folgendes umfasst:

   Bestimmen, ob die Bedingung $|Y_{out}(n)|-C*max(|X(n)|,|X(n-1)|,...,|X(n-L+1|)>0$ erfüllt ist; und
   wenn die Bedingung erfüllt ist, Bestimmen, dass die aktuelle Zeit eine Dual-Ended-Sprachzeit ist, und
   wenn die Bedingung nicht erfüllt ist, Bestimmen, dass die aktuelle Zeit keine Dual-Ended-Sprachzeit ist;

wobei n die aktuelle Zeit ist, C und L empirisch bestimmte Konstanten sind, $Y_{out}(n)$ das Netzausgangssignal ist, x (n) das Endgeräteeingangssignal zur aktuellen Zeit ist, x(n-1) das Endgeräteeingangssignal zur Zeit (n-1) ist und x (n-L+1) das Endgeräteeingangssignal zur Zeit (n-L+1) ist.

Revendications

1. Dispositif de suppression d'écho d'électricité, comprenant un module de calcul de retard d'écho de réseau (22), un module de mémoire tampon d'entrée (21) et un module de filtrage adaptatif (23):

le module de calcul de retard d'écho de réseau (22) étant configuré pour calculer un retard d'écho de réseau en fonction d'un paquet de Protocole de Contrôle en Temps Réel, RTCP, transmis par le réseau ;
le module de mémoire tampon d'entrée (21) étant configuré pour déterminer un signal d'entrée de terminal à filtrer de manière adaptative en fonction du retard d'écho de réseau produit en sortie le plus récemment par le module de calcul de retard d'écho de réseau (22), et produire en sortie le signal d'entrée de terminal vers le module de filtrage adaptatif (23) ; et
le module de filtrage adaptatif (23) étant configuré pour calculer un signal d'écho d'électricité et un signal de sortie de réseau,

caractérisé en ce que le module de filtrage adaptatif (23) comprend :

un filtre adaptatif (231), configuré pour calculer le signal d'écho d'électricité en fonction du signal d'entrée de terminal produit en sortie par le module de mémoire tampon d'entrée (21) et d'un coefficient de filtrage maintenu dans le filtre adaptatif (231), produire en sortie le signal d'écho d'électricité vers un soustracteur (232), régler le coefficient de filtrage courant en fonction d'un signal de sortie de réseau produit en sortie par le soustracteur (232) ; et
le soustracteur (232) est configuré pour soustraire le signal d'écho d'électricité produit en sortie par le filtre adaptatif (231) d'un signal d'entrée de réseau provenant du réseau, et produire en sortie le signal de sortie de réseau dérivé par la soustraction vers le terminal et le filtre adaptatif (231),
le coefficient de filtrage courant étant réglé en

$$e(n+1) = e(n) + \mu * \frac{\Delta(n)}{P(n-K)} * X(n-K),$$

où n est le temps courant, μ = 0,5, K est le retard d'écho de réseau courant, e(n) est le coefficient de filtrage courant, e(n+1) est le coefficient de filtrage réglé, $\Delta(n)$ est le signal de sortie de réseau, X(n-K) est le signal d'entrée de terminal au temps (n-K), et $P(n-K) = X^T(n-K)*X(n-K)$ où $X^T(n-K)$ est le vecteur transposé de X(n-K).

2. Dispositif selon la revendication 1, dans lequel le module de filtrage adaptatif (23) comprend en outre :

un module de détection de voix aux deux extrémités (233), configuré pour détecter si le temps courant est un temps de voix aux deux extrémités en fonction du signal d'entrée de réseau provenant du réseau et du signal d'entrée de terminal provenant du module de mémoire tampon d'entrée (21), et si le temps courant est un temps de voix aux deux extrémités, produire en sortie le signal d'interruption du réglage de coefficient vers le filtre adaptatif (231), et
dans lequel le filtre adaptatif (231) est configuré en outre pour interrompre le réglage du coefficient de filtrage courant après avoir reçu un signal d'interruption du réglage de coefficient depuis le module de détection de voix aux deux extrémités (233).

3. Dispositif selon la revendication 2, dans lequel le signal d'entrée de terminal produit en sortie par le module de mémoire tampon d'entrée (21) vers le module de détection de voix aux deux extrémités (233) est déterminé en fonction d'un algorithme de détection de voix aux deux extrémités employé.

4. Terminal, comprenant le dispositif de suppression d'écho d'électricité selon l'une quelconque des revendications 1 à 3.

5. Procédé de suppression d'écho d'électricité, comprenant :

le calcul d'un retard d'écho de réseau en fonction d'un paquet de Protocole de Contrôle en Temps Réel, RTCP, quand le paquet RTCP arrive ;
l'actualisation du retard d'écho de réseau courant avec le retard d'écho de réseau ;
la détermination d'un signal d'entrée de terminal à filtrer de manière adaptative en fonction du retard d'écho de réseau courant et d'un algorithme de filtrage adaptatif ;
le calcul d'un signal d'écho d'électricité en exécutant un filtrage adaptatif sur le signal d'entrée de terminal ; et
le calcul de la différence entre un signal d'entrée de réseau et le signal d'écho d'électricité pour obtenir un signal de sortie de réseau,

caractérisé en ce que l'algorithme de filtrage adaptatif comprend :

le réglage du coefficient de filtrage courant en

$$e(n+1) = e(n) + \mu * \left[\frac{\Delta(n)}{P(n-K)}\right] * X(n\text{-}K),$$

où n est le temps courant, μ = 0,5, K est le retard d'écho de réseau courant, e(n) est le coefficient de filtrage courant, e(n+1) est le coefficient de filtrage réglé, Δ(n) est le signal de sortie de réseau, X(n-K) est le signal d'entrée de terminal au temps (n-K), et $P(n\text{-}K) = X^T(n\text{-}K)*X(n\text{-}K)$ où $X^T(n\text{-}K)$ est le vecteur transposé de X(n-K).

6. Procédé selon la revendication 5, dans lequel le calcul du retard d'écho de réseau selon le paquet RTCP comprend :

la soustraction, d'un temps de Protocole de Temps de Réseau, NTP, auquel le paquet RTCP arrive, d'un temps, porté par le paquet RTCP, auquel un paquet transmis est reçu le plus récemment, et la soustraction supplémentaire d'un intervalle de temps entre le temps auquel un paquet transmis est reçu le plus récemment et le temps auquel le paquet RTCP est transmis ; et
la division de la différence résultante dérivée par les deux soustractions par un intervalle de temps d'échantillonnage afin d'obtenir le retard d'écho de réseau.

7. Procédé selon la revendication 5, dans lequel le signal d'écho d'électricité est calculé selon

$$r(n) = \sum_{m=0}^{M-1} e(n)_m \,.\, X(n\text{-}K\text{-}m),$$

où n est le temps courant, M est l'ordre total de filtrage adaptatif, K est le retard d'écho de réseau courant actualisé, r(n) est le signal d'écho d'électricité courant, $e(n)_m$ est le coefficient de filtrage courant du $m^{ième}$ ordre, et x(n-K-m) est le signal d'entrée de terminal au temps (n-K-m).

8. Procédé selon la revendication 5, dans lequel le procédé comprend en outre :

la détermination si le temps courant est un temps de voix aux deux extrémités; et
si le temps courant est un temps de voix aux deux extrémités, le maintien tel quel du coefficient de filtrage courant ; et
si le temps courant n'est pas un temps de voix aux deux extrémités, le réglage du coefficient de filtrage courant en fonction de l'algorithme de filtrage adaptatif.

9. Procédé selon la revendication 8, dans lequel la détermination si le temps courant est un temps de voix aux deux extrémités comprend :

la détermination si la condition $|Y_{sortie}(n)|\text{-}C*\max(|X(n)|, |X(n\text{-}1)|, ..., |X(n\text{-}L+1|) > 0$ est satisfaite ou non ; et
si la condition est satisfaite, la détermination que le temps courant est un temps de voix aux deux extrémités ; et
si la condition n'est pas satisfaite, la détermination que le temps courant n'est pas un temps de voix aux deux

extrémités ;
où n est le temps courant, C et L sont des constantes déterminées par expérience, $Y_{sortie}(n)$ est le signal de sortie de réseau, x(n) est le signal d'entrée de terminal au temps courant, x(n-1) est le signal d'entrée de terminal au temps (n-1), et x(n-L+1) est le signal d'entrée de terminal au temps (n-L+1).

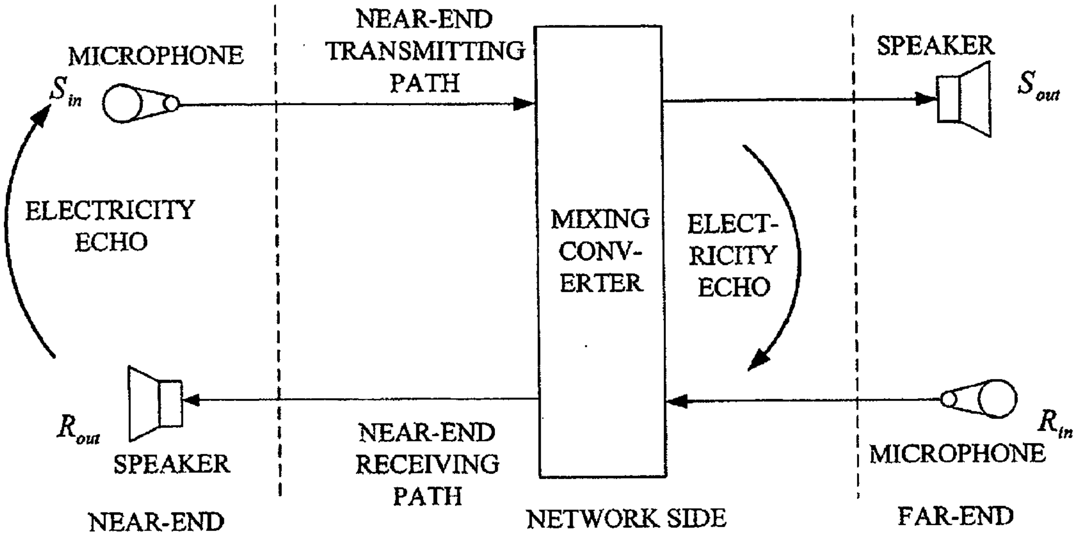
NEAR-END
TRANSMITTING
PATH
MICROPHONE
S_{in}
SPEAKER
S_{out}
ELECTRICITY
ECHO
MIXING
CONV-
ERTER
ELECT-
RICITY
ECHO
R_{out}
SPEAKER
NEAR-END
RECEIVING
PATH
R_{in}
MICROPHONE
NEAR-END
NETWORK SIDE
FAR-END

Fig. 1

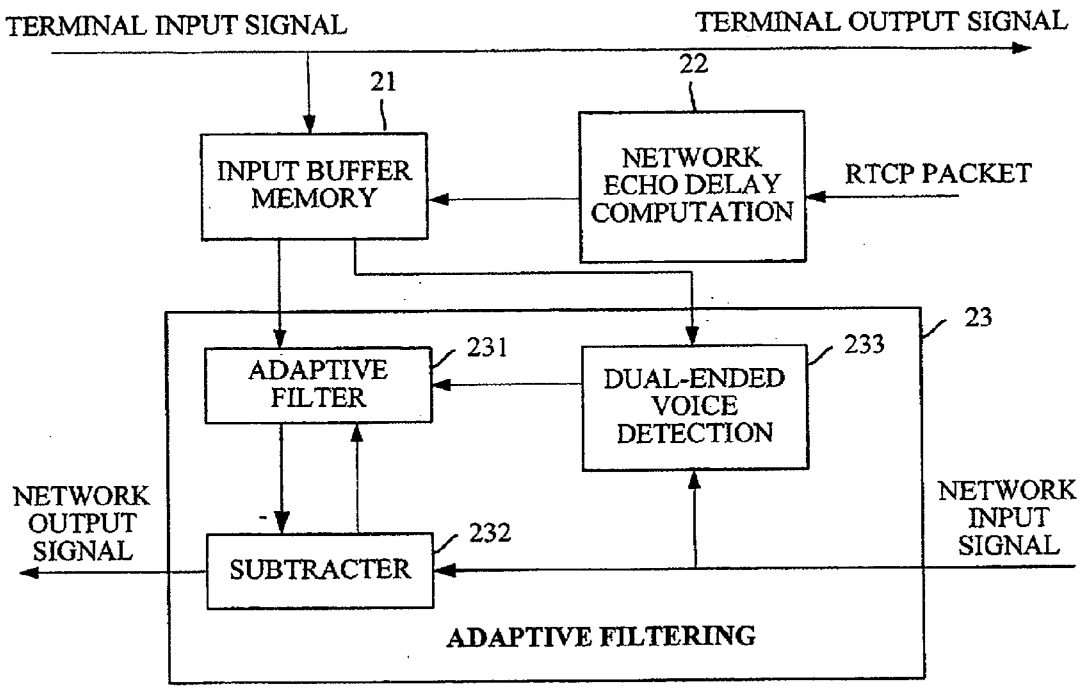
TERMINAL INPUT SIGNAL
TERMINAL OUTPUT SIGNAL
21
22
INPUT BUFFER MEMORY
NETWORK ECHO DELAY COMPUTATION
RTCP PACKET
23
231
233
ADAPTIVE FILTER
DUAL-ENDED VOICE DETECTION
NETWORK OUTPUT SIGNAL
NETWORK INPUT SIGNAL
-
232
SUBTRACTER
ADAPTIVE FILTERING

Fig. 2

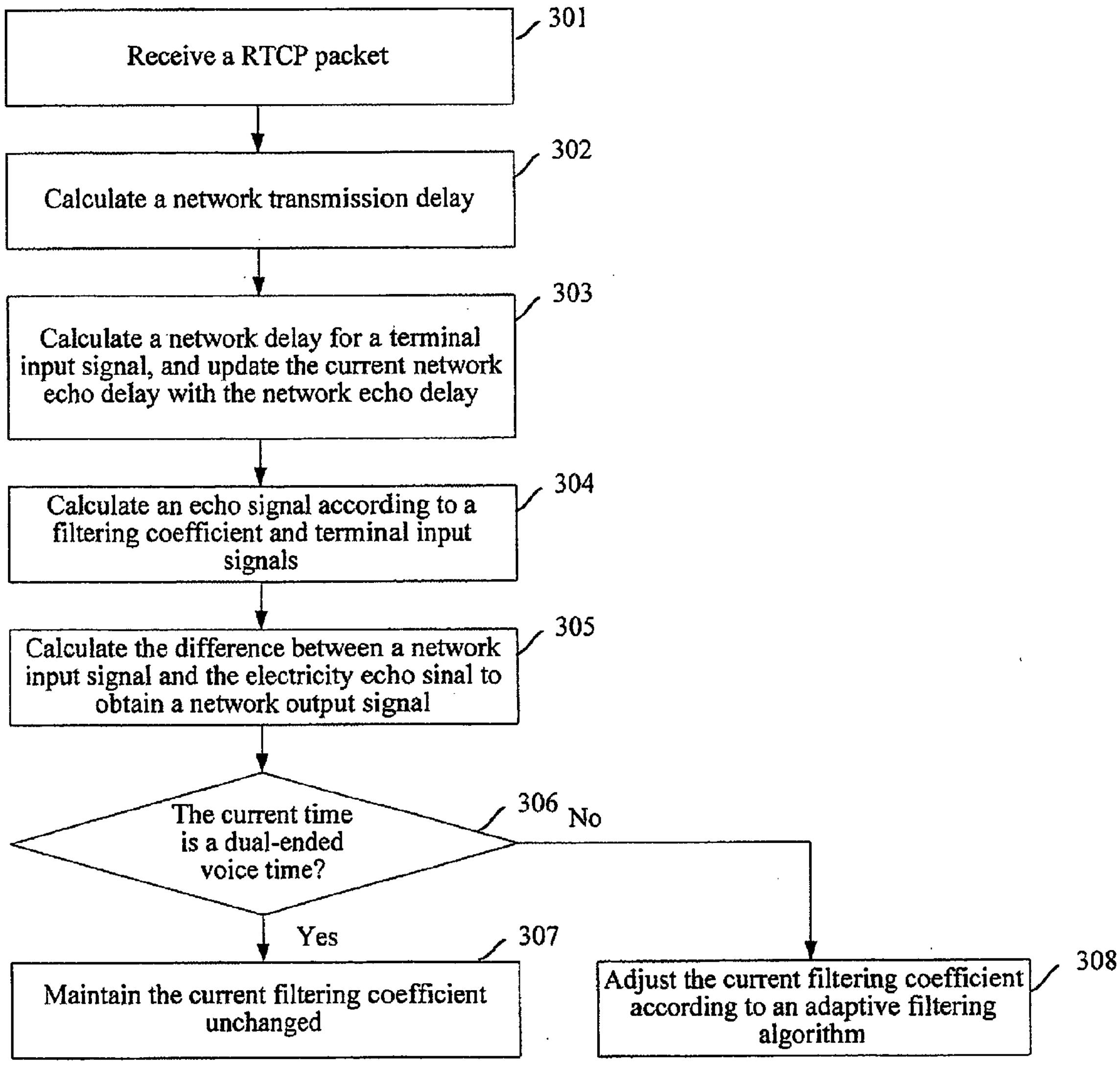
Receive a RTCP packet
301
Calculate a network transmission delay
302
Calculate a network delay for a terminal input signal, and update the current network echo delay with the network echo delay
303
Calculate an echo signal according to a filtering coefficient and terminal input signals
304
Calculate the difference between a network input signal and the electricity echo sinal to obtain a network output signal
305
The current time is a dual-ended voice time?
306
No
Yes
Maintain the current filtering coefficient unchanged
307
Adjust the current filtering coefficient according to an adaptive filtering algorithm
308

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0986190 A2 **[0007]**
- WO 0145291 A1 **[0007]**
- US 6724736 B1 **[0007]**
- US 6792106 B1 **[0007]**