

DESCRIPTION

Title of Invention: BANDWIDTH MEASURING DEVICE AND PROGRAM

Technical Field

[0001]

The present invention relates to a bandwidth measuring device and a program.

Background Art

[0002]

For measuring the actual communication performance between communication devices connected to each other via a communication network, the bandwidth used between the communication devices is sometimes measured (see, for example, PTL 1).

[0003]

The congestion status of a communication network is ever-changing, and thus, it is desirable to sequentially measure a bandwidth at a timing suited to a change in the congestion status of a communication network.

Citation List

Patent Literature

[0004]

PTL 1: Japanese Unexamined Patent Application

Publication No. 2000-106557

Summary of Invention

Technical Problem

[0005]

It is an object of the present invention to provide a bandwidth measuring device that is able to measure a bandwidth at a timing suited to a change in the congestion status of a communication network to be used and to provide a program therefor.

Solution to Problem

[0006]

According to the invention recited in Claim 1, there is provided a bandwidth measuring device including: means for extracting, as a cutoff frequency, a highest frequency component among frequency components obtained by performing Fourier transform on transition data which indicates a transition of communication congestion traffic with respect to a time in a communication network to be used; determining means for determining, on the basis of a relationship between an error ratio and the number of measurement times in a cycle corresponding to the cutoff frequency, a minimum value of the number of measurement times that satisfy a given error ratio; setting means for setting each of a measurement cycle and a measurement time so as to satisfy both conditions of a maximum value in the measurement cycle determined on the basis of the cutoff frequency and the minimum value of the number of measurement times in the cycle corresponding to the cutoff frequency determined by

the determining means; and measuring means for measuring a bandwidth of communication performed by using the communication network, on the basis of the measurement cycle and the measurement time set by the setting means.

[0007]

According to the invention recited in Claim 2, in the bandwidth measuring device recited in Claim 1, the measuring means may set the measurement cycle to be $1/2$ of the cycle corresponding to the cutoff frequency.

[0008]

According to the invention recited in Claim 3, in the bandwidth measuring device recited in Claim 1 or 2, the relationship between the error ratio $e(M)$ and the number of measurement times M in the cycle corresponding to the cutoff frequency may be expressed by $e(M) = 1 - \text{sinc}(\pi/M)$.

[0009]

According to the invention recited in Claim 4, the bandwidth measuring device recited in one of Claims 1 to 3 may further include: sending means for sending information concerning a bandwidth measured by the measuring means when requesting an information distribution device connected to the communication network to distribute data; and receiving means for receiving, from the information distribution device, data of a quality selected corresponding to the information concerning the bandwidth sent by the sending

means.

[0010]

According to the invention recited in Claim 5, in the bandwidth measuring device recited in Claim 4, the sending means may send the information concerning the bandwidth measured by the measuring means after receiving a request to distribute the data.

[0011]

According to the invention recited in Claim 6, the bandwidth measuring device recited in Claim 4 may further include storage means for storing information concerning a latest bandwidth measured by the measuring means. The sending means may send the information concerning the latest bandwidth stored in the storage means when requesting the information distribution device connected to the communication network to distribute data.

[0012]

According to the invention recited in Claim 7, the bandwidth measuring device recited in one of Claims 1 to 3 may further include sending means for sending data of a quality selected corresponding to information concerning a bandwidth measured by the measuring means to a different device connected to the communication network when receiving a request to distribute data from the different device.

[0013]

According to the invention recited in Claim 8, there is provided a program causing a computer to function as: means for extracting, as a cutoff frequency, a highest frequency component among frequency components obtained by performing Fourier transform on transition data which indicates a transition of communication congestion traffic with respect to a time in a communication network to be used; determining means for determining, on the basis of a relationship between an error ratio and the number of measurement times in a cycle corresponding to the cutoff frequency, a minimum value of the number of measurement times that satisfy a given error ratio; setting means for setting each of a measurement cycle and a measurement time so as to satisfy both conditions of a maximum value in the measurement cycle determined on the basis of the cutoff frequency and the minimum value of the number of measurement times in the cycle corresponding to the cutoff frequency determined by the determining means; and measuring means for measuring a bandwidth of communication performed by using the communication network, on the basis of the measurement cycle and the measurement time set by the setting means.

Advantageous Effects of Invention

[0014]

According to the inventions recited in Claims 1 and 8, it is possible to measure a bandwidth at a timing suited to

a change in the congestion status of a communication network to be used.

[0015]

According to the invention recited in Claim 2, it is possible to decrease the frequency of measurements, compared with a case in which the configuration of this invention is not provided.

[0016]

According to the invention recited in Claim 3, it is possible to easily obtain the error ratio from the number of measurement times, compared with a case in which the configuration of this invention is not provided.

[0017]

According to the invention recited in Claim 4, it is possible to receive the distribution of data of a quality corresponding to the bandwidth.

[0018]

According to the invention recited in Claim 5, it is possible to receive the distribution of data of a quality corresponding to the bandwidth used when a data distribution request has been sent.

[0019]

According to the invention recited in Claim 6, it is possible to reduce the wait time until video is distributed to be shorter than a case in which the bandwidth is measured

after sending a data distribution request.

[0020]

According to the invention recited in Claim 7, it is possible to distribute data of a quality corresponding to the bandwidth to a data distribution destination.

Brief Description of Drawings

[0021]

[Fig. 1] Fig. 1 is a system block diagram of an information distribution system according to an exemplary embodiment of the present invention.

[Fig. 2] Fig. 2 is a diagram illustrating an example of the hardware configuration of each of an information distribution server and a client device.

[Fig. 3] Fig. 3 is a diagram illustrating an example of a distribution video data management table.

[Fig. 4] Fig. 4 is a diagram illustrating an example of communication congestion status transition data.

[Fig. 5] Fig. 5 is a sequence diagram of video distribution processing according to a first exemplary embodiment.

[Fig. 6] Fig. 6 is a sequence diagram of video distribution processing according to the first exemplary embodiment.

[Fig. 7] Fig. 7 is a flowchart of measurement time setting processing.

[Fig. 8] Fig. 8 is a sequence diagram of video distribution processing according to a second exemplary embodiment.

[Fig. 9] Fig. 9 is a sequence diagram of video distribution processing according to the second exemplary embodiment.

[Fig. 10] Fig. 10 is a sequence diagram of measurement time setting processing according to a third exemplary embodiment.

[Fig. 11] Fig. 11 is a sequence diagram of video distribution processing according to the third exemplary embodiment.

[Fig. 12] Fig. 12 is a graph of a function $fM(u)$.

[Fig. 13] Fig. 13 is a graph illustrating the relationship between M and the error ratio.

Description of Embodiments

[0022]

A mode for carrying out the present invention (hereinafter referred to as an "exemplary embodiment") will be described below with reference to the drawings.

[0023]

[System Block Diagram]

Fig. 1 is a system block diagram of an information distribution system 1 according to an exemplary embodiment of the present invention. As shown in Fig. 1, the

information distribution system 1 includes an information distribution server 10, one or more base station devices 30, and one or more client devices 40. The information distribution server 10 and each base station device 30 communicate with each other via a network 20, such as an optical communication network, and a base station device 30 and a client device 40 perform wireless communication, such as mobile communication or wireless LAN communication, with each other, thereby implementing communication between the information distribution server 10 and each client device 40.

[0024]

The information distribution server 10 is a computer that stores data, such as video, and provides data in response to a request from a client device 40. In this case, the information distribution server 10 selects qualities (such as the resolution and the size) of data (video) requested by the client device 40, on the basis of the communication bandwidth (BW) between the client device 40 and the information distribution server 10, and provides data of the selected qualities to the client device 40.

[0025]

The base station device 30 is a device that performs wired communication with the information distribution server 10 and performs wireless communication, such as mobile communication, with each client device 40. Wireless

communication between the base station device 30 and the client device 40 may be performed by using various communication systems, such as 3G and 4G mobile communication.

[0026]

The client device 40 is a computer, such as a cellular phone (including a multi-function cellular phone), a tablet terminal, or a personal computer, operated by a user. The client device 40 performs wireless communication with the base station device 30 and performs data communication with the information distribution server 10 via the base station device 30. This enables the client device 40 to receive distribution of, for example, video, from the information distribution server 10. The client device 40 also measures the communication bandwidth (BW) between the client device 40 and the information distribution server 10 for a preset measurement time (τ) at regular preset measurement intervals (T). The measurement interval (T) and the measurement time (τ) are set on the basis of communication congestion status transition data (Congestion Profile) indicating the transition of the congestion status of a network with respect to the time. Details of processing for setting the measurement interval (T) and the measurement time (τ) will be discussed later.

[0027]

An example of the processing performed by the information distribution system 1 according to an exemplary embodiment of the present invention is as follows. Upon receiving a request to receive video distribution from the information distribution server 10 from a user, the client device 40 establishes communication with the information distribution server 10. Then, the client device 40 measures the communication bandwidth (BW) between the information distribution server 10 and the client device 40, on the basis of the measurement interval (T) and the measurement time (τ) which are optimized to a temporal transition of the congestion status (for example, traffic) of a network. Then, the client device 40 sends the measured communication bandwidth, together with specifying information (for example, URL) which specifies the video to be requested, to the information distribution server 10. The information distribution server 10 selects video qualities (such as the resolution and the bit rate) of the video specified by the specifying information, on the basis of the communication bandwidth received from the client device 40, and sends a video-distribution URL corresponding to the selected video qualities to the client device 40. The client device 40 accesses the video-distribution URL sent from the information distribution server 10 and receives the distribution of the video of qualities which are optimized

to the communication bandwidth between the client device 40 and the information distribution server 10. The client device 40 then plays back the distributed video (for example, by stream playback).

[0028]

[Hardware Block Diagram]

The elements of each of the information distribution server 10 and the client device 40 provided for performing the above-described processing will be described below with reference to Fig. 2.

[0029]

[Information Distribution Server 10]

An example of the hardware configuration of the information distribution server 10 will first be discussed. As shown in Fig. 2, the information distribution server 10 includes a controller 11, a storage unit 12, and a communication unit 13.

[0030]

The controller 11 includes a CPU (Central Processing Unit) and executes various arithmetic operations and also controls the individual elements of the information distribution server 10, on the basis of a program stored in the storage unit 12.

[0031]

The storage unit 12 stores a program, such as an

operating system of the information distribution server 10, and data therein, and is also used as a work memory of the controller 11. The program may be stored in an information storage medium, such as an optical disc, a magnetic disk, magnetic tape, a magneto-optical disk, or a flash memory, and be supplied to the information distribution server 10. Alternatively, the program may be supplied to the information distribution server 10 via data communication means, such as the Internet. An example of the data stored in the storage unit 12 will be described below.

[0032]

In the storage unit 12, for example, video data (video files) and a distribution video data management table indicating qualities of video data to be distributed which are determined in accordance with each communication bandwidth, are stored.

[0033]

An example of the distribution video data management table is shown in Fig. 3. As shown in Fig. 3, in the distribution video data management table, the file name of video data, qualities (frame rate, resolution, and bit rate), ranks (ranges) of communication bandwidths, and video-distribution URLs are stored in association with each other. The rank of a communication bandwidth may be determined for each communication system.

[0034]

The communication unit 13 is implemented as a network interface card, and performs data communication with the base station device 30 and the like via a network and also performs data communication with the client device 40 and the like via the base station device 30.

[0035]

[Client Device 40]

An example of the hardware configuration of the client device 40 will now be discussed below. As shown in Fig. 2, the client device 40 includes a controller 41, a storage unit 42, a communication unit 43, an input unit 44, and a display unit 45.

[0036]

The controller 41 includes a CPU (Central Processing Unit) and executes various arithmetic operations and also controls the individual elements of the client device 40, on the basis of a program stored in the storage unit 42.

[0037]

The storage unit 42 stores a program, such as an operating system of the client device 40, and data therein, and is also used as a work memory of the controller 41. The program may be stored in an information storage medium, such as an optical disc, a magnetic disk, magnetic tape, a magneto-optical disk, or a flash memory, and be supplied to

the client device 40. Alternatively, the program may be supplied to the client device 40 via data communication means, such as the Internet.

[0038]

In the storage unit 42, for example, transition data indicating the congestion status of a network with respect to the time (communication congestion status transition data) may be stored.

[0039]

An example of the communication congestion status transition data is shown in Fig. 4. In the example of the communication congestion status transition data shown in Fig. 4, the horizontal axis indicates the time (0 to 23 (hour)) and the vertical axis indicates the communication congestion traffic. The communication congestion traffic may be data based on, for example, packets to be communicated, loss packets, packet delay time. This communication congestion status transition data may be obtained as a result of the client device 40 measuring the communication congestion on the basis of packets regularly sent to the information distribution server 10, or may be obtained from another device or a storage medium. The communication congestion status transition data may be set according to the month or the day of the week.

[0040]

The communication unit 43 includes, for example, a wireless communication antenna, and communicates with the base station device 30 via the wireless communication antenna.

[0041]

The input unit 44 is implemented by an input device, such as a touch panel or a keyboard, and receives input of an operation from a user.

[0042]

The display unit 45 is implemented by a display device, such as a liquid crystal display, and displays results (screen) of information processing executed by the controller 41.

[0043]

[Sequence]

Details of processing executed by the information distribution system 1 according to first through third exemplary embodiments will now be described below with reference to the sequence diagrams and the flow diagrams of Figs. 5 through 11.

[0044]

[First Exemplary Embodiment]

Processing according to the first exemplary embodiment will first be described below with reference to Figs. 5 through 7. The first exemplary embodiment is concerned with

an example of processing in a case in which the client device 40 measures the communication bandwidth (BW) when sending a video distribution request and sends information concerning the communication bandwidth (BW) to the information distribution server 10.

[0045]

A sequence diagram of video distribution processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10 is shown in Figs. 5 and 6.

[0046]

As shown in Fig. 5, as preprocessing, the client device 40 first executes measurement time setting processing for setting the time interval (T) and the measurement time (τ) at and for which the communication bandwidth (BW) is measured (S101). Details of this measurement time setting processing will be discussed later.

[0047]

Upon receiving a video distribution request from a user (S102), the client device 40 accesses the information distribution server 10 based on a link (URL) concerning the video distribution request and sends a video distribution request and a connection establishment request to the information distribution server 10 (S103).

[0048]

Upon receiving a connection establishment request packet from the client device 40, the information distribution server 10 sends an acknowledgement response (ACK) to the connection establishment request packet to the client device 40 (S104).

[0049]

Upon receiving the acknowledgement response (ACK) to the connection establishment request packet from the information distribution server 10, the client device 40 mutually identifies a communication port used for communication with the information distribution server 10 (S105).

[0050]

Then, the client device 40 initializes a timer tA (tA=0) and starts counting the time by using the timer tA (S106). The client device 40 also initializes a timer tB (tB=0) and starts counting the time by using the timer tB (S107). Then, the client device 40 sends a dummy packet to which a time stamp for a sending time is appended to the information distribution server 10 (S108).

[0051]

Upon receiving the dummy packet from the client device 40, the information distribution server 10 appends a time stamp for a sending time to an acknowledgement response (ACK) to the received dummy packet and sends the

acknowledgement response (ACK) to the client device 40 (S109).

[0052]

Upon receiving the acknowledgement response (ACK) to the dummy packet from the information distribution server 10, the client device 40 calculates a round-trip time (RTT) on the basis of the time interval between the time indicated by the time stamp of the dummy packet and that of the acknowledgement response (ACK), and records the calculated round-trip time (RTT) (S110). If the client device 40 has failed to receive ACK in response to the sent dummy packet, it may assume that packet loss has occurred and also record information concerning the occurrence of packet loss. If the timer t_B has not reached τ (S111: N), the client device 40 returns to S108. If the timer t_B has reached τ (S111: Y), the client device 40 determines whether or not the timer t_A has reached T (S112).

[0053]

If the timer t_A has not reached T in S112 (S112: N), the client device 40 waits until the timer t_A reaches T . If the timer t_A has reached T (S112: Y), the client device 40 determines whether or not a measurement completion condition is satisfied (S113). For example, if the number of times dummy packets have been sent is equal to or greater than a number threshold, or if the time elapsed after measurements

have started is equal to or greater than a time threshold, the client device 40 may determine that the measurement completion condition is satisfied.

[0054]

If the measurement completion condition is not satisfied in S113 (S113: N), the client device 40 returns to S106. If the measurement completion condition is satisfied (S113: Y), the client device 40 measures the communication bandwidth (BW) on the basis of the recorded RTT and the packet loss ratio (p) (S114). For example, the communication bandwidth (BW) may be calculated by, for example, the following equation (1). In equation (1), RTT is the average (or may be the median) of recorded RTTs, p is the ratio of loss packets to the number of sent packets, and MSS (Maximum Segment Size) is the maximum segment size of segments forming received data. The equation used for calculating the communication bandwidth (BW) is not restricted to equation (1), and another equation may be used.

[0055]

[Math. 1]

$$BW = \sqrt{\frac{3}{2}} \times \frac{MSS}{RTT \times \sqrt{p}} \quad \dots(1)$$

[0056]

Operations after step S114 will be described below with reference to Fig. 6.

[0057]

As shown in Fig. 6, the client device 40 sends communication status information indicating the communication bandwidth (BW) calculated in S114 to the information distribution server 10 (S115). The communication status information may include information concerning the communication system of wireless communication (for example, the mobile communication system) used by the client device 40.

[0058]

Upon receiving the communication status information including the information concerning the communication system and the communication bandwidth (BW) from the client device 40, the information distribution server 10 selects video qualities corresponding to the received communication system and communication bandwidth (BW) for the video data requested by the client device 40 by referring to the video distribution data management table (S116). For example, the information distribution server 10 may determine under which one of the ranks set for each communication system (for example, in mobile communication system A, L (lower than BWA1), M (BWA1 or higher and lower than BMA2), and H (BWA2 or higher) the communication bandwidth (BW) is classified, and may select video qualities (frame rate, resolution, and bit rate) corresponding to a set of the communication system

and the rank.

[0059]

The information distribution server 10 obtains the distribution URL for distributing the video data of the video qualities selected in S116 from the video distribution data management table (S117), and sends the obtained distribution URL to the client device 40 (S118) so as to redirect the client device 40 to the distribution URL.

[0060]

The client device 40 accesses the distribution URL sent from the information distribution server 10 (S119), receives the distribution of the video data linked to the distribution URL from the information distribution server 10 (S120), and plays back the video data (S121).

[0061]

The above-described processing is the overall flow of the video distribution processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10.

[0062]

[Flowchart of Measurement Time Setting Processing]

Details of the measurement time setting processing executed in S101 of Fig. 5 will be described below with reference to the flowchart of Fig. 7.

[0063]

As shown in Fig. 7, the client device 40 obtains communication congestion status transition data (see Fig. 4) indicating the transition of the congestion status of a network with respect to the time (S1001). The communication congestion status transition data may be obtained as a result of the client device 40 measuring the communication congestion on the basis of packets regularly sent to the information distribution server 10, or may be obtained from another device or a storage medium. If the communication congestion status transition data is set according to the month or the day of the week, the client device 40 may obtain the communication congestion status transition data at a current date.

[0064]

A description will now be given of the relationship between the communication congestion status transition data and a sampling function of a network. It is now assumed that the sampling function $s(t)$ of a network is expressed by the following equation (2) when the sampling period (measurement cycle) is denoted by T and the measurement time is denoted by τ , and that the communication congestion status transition data indicating the transition of the congestion status of a network with respect to time t is represented by $c(t)$. In equation (2), rect is a rectangular function and δ is a delta function.

[0065]

[Math. 2]

$$s(t) = \text{rect}\left(\frac{t}{\tau}\right) * \sum_{n=1}^N \delta(t - nT) \quad \dots (2)$$

[0066]

Then, a network evaluation function NetEst(t) is expressed by the following equation (3) by using s(t) and c(t). The result of performing Fourier transform on NetEst(t) is expressed by equation (4). In equation (4), sinc is a sinc function, u is a frequency component, * is a convolution operator, and S(u) and C(u) are the results of performing Fourier transform on s(t) and c(t), respectively.

[0067]

[Math. 3]

$$\text{NetEst}(t) = s(t) \times c(t) = \left(\text{rect}\left(\frac{t}{\tau}\right) * \sum_{n=1}^N \delta(t - nT) \right) \times c(t) \quad \dots (3)$$

[0068]

[Math. 4]

$$\text{nETeST}(u) = S(u) \times C(u) = \left(\text{Sinc}(u\tau) \times \sum_{m=1}^N \delta\left(u - \frac{m}{T}\right) \right) * C(u) \quad \dots (4)$$

[0069]

The client device 40 performs Fourier transform (for example, FFT) on the communication congestion status transition data so as to calculate the cutoff frequency fc

(S1002). The cutoff frequency f_c is the highest frequency component of $C(u)$ obtained by performing Fourier transform on the communication congestion status transition data $c(t)$.
[0070]

The measurement cycle T and the cutoff frequency f_c satisfy the following equation (5) according to the Nyquist theorem.

$$T \leq 1/(2 \cdot f_c) \quad \dots (5)$$

[0071]

If the number of measurement times in the cycle ($1/f_c$) corresponding to the cutoff frequency f_c is indicated by M , $\tau(M)$ is expressed by the following equation (6).

$$\tau(M) = 1/(M \cdot f_c) \quad \dots (6)$$

[0072]

Fig. 12 is a graph of a function $f_M(u)$ concerning $f_M(U) = \text{sinc}(\pi u \tau) = \text{sinc}(\pi u / M \cdot f_c)$ when M is varied (for example, $M = 1, 5, 25$). When M is 1 or greater, the error ratio $e(M)$ with respect to $u=f_c$ is expressed by the following equation (7).

$$e(M) = 1 - (f_M(f_c) - f_1(f_c)) \quad \dots (7)$$

Equation (7) may be reduced to the following equation.

$$e(M) = 1 - (\text{sinc}(\pi/M) - \text{sinc}(\pi)) = 1 - \text{sinc}(\pi/M)$$

[0073]

Fig. 13 illustrates the relationship between M and the error ratio. In Fig. 13, the horizontal axis indicates M ,

and the vertical axis indicates the error ratio. If a desired error ratio is specified, the corresponding M is determined. For example, in the example shown in Fig. 13, if 0.1% or lower is specified as the error ratio, the corresponding M is about 43 or higher.

[0074]

By referring back to the flowchart of Fig. 7, a description will continue. As discussed above, the client device 40 determines the minimum value M_{min} of the number of measurement times M in the cycle ($1/f_c$) that satisfy a specified error ratio (S1003).

[0075]

Then, the client device 40 determines T that satisfies equation (5) (S1004). For example, the client device 40 may determine that $T=1/(2 \cdot f_c)$. Then, the client device 40 determines τ on the basis of M which is equal to or higher than M_{min} determined in S1003, and also determines the duty ratio τ/T (S1005). The client device 40 then returns. For example, in the case of $M_{min}=43$, if $M=100$, $\tau/T=1/50$.

[0076]

The above-described processing refers to the flow of processing according to the first exemplary embodiment. According to the processing of the first exemplary embodiment, it is possible to distribute video of a quality suited to the communication bandwidth (BW) at a time when

the client device 40 has sent a video distribution request to the information distribution server 10. Additionally, each client device 40 measures the communication bandwidth (BW), thereby preventing the concentration of the processing load on the information distribution server 10.

[0077]

[Second Exemplary Embodiment]

Processing according to a second exemplary embodiment performed by the information distribution system 1 of an exemplary embodiment of the present invention will now be described below with reference to Figs. 8 and 9. The second exemplary embodiment is concerned with an example of processing in a case in which the information distribution server 10 measures the communication bandwidth (BW) when receiving a video distribution request.

[0078]

A sequence diagram of video distribution processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10 is shown in Figs. 8 and 9.

[0079]

As shown in Fig. 8, as preprocessing, the information distribution server 10 first executes measurement time setting processing for setting the time interval (T) and the measurement time (τ) at and for which the communication

bandwidth (BW) is measured (S201). Details of this measurement time setting processing are indicated by the flowchart of Fig. 7, and an explanation thereof will thus be omitted here.

[0080]

Upon receiving a video distribution request from a user (S202), the client device 40 accesses the information distribution server 10 based on a link (URL) concerning the video distribution request and sends a video distribution request and a connection establishment request to the information distribution server 10 (S203).

[0081]

Upon receiving a connection establishment request packet from the client device 40, the information distribution server 10 sends an acknowledgement response (ACK) to the connection establishment request packet to the client device 40 (S204).

[0082]

Upon receiving the acknowledgement response (ACK) to the connection establishment request packet from the information distribution server 10, the client device 40 mutually identifies a communication port used for communication with the information distribution server 10 (S205).

[0083]

Then, the information distribution server 10 initializes a timer t_A ($t_A=0$) and starts counting the time by using the timer t_A (S206). The information distribution server 10 also initializes a timer t_B ($t_B=0$) and starts counting the time by using the timer t_B (S207). Then, the information distribution server 10 sends a dummy packet to which a time stamp for a sending time is appended to the client device 40 (S208).

[0084]

Upon receiving the dummy packet from the information distribution server 10, the client device 40 appends a time stamp for a sending time to an acknowledgement response (ACK) to the received dummy packet and sends the acknowledgement response (ACK) to the information distribution server 10 (S209).

[0085]

Upon receiving the acknowledgement response (ACK) to the dummy packet from the client device 40, the information distribution server 10 calculates a round-trip time (RTT) on the basis of the time interval between the time indicated by the time stamp of the dummy packet and that of the acknowledgement response (ACK), and records the calculated round-trip time (RTT) (S210). If the information distribution server 10 has failed to receive ACK in response to the sent dummy packet, it may assume that packet loss has

occurred and also record information concerning the occurrence of packet loss. If the timer t_B has not reached τ (S211: N), the information distribution server 10 returns to S208. If the timer t_B has reached τ (S211: Y), the information distribution server 10 determines whether or not the timer t_A has reached T (S212).

[0086]

If the timer t_A has not reached T in S212 (S212: N), the information distribution server 10 waits until the timer t_A reaches T . If the timer t_A has reached T (S212: Y), the information distribution server 10 determines whether or not a measurement completion condition is satisfied (S213). For example, if the number of times dummy packets have been sent is equal to or greater than a number threshold, or if the time elapsed after measurements have started is equal to or greater than a time threshold, the information distribution server 10 may determine that the measurement completion condition is satisfied.

[0087]

If the measurement completion condition is not satisfied in S213 (S213: N), the information distribution server 10 returns to S206. If the measurement completion condition is satisfied (S213: Y), the information distribution server 10 measures the communication bandwidth (BW) on the basis of the recorded RTT and the packet loss

ratio (p) (S214). For example, the communication bandwidth (BW) may be calculated by, for example, the above-described equation (1).

[0088]

Operations after step S214 will be described below with reference to Fig. 9.

[0089]

As shown in Fig. 9, on the basis of information concerning a communication system used by the client device 40 and the calculated communication bandwidth (BW), the information distribution server 10 selects video qualities corresponding to the above-described communication system and communication bandwidth (BW) for the video data requested by the client device 40 by referring to the video distribution data management table (S215). For example, the information distribution server 10 may determine under which one of the ranks set for each communication system (for example, in mobile communication system A, L (lower than BWA1), M (BWA1 or higher and lower than BMA2), and H (BWA2 or higher) the communication bandwidth (BW) is classified, and may select video qualities (frame rate, resolution, and bit rate) corresponding to a set of the communication system and the rank.

[0090]

The information distribution server 10 obtains the

distribution URL for distributing the video data of the video qualities selected in S215 from the video distribution data management table (S216), and sends the obtained distribution URL to the client device 40 (S217) so as to redirect the client device 40 to the distribution URL.

[0091]

The client device 40 accesses the distribution URL sent from the information distribution server 10 (S218), receives the distribution of the video data linked to the distribution URL from the information distribution server 10 (S219), and plays back the video data (S220).

[0092]

The above-described processing refers to the overall flow of the video distribution processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10.

[0093]

According to the processing of the second exemplary embodiment, even in a case in which a client device 40 does not have a function of measuring the communication bandwidth (BW), video of a quality suited to the communication bandwidth (BW) at a time when the client device 40 has sent a video distribution request to the information distribution server 10 is distributed to the client device 40.

[0094]

[Third Exemplary Embodiment]

Processing according to a third exemplary embodiment will now be described below with reference to Figs. 10 and 11. The third exemplary embodiment is concerned with an example of processing in a case in which the client device 40 measures the communication bandwidth (BW) on a regular basis and stores it prior to the sending of a video distribution request, and sends information concerning the stored latest communication bandwidth (BW) to the information distribution server 10 when receiving a video distribution request.

[0095]

A sequence diagram of measurement processing for measuring the communication bandwidth (BW) on a regular basis executed by the client device 40 is shown in Fig. 10.

[0096]

As shown in Fig. 10, as preprocessing, the client device 40 first executes measurement time setting processing for setting the time interval (T) and the measurement time (τ) at and for which the communication bandwidth (BW) is measured (S301). Details of this measurement time setting processing are indicated by the flowchart of Fig. 7, and an explanation thereof will thus be omitted here.

[0097]

If the update timing for updating the communication

bandwidth (BW) has not yet arrived (S302: N), the client device 40 waits. If the update timing for updating the communication bandwidth (BW) has arrived (S302: Y), the client device 40 accesses the information distribution server 10 and sends a connection establishment request to the information distribution server 10 (S303).

[0098]

Upon receiving a connection establishment request packet from the client device 40, the information distribution server 10 sends an acknowledgement response (ACK) to the connection establishment request packet to the client device 40 (S304).

[0099]

Upon receiving the acknowledgement response (ACK) to the connection establishment request packet from the information distribution server 10, the client device 40 mutually identifies a communication port used for communication with the information distribution server 10 (S305).

[0100]

Then, the client device 40 initializes a timer tA (tA=0) and starts counting the time by using the timer tA (S306). The client device 40 also initializes a timer tB (tB=0) and starts counting the time by using the timer tB (S307). Then, the client device 40 sends a dummy packet to

which a time stamp for a sending time is appended to the information distribution server 10 (S308).

[0101]

Upon receiving the dummy packet from the client device 40, the information distribution server 10 appends a time stamp for a sending time to an acknowledgement response (ACK) to the received dummy packet and sends the acknowledgement response (ACK) to the client device 40 (S309).

[0102]

Upon receiving the acknowledgement response (ACK) to the dummy packet from the information distribution server 10, the client device 40 calculates a round-trip time (RTT) on the basis of the time interval between the time indicated by the time stamp of the dummy packet and that of the acknowledgement response (ACK), and records the calculated round-trip time (RTT) (S310). If the client device 40 has failed to receive ACK in response to the sent dummy packet, it may assume that packet loss has occurred and also record information concerning the occurrence of packet loss. If the timer t_B has not reached τ (S311: N), the client device 40 returns to S308. If the timer t_B has reached τ (S311: Y), the client device 40 determines whether or not the timer t_A has reached T (S312).

[0103]

If the timer tA has not reached T in S312 (S312: N), the client device 40 waits until the timer tA reaches T. If the timer tA has reached T (S312: Y), the client device 40 determines whether or not a measurement completion condition is satisfied (S313). For example, if the number of times dummy packets have been sent is equal to or greater than a number threshold, or if the time elapsed after measurements have started is equal to or greater than a time threshold, the client device 40 may determine that the measurement completion condition is satisfied.

[0104]

If the measurement completion condition is not satisfied in S313 (S313: N), the client device 40 returns to S306. If the measurement completion condition is satisfied (S313: Y), the client device 40 measures the communication bandwidth (BW) on the basis of the recorded RTT and the packet loss ratio (p) (S314). For example, the communication bandwidth (BW) may be calculated by, for example, the above-described equation (1).

[0105]

The client device 40 stores the calculated latest communication bandwidth (BW) in the storage unit 42 (overwrites the communication bandwidth (BW) in the storage unit 42), and then returns to S302. The above-described processing refers to measurement processing for measuring

the communication bandwidth (BW) on a regular basis executed by the client device 40.

[0106]

Processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10 in the third exemplary embodiment will now be described below with reference to the sequence diagram of Fig. 11.

[0107]

As shown in Fig. 11, upon receiving a video distribution request from a user (S401), the client device 40 sends communication status information indicating the latest communication bandwidth (BW) stored in the storage unit 42 to the information distribution server 10 (S402). The communication status information may include information concerning the communication system of wireless communication (for example, the mobile communication system) used by the client device 40.

[0108]

Upon receiving the communication status information including information concerning the communication system and the communication bandwidth (BW) from the client device 40, the information distribution server 10 selects video qualities corresponding to the above-described communication system and communication bandwidth (BW) for the video data

requested by the client device 40 by referring to the video distribution data management table (S403). For example, the information distribution server 10 may determine under which one of the ranks set for each communication system (for example, in mobile communication system A, L (lower than BWA1), M (BWA1 or higher and lower than BMA2), and H (BWA2 or higher)) the communication bandwidth (BW) is classified, and may select video qualities (frame rate, resolution, and bit rate) corresponding to a set of the communication system and the rank.

[0109]

The information distribution server 10 obtains the distribution URL for distributing the video data of the video qualities selected in S403 from the video distribution data management table (S404), and sends the obtained distribution URL to the client device 40 (S405) so as to redirect the client device 40 to the distribution URL.

[0110]

The client device 40 accesses the distribution URL sent from the information distribution server 10 (S406), receives the distribution of the video data linked to the distribution URL from the information distribution server 10 (S407), and plays back the video data (S408).

[0111]

The above-described processing refers to the flow of

the video distribution processing to be executed when the client device 40 sends a video distribution request to the information distribution server 10 in the third exemplary embodiment.

[0112]

According to the processing of the third exemplary embodiment, since the client device 40 measures and stores the communication bandwidth (BW) in advance, it is able to immediately send the communication bandwidth (BW) to the information distribution server 10 when sending a video distribution request. This makes it possible to reduce the wait time until video is distributed to be shorter than that of the first exemplary embodiment.

[0113]

The present invention is not restricted to the above-described exemplary embodiments. For example, in the above-described exemplary embodiments, an example in which the client device 40 performs wireless data communication has been discussed. However, the client device 40 may perform wired data communication.

[0114]

In the third exemplary embodiment, timings at which the client device 40 updates the communication bandwidth (BW) may include, not only regular timings, but also times at which a predetermined event occurs (for example, when a

predetermined operation is received from a user or when the base station device 30 to be communicated is changed).

[0115]

In the above-described exemplary embodiments, an example in which the information distribution server 10 distributes video data to the client device 40 has been discussed. However, data to be distributed is not restricted to video data, and may be another type of data.

Reference Signs List

[0116]

1 information distribution system, 10 information distribution server, 11 controller, 12 storage unit, 13 communication unit, 20 network, 30 base station device, 40 client device, 41 controller, 42 storage unit, 43 communication unit, 44 input unit, 45 display unit

CLAIMS

[Claim 1]

A bandwidth measuring device comprising:

means for extracting, as a cutoff frequency, a highest frequency component among frequency components obtained by performing Fourier transform on transition data which indicates a transition of communication congestion traffic with respect to a time in a communication network to be used;

determining means for determining, on the basis of a relationship between an error ratio and the number of measurement times in a cycle corresponding to the cutoff frequency, a minimum value of the number of measurement times that satisfy a given error ratio;

setting means for setting each of a measurement cycle and a measurement time so as to satisfy both conditions of a maximum value in the measurement cycle determined on the basis of the cutoff frequency and the minimum value of the number of measurement times in the cycle corresponding to the cutoff frequency determined by the determining means; and

measuring means for measuring a bandwidth of communication performed by using the communication network, on the basis of the measurement cycle and the measurement time set by the setting means.

[Claim 2]

The bandwidth measuring device according to Claim 1, wherein the measuring means sets the measurement cycle to be $1/2$ of the cycle corresponding to the cutoff frequency.

[Claim 3]

The bandwidth measuring device according to Claim 1 or 2, wherein the relationship between the error ratio $e(M)$ and the number of measurement times M in the cycle corresponding to the cutoff frequency is expressed by $e(M) = 1 - \text{sinc}(\pi/M)$.

[Claim 4]

The bandwidth measuring device according to one of Claims 1 to 3, further comprising:

sending means for sending information concerning a bandwidth measured by the measuring means when requesting an information distribution device connected to the communication network to distribute data; and

receiving means for receiving, from the information distribution device, data of a quality selected corresponding to the information concerning the bandwidth sent by the sending means.

[Claim 5]

The bandwidth measuring device according to Claim 4, wherein the sending means sends the information concerning the bandwidth measured by the measuring means after receiving a request to distribute the data.

[Claim 6]

The bandwidth measuring device according to Claim 4,
further comprising:

storage means for storing information concerning a
latest bandwidth measured by the measuring means,

wherein the sending means sends the information
concerning the latest bandwidth stored in the storage means
when requesting the information distribution device
connected to the communication network to distribute data.

[Claim 7]

The bandwidth measuring device according to one of
Claims 1 to 3, further comprising:

sending means for sending data of a quality selected
corresponding to information concerning a bandwidth measured
by the measuring means to a different device connected to
the communication network when receiving a request to
distribute data from the different device.

[Claim 8]

A program causing a computer to function as:

means for extracting, as a cutoff frequency, a highest
frequency component among frequency components obtained by
performing Fourier transform on transition data which
indicates a transition of communication congestion traffic
with respect to a time in a communication network to be
used;

determining means for determining, on the basis of a relationship between an error ratio and the number of measurement times in a cycle corresponding to the cutoff frequency, a minimum value of the number of measurement times that satisfy a given error ratio;

setting means for setting each of a measurement cycle and a measurement time so as to satisfy both conditions of a maximum value in the measurement cycle determined on the basis of the cutoff frequency and the minimum value of the number of measurement times in the cycle corresponding to the cutoff frequency determined by the determining means; and

measuring means for measuring a bandwidth of communication performed by using the communication network, on the basis of the measurement cycle and the measurement time set by the setting means.