

DESCRIPTION

Title of Invention:

INFORMATION PROCESSING SYSTEM, INFORMATION PROCESSING
APPARATUS, AND PROGRAM

Technical Field

[0001]

The present invention relates to an information processing system, an information processing apparatus, and a program.

Background Art

[0002]

There is a system in which an information processing apparatus successively receives packets of streaming data distributed from an information distribution apparatus, and reproduces data based on the received packets (for example, see PTL 1 written below).

Citation List

Patent Literature

[0003]

PTL 1: U.S. Patent No. 8,285,886

Summary of Invention

Technical Problem

[0004]

An object of the present invention is to provide an information processing system, an information processing apparatus, and a program each of which can change a bit rate in response to occurrence of communication congestion and an increase in packet loss rate during reception of distribution data.

[0005]

Another object of the present invention is to provide an information processing system, an information processing apparatus, and a program each of which can

change a bit rate in accordance with a remaining time available for reproduction with packets received for distribution data.

Solution to Problem

[0006]

The invention according to claim 1 is an information processing system including an information processing apparatus and an information distribution apparatus. The information processing apparatus includes receiving means for successively receiving a plurality of packets that configure distribution data from the information distribution apparatus; first judging means for judging whether or not congestion occurs in communication with the information distribution apparatus, based on a change in time interval from transmission to reception of each of the packets successively received by the receiving means; second judging means for judging whether or not a packet loss rate, which is a rate of a loss packet corresponding to a loss included in the packets transmitted from the information distribution apparatus and calculated based on the packets successively received by the receiving means, is increased as compared with a value obtained by multiplying a packet loss rate before the packets that configure the distribution data are received, by a predetermined weight; and requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on a judgment result by the first judging means and a judgment result by the second judging means. The information distribution apparatus includes updating means for updating the bit rate of the packets that configure the distribution data, in response to the request by the requesting means.

[0007]

The invention according to claim 2 is the information processing system described in claim 1, in which the information processing apparatus may further include jitter calculating means for calculating a difference between a time interval from transmission to reception of a packet and a time interval from transmission to reception of a packet transmitted before the former packet, as a jitter, for each of the packets successively received by the receiving means. Also, the first judging means may judge that the congestion occurs in the communication with the information distribution apparatus if an increase of a jitter of a packet newly received by the receiving means with respect to a jitter of a packet received in the past by the

receiving means satisfies a predetermined condition.

[0008]

The invention according to claim 3 is the information processing system described in claim 1 or 2, in which the requesting means may request the information distribution apparatus to change the bit rate of the packets that configure the distribution data to a lower bit rate than a current bit rate if the first judging means judges that the congestion occurs in the communication, and if the second judging means judges that the packet loss rate, which is the rate of the loss packet corresponding to the loss included in the packets transmitted from the information distribution apparatus, is increased as compared with the value obtained by multiplying the packet loss rate before the packets that configure the distribution data are received, by the predetermined weight.

[0009]

The invention according to claim 4 is the information processing system described in any of claims 1 to 3, in which the information processing apparatus may further include means for storing the packets successively received by the receiving means, in storing means; reproducing means for reproducing the packets stored in the storing means; calculating means for calculating a reproduction available remaining time, which is a remaining time available for reproduction with packets not reproduced yet by the reproducing means among the packets stored in the storing means; and bit rate change judging means for judging whether or not the bit rate of the packets that configure the distribution data is changed, based on a difference between the reproduction available remaining time and a predetermined required time. Also, the requesting means may request the information distribution apparatus to change the bit rate of the packets that configure the distribution data, based on a judgment result by the bit rate change judging means.

[0010]

The invention according to claim 5 is the information processing system described in claim 4, in which the information processing apparatus may further include difference time calculating means for calculating a difference time based on the difference between the reproduction available remaining time and the predetermined required time; and evaluation value calculating means for calculating an evaluation value, based on the difference time and a proportional coefficient, an

amount of change of the difference time and a differential coefficient in a predetermined time range, and a cumulative value of the difference time and an integration constant in a predetermined time range. Also, the bit rate change means may judge the change of the bit rate, based on the evaluation value calculated by the evaluation value calculating means and an evaluation value range determined for each bit rate.

[0011]

The invention according to claim 6 is an information processing apparatus including receiving means for successively receiving a plurality of packets that configure distribution data from an information distribution apparatus; first judging means for judging whether or not congestion occurs in communication with the information distribution apparatus, based on a change in time interval from transmission to reception of each of the packets successively received by the receiving means; second judging means for judging whether or not a packet loss rate, which is a rate of a loss packet corresponding to a loss included in the packets transmitted from the information distribution apparatus and calculated based on the packets successively received by the receiving means, is increased as compared with a value obtained by multiplying a packet loss rate before the packets that configure the distribution data are received, by a predetermined weight; and requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on a judgment result by the first judging means and a judgment result by the second judging means.

[0012]

The invention according to claim 7 is an information processing apparatus including receiving means for successively receiving a plurality of packets that configure distribution data from the information distribution apparatus; means for storing the packets successively received by the receiving means, in storing means; reproducing means for reproducing the packets stored in the storing means; calculating means for calculating a reproduction available remaining time, which is a remaining time available for reproduction with packets not reproduced yet by the reproducing means among the packets stored in the storing means; and requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on a difference between the

reproduction available remaining time and a predetermined required time.

[0013]

The invention according to claim 8 is a program for causing a computer to function as: receiving means for successively receiving a plurality of packets that configure distribution data from an information distribution apparatus; first judging means for judging whether or not congestion occurs in communication with the information distribution apparatus, based on a change in time interval from transmission to reception of each of the packets successively received by the receiving means; second judging means for judging whether or not a packet loss rate, which is a rate of a loss packet corresponding to a loss included in the packets transmitted from the information distribution apparatus and calculated based on the packets successively received by the receiving means, is increased as compared with a value obtained by multiplying a packet loss rate before the packets that configure the distribution data are received, by a predetermined weight; and requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on a judgment result by the first judging means and a judgment result by the second judging means.

[0014]

The invention according to claim 9 is a program for causing a computer to function as: receiving means for successively receiving a plurality of packets that configure distribution data from the information distribution apparatus; means for storing the packets successively received by the receiving means, in storing means; reproducing means for reproducing the packets stored in the storing means; calculating means for calculating a reproduction available remaining time, which is a remaining time available for reproduction with packets not reproduced yet by the reproducing means among the packets stored in the storing means; and requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on a difference between the reproduction available remaining time and a predetermined required time.

Advantageous Effects of Invention

[0015]

With the invention according to any of claims 1, 6, and 8, the bit rate can be

changed in response to the occurrence of the communication congestion and the increase in packet loss rate during the reception of the distribution data.

[0016]

With the invention according to claim 2, the occurrence of the communication congestion can be more accurately judged as compared with a case without this configuration.

[0017]

With the invention according to claim 3, the occurrence of the communication congestion and the increase in packet loss rate during the reception of the distribution data can be restricted.

[0018]

With the invention according to claim 4, the bit rate can be changed in accordance with the reproduction available remaining time with the packets received for the distribution data.

[0019]

With the invention according to claim 5, the bit rate can be changed to a proper value as compared with a case without this configuration.

[0020]

With the invention according to any of claims 7 and 9, the bit rate can be changed in accordance with the remaining time available for reproduction with the packets received for the distribution data.

Brief Description of Drawings

[0021]

[Fig. 1] Fig. 1 is a system configuration diagram of an information processing system according to this exemplary embodiment.

[Fig. 2] Fig. 2 is a hardware configuration diagram of an information terminal and an information distribution server.

[Fig. 3] Fig. 3 is a functional block diagram of the information terminal.

[Fig. 4] Fig. 4 is a functional block diagram of a buffer controller.

[Fig. 5] Fig. 5 is an illustration showing an example of a bit rate threshold management table.

[Fig. 6] Fig. 6 is an illustration for describing a sequence example in the

information processing system.

[Fig. 7] Fig. 7 is an illustration for describing a sequence example in the information processing system.

[Fig. 8] Fig. 8 is an illustration for describing a sequence example in the information processing system.

Description of Embodiments

[0022]

An exemplary embodiment for implementing the present invention (hereinafter, referred to as exemplary embodiment) is described below with reference to the drawings.

1. Description for System Configuration

[0023]

Fig. 1 shows a system configuration diagram of an information processing system 1 according to this exemplary embodiment. As shown in Fig. 1, the information processing system 1 includes an information terminal 10, and an information distribution server 20. The information terminal 10 and the information distribution server 20 are connected to each other through a network 5 and hence can mutually make communication.

[0024]

Described in this exemplary embodiment is processing for actively optimizing the data quality of streaming data based on packets of the streaming data successively received from the information distribution server 20 when the information terminal 10 receives distribution of the streaming data from the information distribution server 20.

2. Description for Hardware Configuration

[0025]

To provide the above-described processing, an example of hardware configurations provided in the information terminal 10 and the information distribution server 20 included in the information processing system 1 is described below with reference to a hardware configuration diagram shown in Fig. 2.

2-1. Hardware Configuration of Information Terminal 10

[0026]

As shown in Fig. 2, the information terminal 10 includes a controller 11, a memory 12, a communication unit 13, an input unit 14, and a display 15.

[0027]

The controller 11 includes a CPU (Central Processing Unit). The controller 11 executes various arithmetic processing and controls respective units of the information terminal 10 based on a program stored in the memory 12.

[0028]

The memory 12 stores a control program such as an operating system and data of the information terminal 10, and is also used as a work memory of the controller 11. The program may be previously written in the memory 12, may be supplied to the information terminal 10 in a stored state in an information storage medium, such as an optical disk, a magnetic disk, a magnetic tape, a magneto-optical disk, or a flash memory, or may be supplied to the information terminal 10 through a data communication network such as the Internet.

[0029]

The communication unit 13 includes, for example, a wired or wireless communication interface. The communication unit 13 is connected to the network through the communication interface, and makes communication with the information distribution server 20 connected to the network.

[0030]

The input unit 14 is provided by an input device, such as a touch panel or a keyboard. The input unit 14 receives an operation input from a user.

[0031]

The display 15 is provided by a display device such as a liquid crystal display. The display 15 displays a result of information processing by the controller 11 (screen).

2-2. Hardware Configuration of Information Distribution Server 20

[0032]

Next, a hardware configuration example of the information distribution server 20 is described. As shown in Fig. 2, the information distribution server 20 includes a controller 21, a memory 22, and a communication unit 23.

[0033]

The controller 21 includes a CPU (Central Processing Unit). The controller 21

executes various arithmetic processing and controls respective units of the information distribution server 20 based on a program stored in the memory 22.

[0034]

The memory 22 stores a control program such as an operating system and data of the information distribution server 20, and is also used as a work memory of the controller 21. The program may be supplied to the information distribution server 20 in a stored state in an information storage medium, such as an optical disk, a magnetic disk, a magnetic tape, a magneto-optical disk, or a flash memory, or may be supplied to the information distribution server 20 through data communication means such as the Internet.

[0035]

For example, the memory 22 may store streaming data (for example, movie data, audio data, etc.) for each of plural data qualities (for example, HD, H, MH, MLM, L, and UL in order from high quality), image data (for example, still images with different data sizes), and application data.

[0036]

The communication unit 23 includes, for example, a network interface card (NIC) and is connected to the network 5 through the NIC to communicate with the information terminal 10.

3. Description for Functions Included in Information Terminal 10

[0037]

Next, the details of functions included in the information terminal 10 according to this exemplary embodiment are described below with reference to Figs. 3 and 4.

[0038]

Fig. 3 shows a functional block diagram of the information terminal 10. As shown in Fig. 3, the information terminal 10 includes an operation receiver 101, a data distribution request unit 102, a packet receiver 103, a buffer unit 104, a congestion occurrence detector CR, a data reproduction unit 110, a reproduction available remaining time calculator 111, a buffer controller 112, and a distribution data quality update request unit 113. The respective functions included in the information terminal 10 may be provided by the respective units of the controller 11, the memory 12, the communication unit 13, the input unit 14, and the display 15 included in the information terminal 10 shown in Fig. 2.

[0039]

The operation receiver 101 receives an operation input from the user, and starts processing in accordance with the received operation input. For example, in this exemplary embodiment, the operation receiver 101 may receive designation of a data distribution source and distribution data from the user.

[0040]

The data distribution request unit 102 makes a request for distribution of data designated to a data distribution source in accordance with an input received by the operation receiver 101. For example, in this exemplary embodiment, the data distribution request unit 102 may request the information distribution server 20 for streaming distribution of designated data (for example, movie data).

[0041]

The packet receiver 103 receives data (packet) transmitted from a data distribution target in response to the data distribution request by the data distribution request unit 102. For example, the packet receiver 103 may successively receive plural packets that configure streaming data transmitted from the information distribution server 20.

[0042]

The buffer unit 104 is a temporary memory that successively accumulates the packets successively received by the packet receiver 103.

[0043]

The congestion occurrence detector CR judges whether or not congestion occurs in communication between the information distribution server 20 and the information terminal 10 based on information of the packets stored in the buffer unit 104, and detects occurrence of communication congestion based on the judgment result. The congestion occurrence detector CR includes a jitter calculator 105, a first judgment unit 106, a packet loss rate calculator 107, a second judgment unit 108, and a congestion occurrence judgment unit 109. The details of the jitter calculator 105, the first judgment unit 106, the packet loss rate calculator 107, the second judgment unit 108, and the congestion occurrence judgment unit 109 are described below.

[0044]

The jitter calculator 105 calculates a delay (jitter) since reception of a packet with a previous sequence number, for each packet accumulated in the buffer unit 104.

To be specific, for a packet P_i (assuming that packets are transmitted in order of the sequence number) of a sequence number i (i being an integer equal to or larger than 2) of streaming data, the jitter calculator 105 calculates a jitter J_i by Expression (1) as follows. Herein, RD_i may be a time interval from transmission to reception of a packet P_i , and RD_i may be calculated from a transmission time at which the packet is stored in a header and a reception time at which the packet is actually received.

$$J_i = RD_i - RD_{i-1} \quad (1)$$

[0045]

Also, the jitter calculator 105 calculates a first index value J_{Mean} of the jitters based on the jitters calculated for the respective packets accumulated in the buffer unit 104. For example, the first index value may be a value corresponding to a mean value (or may be a mean value) of jitters calculated for a target packet group (P_1 to P_i). To be specific, the jitter calculator 105 calculates the first index value by Expression (2) as follows. It is to be noted that α may be a real number that satisfies $0 < \alpha < 1$.

$$J_{\text{Mean}} = (1 - \alpha)J_{\text{Mean}} + \alpha J_i \quad (2)$$

[0046]

Further, the jitter calculator 105 calculates a second index value J_{var} of the jitters based on the jitters calculated for the respective packets accumulated in the buffer unit 104. For example, the second index value may be a value corresponding to a variance (or may be a variance) of the jitters calculated for a target packet group (P_j (j being an integer smaller than i and equal to or larger than 1, for example, $j = 1$) to P_i). To be specific, the jitter calculator 105 calculates the second index value by Expression (3) as follows. It is to be noted that α may be a real number that satisfies $0 < \alpha < 1$.

$$J_{\text{var}} = (1 - 2\alpha)J_{\text{var}} + 2\alpha|J_i - J_{\text{Mean}}| \quad (3)$$

[0047]

The first judgment unit 106 judges whether a first congestion occurrence condition is satisfied or not based on the jitters calculated by the jitter calculator 105 and the index value of the jitters. To be specific, when the first congestion occurrence condition is expressed by Expression (4) as follows, the first judgment unit 106 may judge that the first congestion occurrence condition is satisfied if Expression (4) is satisfied, and otherwise may judge that the first congestion occurrence condition

is not satisfied. It is to be noted that K1 may be a predetermined positive coefficient.

$$|J_i - J_{\text{Mean}}| > K1 \cdot J_{\text{var}} \quad (4)$$

[0048]

The packet loss rate calculator 107 calculates a packet loss rate relating to data distributed from the information distribution server 20 based on information of the respective packets accumulated in the buffer unit 104. For example, in the target packet group (P_j (j being an integer smaller than i and equal to or larger than 1, for example, j = 1) to P_i), the packet loss rate calculator 107 may calculate a value as a packet loss rate (P_{loss}), the value being obtained by counting the sum (L) of the number of lost packets and the number of packets which have not reached in order of the sequence number, and dividing L by the total number (i) of transmission packets. Also, the packet loss rate calculator 107 may also previously calculate a basic packet loss rate P_{RAW} before distribution of data from the information distribution server 20.

[0049]

The second judgment unit 108 judges whether a second congestion occurrence condition is satisfied or not based on the packet loss rate calculated by the packet loss rate calculator 107 and the basic packet loss rate. To be specific, when the second congestion occurrence condition is expressed by Expression (5) as follows, the second judgment unit 108 may judge that the second congestion occurrence condition is satisfied if Expression (5) is satisfied, and otherwise may judge that the second congestion occurrence condition is not satisfied. It is to be noted that K2 may be a predetermined positive coefficient.

$$P_{\text{loss}} > K2 \cdot P_{\text{RAW}} \quad (5)$$

[0050]

The congestion occurrence judgment unit 109 judges whether communication congestion occurs or not based on the judgment results of the first judgment unit 106 and the second judgment unit 108 while the information terminal 10 receives distribution of data from the information distribution server 20. To be specific, the congestion occurrence judgment unit 109 may judge that communication congestion occurs if the first judgment unit 106 judges that the first congestion occurrence condition is satisfied and the second judgment unit 108 judges that the second congestion occurrence condition is satisfied, and otherwise may judge that communication congestion does not occur.

[0051]

The data reproduction unit 110 reproduces data based on the packets accumulated in the buffer unit 104. For example, if the information terminal 10 receives streaming distribution of multimedia data (for example, video data) from the information distribution server 20, streaming reproduction of the multimedia data may be executed based on the packets accumulated in the buffer unit 104. At this time, the data reproduction unit 110 may execute data reproduction if there is a predetermined amount of packets, which are accumulated in the buffer unit 104 and are not reproduced yet, and may become a standby state for data reproduction if there is not the predetermined amount of packets, which are accumulated in the buffer unit 104 and are not reproduced yet.

[0052]

The reproduction available remaining time calculator 111 calculates a remaining time available for reproduction (reproduction available remaining time) with the packets accumulated in the buffer unit 104. For example, the reproduction available remaining time calculator 111 may calculate a reproduction available time with packets which are not reproduced yet by the data reproduction unit 110 among the packets accumulated in the buffer unit 104, as a reproduction available remaining time. To be specific, a reproduction available remaining time ($T_c(t) = PL(t)/FR(t)$) may be calculated by dividing a length $PL(t)$ of a buffer available for reproduction at a time t by a frame rate ($FR(t)$).

[0053]

The buffer controller 112 controls the quality of the distribution data based on the reproduction available remaining time calculated by the reproduction available remaining time calculator 111. The detailed configuration of the buffer controller 112 is described with reference to Fig. 4.

[0054]

As shown in Fig. 4, the buffer controller 112 includes a required time setting unit 112A, a comparator 112B, an environment judgment unit 112C, a parameter selection unit 112D, a PID controller 112E, and a bit rate change judgment unit 112F.

[0055]

The required time setting unit 112A sets a required time (T_r) of the reproduction available remaining time. For example, the required time may be previously

determined as an initial value, or may be set in accordance with an input by the user.
[0056]

The comparator 112B compares the reproduction available remaining time $T_c(t)$ at the time t calculated by the reproduction available remaining time calculator 111 with the required time T_r . For example, the comparator 112B may calculate a difference $T_d(t)$ between the reproduction available remaining time $T_c(t)$ and the required time T_r by Expression (6) as follows, or may calculate $T_d(t)$ with regard to a control time T_{control} by Expression (7). It is to be noted that the control time T_{control} may be calculated by Expression (8). RTT indicates a roundtrip time, T_{enc} indicates a time required for encoding of a packet, and T_{dec} indicates a time required for decoding.

$$T_d(t) = T_c(t) - T_r \quad (6)$$

$$T_d(t) = T_c(t) - T_r - T_{\text{control}} \quad (7)$$

$$T_{\text{control}} = RTT / (1 - P_{\text{loss}}) + T_{\text{enc}} + T_{\text{dec}} \quad (8)$$

[0057]

The environment judgment unit 112C judges the communication environment of the information terminal 10. For example, when the information terminal 10 executes wireless communication, the environment judgment unit 112C may judge whether a communication state with a wireless communication target is a state (profile 1) in which a communication antenna is likely changed (for example, during moving at high speed), a state (profile 2) with stable communication, and a state (profile 3) in which the communication state is likely changed, in accordance with the communication state with the wireless communication target.

[0058]

The parameter selection unit 112D selects a parameter corresponding to the profile judged by the environment judgment unit 112C. For example, the information terminal 10 may hold a parameter set of K_p , K_i , and K_d for each profile of the communication state (profiles 1 to N (N being an integer equal to or larger than 2)), and may select a corresponding parameter set of K_p , K_i , and K_d based on the profile judged by the environment judgment unit 112C.

[0059]

The PID controller 112E executes PID control based on the parameter set of K_p , K_i , and K_d selected by the parameter selection unit 112D and the data ($T_d(t)$) output from the comparator 112B. To be specific, the PID controller 112E calculates

a PID evaluation value $V(t)$ by Expression (9) as follows, based on the parameter set of K_p , K_i , and K_d , $T_d(t)$ which is the comparison result between the reproduction available remaining time $T_c(t)$ at the time t and the required time T_r , an integrated value relating to $T_d(t)$ within M (M being a real number larger than 0) seconds from the time t , and a differential value relating to $T_d(t)$ within the M seconds from the time t .

[0060]

$$V(t) = K_p T_d(t) + K_i \Sigma_M T_d(t) + K_d \Delta_M T_d(t) \quad (9)$$

[0061]

The bit rate change judgment unit 112F judges whether the bit rate is required to be changed or not based on the PID evaluation value $V(t)$ calculated by the PID controller 112E. For example, the bit rate change judgment unit 112F judges the necessity or non-necessity of the change of the bit rate based on the comparison result between the PID evaluation value $V(t)$ calculated by the PID controller 112E and a threshold of at least one bit rate selected in accordance with the current bit rate. A specific example of bit rate change judgment processing by the bit rate change judgment unit 112F is described with reference to a bit rate threshold management table shown in Fig. 5.

[0062]

The bit rate threshold management table shown in Fig. 5 stores, for each current bit rate, a threshold of other at least one bit rate. The other bit rate (changed bit rate) is specified by the current bit rate and the range of the PID evaluation value. For example, when the current bit rate is 800 Kbps, the bit rate change judgment unit 112F does not change the bit rate if the PID evaluation value is smaller than 3.5, changes the bit rate to 1200 Kbps if the PID evaluation value is 8.5 or larger and smaller than 8.7, and changes the bit rate to 2000 Kbps if the PID evaluation value is 8.7 or larger. Also, when the current bit rate is 1200 Kbps, the bit rate change judgment unit 112F changes the bit rate to 800 Kbps if the PID evaluation value is smaller than -2.2, does not change the bit rate if the PID evaluation value is -2.2 or larger and smaller than 5.6, and changes the bit rate to 2000 Kbps if the PID evaluation value is 5.6 or larger.

[0063]

The distribution data quality update request unit 113 requests the information

distribution server 20 to update the quality of data being distributed, based on the judgment results of the congestion occurrence judgment unit 109 and the bit rate change judgment unit 112F. For example, the distribution data quality update request unit 113 may request the information distribution server 20 to reduce the quality of the distribution data to be lower than the current bit rate if the congestion occurrence judgment unit 109 judges that communication congestion occurs. Also, if the bit rate change judgment unit 112F makes judgment to change the bit rate, the distribution data quality update request unit 113 may request the information distribution server 20 to change the quality of the distribution data to the changed bit rate judged by the bit rate change judgment unit 112F.

4. Description for Sequence

[0064]

Next, the details of processing that is executed by the information processing system 1 are described with reference to sequence diagrams and flowcharts shown in Figs. 6 to 8.

[0065]

As shown in Fig. 6, when the information terminal 10 receives a distribution request for streaming data (distribution data) from a user (S101), the information terminal 10 requests the information distribution server 20, which is a distribution source of the streaming data, to distribute the streaming data (S102).

[0066]

When the information distribution server 20 receives the distribution request from the information terminal 10, the information distribution server 20 executes initialization by setting a packet sequence number i at 1, a reproduction time t at 0, and a data quality Q at an initial value, for the streaming data corresponding to the distribution request (S103).

[0067]

Then, the information distribution server 20 acquires a packet P_i (S104) obtained by encoding data part (UDP) based on the reproduction time t and the data quality Q for the streaming data to be distributed (S104), and transmits the packet P_i to the information terminal 10 (S105). It is to be noted that the information distribution server 20 may generate the packet P_i by encoding movie data for the reproduction time t in the streaming data according to the data quality Q . Also, the

information distribution server 20 may transmit the packet P_i with information of the transmission time and the data quality (bit rate) added to the packet P_i .

[0068]

The information distribution server 20 updates the reproduction time t based on the transmitted packet P_i (S106). If the reproduction time t does not reach a reproduction end time T of the streaming data (S107: N), the information distribution server 20 increments i (by adding 1) (S108), returns to S104, and repeats the subsequent processing. If the reproduction time t reaches the reproduction end time T of the streaming data (S108: Y), the information distribution server 20 ends the processing.

[0069]

Also, the information terminal 10 receives the packet P_i transmitted from the information distribution server 20, and stores the received packet P_i in the buffer (S109).

[0070]

If reproduction of the streaming data is not available based on the packet stored in the buffer (S110: N), the information terminal 10 becomes a standby state. If reproduction of the streaming data is available based on the packet stored in the buffer (S110: Y), the information terminal 10 executes reproduction of the streaming data (S111). If the reproduction is not ended (S112: N), the information terminal 10 returns to S109 and repetitively executes the subsequent processing.

[0071]

Also, the information terminal 10 executes update judgment for the quality of the streaming data and update request processing based on the result of the update judgment, based on the information of the packet stored in the buffer, in parallel to the reproduction of the data based on the packet stored in the buffer. The details of the update judgment processing and the update request processing of the streaming data are described with reference to sequence diagrams shown in Figs. 7 and 8. First, an example of data quality update processing based on the judgment of communication congestion shown in Fig. 7 is described.

[0072]

As shown in Fig. 7, when the packet P_i is stored in the buffer in S109 in Fig. 6, if i is not 2 or larger (S201: N), the information terminal 10 returns to a state before

S109 in Fig. 6, and if i is 2 or larger (S201: Y), the information terminal 10 calculates a jitter J_i based on the packet P_i and a packet P_{i-1} (S202), and calculates jitters J_M (J_{Mean}) and J_V (J_{Var}) (S203). The jitter J_i , and the jitters J_M (J_{Mean}) and J_V (J_{Var}) may be calculated by the above-described jitter calculator 105.

[0073]

Then, based on the calculated jitter J_i , and jitters J_M (J_{Mean}) and J_V (J_{Var}), if $|J_i - J_M| > K1 \cdot J_V$ is not satisfied (S204: N), the information terminal 10 returns to a state before S109 in Fig. 6, and if $|J_i - J_M| > K1 \cdot J_V$ is satisfied (S204: Y), the information terminal 10 goes to S207.

[0074]

Also, when the packet P_i is stored in S109 in Fig. 6, the information terminal 10 counts the number of loss packets from P_1 to P_i (S205), and calculates a packet loss rate P_L based on the counted number of loss packets (S206). The packet loss rate P_L (P_{Loss}) may be calculated by the above-described packet loss rate calculator 107.

[0075]

Then, in S207, if the packet loss rate P_L calculated in S206 does not satisfy $P_L > K2 \cdot P_{RAW}$ (S207: N), the information terminal 10 returns to a state before S109 in Fig. 6. If the packet loss rate P_L satisfies $P_L > K2 \cdot P_{RAW}$ (S207: Y), the information terminal 10 detects occurrence of communication congestion between the information terminal 10 and the information distribution server 20 (S208), and requests the information distribution server 20 to reduce the bit rate (S209).

[0076]

When the information distribution server 20 receives the reduction request for the bit rate from the information terminal 10, the information distribution server 20 updates the data quality Q of the streaming data being distributed, to be lower than the current data quality (S210), returns to S104 in Fig. 6, and executes the subsequent processing.

[0077]

The above-described example is the example for the data quality update processing based on the judgment of communication congestion. Next, an example of data quality update processing based on the reproduction available remaining time is described with reference to Fig. 8.

[0078]

As shown in Fig. 8, when the packet P_i is stored in the buffer in S109 in Fig. 6, the information terminal 10 calculates a reproduction available remaining time $T_c(t)$ based on information of the packet stored in the buffer (S301), and calculates $T_d(t)$ based on the difference between a required time T_r of a previously set reproduction available remaining time and the reproduction available remaining time $T_c(t)$ (S302). The reproduction available remaining time $T_c(t)$ and $T_d(t)$ may be calculated by the above-described reproduction available remaining time calculator 111 and the comparator 112B.

[0079]

Then, the information terminal 10 acquires PID parameters K_p , K_i , and K_d in accordance with the communication state of the information terminal 10 (S303), calculates a first evaluation value S_1 based on K_p and $T_d(t)$ (S304), calculates a second evaluation value S_2 based on K_i and $T_d(t)$ (S305), and a third evaluation result S_3 based on K_d and $T_d(t)$ (S306), and calculates a PID evaluation value $V(t)$ as $V(t) = S_1 + S_2 + S_3$ (S307). It is to be noted that the PID evaluation value $V(t)$ may be calculated by the above-described PID controller 112E.

[0080]

The information terminal 10 compares the PID evaluation value $V(t)$ with a threshold C_{th} of other bit rate based on the current bit rate (S308), and judges whether the bit rate is changed or not based on the comparison result (S309). The judgment processing for the change of the bit rate may be executed by the bit rate change judgment unit 112F. Then, if the bit rate is not changed (S309: N), the information terminal 10 returns to a state before S109 in Fig. 6, and if the bit rate is changed (S309: Y), the information terminal 10 requests the information distribution server 20 for update of the bit rate (S310).

[0081]

When the information distribution server 20 receives the update request for the bit rate from the information terminal 10, the information distribution server 20 updates the data quality Q of the streaming data being distributed (S311) in response to the received update request, returns to S104 in Fig. 6, and executes the subsequent processing.

[0082]

The above-described example is the example for the data quality update

processing based on the reproduction available remaining time. With the above-described sequence, the information processing system 1 actively updates the data quality based on the congestion state of communication and the state of the reproduction available remaining time during data distribution, and hence can prevent data reproduction from being interrupted.

[0083]

Also, the present invention is not limited to the above-described exemplary embodiment. For example, in the above-described exemplary embodiment, the information terminal 10 may receive a test packet from the information distribution server 20 before the information terminal 10 receives distribution of streaming data from the information distribution server 20, and may set an initial value of the data quality based on the received test packet.

Reference Signs List

[0084]

- 1 information processing system
- 5 network
- 10 information terminal
- 11 controller
- 12 memory
- 13 communication unit
- 14 input unit
- 15 display
- 101 operation receiver
- 102 data distribution request unit
- 103 packet receiver
- 104 buffer unit
- CR congestion occurrence detector
- 105 jitter calculator
- 106 first judgment unit
- 107 packet loss rate calculator
- 108 second judgment unit
- 109 congestion occurrence judgment unit

- 110 data reproduction unit
- 111 reproduction available remaining time calculator
- 112 buffer controller
- 112A required time setting unit
- 112B comparator
- 112C environment judgment unit
- 112D parameter selection unit
- 112E PID controller
- 112F bit rate change judgment unit
- 113 distribution data quality update request unit

CLAIMS

[Claim 1]

An information processing system comprising:

an information processing apparatus and an information distribution apparatus,
wherein the information processing apparatus includes

receiving means for successively receiving a plurality of packets that
configure distribution data from the information distribution apparatus,
reproducing means for reproducing the packets successively received by the receiving
means,

calculating means for calculating a reproduction available remaining time, which is a
remaining time available for reproduction with packets not reproduced yet by the
reproducing means among the packets stored in the storing means,

difference time calculating means for calculating a difference time based on the difference
between the reproduction available remaining time and the predetermined required time,

evaluation value calculating means for calculating an evaluation value, based on the
difference time and a proportional coefficient, an amount of change of the difference time
and a differential coefficient in a predetermined time range, and a cumulative value of the
difference time and an integration constant in a predetermined time range, and

requesting means for requesting the information distribution apparatus to
change a bit rate of the packets that configure the distribution data, based on the evaluation
value calculated by the evaluation value calculating means, and

wherein the information distribution apparatus includes

updating means for updating the bit rate of the packets that configure the
distribution data, in response to the request by the requesting means.

[Claim 2]

The information processing system according to claim 1,

wherein the information processing apparatus further includes

first judging means for judging whether or not congestion occurs in communication with the information distribution apparatus, based on a change in time interval from transmission to reception of each of the packets successively received by the receiving means, and

second judging means for judging whether or not a packet loss rate, which is a rate of a loss packet corresponding to a loss included in the packets transmitted from the information distribution apparatus and calculated based on the packets successively received by the receiving means, is increased as compared with a value obtained by multiplying a packet loss rate before the packets that configure the distribution data are received, by a predetermined weight, and

the requesting means requests the information distribution apparatus to change a bit rate of the packets based on a judgment result by the first judging means, a judgment result by the second judging means, and the evaluation value.

[Claim 3]

The information processing system according to claim 2,

wherein the information processing apparatus further includes

jitter calculating means for calculating a difference between a time interval from transmission to reception of a packet and a time interval from transmission to reception of a packet transmitted before the former packet, as a jitter, for each of the packets successively received by the receiving means, and

wherein the first judging means judges that the congestion occurs in the communication with the information distribution apparatus if an increase of a jitter of a packet newly received by the receiving means with respect to a jitter of a packet received in the past by the receiving means satisfies a predetermined condition.

[Claim 4]

The information processing system according to any one of claims 1 to 3, wherein the requesting means requests the information distribution apparatus to change the bit rate of the packets that configure the distribution data to a lower bit rate than a current bit rate if the first judging means judges that the congestion occurs in the communication, and if the second judging means judges that the packet loss rate, which is the rate of the loss packet corresponding to the loss included in the packets transmitted from the information distribution apparatus, is increased as compared with the value obtained by multiplying the packet loss rate before the packets that configure the distribution data are received, by the predetermined weight.

[Claim 5]

An information processing apparatus comprising:

receiving means for successively receiving a plurality of packets that configure distribution data from an information distribution apparatus;

reproducing means for reproducing the packets successively received by the receiving means,

calculating means for calculating a reproduction available remaining time, which is a remaining time available for reproduction with packets not reproduced yet by the reproducing means among the packets stored in the storing means, difference time

calculating means for calculating a difference time based on the difference between the reproduction available remaining time and the predetermined required time, evaluation value calculating means for calculating an evaluation value, based on the difference time and a proportional coefficient, an amount of change of the difference time and a differential coefficient in a predetermined time range, and a cumulative value of the difference time and an integration constant in a predetermined time range; and

requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on the evaluation value calculated by the evaluation value calculating means.

[Claim 6]

A program for causing a computer to function as:

receiving means for successively receiving a plurality of packets that configure distribution data from an information distribution apparatus;

reproducing means for reproducing the packets successively received by the receiving means,

calculating means for calculating a reproduction available remaining time, which is a remaining time available for reproduction with packets not reproduced yet by the reproducing means among the packets stored in the storing means,

difference time calculating means for calculating a difference time based on the difference between the reproduction available remaining time and the predetermined required time,

evaluation value calculating means for calculating an evaluation value, based on the difference time and a proportional coefficient, an amount of change of the difference time and a differential coefficient in a predetermined time range, and a cumulative value of the difference time and an integration constant in a predetermined time range; and

requesting means for requesting the information distribution apparatus to change a bit rate of the packets that configure the distribution data, based on the evaluation value calculated by the evaluation value calculating means.