
PELOTON INTERACTIVE, INC.,

Petitioner

V.

NEC CORPORATION,

Patent Owner

IPR2023-01239

U.S. Patent No. 8,752,101

Petitioner's Demonstratives

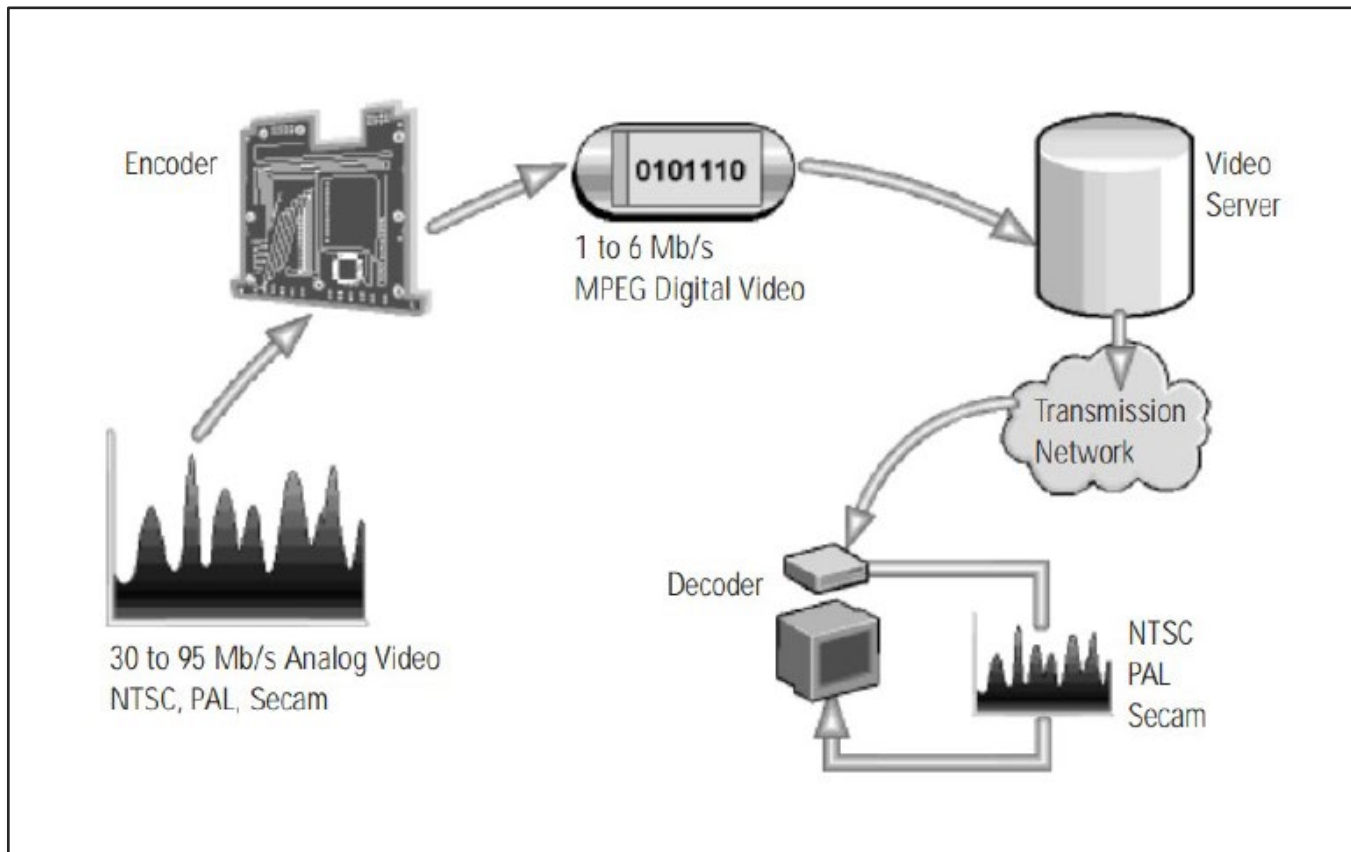
November 22, 2024 Oral Hearing

Demonstrative Exhibit – Not Evidence

Petitioner's Grounds

Claims Challenged	35 U.S.C. § ³	Reference(s)/Basis
1, 2, 4, 5, 7, 11, 12, 14–18, 20–23, 25–29	103(a)	Chou ⁴
1, 2, 4, 5, 7, 11, 12, 14–18, 20–23, 25–29	103(a)	Chou, Wang ⁵
5, 7, 15	103(a)	Chou, Nobuyoshi ⁶

Transmission Over a Network Introduces Uncertainty at the Decoder (Client)



Solutions:

- **Buffering**
- **Control code rate**

'101 Patent: Disputed Limitation 1(d)

[1d] the distribution system, comprising a code rate determining unit for **determining the code rate**:

- (a) based on a **remaining time before reproduction start** time set as time at which the reception device starts reproduction of the content from a present moment
- (b) and based on an **available reproduction time**, which is a time available for reproducing the content **based on the content data stored in the storage device** of the reception device, ...

Chou's System Adjusts Code Rate to Control Client Buffer Duration

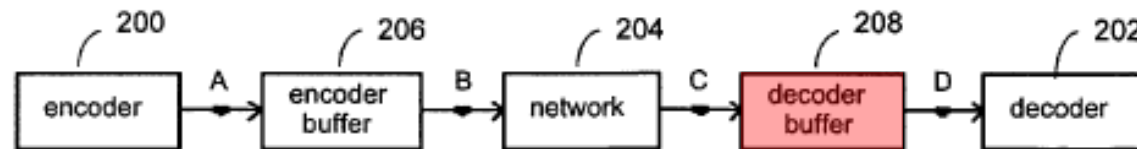


FIG. 2

(57)

ABSTRACT

A system and process for controlling the coding bit rate of streaming media data is presented. This coding bit rate control involves dynamically adjusting the coding bit rate to control client buffer duration to prevent the buffer from underflowing, while keeping the average coding bit rate close to the average transmission bit rate of the network (and thus maximizing the quality of the data playback). Using the theory of optimal linear quadratic control, the client buffer duration is kept as close as possible to a target level while still keeping the coding bit rate (and hence the quality) as constant as possible. In addition, a leaky bucket model is

* * *

Chou's System Adjusts Code Rate to Control Client Buffer Duration

SUMMARY

[0019] The present invention is directed toward a system and process for controlling a coding bit rate of streaming media data being transmitted to a client from a server over a computer network. In general, this coding bit rate control involves dynamically adjusting the coding bit rate of the streaming media data to control the client buffer duration.

The purpose of this is to prevent the client buffer from underflowing, while keeping the average coding bit rate close to the average transmission bit rate of the network (and thus maximizing the quality of the playback of the data). The problem of coding bit rate control is formulated as a standard problem in linear quadratic optimal control, in which the client buffer duration is controlled as closely as possible to a target level. The smoothness of the average coding bit rate over consecutive frames is also considered when deciding whether to change the coding bit rate as part of the optimal control process. This yields a higher and more stable quality

* * *

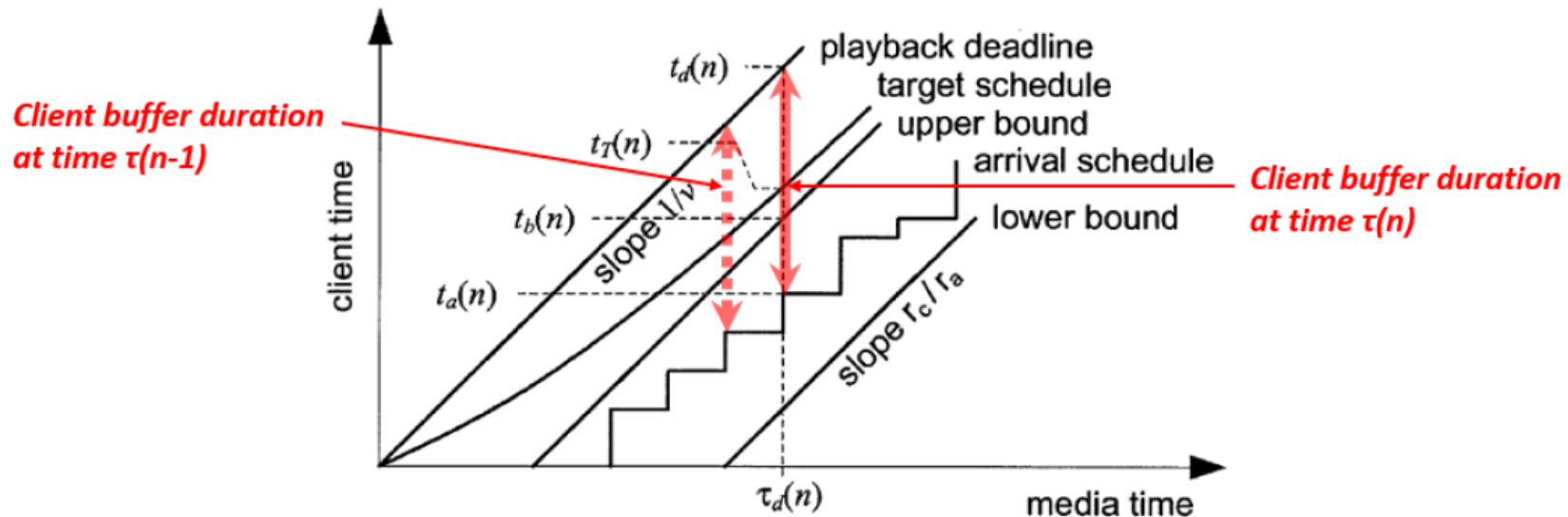
[0020] Preventing the client buffer from underflowing, while keeping the average coding bit rate close to the average transmission bit rate of the network, meets two of the aforementioned user expectations. Namely, if the buffer never underflows, it allows for continuous playback. In addition, keeping the average coding bit rate close to the average transmission bit rate of the network means the data is played back with the highest possible quality given the average communication bandwidth available. This leaves the remaining issue of startup delay. This issue is resolved in the present system and process by controlling the size of the client buffer over time. More particularly, the aforementioned client buffer target level is adjusted to start small, and then grow slowly over time. If the buffer is initially small, it allows for shorter startup delay. In addition, as the buffer is eventually allowed to grow large, it enhances the robustness of the system as well as creating high, nearly constant quality. Thus, client buffer management is a key element affecting the performance of streaming media systems.

Chou Discloses Determining Code Rate Based on Available Time

[1d] the distribution system, comprising a code rate determining unit for **determining the code rate**:

- (a) based on a **remaining time before reproduction start** time set as time at which the reception device starts reproduction of the content from a present moment
- (b) and based on an **available reproduction time**, which is a time available for reproducing the content **based on the content data stored in the storage device** of the reception device, ...

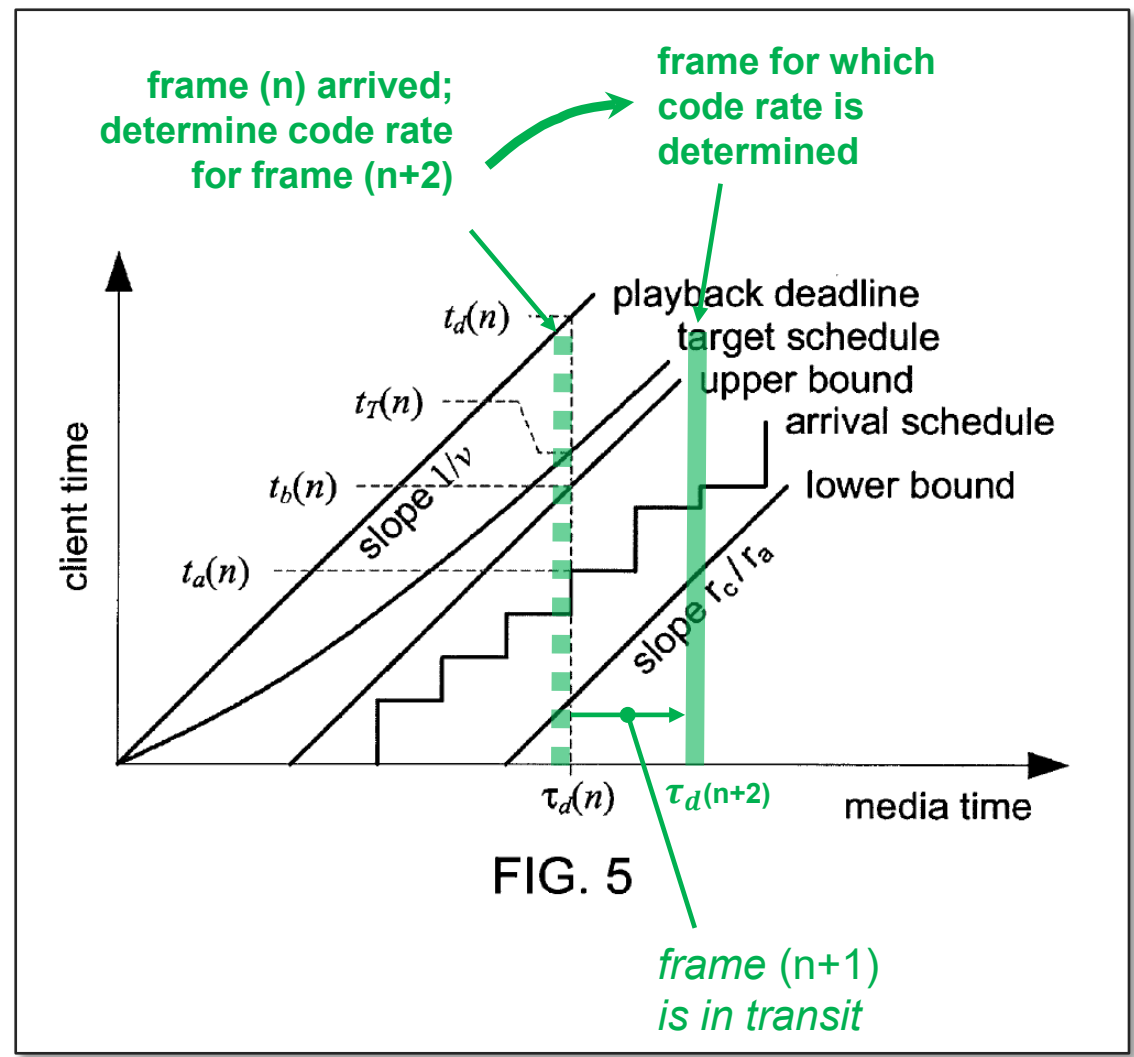
Chou's Client Buffer Duration Is "Available Time"



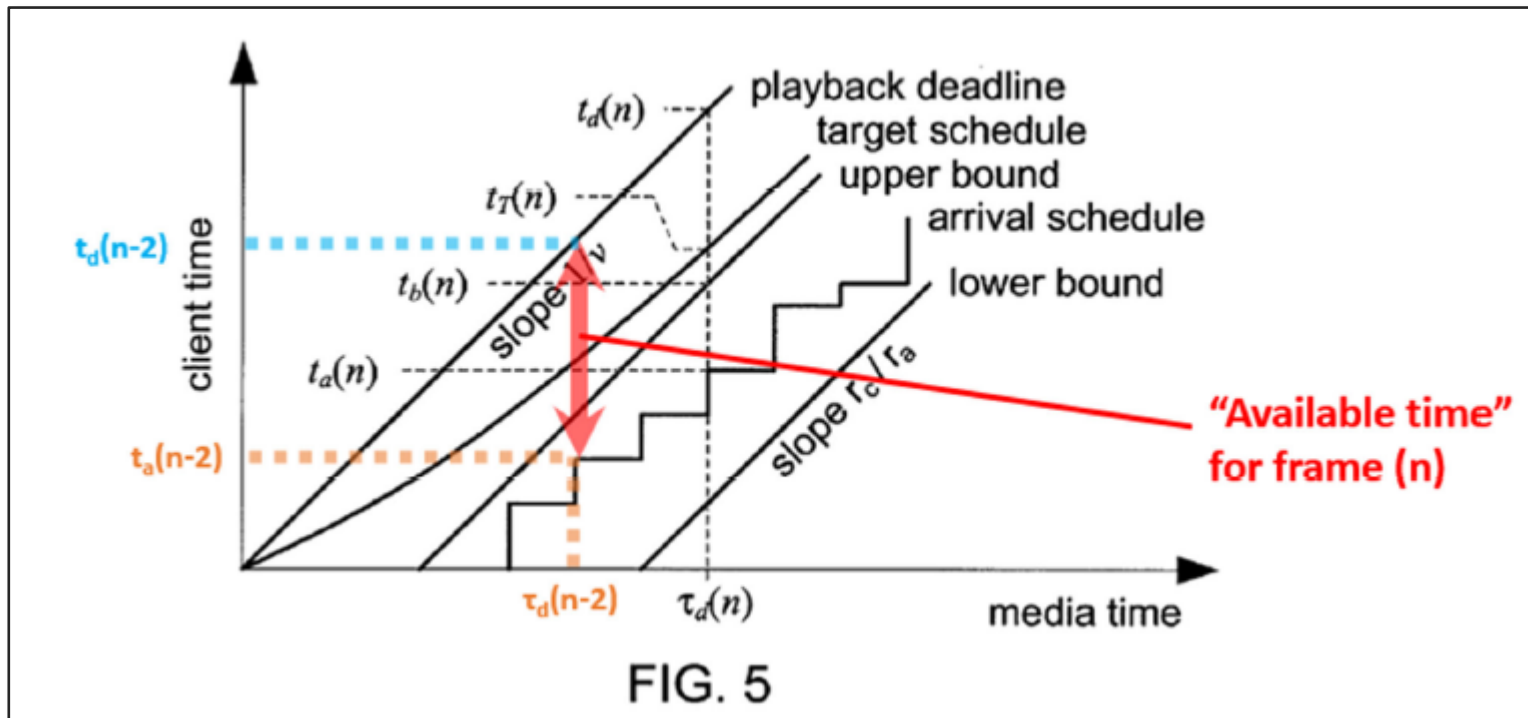
instantaneous decoding). Thus the gap between a frame's arrival time and its playback deadline is the client buffer duration at the time of the frame arrival. This must be non-negative to allow continuous playback.

Chou's System Accounts for a "One-Frame Delay"

[0081] "... Indeed, at time $t_a(n)$, frame $n+2$ is the earliest frame for which the controller can determine the coding bit rate. Hence at time $t_a(n)$, the controller's job must be to choose $r(n+2)$. This one-frame delay in the feedback loop must be explicitly accounted for."

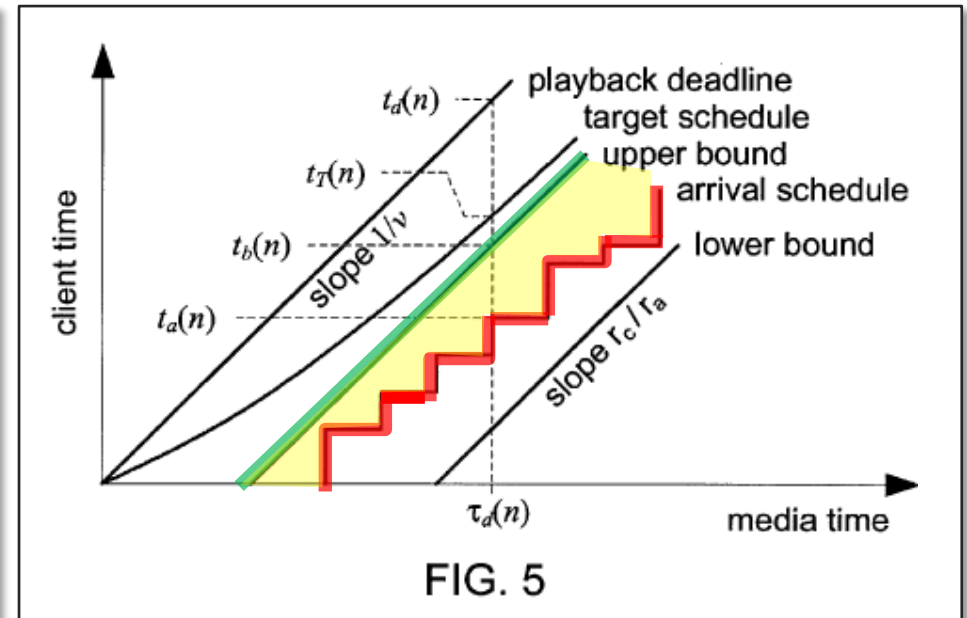
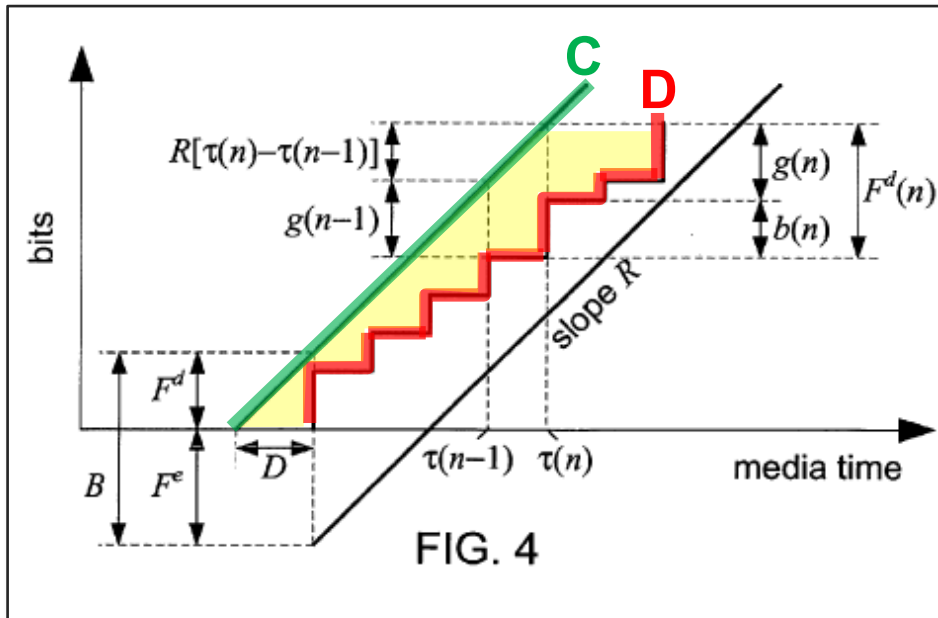


Chou Uses Client Buffer Duration to Calculate Code Rate for Frame (n)



[0070] “. . . By regulating the coding bit rate, it is attempted to control the buffer tube upper bound so that it tracks the target schedule. If the buffer tube upper bound is close to the target schedule, then the arrival times of all frames will certainly be earlier than their playback deadlines and thus uninterrupted playback will be ensured. . . .”

Chou's Client Buffer Duration Is Based on Decoder Buffer Status

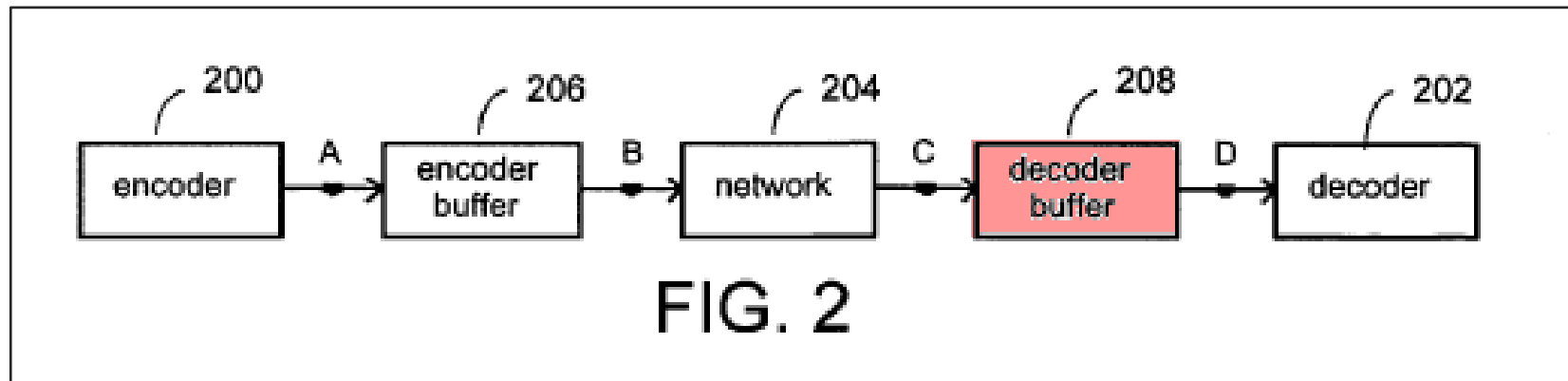


[0060] “. . . [T]he gap between Schedules **C** and **D** likewise represents the size of the decoder buffer. . . .”

[0067] “. . . The **coding schedule** divided by r_a becomes the **arrival schedule**, which provides for each n the time $t_a(n)$ of arrival of frame n at the client. . . The **buffer tube upper bound (in bits)** divided by r_a , becomes the **buffer tube upper bound (in time)**, which provides for each n the time $t_b(n)$ by which frame n is guaranteed to arrive. . . .”

“Network Jitter, Delays, and Throughput Changes” Impact Only the Decoder Buffer

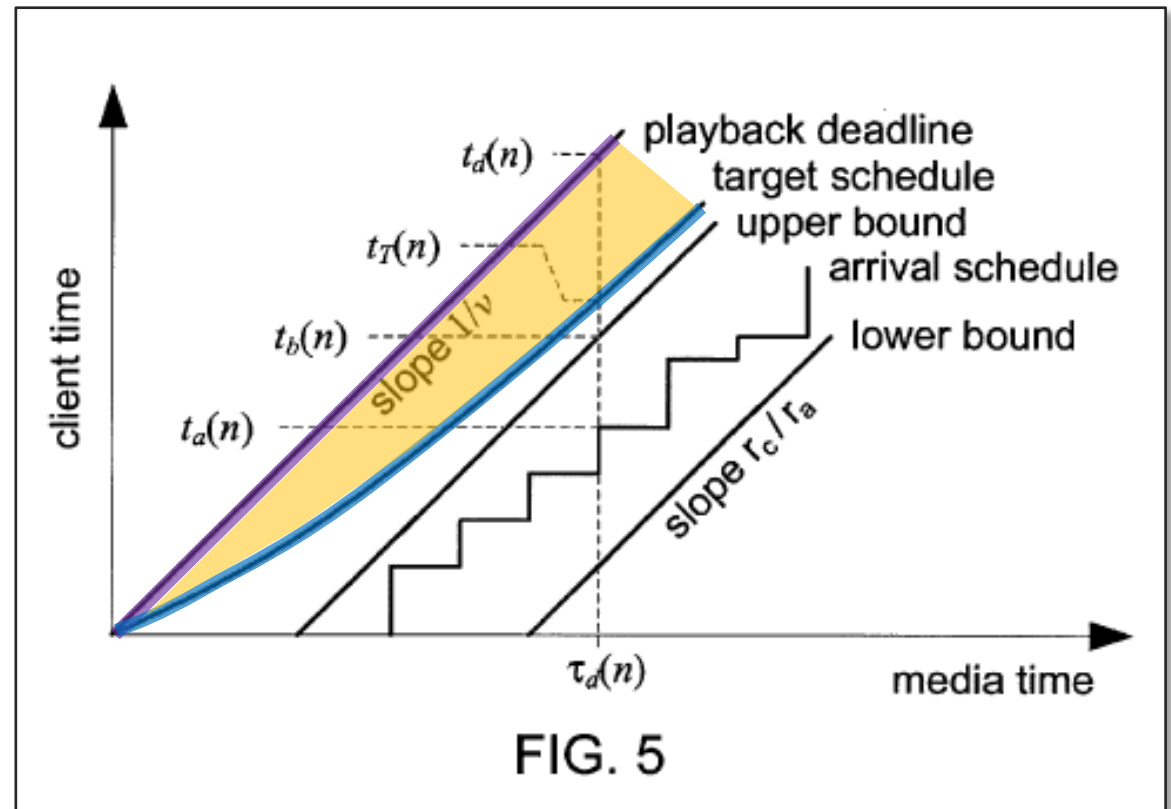
[0027] In regard to the target arrival time for each frame, these are chosen so as to make the amount of time between the target time of a frame and its playback time large enough, after the startup period, that network jitter, delays and throughput changes which may cause the actual arrival time of the frame to be after its target arrival time do not result in the frame arriving after its scheduled playback time.



Chou Adds a “Margin of Safety” to the Decoder Buffer to Account for Network Delays

[0067] “. . . In the same plot the **playback deadline** is shown, which is the time $t_d(n)$ at which frame n is scheduled to be played (after instantaneous decoding).”

[0070] “. . . To introduce a margin of safety that increases over time, a **target schedule** is introduced, as illustrated in FIG. 5, whose distance from the **playback deadline** grows slowly over time. . . .”



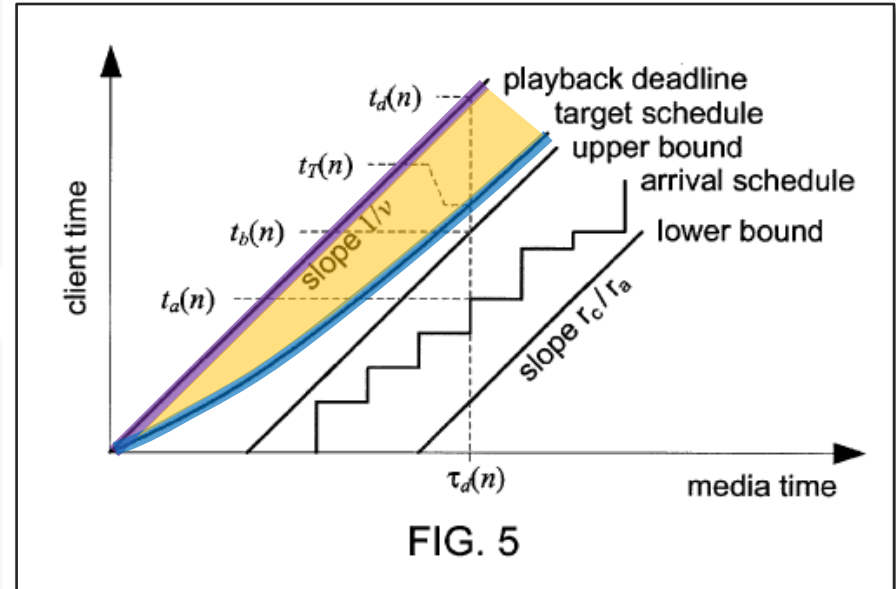
NEC's Expert Admits that the Playback Deadline & Target Schedule are Maintained by the Client

Q Okay. And so who is keeping track of the playback deadline, client or server?

A The playback deadline, what I expect, would have to be maintained at the client side. The client is ultimately the party that determines when it is playing back content.

A Just – sorry, before you do, I do note a reference to an earlier question, later in this same paragraph 112, we have, With this information, the client can properly adjust its control target schedule as well as its upper bound.

So here, at least, we have the client presumably being responsible for controlling its upper bound.



The Board Correctly Found That Chou Discloses Determining Code Rate Based on Available Time

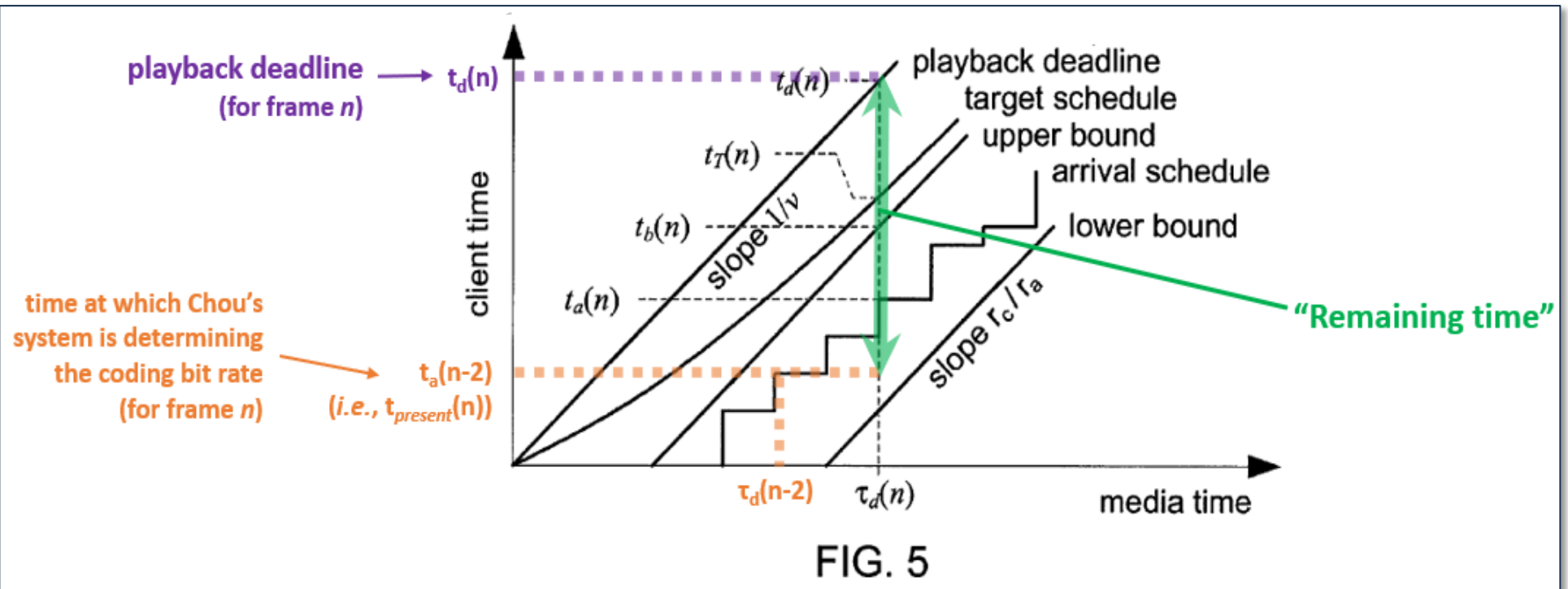
Moreover, Patent Owner's arguments concerning examining buffer fullness (*see id.* at 20–21) and calculating a difference in playback and arrive times (*see id.* at 22) do not appear to be commensurate in scope with claim 1, which has no such requirements, much less a requirement to monitor the actual reproduction time of content data stored in the storage device of the reception device. Limitation [1d] merely requires that a coding rate be determined “based on” an available reproduction time. As cited by Petitioner, Chou describes “dynamically adjusting the coding bit rate to control client buffer duration . . . [u]sing the theory of optimal linear quadratic control[of] the client buffer duration.” Ex. 1004, code (57) (cited by Pet. 38). Thus, on the preliminary record before us, we are persuaded by Petitioner's showing that Chou's coding bit rate is adjusted in response to or “based on” maintaining client buffer duration (i.e., available reproduction time) at a target level. *See* Pet. 38.

Chou Determines Code Rate Based on Remaining Time

[1d] the distribution system, comprising a code rate determining unit for **determining the code rate**:

- (a) based on a **remaining time before reproduction start** time set as time at which the reception device starts reproduction of the content from a present moment
- (b) and based on an **available reproduction time**, which is a time available for reproducing the content based on the content data stored in the storage device of the reception device, ...

Chou Discloses “Remaining Time”



**NEC admits this is
“Remaining Time”**

Moreover, *in client time*, time $t_a(n-2)$ is the “present moment” (e.g., the present moment of when the bit rate is being determined for frame “n”) and the “reproduction start time” corresponds to the “playback deadline” (in client time) of frame “n,” $t_d(n)$. EX2012, ¶113.

Chou Discloses Determining Code Rate Based on “Remaining Time”

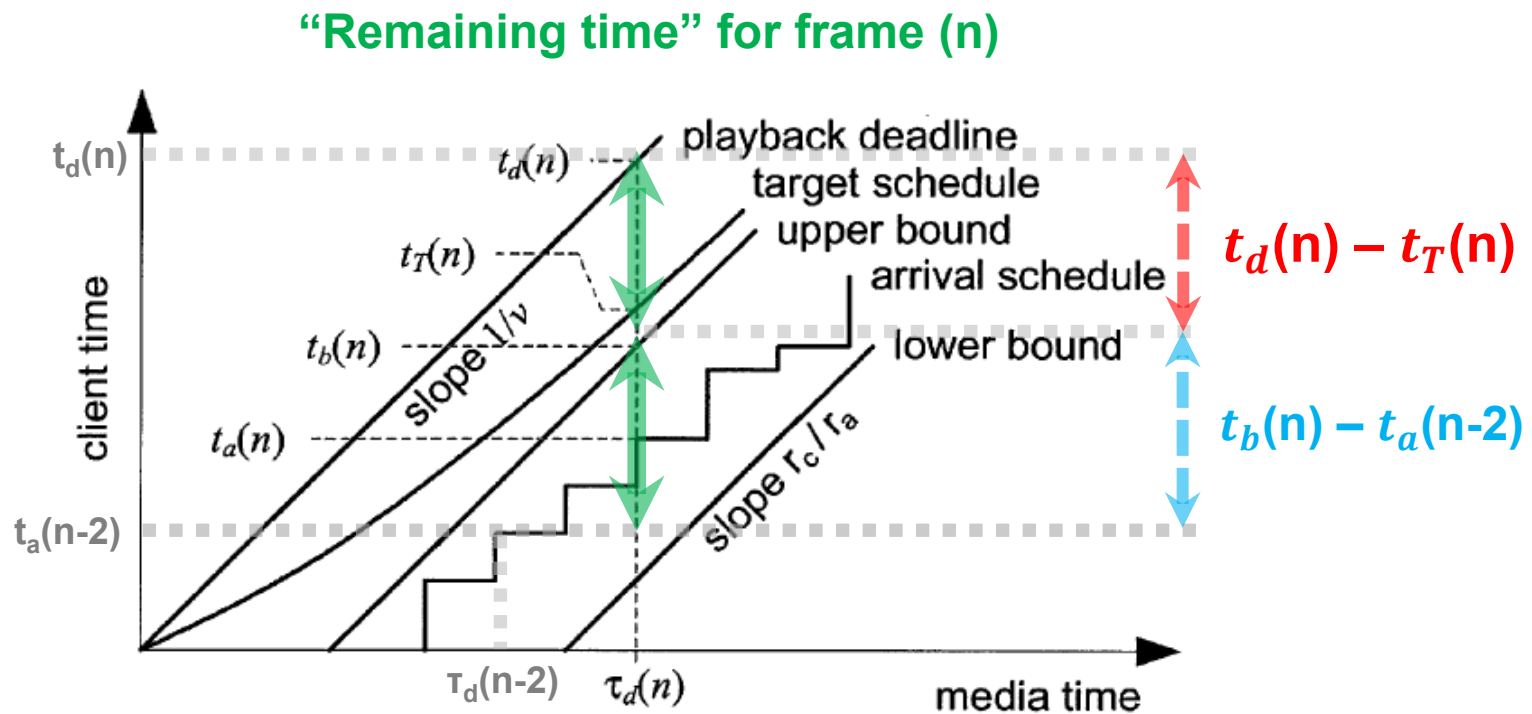


FIG. 5

NEC's Construction of "Based on" is Flawed

NEC's Patent Owner Response

A POSITA would understand that the claims require these two variables to be values that need to be used as an input to the determination process. *See infra*, §V.A. Moreover, as a threshold matter, a POSITA would understand that in order for these two variables to be used as the basis of the determination of the code rate of subsequent content data that is to be transmitted by the server, they must be first be determined (examined, acquired etc.), otherwise they could not provide a basis for the determination. *See infra*, §V.A. Accordingly, the Petition fails because (1) none of the identified elements of the cited references correspond to the available time or the remaining time; and (2) even if the identified elements of the references were determined, they do not serve as a basis for the determination of the code rate of content data that is to be transmitted by the server, as the claims require. *See infra*, §V.B-D.

NEC's Construction of "Based on" is Flawed

NEC's Expert Declaration

64. In other words, the '101 Patent makes clear that the term "based on" is used to signify a direct use of the values representing the "available reproduction time" and the "remaining time," as defined by the claims themselves, when determining the code rate.

NEC Advanced This Narrowing Construction in its Preliminary Response

NEC's Preliminary Response

¶67; EX2001, ¶46; Pet., 39-40. Yet, as discussed in greater detail below, this is a theoretical value; Chou does not disclose calculating it or much less using it to determine code rate. *Infra*, §§IV.A.2-3; EX2001 ¶46.

*

*

*

*

of the frame arrival.” Pet., 40 (citing EX1004, ¶67). Nowhere does the Petition allege that the difference in playback time and arrival time is determined or otherwise calculated in Chou’s system (because it is not). EX2001, ¶51. Yet, even

NEC's Patent Owner Response

A POSITA would understand that the claims require these two variables to be values that need to be used as an input to the determination process. *See infra*, §V.A. Moreover, as a threshold matter, a POSITA would understand that in order for these two variables to be used as the basis of the determination of the code rate of subsequent content data that is to be transmitted by the server, they must be first be determined (examined, acquired etc.), otherwise they could not provide a basis for the determination. *See infra*, §V.A. Accordingly, the Petition fails because (1) none

The Board Already Considered and Rejected NEC's Narrowing Construction

Moreover, Patent Owner's arguments concerning examining buffer fullness (*see id.* at 20–21) and calculating a difference in playback and arrive times (*see id.* at 22) do not appear to be commensurate in scope with claim 1, which has no such requirements, much less a requirement to monitor the actual reproduction time of content data stored in the storage device of the reception device. Limitation [1d] merely requires that a coding rate be determined “based on” an available reproduction time. As cited by Petitioner, Chou describes “dynamically adjusting the coding bit rate to control client buffer duration . . . [u]sing the theory of optimal linear quadratic control[of] the client buffer duration.” Ex. 1004, code (57) (cited by Pet. 38). Thus, on the preliminary record before us, we are persuaded by Petitioner's showing that Chou's coding bit rate is adjusted in response to or “based on” maintaining client buffer duration (i.e., available reproduction time) at a target level. *See* Pet. 38.

The Plain Meaning of “Based on” is Broad

Masimo Corp. V. Sotera Wireless, Inc., 2023 WL 630 7959, at *2 (Fed. Cir. 2023) (cit. omitted).

“the plain meaning of ‘**based on**’ [is] **broad**.”

Claim term: “trigger a second alarm *based on* . . . exceeding [the] second alarm threshold”

Court found: “this broad language claim language **does not exclude** the use of **additional** alarm thresholds or **other conditions** to trigger an alarm.”

Koninklijke Phillips N.V. V. Szoll Lifecor Corp., 2014 WL 5088863 at *14, *18 (W.D.Pa. Jul. 31, 2014) (Special Master Report & Recomm.)

Claim term: “adjust the tilt of the waveform *based on* the value of the monitored electrical parameter”

Special Master R&R: “‘**based on**’ is **not limited** to ‘as a **direct** and **immediate** consequence of, or ‘as a direct and **uninterrupted** consequence of’”

The Intrinsic Record Does Not Warrant a Narrower Construction

- Dependent Clams
- “Exemplary Embodiment” / Equation 5

'101 Patent Specification

In this exemplary embodiment, assuming a communication speed is kept at the communication speed B_n during a period between the present moment and the reproduction start time, the code rate determining part 47 determines a code rate r_{n+1} of content data to be transmitted by time of the available reproduction time information next time (i.e., time at a moment that is the change period after). That is to say, the code rate determining part 47 determines the code rate r_{n+1} , based on an equation (5) shown below.

$$r_{n+1} = B_n \cdot (t_s - t_n) / (T_d - T_n) \quad (5)$$

That is to say, the code rate determining part 47 determines, as the code rate r_{n+1} , a result of dividing a result of multiplying the acquired communication speed B_n and a remaining time $t_s - t_n$ by a result $T_d - T_n$ of subtracting the available reproduction time T_n from the target available reproduction time T_d .

Chou Relies Upon the Decoder Buffer

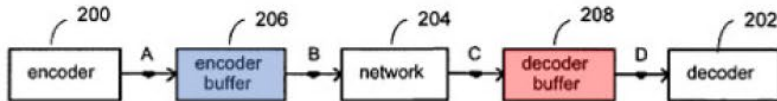


FIG. 2

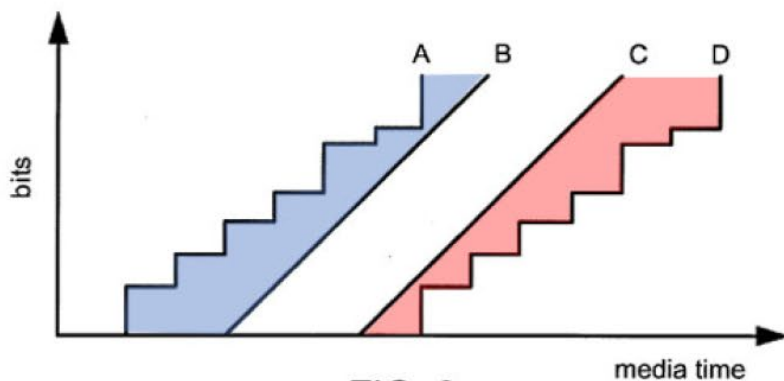


FIG. 3

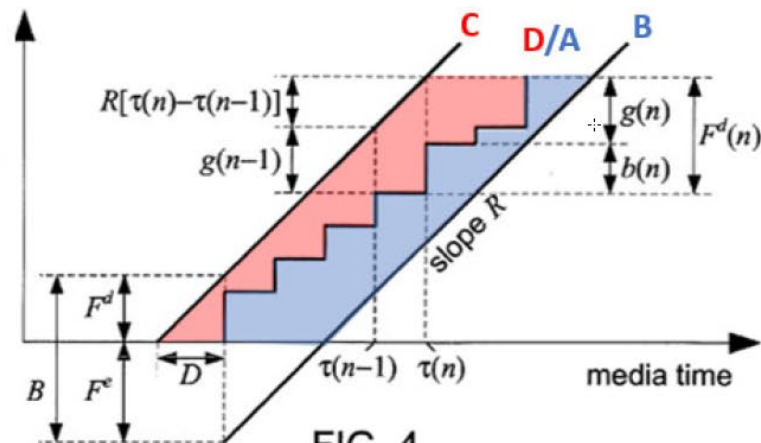


FIG. 4

[0060] “. . .Indeed, the gap between Schedules A and B represents, at any point in time, the size in bits of the encoder buffer, while the gap between Schedules C and D likewise represents the size of the decoder buffer. The encoder and decoder buffer sizes are complementary. . .”

[0066] “In the following the gap $g(n)$ at frame n between the buffer tube upper bound and the coding schedule is considered, as depicted in FIG. 4.”

Chou Determines Code Rate Based On the Decoder Buffer's Status

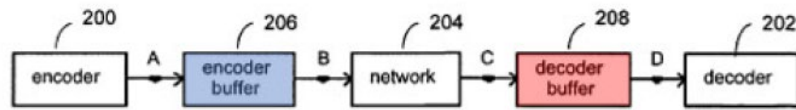


FIG. 2

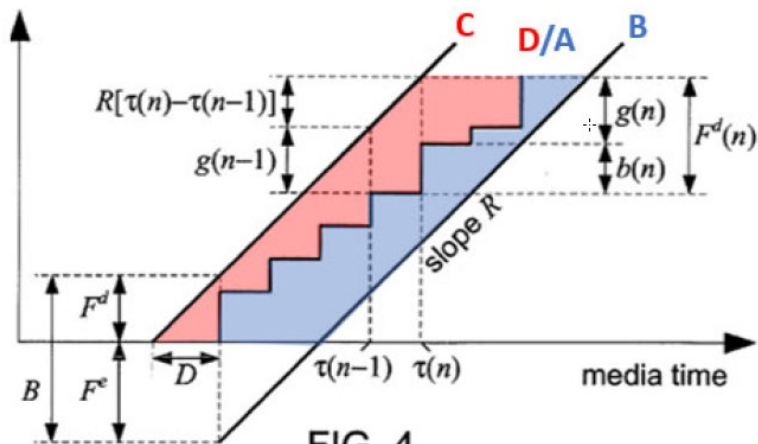
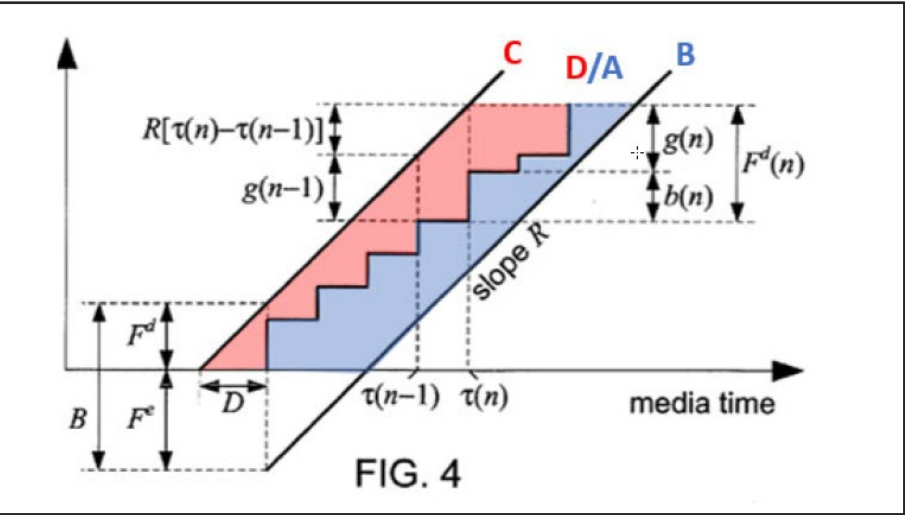


FIG. 4

- [0027] Only decoder can address “network jitter, delays, throughput changes”
- [0060] Fig. 4 shows decoder buffer size between schedules C and D
- [0066] Describes decoder buffer fullness F_d as $g(n) + b(n)$ and in terms of $g(n-1)$
- [0068] Equations 10-19 rely upon $g(n-1)$ and arrival time
- [0067] Lists parameters of decoder buffer
- Cooperstock admission re “playback deadline” and “target schedule”
- [0130] Server has to infer decoder status

Chou Determines Code Rate Based On the Decoder Buffer Size



[0070] “With the state transition equation defined in Eq.(18), uninterrupted playback can be achieved by regulating the coding bit rate so that the client buffer does not under flow. To introduce a margin of safety that increases over time, a target schedule is introduced, as illustrated in FIG. 5, ...”

$$F^d(n) = b(n) + g(n) = g(n-1) + \frac{r_c(n)}{f(n)}, \quad (10)$$

$$t_b(n) = t_a(n) + \frac{g(n)}{\tilde{r}_a(n)}, \text{ so that} \quad (16)$$

$$t_b(n) - t_b(n-1) = t_a(n) - t_a(n-1) + \frac{g(n)}{\tilde{r}_a(n)} - \frac{g(n-1)}{\tilde{r}_a(n-1)}, \quad (17)$$

$$t_b(n) = t_b(n-1) + \frac{r_c(n)}{f(n)\tilde{r}_a(n)} + w(n-1), \text{ where} \quad (18)$$

$$w(n-1) = \frac{g(n-1)}{\tilde{r}_\sigma(n)} - \frac{g(n-1)}{\tilde{r}_\sigma(n-1)} + v(n). \quad (19)$$

$$I = \sum_{n=0}^N \left[(t_b(n) - t_T(n))^2 + \sigma \left(\frac{r_c(n+1) - r_c(n)}{\tilde{r}_a(n)} \right)^2 \right], \quad (20)$$

Chou's Uses "Gap" in Different Contexts

- [0024]-[0025]: "upper bound gap" that the extra (free) space in the encoder buffer
- [0026], [0031], [0098], [0110], [0112]-[0113] & Fig. 10: "upper bound gap" in buffer tube that is used to change the control target schedule
- [0060], [0067] and Figs. 3 & 4: gap $g(n)$ and $g(n-1)$ at decoder buffer is used to determine the code rate
- [0110]: "upper bound" that is the buffer tube upper bound gap sender transmits "current gap the upper bound $g_{\text{new}}(n)$ "

Chou Uses “Upper Bound Gap” to Avoid Underflow When Changing Code Rate

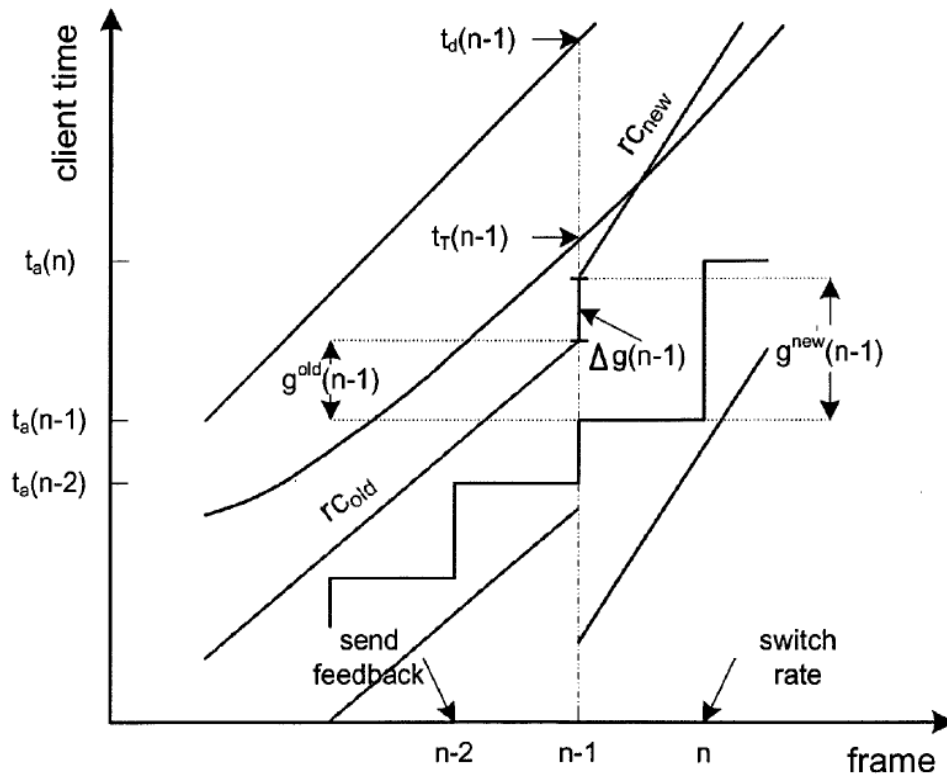


FIG. 10

[0024] In addition to the initial encoder buffer parameters, the server also computes an upper bound gap for each frame of the streaming media data generated for each coding bit rate supported by the server. This upper bound gap is defined as the number of data bits that the server's encoder buffer can contain over the bits currently contained therein after a just-generated frame is fully input into the buffer. More particularly, the upper bound gap for each frame is computed as the difference between the encoder buffer size and the last computed value for an encoder buffer fullness after insertion of the just-generated frame. The encoder buffer fullness

* * *

buffer, while the gap between Schedules C and D likewise represents the size of the decoder buffer. The encoder and decoder buffer sizes are complementary. Thus the coding schedule (either A or D) can be contained within a buffer tube, as illustrated in the graph of FIG. 4, having slope R,

* * *

Chou Uses $g(n-1)$ to Calculate Code Rate in Eq. 18 and 19

- [0066]-[0067], Figs. 3 & 4: $g(n)$ and $g(n-1)$ denote the status of the decoder buffer
- [0069]: $g(n-1)$ “can be transmitted to the client ... or computed at the client as described in Section V.E”
- [0113]: “Whenever a new coding bit rate starts, the client receives the value $g(n)$ along with the new frame. The values of $g(n)$ for successive frames can be then inferred by the client itself based on the coding bit rate $r(n)$ and the frame size $b(n)$.”

NEC Misinterprets Chou; Code Rate is Determined Using Data from the *Decoder Buffer*

[0066] In the following the gap $g(n)$ at frame n between the buffer tube upper bound and the coding schedule is considered, as depicted in **FIG. 4**. Note that the decoder buffer fullness $F^d(n)=B-F^e(n)$ can also be expressed

$$F^d(n) = b(n) + g(n) = g(n-1) + \frac{r_c(n)}{f(n)}, \quad (10)$$

where $r_c(n)$ is the coding bit rate of the buffer tube, now taking into account that different frames may lie in different buffer tubes with different coding bit rates as coding bit rate control is applied and streams are switched.

Chou's Algorithm Determines Code Rate With a Margin of Safety

D. Control Objective

[0070] With the state transition equation defined in Eq. (18), uninterrupted playback can be achieved by regulating the coding bit rate so that the client buffer does not underflow. To introduce a margin of safety that increases over time, a target schedule is introduced, as illustrated in FIG. 5, whose distance from the playback deadline grows slowly over time. By regulating the coding bit rate, it is attempted to control the buffer tube upper bound so that it tracks the target schedule. If the buffer tube upper bound is close to the target schedule, then the arrival times of all frames will certainly be earlier than their playback deadlines and thus uninterrupted playback will be ensured. Note that controlling the actual arrival times (rather than their upper bounds) to the target would result in an approximately constant number of bits per frame, which would in turn result in very poor quality overall. By taking the leaky bucket model into account, it is possible to establish a control that allows the instantaneous coding bit rate to fluctuate naturally according to the encoding complexity of the content, within previously established bounds for a given average coding bit rate.

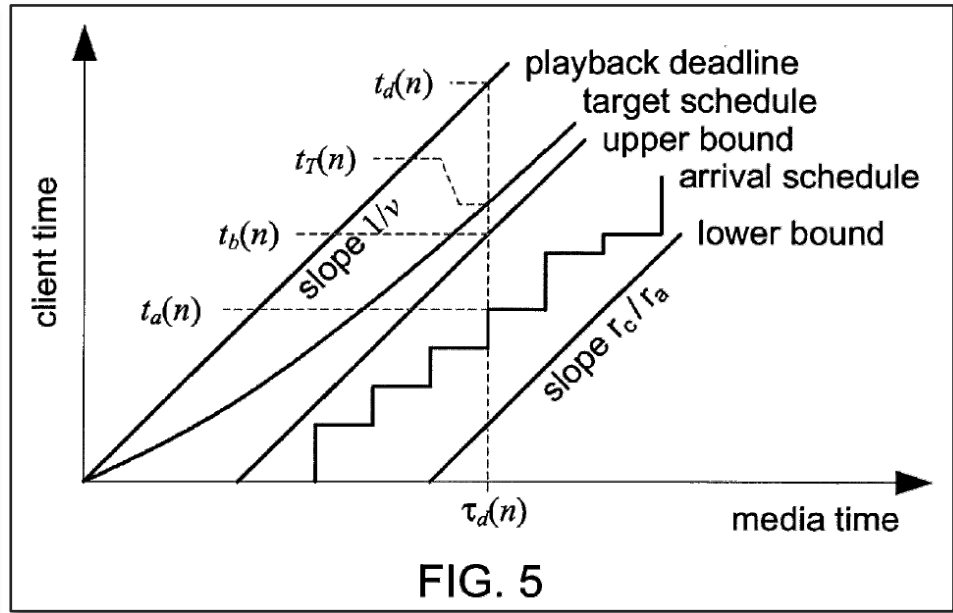


FIG. 5

$$t_b(n) = t_b(n-1) + \frac{r_c(n)}{f(n)\tilde{r}_a(n)} + w(n-1), \text{ where} \quad (18)$$

$$w(n-1) = \frac{g(n-1)}{\tilde{r}_a(n)} - \frac{g(n-1)}{\tilde{r}_a(n-1)} + v(n). \quad (19)$$

$$I = \sum_{n=0}^N \left((t_b(n) - t_T(n))^2 + \sigma \left(\frac{r_c(n+1) - r_c(n)}{\tilde{r}_a(n)} \right)^2 \right), \quad (20)$$

Dr. Cooperstock's Testimony is Unreliable

- Equated “Remaining Time” with Chou’s *target buffer duration*
- 1st declaration: had not analyzed Chou’s Fig. 4, or Chou’s equations; struggled to explain its schedules, including C & D (which define the size of the decoder/client buffer)
- 2nd declaration: had not analyzed Chou’s Fig. 10, which shows that the gaps gnew/gold are *different* than the gap in Fig. 4 (decoder/client buffer size)
- “Encoder Parameters Only” argument does not account for transmission factors (jitter, delay, throughput)
- Avoided opining on Chou’s feedback system in determining code rate