Amended Set of Claims 1 to 45

1. A method for decoding video data, the method comprising:

deriving at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determining a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

decoding video data of the AU based at least in part on the removal time.

2. The method of claim 1, further comprising:

responsive to the syntax element having a true value, deriving a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, deriving a CPB removal time only for the sub-picture level.

3. The method of claim 1, wherein the at least one of the CPB arrival time or the CPB nominal removal time are derived only when a syntax flag that indicates CPB parameters are present has a true value.

4. The method of claim 1, further comprising:

decoding a duration between CPB removal of a first DU in the AU and CPB removal of a second DU;

determining a removal time of the first DU based at least in part on the decoded duration; and

decoding video data of the first DU based at least in part on at least one of the removal time, the CPB arrival time, or the CPB nominal removal time.

5. The method of claim 4, wherein the second DU is subsequent to the first DU in decoding order and in the same AU as the first DU.

6. The method of claim 4, further comprising:

decoding one or more sub-picture level CPB parameters, wherein determining the removal time of the first DU comprises determining the removal time of the first DU based at least in part on the decoded duration and the sub-picture level CPB parameters.

7. The method of claim 1, further comprising:

decoding a sequence level flag to determine the presence of sub-picture level CPB parameters either in picture timing SEI messages or in sub-picture timing SEI messages.

8. The method of claim 1, wherein the first DU comprises a non-video coding layer (VCL) network abstraction layer (NAL) unit with nal_unit_type equal to UNSPEC0, EOS_NUT, EOB_NUT, in the range of RSV_NVCL44 to RSV_NVCL47 or in the range of UNSPEC48 to UNSPEC63.

9. The method of claim 1, wherein the AU has a TemporalId equal to 0, the method further comprising:

decoding at least one of a buffering period supplemental enhancement information (SEI) message or a recovery point SEI message associated with the AU.

10. A video decoding device comprising a video decoder configured to:

derive at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determine a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

decode video data of the AU based at least in part on the removal time.

11. The video decoding device of claim 10, the video decoder further configured to:

responsive to the syntax element having a true value, derive a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, derive a CPB removal time only for the sub-picture level.

12. The video decoding device of claim 10, wherein the at least one of the CPB arrival time or the CPB nominal removal time are derived only when a syntax flag that indicates CPB parameters are present has a true value.

13. The video decoding device of claim 10, the video decoder further configured to:

decode a duration between CPB removal of a first DU in the AU and CPB removal of a second DU;

determine a removal time of the first DU based at least in part on the decoded duration; and

decode video data of the first DU based at least in part on at least one of the removal time, the CPB arrival time, or the CPB nominal removal time.

14. The video decoding device of claim 13, wherein the second DU is subsequent to the first DU in decoding order and in the same AU as the first DU.

15. The video decoding device of claim 13, the video decoder further configured to decode one or more sub-picture level CPB parameters, wherein determine the removal time of the first DU comprises determine the removal time of the first DU based at least in part on the decoded duration and the sub-picture level CPB parameters.

16. The video decoding device of claim 10, the video decoder further configured to decode a sequence level flag to determine the presence of sub-picture level CPB parameters either in picture timing SEI messages or in sub-picture timing SEI messages.

17. The video decoding device of claim 10, wherein the first DU comprises a non-video coding layer (VCL) network abstraction layer (NAL) unit with nal_unit_type equal to UNSPEC0, EOS_NUT, EOB_NUT, in the range of RSV_NVCL44 to RSV_NVCL47 or in the range of UNSPEC48 to UNSPEC63.

18. The video decoding device of claim 10, wherein the AU has a TemporalId equal to 0, the video decoder further configured to decode at least one of a buffering period supplemental enhancement information (SEI) message or a recovery point SEI message associated with the AU.

19. A computer-readable storage medium having stored thereon instructions that, when executed, cause a processor of a device for decoding video data to:

derive at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determine a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

decode video data of the AU based at least in part on the removal time.

20. The computer-readable storage medium of claim 19, the instructions further cause the processor to:

responsive to the syntax element having a true value, derive a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, derive a CPB removal time only for the sub-picture level.

21. The computer-readable storage medium of claim 19, wherein the at least one of the CPB arrival time or the CPB nominal removal time are derived only when a syntax flag that indicates CPB parameters are present has a true value.

22. A video decoding device comprising:

means for deriving at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

means for determining a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

means for decoding video data of the AU based at least in part on the removal time.

23. The video decoding device of claim 22, further comprising:

responsive to the syntax element having a true value, means for deriving a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, means for deriving a CPB removal time only for the sub-picture level.

24. The video decoding device of claim 22, wherein the at least one of the CPB arrival time or the CPB nominal removal time are derived only when a syntax flag that indicates CPB parameters are present has a true value.

25. A method for encoding video data, the method comprising:

deriving at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determining a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

encoding the removal time.

26. The method of claim 25, further comprising:

responsive to the syntax element having a true value, encoding a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, encoding a CPB removal time only for the sub-picture level.

27. The method of claim 25, wherein the at least one of the CPB arrival time or the CPB nominal removal time are encoded only when a syntax flag that indicates CPB parameters are present has a true value.

28. The method of claim 25, further comprising:

encoding a duration between CPB removal of a first DU in the AU and CPB removal of a second DU, wherein encoding the removal time further comprises encoding the duration.

29. The method of claim 28, wherein the second DU is subsequent to the first DU in decoding order and in the same AU as the first DU.

30. The method of claim 28, further comprising:

encoding one or more sub-picture level CPB parameters, wherein determining the removal time of the first DU comprises determining the removal time of the first DU based at least in part on the duration and the sub-picture level CPB parameters.

31. The method of claim 25, further comprising:

encoding a sequence level flag to indicate the presence of sub-picture level CPB parameters either in picture timing SEI messages or in sub-picture timing SEI messages.

32. The method of claim 25, wherein the first DU comprises a non-video coding layer (VCL) network abstraction layer (NAL) unit with nal_unit_type equal to UNSPEC0, EOS_NUT, EOB_NUT, in the range of RSV_NVCL44 to RSV_NVCL47 or in the range of UNSPEC48 to UNSPEC63.

33. The method of claim 25, wherein the AU has a TemporalId equal to 0, the method further comprising:

encoding at least one of a buffering period supplemental enhancement information (SEI) message or a recovery point SEI message associated with the AU.

34. A video encoding device comprising a video encoder configured to:

derive at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determine a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

encode the removal time.

35. The video encoding device of claim 34, the video encoder further configured to:

responsive to the syntax element having a true value, encode a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, encode a CPB removal time only for the sub-picture level.

36. The video encoding device of claim 34, wherein the at least one of the CPB arrival time or the CPB nominal removal time are encoded only when a syntax flag that indicates CPB parameters are present has a true value.

37. The video encoding device of claim 34, the video encoder is further configured to encode a duration between CPB removal of a first DU in the AU and CPB removal of a second DU, wherein encode the removal time further comprises encode the duration.

38. The video encoding device of claim 37, wherein the second DU is subsequent to the first DU in decoding order and in the same AU as the first DU.

39. The video encoding device of claim 37, the video encoder further configured to encode one or more sub-picture level CPB parameters, wherein determining the removal time of the first DU comprises determining the removal time of the first DU based at least in part on the duration and the sub-picture level CPB parameters.

40. The video encoding device of claim 34, the video encoder further configured to encode a sequence level flag to indicate the presence of sub-picture level CPB parameters either in picture timing SEI messages or in sub-picture timing SEI messages.

41. The video encoding device of claim 34, wherein the first DU comprises a non-video coding layer (VCL) network abstraction layer (NAL) unit with nal_unit_type equal to UNSPEC0, EOS_NUT, EOB_NUT, in the range of RSV_NVCL44 to RSV_NVCL47 or in the range of UNSPEC48 to UNSPEC63.

42. The video encoding device of claim 34, wherein the AU has a TemporalId equal to 0, the video encoder further configured to encode at least one of a buffering period supplemental enhancement information (SEI) message or a recovery point SEI message associated with the AU.

43. A computer-readable storage medium having stored thereon instructions that, when executed, cause a processor of a device for encoding video data to:

derive at least one of a coded picture buffer (CPB) arrival time or a CPB nominal removal time for an access unit (AU) at both an access unit level and a sub-picture level regardless of a value of a syntax element that defines whether a decoding unit (DU) is the entire AU;

determine a removal time of the AU based at least in part on one of the CPB arrival time or the CPB nominal removal time; and

encode the removal time.

44. The computer-readable storage medium of claim 43, wherein the instructions further cause the processor to:

responsive to the syntax element having a true value, encode a CPB removal time only for the AU level; and

responsive to the syntax element having a false value, encode a CPB removal time only for the sub-picture level.

45. The computer-readable storage medium of claim 43, wherein the at least one of the CPB arrival time or the CPB nominal removal time are encoded only when a syntax flag that indicates CPB parameters are present has a true value.

CLAIMS

1. A method for decoding video data, the method comprising:

determining a value of a syntax element, the value of the syntax element signaling whether or not sub-picture level coded picture buffer (CPB) removal delay parameters are present in a picture timing Supplemental Enhancement Information (SEI) messages;

regardless of a value of a variable, deriving a CPB arrival time for an access unit (AU) and a nominal removal time for the AU at an AU level, wherein a CPB operates at the AU level when the value of the variable is 0 and the CPB operates at a sub-picture level when the value of the variable is 1;

setting a nominal removal time of a decoding unit (DU) based on the syntax element indicating whether the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, the nominal removal time of the DU is set equal to the nominal removal time for the AU minus a sub-picture clock tick multiplied by a CPB removal delay; wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, the nominal removal time of the DU is set equal to a nominal removal time of a next DU minus the sub-picture clock tick multiplied by the CPB removal delay;

based on the variable being equal to 1 and either a low_delay_hrd_flag being equal to 0 or the nominal removal time of the DU being greater than or equal to a final CPB arrival time of the DU, setting a CPB removal time of the DU to the nominal removal time of the DU; and

at the CPB removal time of the DU, decoding the DU.

2. A device for decoding video data, the device comprising:

a coded picture buffer (CPB); and

a video decoder configured to:

determine a value of a syntax element, the value of the syntax element signaling whether or not sub-picture level CPB removal delay parameters are present in picture timing Supplemental Enhancement Information (SEI) messages;

regardless of a value of a variable, derive a CPB arrival time for an access unit (AU) and a nominal removal time for the AU at an AU level, wherein the CPB

operates at the AU level when the value of the variable is 0 and the CPB operates at a sub-picture level when the value of the variable is 1;

set a nominal removal time of a decoding unit (DU) based on the syntax element indicating whether the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, the nominal removal time of the DU is set equal to the nominal removal time for the AU minus a sub-picture clock tick multiplied by a CPB removal delay, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, the nominal removal time of the DU is set equal to a nominal removal time of a next DU minus the sub-picture clock tick multiplied by the CPB removal delay;

based on the variable being equal to 1 and either a low_delay_hrd_flag being equal to 0 or the nominal removal time of the DU being greater than or equal to a final CPB arrival time of the DU, set a CPB removal time of the DU to the nominal removal time of the DU; and

at the CPB removal time of the DU, decode the DU.

3. A non-transitory computer-readable storage medium having stored thereon instructions that, when executed, cause a processor of a device for decoding video data to:

determine a value of a syntax element, the value of the syntax element signaling whether or not sub-picture level coded picture buffer (CPB) removal delay parameters are present in picture timing Supplemental Enhancement Information (SEI) messages;

regardless of a value of a variable, derive a CPB arrival time for an access unit (AU) and a nominal removal time for the AU at an AU level, wherein a CPB operates at the AU level when the value of the variable is 0 and the CPB operates at a sub-picture level when the value of the variable is 1;

set a nominal removal time of a decoding unit (DU) based on the syntax element indicating whether the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, the nominal removal time of the DU is set equal to the nominal removal time for the AU minus a sub-picture clock tick multiplied by a CPB removal delay, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are present in the

picture timing SEI messages, the nominal removal time of the DU is set equal to a nominal time of a next DU minus the sub-picture clock tick multiplied by the CPB removal delay;

based on the variable being equal to 1 and either a low_delay_hrd_flag being equal to 0 or the nominal removal time of the DU being greater than or equal to a final CPB arrival time of the DU, set a CPB removal time of the DU to the nominal removal time of the DU; and

at the CPB removal time of the DU, decode the DU.

4. A device for decoding video data, the device comprising:

means for determining a value of a syntax element, the value of the syntax element signaling whether or not sub-picture level coded picture buffer (CPB) removal delay parameters are present in picture timing Supplemental Enhancement Information (SEI) messages;

means for deriving, regardless of a value of a variable, a CPB arrival time for an access unit (AU) and a nominal removal time for the AU at an AU level, wherein a CPB operates at the AU level when the value of the variable is 0 and the CPB operates at a sub-picture level when the value of the variable is 1;

means for setting a nominal removal time of a decoding unit (DU) based on the syntax element indicating whether the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, the nominal removal time of the DU is set equal to the nominal removal time for the AU minus a sub-picture clock tick multiplied by a CPB removal delay, wherein based on the syntax element indicating the sub-picture level CPB removal delay parameters are present in the picture timing SEI messages, the nominal removal time of the DU is set equal to a nominal removal time of a next DU minus the sub-picture clock tick multiplied by the CPB removal delay;

means for setting, based on the variable being equal to 1 and either a low_delay_hrd_flag being equal to 0 or the CPB nominal removal time of the DU being greater than or equal to a final CPB arrival time of the DU, a CPB removal time of the DU to the nominal removal time of the DU; and

means for decoding the DU at the CPB removal time for the DU.

5. The method of claim 1, wherein the syntax element is a first syntax element, the method further comprising:

determining, based on the first syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, that the CPB removal delay is set to a second syntax element, the second syntax element being in a sub-picture timing SEI message, the second syntax element specifying a duration, in units of sub-picture clock ticks, between removal from the CPB of a last DU in decoding order in a current AU containing the sub-picture timing SEI message and a DU associated with the sub-picture timing SEI message.

6. The device of claim 2, wherein the syntax element is a first syntax element, the video decoder configured to:

determine, based on the first syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, that the CPB removal delay is set to a second syntax element, the second syntax element being in a sub-picture timing SEI message, the second syntax element specifying a duration, in units of sub-picture clock ticks, between removal from the CPB of a last DU in decoding order in a current AU containing the sub-picture timing SEI message and a DU associated with the sub-picture timing SEI message.

7. The non-transitory computer-readable storage medium of claim 3, wherein the syntax element is a first syntax element, the instructions, when executed, causing the processor to:

determine, based on the first syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, that the CPB removal delay is set to a second syntax element, the second syntax element being in a sub-picture timing SEI message, the second syntax element specifying a duration, in units of sub-picture clock ticks, between removal from the CPB of a last DU in decoding order in a current AU containing the sub-picture timing SEI message and a DU associated with the sub-picture timing SEI message.

8. The device of claim 4, wherein the syntax element is a first syntax element, the device further comprising:

means for determining, based on the first syntax element indicating the sub-picture level CPB removal delay parameters are not present in the picture timing SEI messages, that

the CPB removal delay is set to a second syntax element, the second syntax element being in a sub-picture timing SEI message, the second syntax element specifying a duration, in units of sub-picture clock ticks, between removal from the CPB of a last DU in decoding order in a current AU containing the sub-picture timing SEI message and a DU associated with the sub-picture timing SEI message.