CLAIMS

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

storing a plurality of decoding units associated with an access unit of the video data in a picture buffer, each decoding unit of the plurality being a subset of the access unit, and each decoding unit of the plurality comprising at least one video coding layer (VCL) network abstraction layer (NAL) unit of the access unit and any non-VCL NAL unit that is associated with the at least one VCL NAL unit;

obtaining a respective buffer removal time for each stored decoding unit of the plurality of stored decoding units, wherein obtaining the respective buffer removal time for a respective stored decoding unit comprises receiving respective signaled information indicative of the respective buffer removal time for the respective stored decoding unit;

removing the plurality of stored decoding units from the picture buffer in accordance with the obtained buffer removal times; and

coding the video data corresponding to the plurality of removed decoding units, wherein coding the video data comprises decoding the plurality of removed decoding units.

2. The method of claim **1**, wherein storing the plurality of decoding units in the picture buffer comprises storing the plurality of decoding units of the video data in a continuous decoding order in the picture buffer.

3. The method of claim **2**, further comprising receiving the plurality of decoding units of the video data in the continuous decoding order prior to storing the plurality of received decoding units in the picture buffer.

4. The method of claim **1**, wherein the picture buffer is a coded picture buffer.

5. The method of claim **4**, the method further comprising removing a first decoding unit of the plurality of stored decoding units from the coded picture buffer prior to removing a second decoding unit of the plurality of stored decoding units from the coded picture buffer, wherein the first decoding unit and the second decoding unit comprise respective subsets of the access unit.

6. The method of claim **1**, wherein the respective signaled information indicative of the buffer removal time further comprises a signaled value indicative of a number of network abstraction layer (NAL) units included in the respective stored decoding unit.

7. The method of claim **1**, wherein the plurality of decoding units comprise a plurality of sub-pictures of a common picture, and wherein receiving the respective signaled information indicative of the respective buffer removal time comprises receiving a respective signaled value indicative of the buffer removal time for each of the sub-pictures of the common picture.

8. The method of claim **1**, wherein the picture buffer is a coded picture buffer (CPB), and wherein receiving the respective signaled information indicative of the buffer removal time comprises receiving respective signaled values indicative of one or more of an initial CPB removal delay at an access unit level, an initial CPB removal delay offset at the access unit level, an initial CPB removal delay at a sub-picture level, or an initial CPB removal delay offset at the sub-picture level.

9. The method of claim **1**, wherein the respective signaled information indicative of the buffer removal time is included in a picture timing supplemental enhancement information (SEI) message.

10. The method of claim **1**, wherein the respective signaled information indicative of the buffer removal time is included in a decoding unit timing supplemental enhancement information (SEI) message.

11. The method of claim **1**, wherein removing the plurality of stored decoding units from the picture buffer in accordance with the obtained respective buffer removal times comprises removing at least one stored decoding unit of the plurality of stored decoding units from the picture buffer after a respective obtained buffer removal time for the at least one stored decoding unit has passed since the at least one stored decoding unit was stored in the picture buffer.

12. The method of claim **1**, wherein each of the plurality of stored decoding units comprises one or more respective sub-pictures.

13. The method of claim **12**, further comprising receiving a signaled value indicative of a byte alignment of at least one sub-picture of the one or more respective sub-pictures within a larger set of the video data, the larger set of the video data comprising the at least one sub-picture.

14. The method of claim **13**, wherein the larger set of the video data comprises at least one of an access unit, a subset of an access unit, a picture, a frame, a slice, a wave, or a tile.

15. The method of claim **12**, wherein each sub-picture of the one or more sub-pictures corresponds to at least one of one or more sequences of blocks of the video data, one or more slices, one or more waves, one or more tiles, or one or more network abstraction layer (NAL) units.

16. The method of claim **1**, wherein obtaining the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units comprises performing one of:

based on the respective decoding unit comprising an ordinal first decoding unit of the video data, determining that the buffer removal time comprises a coded picture buffer removal delay value specified in a buffering period supplemental enhancement information (SEI) message associated with an access unit that comprises the respective decoding unit; or

based on the respective decoding unit not comprising the ordinal first decoding unit of the video data, wherein the respective decoding unit comprises an ordinal i^{th} decoding unit where i>0, determining that the buffer removal time comprises a decoding unit coded picture buffer removal delay [i] specified in the picture timing SEI message associated with the access unit that comprises the respective decoding unit.

17. The method of claim **1**, wherein obtaining the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units comprises performing one of:

based on the respective decoding unit comprising an ordinal first decoding unit of an access unit of the video data, determining that a nominal removal time for the decoding unit comprises an initial coded picture buffer removal delay value divided by 90000; or

based on the respective decoding unit not comprising the ordinal first decoding unit of the access unit, wherein the decoding unit comprises an ordinal m^{th} decoding unit where m>0 of the access unit, determining that a nominal removal time for the decoding unit comprises a nominal removal time of an ordinal first decoding unit of a previous buffering period plus a clock tick times a coded picture buffer removal delay associated with the ordinal m^{th} decoding unit.

18. The method of claim **1**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of coding blocks, and wherein coding the video data corresponding to the plurality of removed decoding units comprises coding the different numbers of coding blocks in the at least two stored decoding units.

19. The method of claim **1**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of bits, and wherein coding the video data corresponding to the plurality of removed decoding units comprises coding the different numbers of bits in the at least two stored decoding units.

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

a memory configured to store at least a portion of the video data; and

a video decoder configured to:

store a plurality of decoding units associated with an access unit of video data in a picture buffer, each decoding unit of the plurality being a subset of the access unit, and each decoding unit of the plurality comprising at least one video coding layer (VCL) network abstraction layer (NAL) unit of the access unit and any non-VCL NAL unit that is associated with the at least one VCL NAL unit;

obtain a respective buffer removal time for each stored decoding unit of the plurality of stored decoding units, wherein to obtain the respective buffer removal time for a respective stored decoding unit, the video decoder is configured to receive respective signaled information indicative of the respective buffer removal time for the respective stored decoding unit;

remove the plurality of stored decoding units from the picture buffer in accordance with the obtained buffer removal times; and

code the video data corresponding to the plurality of removed decoding units, wherein to code the video data, the video decoder is configured to decode the plurality of removed decoding units.

21. The device of claim **20**, wherein the video decoder is further configured to store the plurality of decoding units of the video data in a continuous decoding order in the picture buffer.

22. The device of claim **21**, wherein the video decoder is further configured to receive the plurality of decoding units

of the video data in the continuous decoding order prior to storing the plurality of received decoding units in the picture buffer.

23. The device of claim **20**, wherein the picture buffer is a coded picture buffer.

24. The device of claim **23**, wherein the video decoder is further configured to remove a first decoding unit of the plurality of stored decoding units from the coded picture buffer prior to removal of a second decoding unit of the plurality of stored decoding units from the coded picture buffer, wherein the first decoding unit and the second decoding unit comprise respective subsets of the access unit.

25. The device of claim **20**, wherein the respective signaled information indicative of the buffer removal time further comprises a signaled value indicative of a number of network abstraction layer (NAL) units included in the respective stored decoding unit.

26. The device of claim **20**, wherein the plurality of decoding units comprise a plurality of sub-pictures of a common picture, and wherein the decoder is further configured to receive a respective signaled value indicative of the buffer removal time for each of the sub-pictures of the common picture.

27. The device of claim **20**, wherein the picture buffer is a coded picture buffer (CPB), and wherein the decoder is further configured to receive respective signaled values indicative of one or more of an initial CPB removal delay at an access unit level, an initial CPB removal delay offset at the access unit level, an initial CPB removal delay at a sub-picture level, or an initial CPB removal delay offset at the sub-picture level.

28. The device of claim **20**, wherein the decoder is further configured to obtain the respective signaled information

indicative of the buffer removal time from a picture timing supplemental enhancement information (SEI) message.

29. The device of claim **20**, wherein the decoder is further configured to obtain the respective signaled information indicative of the buffer removal time from a supplemental enhancement information (SEI) message.

30. The device of claim **20**, wherein, the video decoder is further configured to remove at least one stored decoding unit of the plurality of stored decoding units from the picture buffer after a respective obtained buffer removal time for the at least one stored decoding unit has passed since the at least one stored decoding unit was stored in the picture buffer.

31. The device of claim **20**, wherein each of the plurality of stored decoding units comprises one or more respective sub-pictures.

32. The device of claim **31**, wherein the video decoder is further configured to receive a signaled value indicative of a byte alignment of at least one sub-picture of the one or more respective sub-pictures within a larger set of the video data, the larger set of the video data comprising the at least one sub-picture.

33. The device of claim **32**, wherein video decoder is further configured to receive the larger set of the video data as at least one of an access unit, a subset of an access unit, a picture, a frame, a slice, a wave, or a tile.

34. The device of claim **31**, wherein the video decoder is configured to receive each sub-picture of the one or more sub-pictures corresponding to at least one of one or more sequences of blocks of video data, one or more slices, one or more waves, one or more tiles, or one or more network abstraction layer (NAL) units.

35. The device of claim **20**, wherein, the video decoder is further configured to:

determine, based on the respective decoding unit com-

prising an ordinal first decoding unit of the video data, that the buffer removal time comprises a coded picture buffer removal delay value specified in a buffering period supplemental enhancement information (SEI) message associated with an access unit that comprises the respective decoding unit; and

determine, based on the respective decoding unit not comprising the ordinal first decoding unit of the video data, wherein the respective decoding unit comprises an ordinal i^{th} decoding unit where i>0, that the buffer removal time comprises a decoding unit coded picture buffer removal delay as specified in the picture timing SEI message associated with the access unit that comprises the respective decoding unit.

36. The device of claim **20**, wherein the video decoder is further configured to:

determine, based on the respective decoding unit comprising an ordinal first decoding unit of an access unit of the video data, that a nominal removal time for the decoding unit comprises an initial coded picture buffer removal delay value divided by 90000; and

determine, based on the respective decoding unit not comprising the ordinal first decoding unit of the access unit, wherein the decoding unit comprises an ordinal m^{th} decoding unit where m>0 of the access unit, that a nominal removal time for the decoding unit comprises a nominal removal time of an ordinal first decoding unit of a previous buffering period plus a clock tick times a coded picture buffer removal delay associated with the ordinal m^{th} decoding unit.

37. The device of claim **20**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of coding blocks, and wherein, the

video decoder is further configured to code the different numbers of coding blocks in the at least two stored decoding units.

38. The device of claim **20**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of bits, and wherein, the video decoder is further configured to code the different numbers of bits in the at least two stored decoding units.

39. The device of claim **20**, wherein the device comprises at least one of:

one or more integrated circuits;

one or more microprocessors;

one or more digital signal processors (DSPs);

one or more field programmable gate arrays (FPGAs);

a desktop computer;

a laptop computer;

a tablet computer;

a phone;

a television;

a camera;

a display device;

a digital media player;

a video game console;

a video game device;

a video streaming device; or

a wireless communication device.

40. The device of claim **20**, wherein the picture buffer is a coded picture buffer, and wherein the video decoder is further configured to store one or more decoded pictures in a decoded picture buffer.

41. The device of claim **20**, wherein the picture buffer is a coded picture buffer, and wherein the video decoder is further configured to store coded video data in the coded

picture buffer.

42. The device of claim **20**, wherein the picture buffer is a coded picture buffer, and the device further comprises a stream scheduling unit configured to store coded video data to the coded picture buffer.

43. An apparatus for decoding video data, the apparatus comprising:

means for storing a plurality of decoding units associated with an access unit of video data in a picture buffer, each decoding unit of the plurality being a subset of the access unit, and each decoding unit of the plurality comprising at least one video coding layer (VCL) network abstraction layer (NAL) unit of the access unit and any non-VCL NAL unit that is associated with the at least one VCL NAL unit;

means for obtaining a respective buffer removal time for each stored decoding unit of the plurality of stored decoding units, wherein the means for obtaining the respective buffer removal time for a respective stored decoding unit comprises means for receiving a respective signaled information indicative of the respective buffer removal time for the respective stored decoding unit;

means for removing the plurality of stored decoding units from the picture buffer in accordance with the obtained buffer removal times; and

means for coding the video data corresponding to the plurality of removed decoding units, wherein the means for coding the video data comprises means for decoding the plurality of removed decoding units.

44. The apparatus of claim **43**, wherein the means for storing the plurality of decoding units in the picture buffer

comprises means for storing the plurality of decoding units of the video data in a continuous decoding order in the picture buffer.

45. The apparatus of claim **44**, further comprising means for receiving the plurality of decoding units of the video data in the continuous decoding order prior to storing the received plurality of decoding units in the picture buffer.

46. The apparatus of claim **43**, wherein the picture buffer is a coded picture buffer.

47. The apparatus of claim **46**, further comprising means for removing a first decoding unit of the plurality of stored decoding units from the coded picture buffer prior to removing a second decoding unit of the plurality of stored decoding units from the coded picture buffer, wherein the first decoding unit and the second decoding unit comprise respective subsets of the access unit.

48. The apparatus of claim **43**, wherein the respective signaled information indicative of the buffer removal time further comprises a signaled value indicative of a number of network abstraction layer (NAL) units included in the respective stored decoding unit.

49. The apparatus of claim **43**, wherein the decoding units plurality of comprise a plurality of sub-pictures of a common picture, and wherein the means for receiving the respective signaled value indicative of the respective buffer removal time comprises means for receiving a respective signaled value indicative of the buffer removal time for each of the sub-pictures of the common picture.

50. The apparatus of claim **43**, wherein the picture buffer is a coded picture buffer (CPB), and wherein the means for receiving the respective signaled information indicative of the buffer removal time comprises means for receiving

respective signaled values indicative of one or more of an initial CPB removal delay at an access unit level, an initial CPB removal delay offset at the access unit level, an initial CPB removal delay at a sub-picture level, or an initial CPB removal delay offset at the sub-picture level.

51. The apparatus of claim **43**, wherein the respective signaled information indicative of the buffer removal time is included in a picture timing supplemental enhancement information (SEI) message.

52. The apparatus of claim **43**, wherein the respective signaled information indicative of the buffer removal time is included in a decoding unit timing supplemental enhancement information (SEI) message.

53. The apparatus of claim **43**, wherein the means for removing the plurality of stored decoding units from the picture buffer in accordance with the respective obtained buffer removal times comprises means for removing at least one stored decoding unit of the plurality of stored decoding units from the picture buffer after a respective obtained buffer removal time for the at least one stored decoding unit has passed since the at least one stored decoding unit was stored in the picture buffer.

54. The apparatus of claim **43**, wherein each of the plurality of stored decoding units comprises one or more respective sub-pictures.

55. The apparatus of claim **54**, further comprising means for receiving a signaled value indicative of a byte alignment of at least one sub-picture of the one or more respective sub-pictures within a larger set of the video data, the larger set of the video data comprising the at least one sub-picture.

56. The apparatus of claim **55**, wherein the larger set of the video data comprises at least one of an access unit, a subset of an access unit, a picture, a frame, a slice, a wave, or a tile.

57. The apparatus of claim **54**, wherein each sub-picture of the one or more sub-pictures corresponds to at least one of one or more sequences of blocks of video data, one or more slices, one or more waves, one or more tiles, or one or more network abstraction layer (NAL) units.

58. The apparatus of claim **43**, wherein the means for obtaining the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units comprises one of:

means for determining, based on the respective decoding unit comprising an ordinal first decoding unit of the video data, that the buffer removal time comprises a coded picture buffer removal delay value specified in a buffering period supplemental enhancement information (SEI) message associated with an access unit that comprises the respective decoding unit; or

means for determining, based on the respective decoding unit not comprising the ordinal first decoding unit of the video data, wherein the respective decoding unit comprises an ordinal i^{th} decoding unit where i>0, that the buffer removal time comprises a decoding unit coded picture buffer removal delay [i] as specified in the picture timing SEI message associated with the access unit that comprises the respective decoding unit.

59. The apparatus of claim **43**, wherein the means for obtaining the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units comprises one of:

means for determining, based on the respective decoding unit comprises an ordinal first decoding unit of an access unit of the video data, that a nominal removal time for the decoding unit comprises an initial coded picture buffer removal delay value divided by 90000; and

means for determining, based on the respective decoding unit not comprising the ordinal first decoding unit of the access unit, wherein the decoding unit comprises an ordinal m^{th} decoding unit where m>0 of the access unit, that a nominal removal time for the decoding unit comprises a nominal removal time of an ordinal first decoding unit of a previous buffering period plus a clock tick times a coded picture buffer removal delay associated with the ordinal m^{th} decoding unit.

60. The apparatus of claim **43**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of coding blocks, and wherein the means for coding the video data corresponding to the plurality of removed decoding units comprises means for coding the different numbers of coding blocks in the at least two stored decoding units.

61. The apparatus of claim **43**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of bits, and wherein the means for coding the video data corresponding to the plurality of removed decoding units comprises means for coding the different numbers of bits in the at least two stored decoding units.

62. The apparatus of claim **43**, wherein the apparatus comprises at least one of:

one or more integrated circuits;

one or more microprocessors;

one or more digital signal processors (DSPs);

one or more field programmable gate arrays (FPGAs);

a desktop computer;

a laptop computer;

a tablet computer;

a phone;

a television;
a camera;
a display device;
a digital media player;
a video game console;
a video game device;
a video streaming device; or
a wireless communication device.

63. A computer program product comprising a non-transitory computer-readable storage medium encoded with instructions stored thereon that, when executed, cause one or more processors of a video decoding device to:

store a plurality of decoding units associated with an access unit of video data in a picture buffer, decoding units being subsets of access units, and each decoding unit of the plurality comprising at least one video coding layer (VCL) network abstraction layer (NAL) unit of the access unit and any non-VCL NAL unit that is associated with the at least one VCL NAL unit;

obtain a respective buffer removal time for each stored decoding unit of the plurality of stored decoding units, wherein the instructions that cause the one or more processors to obtain the respective buffer removal time comprise instructions that cause the one or more processors to receive respective signaled information indicative of the respective buffer removal time for the respective stored decoding unit;

remove the plurality of stored decoding units from the picture buffer in accordance with the obtained buffer removal times; and

code the video data corresponding to the plurality of removed decoding units, wherein the instructions that cause the one or more processors to code the video data

instructions that cause the one or more processors to decode the plurality of removed decoding units.

64. The computer program product of claim **63**, wherein the non-transitory computer-readable storage medium further comprises instructions that, when executed, cause the one or more processors to store the plurality of decoding units of the video data in a continuous decoding order in the picture buffer.

65. The computer program product of claim **64**, wherein the non-transitory computer-readable storage medium further comprises instructions that, when executed, cause the one or more processors to receive the plurality of decoding units of the video data in the continuous decoding order prior to storing the received one or more decoding units in the picture buffer.

66. The computer program product of claim **63**, wherein the picture buffer is a coded picture buffer.

67. The computer program product of claim **66**, wherein the non-transitory computer-readable storage medium further comprises instructions that, if executed, cause the one or more processors to remove a first decoding unit of the plurality of stored decoding units from the coded picture buffer prior to removing a second decoding unit of the plurality of stored decoding units from the coded picture buffer, wherein the first decoding unit and the second decoding unit comprise respective subsets of the access unit.

68. The computer program product of claim **63**, wherein the respective signaled information indicative of the buffer removal time comprises a signaled value indicative of a number of network abstraction layer (NAL) units included in the respective stored decoding unit.

69. The computer program product of claim **63**, wherein the plurality of decoding units comprise a plurality of sub-pictures of a common picture, and wherein the instruc-

tions that cause the one or more processors to receive the respective signaled information indicative of the respective buffer removal time comprise instructions that, when executed, cause the one or more processors to receive a respective signaled value indicative of the buffer removal time for each of the sub-pictures of the common picture.

70. The computer program product of claim **63**, wherein the picture buffer is a coded picture buffer (CPB), and wherein the instructions that cause the one or more processors to receive the respective signaled information indicative of the buffer removal time comprise instructions that, plurality of executed, cause the one or more processors to receive respective signaled values indicative of one or more of an initial CPB removal delay at an access unit level, an initial CPB removal delay offset at the access unit level, an initial CPB removal delay at a sub-picture level, or an initial CPB removal delay offset at the sub-picture level.

71. The computer program product of claim **63**, wherein the respective signaled information indicative of the buffer removal time is included in a picture timing supplemental enhancement information (SEI) message.

72. The computer program product of claim **63**, wherein the respective signaled information indicative of the buffer removal time is included in a decoding unit timing supplemental enhancement information (SEI) message.

73. The computer program product of claim **63**, wherein the instructions that cause the one or more processors to remove the plurality of stored decoding units from the picture buffer in accordance with the respective obtained buffer removal times comprise instructions that, when

executed, cause the one or more processors to remove at least one stored decoding unit of the plurality of stored decoding units from the picture buffer after a respective obtained buffer removal time for the at least one stored decoding unit has passed since the at least one stored decoding unit was stored in the picture buffer.

74. The computer program product of claim **63**, wherein each of the plurality of stored decoding units comprises one or more respective sub-pictures.

75. The computer program product of claim **74**, wherein the non-transitory computer-readable storage medium further comprises instructions that, when executed, cause the one or more processors to receive a signaled value indicative of a byte alignment of at least one sub-picture of the one or more respective sub-pictures within a larger set of the video data, the larger set of the video data comprising the at least one sub-picture.

76. The computer program product of claim **75**, wherein the larger set of the video data comprises at least one of an access unit, a subset of an access unit, a picture, a frame, a slice, a wave, or a tile.

77. The computer program product of claim **74**, wherein each sub-picture of the one or more sub-pictures corresponds to at least one of one or more sequences of blocks of video data, one or more slices, one or more waves, one or more tiles, or one or more network abstraction layer (NAL) units.

78. The computer program product of claim **63**, wherein the instructions that cause the one or more processors to obtain the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units

comprise instructions that, when executed, cause the one or more processors to perform one of:

determine, based on the respective decoding unit comprising an ordinal first decoding unit of the video data, that the buffer removal time comprises a coded picture buffer removal delay value specified in a buffering period supplemental enhancement information (SEI) message associated with an access unit that comprises the respective decoding unit; or

determine, based on the respective decoding unit not comprising the ordinal first decoding unit of the video data, wherein the respective decoding unit comprises an ordinal i^{th} decoding unit where i>0, that the buffer removal time comprises a decoding unit coded picture buffer removal delay [i] as specified in the picture timing SEI message associated with the access unit that comprises the respective decoding unit.

79. The computer program product of claim **63**, wherein the instructions that cause the one or more processors to obtain the respective buffer removal time for a respective stored decoding unit of the plurality of stored decoding units comprises comprise instructions that, when executed, cause the one or more processors to perform one of:

determine, based on the respective decoding unit comprising an ordinal first decoding unit of an access unit of the video data, that a nominal removal time for the decoding unit comprises an initial coded picture buffer removal delay value divided by 90000; and

determine, based on the respective decoding unit not comprising the ordinal first decoding unit of the access

unit, wherein the decoding unit comprises an ordinal m^{th} decoding unit where m>0 of the access unit, that a nominal removal time for the decoding unit comprises a nominal removal time of an ordinal first decoding unit of a previous buffering period plus a clock tick times a coded picture buffer removal delay associated with the ordinal m^{th} decoding unit.

80. The computer program product of claim **63**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of coding blocks, and wherein the instructions that cause the one or more processors to code the video data corresponding to the plurality of removed decoding units comprise instructions that, if executed, cause the one or more processors to code the different numbers of coding blocks in the at least two stored decoding units.

81. The computer program product of claim **63**, wherein at least two stored decoding units of the plurality of stored decoding units include different numbers of bits, and wherein the instructions that cause the one or more processors to code the video data corresponding to the plurality of removed decoding units comprise instructions that, if executed, cause the one or more processors to code the different numbers of bits in the at least two stored decoding units.

82. The device of claim **20**, further comprising a display device configured to output at least a portion of the video data.

83. The apparatus of claim **43**, further comprising means for outputting at least a portion of the video data for display.