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APPLICATION NUMBER: ***61/500,903***
FILING DATE: ***June 24, 2011***

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS ***US61/500,903***

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ASUS-1013

Electronic Acknowledgement Receipt

EFS ID:	10383802
Application Number:	61500903
International Application Number:	
Confirmation Number:	9868
Title of Invention:	METHOD FOR REMOVING REDUNDANCY IN MOTION VECTOR PREDICTORS
First Named Inventor/Applicant Name:	Jian-Liang Lin
Customer Number:	24504
Filer:	Daniel R. McClure/Brooke French
Filer Authorized By:	Daniel R. McClure
Attorney Docket Number:	251343-8600
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1	Provisional Cover Sheet (SB16)	01393111.PDF	1060278 4fb77dc146f0c31a02c057f34917699616ece6e3	no	3
Warnings:					
Information:					
2	Specification	01393108.PDF	232537 da20c3735040d8a6945bc436c0c5c02d5e3b4378	no	12
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29873 052ac27759e08fc1af5233d07e6f70e2313a16bc	no	2
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Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

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Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

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All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. [Add]

Title of Invention	METHOD FOR REMOVING REDUNDANCY IN MOTION VECTOR PREDICTORS
Attorney Docket Number (if applicable)	251343-8600

Correspondence Address

Direct all correspondence to (select one):

(●) The address corresponding to Customer Number	( ) Firm or Individual Name
Customer Number	24504

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

(●) No.

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Document Description: Provisional Cover Sheet (SB16)

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Entity Status

Applicant claims small entity status under 37 CFR 1.27

○ Yes, applicant qualifies for small entity status under 37 CFR 1.27

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Signature	/Daniel R. McClure/			Date (YYYY-MM-DD)	2011-06-24
First Name	Daniel	Last Name	McClure	Registration Number (If appropriate)	38962

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Title: Method for removing redundancy in motion vector predictors

Authors: Jian-Liang Lin, Yi-Wen Chen, Yu-Wen Huang, and Shaw-Min Lei

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Related Arts

High-Efficiency Video Coding (HEVC) is a new international video coding standard that is being developed by the Joint Collaborative Team on Video Coding (JCT-VC). HEVC is based on the hybrid block-based motion-compensated DCT-like transform coding architecture. The basic unit for compression, termed coding unit (CU), is a 2Nx2N square block, and each CU can be recursively split into four smaller CUs until the predefined minimum size is reached. Each CU contains one or multiple prediction units (PUs). The PU sizes can be 2Nx2N, 2NxN, Nx2N, and NxN.

To increase the coding efficiency of motion vector coding in HEVC, the motion vector competition (MVC) based scheme is applied to select one motion vector predictor (MVP) among a given candidate set of MVPs which includes spatial and temporal MVPs. There are three inter-prediction modes including Inter, Skip, and Merge in the HEVC test model version 3.0 (HM-3.0). The Inter mode performs motion-compensated prediction with transmitted motion vector differences (MVDs) that can be used together with MVPs for deriving motion vectors (MVs), while the Skip and Merge modes utilize motion inference methods (MV=MVP+MVD where MVD is zero) to obtain the motion information from spatially neighboring blocks (spatial candidates) or a temporal block (temporal candidate) located in a co-located picture where the co-located picture is the first reference picture in list 0 or list 1, which is signalled in the slice header. When a PU is coded in either Skip or Merge mode, no motion information is transmitted except the index of the selected candidate. In the case of a Skip PU, the residual signal is also omitted. For the Inter modes in HM-3.0, the advanced motion vector prediction (AMVP) scheme is used to select a motion vector predictor among an AMVP candidate set including two spatial MVPs and one temporal MVP. As for the Merge and Merge-Skip mode in HM-3.0, the Merge scheme is used to select a motion vector predictor among a Merge candidate set containing four spatial MVPs and one temporal MVP.

For the Inter mode, the reference picture index is explicitly transmitted to the decoder. The MVP is then selected among the candidate set for a given reference picture index. As shown in Figure 1, the MVP candidate set for the Inter mode in

HM-3.0 includes two spatial MVPs and one temporal MVP:

1. Left predictor (the first available one from A_0, A_1)
2. Top predictor (the first available one from B_0, B_1, B_{n+1})
3. Temporal predictor (the first available one from T_{BR} and T_{CTR})

A temporal predictor is derived from a block (T_{BR} or T_{CTR}) located in a co-located picture where the co-located picture is the first reference picture in list 0 or list 1. Since the block where a temporal MVP is located may have two MVs, one MV from list 0 and one MV from list 1, the temporal MVP is derived from the MV from list 0 or list 1 according to the following rule:

1. The MV that crosses the current picture is chosen first.

2. If both MVs cross the current picture or both do not cross, the one with same reference list as the current list will be chosen.

In HM-3.0, if a particular block is encoded as Merge, an MVP index is signaled to indicate which MVP among the MVP candidate set is used for this block to be merged. To follow the essence of motion information sharing, each merged PU reuses the MV, prediction direction, and reference picture index of the selected candidate. It is noted that if the selected MVP is a temporal MVP, the reference picture index is always set to the first reference picture. As shown in Figure 2, the candidate set of MVPs includes four spatial MVPs and one temporal MVP:

1. Left predictor (A_m)
2. Top predictor (B_n)
3. Temporal predictor (the first available one from T_{BR} and T_{CTR})
4. Above right predictor (B_0)
5. Below left predictor (A_0)

In HM-3.0, a process is utilized in both Inter and Merge modes to avoid an empty candidate set. With this process, a candidate with zero MV is added to the candidate set when no candidate can be inferred in Inter or Merge mode.

Based on the rate-distortion optimization (RDO) decision, the encoder selects one final MVP within a given candidate set of MVPs for Inter, Skip, or Merge modes and transmits the index of the selected MVP to the decoder after removing the redundant candidates. However, because the temporal motion predictor is included in the candidate sets of motion vector predictors (MVPs) to improve the coding efficiency; it can cause parsing errors and thus severe error propagation. When a motion vector (MV) of a previous picture cannot be decoded correctly, a mismatch between the candidate set on the encoder side and that on the decoder side may occur, resulting in parsing error of the index of the best MVP candidate. Then, the rest of the current picture cannot be parsed or decoded properly. What is even worse, this parsing error can affect subsequent inter pictures that also allow temporal MVP candidates. One small decoding error of an MV may cause failure of parsing many subsequent pictures.

In order to compress the memory of storing the data of MVs in a coded picture for using temporal MVPs, a tool of memory compression, motion data storage reduction (MDSR), was adopted in HEVC. In this method, MV data of one block in an MDSR unit will be used as the representative MV data for the entire MDSR unit, and all the MV data of other blocks in the MDSR will be discarded.

Proposed Methods

In this invention, we propose a scheme to remove the redundant MVPs in the MVP candidate set for AMVP and Merge modes without using the values of motion vectors. Different types of redundancy removing methods without using the values of motion vectors are shown as follows.

1. <u>Removing redundant MVPs within the same PU</u>

   If more than one MVPs in the MVP candidates set for AMVP and Merge modes are located within in the same PU, those MVPs will be identical; and therefore, the redundant MVPs can be removed without comparing their MVs. An example of Merge mode is shown in Figure 3. Since MVP B and MVP C are both located within the same PU, MVP C is redundant and shall be removed.

2. <u>Removing redundant MVPs caused by MDSR</u>

   A temporal predictor is derived from a block located in a co-located picture and the MV is scaled according POCs. As shown in Figure 4, if H' and H are within the same MDSR unit and have the same scaling factor and are derived from the MV of the same reference picture list, and if the neighboring PU (Figure 4 uses the above PU as example) is merged with the temporal MVP H' or selects the temporal MVP H' with zero MVD, the MVP B and MVP H will be identical, and therefore one of them can be removed.

3. <u>Removing redundant MVPs caused by Merge</u>

   If multiple MVPs are located in different PUs and the PUs are merged together, those MVPs will be identical and the redundancy can be removed. Figure 5 shows an example which assumes the PUs in green color are merged together. Since MVP A and MVP C are identical, MVP C can be removed.

4. Removing redundant MVPs caused by Inter mode with zero MVD

If multiple MVPs are located in different PUs and some MVPs are predicted by the other MVPs with zero MVDs in Inter mode, those MVPs will be identical and the redundancy can be removed. Figure 6 shows an example which assumes the PU of MVP A is coded as Inter mode using MVP B without scaling and with zero MVD. For the current PU, since MVP A and MVP B are identical, MVP B can be removed.

5. Removing redundant MVPs to avoid imitation in Merge mode

For the second PU of 2NxN or Nx2N Merge mode, those MVPs which will make this 2NxN or Nx2N PU Merge as a 2Nx2N PU Merge can be removed without comparing the values of MVs. As shown in the Figure 7, the MVP B of the 2nd 2NxN merge mode and the MVP A of the 2nd Nx2N merge mode can be removed to avoid the imitation.

For the fourth PU in NxN Merge mode, those MVPs which will make this NxN Merge as one of 2Nx2N, 2NxN or Nx2N PU Merge can also be removed without comparing the values of MVs. Figure 8 shows the examples of avoid the imitation of NxN Merge mode. As shown in figure 8(a), if PU1 and PU3 are merged, the MVP B of PU4 can be removed to avoid the imitation of Nx2N merge. As shown in figure 8(b), if PU1 and PU2 are merged, the MVP A of PU4 can be removed to avoid the imitation of 2NxN Merge. As shown in figure 8(c), if PU1, PU2 and PU3 are merged, the MVP A and B can be removed to avoid the imitation of 2Nx2N Merge.

6. Removing redundant MVPs caused by combination of different types of redundancy

The redundancy may be created by the interaction. An example is shown in Figure 9, assuming H' and H are within the same MDSR unit and have same scaling factor, and the 1st 2NxN PU is merged with H'. In order to avoid the imitation of 2Nx2N Merge, the MVP B for the 2nd PU can be removed. However, because H is identical to B (H and H' are identical, and the 1st PU (B) is merged with H'), H can also be removed.

7. Removing redundant MVPs using motion ID

The motion ID is proposed to describe the inheritance process of motion information passed from a coded PU to the current PU to follow the trail of the MV. A unique motion ID is assigned for each new MV which is created in the

Inter mode (new MV = MVP+MVD) or the Merge mode which is merged with a new temporal MVP. However, if two PUs are both merged with temporal MVPs which are derived from the co-located blocks within the same MDSR unit and based on the same target reference picture and same picture reference list, the same motion ID will be assigned for the two PUs. As depicted in Figure 10, if both above and current PUs are merged with their temporal MVPs H and H' which are derived from the co-located blocks within the same MDSR unit, an identical motion ID will be assigned for these two PUs. In addition, a unique motion ID is also assigned for the MVs which are merged with or predicted (with zero MVD) by the candidates with zero MVs created by the process of avoiding empty candidate set in HEVC.

The motion ID can be inherited in the Merge, Merge-Skip mode and Inter modes. In Merge mode, an MVP index is signaled to indicate which MVP among the MVP candidate set is used for this block to be merged. To follow the essence of motion information sharing, each merged PU reuses the MV, prediction direction, and reference picture index of the selected candidate. As shown in the left part of Figure 11, the merged PU will also inherit the motion ID(s) of the selected candidate. As shown in the right part of Figure 11, the motion ID can also be inherited by the Inter mode, when the MVD equals to zeros and the derived MVP is exactly the same as that of the neighboring block (without scaling). By comparing the motion ID, the MVP which has an identical motion ID with a previous MVP in the candidate set can thus be removed.

8. <u>Removing redundant MVPs to avoid imitation in Merge mode using motion ID</u>

For the second PU of 2NxN or Nx2N Merge mode, those MVPs whose motion ID is identical to that of the first PU can be removed without comparing the values of MVs.

For the fourth PU in NxN Merge mode, those MVPs which will make this NxN Merge as one of 2Nx2N, 2NxN or Nx2N PU Merge can also be removed using motion ID. Figure 8 shows the examples of avoid the imitation of NxN Merge mode. As shown in figure 8(a), if PU1 and PU3 have the same motion ID, the MVPs whose motion IDs are identical to that of PU2 can be removed to avoid the imitation of Nx2N Merge. As shown in figure 8(b), if PU1 and PU2 have the same motion ID, the MVPs whose motion IDs are identical to that of PU3 can be removed to avoid the imitation of 2NxN Merge. As shown in figure 8(c), if PU1, PU2 and PU3 have the same motion ID, the MVPs whose motion IDs are identical to that of PU1, PU2 and PU3 can be removed to avoid the imitation of 2Nx2NMerge.

Summary

1. A method of the removing redundant MVPs in the MVP candidate set without using the values of MVs.
2. In item 1, the MVPs within the same PU are identical, and the redundant MVP(s) is removed.
3. In item 1, the MVPs within the same MDSR unit have the same scaling factor and are derived from the MV of same reference picture list are identical; and the redundant MVP(s) is removed.
4. In item 1, the MVPs within the same MDSR unit are considered as identical whatever the scaling factor and the reference picture list are; and the redundant MVP(s) is removed.
5. In item 1, the MVPs within the same MDSR unit and have same scaling factor are considered as identical whatever the reference picture list is; and the redundant MVP(s) is removed.
6. In item 1, if multiple MVPs are located in different PUs and merged together, those MVP are identical, and the redundant MVP(s) is removed.
7. For the second PU of 2NxN or Nx2N Merge mode, those MVPs which will make this 2NxN or Nx2N Merge as a 2Nx2N PU Merge mode can be removed without comparing the values of MVs.
8. For the fourth PU in NxN Merge mode, those MVPs which will make this NxN Merge as one of 2Nx2N, 2NxN or Nx2N Merge mode can be removed without comparing the values of MVs.
9. The redundant MVPs caused by the combination of different types of redundancy listed in item 2~8 are removed.
10. A motion ID is used to follow the trail of the MV
11. In item 10, the redundant MVP which has an identical motion ID to previous MVP in the candidate set can be removed.
12. In item 10, a unique motion ID is assigned for each new MV which is created in Inter mode.
13. In item 10, a unique motion ID is assigned for each new MV which is created in Merge mode merged with a new temporal MVP.
14. In item 13, an identical motion ID is assigned for the MVs which are merged with the temporal MVPs from the same MDSR units using the same scaling factors.
15. In item 10, a unique motion ID is assigned for the MVs which are merged with the candidate of zero MV created by the process of avoiding empty candidate set in

Merge mode. In Inter mode, if MVD is zero, this unique motion ID is also assigned for the MVs which are predicted by the candidate of zero MV created by the process of avoiding empty candidate set.

16. In item 10, the motion ID is inherited by the Merge and Merge-Skip modes.
17. In item 10, the motion ID is inherited by the Merge and Merge-Skip modes which are merged with the spatial candidates.
18. In item 10, the motion ID is inherited by a Inter mode with zero MVD and its derived MVP is exactly the same as the MV of that neighboring block (without scaling)
19. For the second PU of 2NxN or Nx2N Merge mode, those MVPs whose motion ID are identical to that of first PU can be removed to avoid imitating a 2Nx2N PU Merge.
20. For the fourth PU in NxN Merge mode as depicted in Figure 12, those MVPs which will make this NxN Merge as one of 2Nx2N, 2NxN or Nx2N Merge can be removed using motion IDs. If PU1 and PU3 have the same motion ID, the MVPs whose motion IDs are identical to that of PU2 can be removed to avoid the imitation of Nx2N Merge. If PU1 and PU2 have the same motion ID, the MVPs whose motion IDs are identical to that of PU3 can be removed to avoid the imitation of 2NxN Merge. If PU1, PU2 and PU3 have the same motion ID, the MVPs whose motion IDs are identical to that of PU1, PU2 and PU3 can be removed to avoid the imitation of 2Nx2N Merge.
21. In item 1, a flag is encoded in the sequence, picture or slice header to indicate whether that method is enabled.
22. In item 11, a flag is encoded in the sequence, picture or slice header to indicate whether that method is enabled.

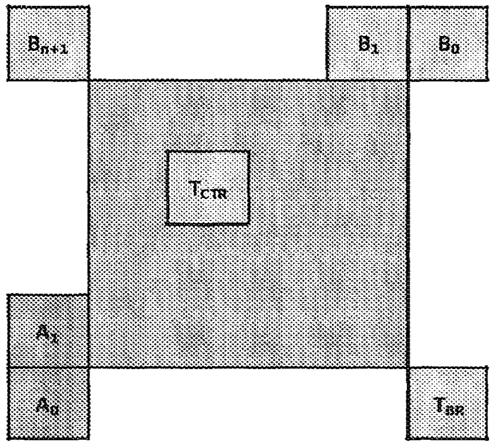

Figure 1 . The MVP candidate set for Inter in HM-3.0.

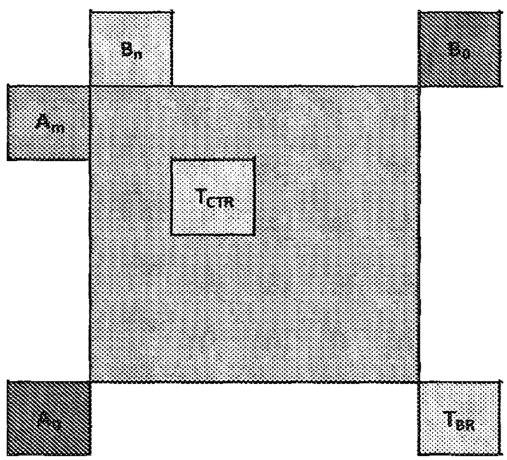

Figure 2. The MVP candidate set for Merge in HM-3.0.

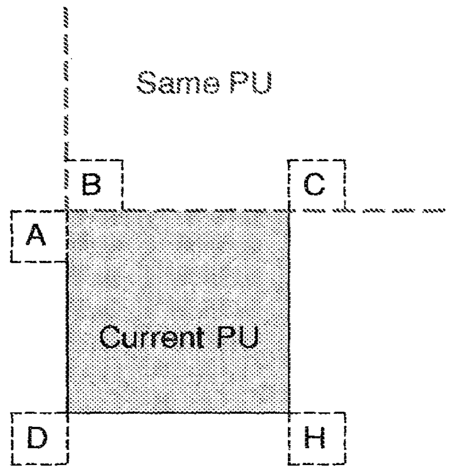

Figure 3. An example of removing redundant MVPs within the same PU.

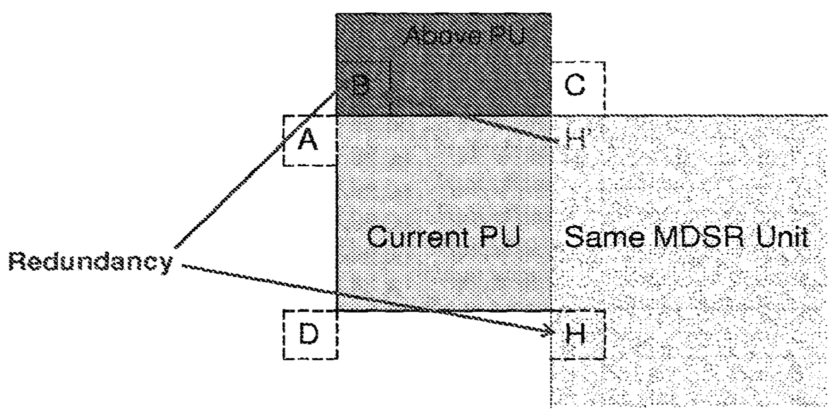

Figure 4. An example of removing redundant MVPs caused by MDSR.

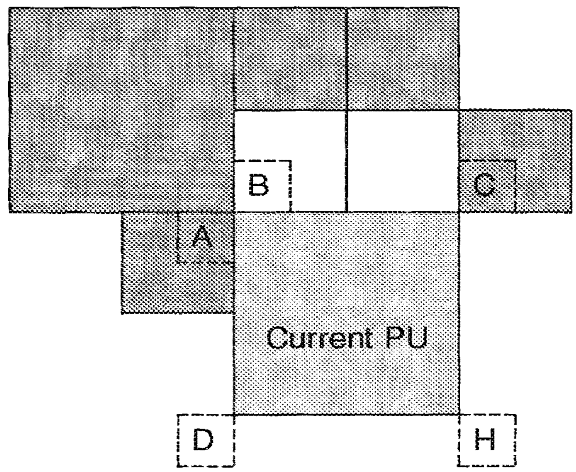

Figure 5. An example of removing redundant MVPs caused by Merge.

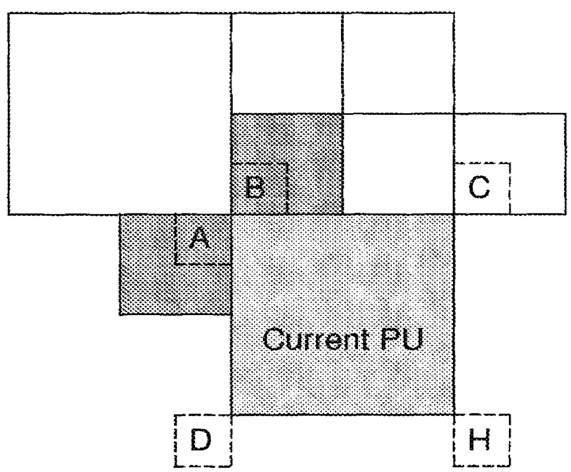

Figure 6. An example of removing redundant MVPs caused by Inter mode with zero MVD

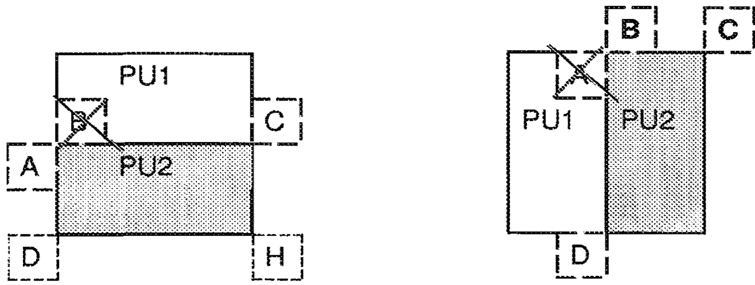

Figure 7. An example of removing redundant MVPs in 2NxN and Nx2N Merge mode to avoid imitation.

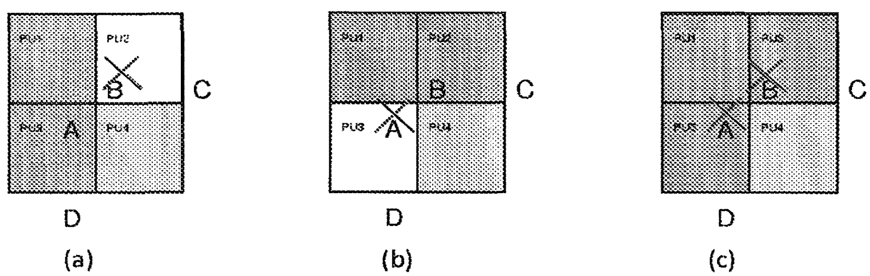

Figure 8. An example of removing redundant MVPs in NxN Merge mode to avoid imitation.

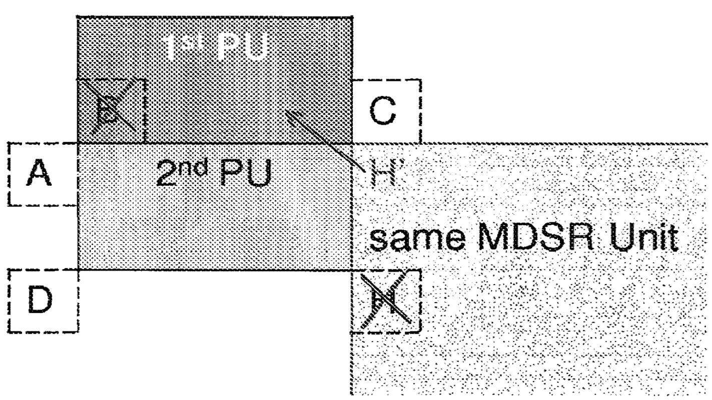

Figure 9. An example of removing redundant MVPs caused by combination of different types of redundancy.

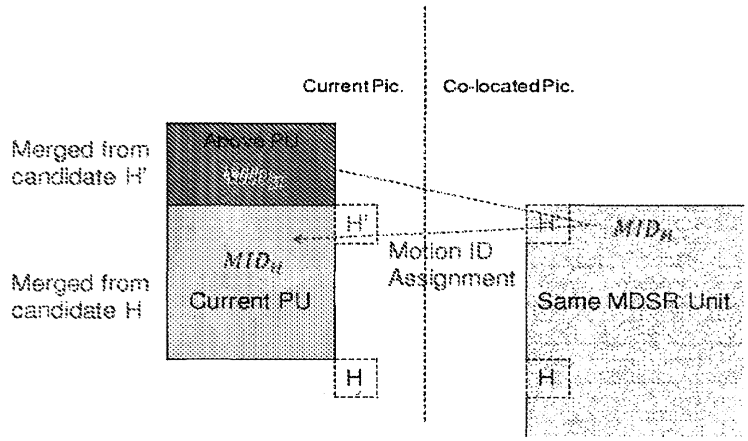

Figure 10. An example of motion ID assignment by temporal merging.

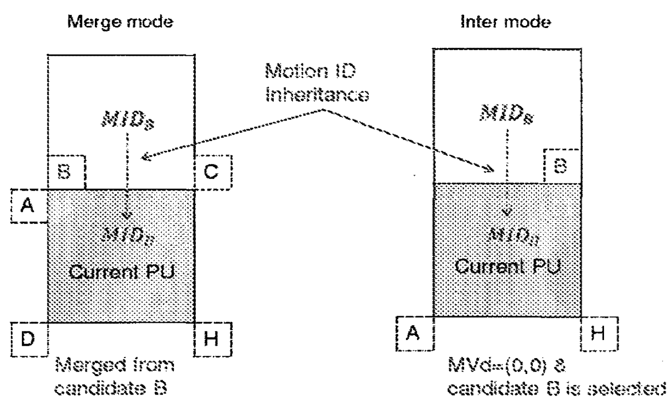

Figure 11. An example of motion ID inheritance through motion sharing.

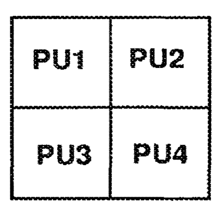

Figure 12. An example of an NxN CU.

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