Figure 1. Four types of macroblocks in one frame, 1 stands for inter macroblock, 2 stands for intra macroblock, 3 stands for inter macroblock with redundant version and 4 stands for intra macroblock with redundant version. The redundant version macroblocks are encapsulated in the redundant picture.

this is implemented by setting a relative larger Quantization Parameter (QP) for redundant version macroblock. Like the selection of the coding type for each macroblock, the selection of the appropriate QP value for redundant macroblock is also optimized in the end-to-end RD optimization process. Fig.2 shows the QP value for redundant frame in the Foreman CIF sequence, where the QP of primary macroblock is 22. In order to present all information in one figure, we use positive number for inter macroblock and negative number for intra macroblock. The valid QP range is (1-51) in H.264/AVC, so we use 60 to denote inter macroblock without redundant version and −60 to denote intra macroblock without redundant version. For example, if a macroblock in Fig.2 has a value −34, this means it is an intra macroblock with QP 34; whereas for a macroblock with value 34, it is an inter macroblock with QP 34. It can be seen that most of the background areas are encoded with inter coding without redundant version, because these areas are relatively static, and with the temporal replacement concealment algorithm losing these areas will not lead to huge distortion. On the contrary, the parts of foreground, which is the foreman face area in this frame, are strongly protected with intra coding and/or redundant coding. Note both the macroblock type and QP value is optimized in the RD optimization process, which is presented in the next section.

A. The HRMIR Rate-distortion Optimization

As in the other encoding approaches, in the HRMIR rate-distortion optimization process, the encoder selects the coding option $O^*$ for current macroblock, so that the Lagrangian cost functional