3GPP TSG RAN WG1 #50 R1-073793
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Agenda Item: 7.3

Source: Broadcom

Title: Utilization of the redundancy version (RV) parameter for HARQ

Document for: Decision

The benefit of using circular buffer rate matching (CBRM) given in TS 36.212 is that the re-transmission can start at the point following the end point of the previous transmission. In general, the CRBM has orthogonal property. This property is critical when the incremental redundancy method for HARQ is used. However, as shown in Table 2 of this document, the starting point decided by RV with the formula $k_0=R\times(24\times RV+\sigma)$ in TS36.212 (where R is the number of rows of the matrix used to define the sub-interleave and σ is the skip index) and the starting point decided by CBRM are not matching, at least for rate 0.8, 0.7, 0.6 and 0.5 and with all possible QPP interleave sizes.

For example, consider an interleave size of 1024. Then R=33 and σ =2 as in TS36.212. Assume that for the initial transmission, RV=0 is used and the starting point is therefore k_0=66. Then, for rate = 0.5, 2048 bits are sent during the initial transmission and 56 dummy bits are de-padded, so the starting point for the 1st re-transmission should be 2170, according to CBRM. However, the formula in TS36.212 indicates the starting point k_0=858 for RV=1, k_0=1650 for RV=2, and k_0=2442 for RV=3, respectively. So, with the formula given TS36.212 there is no possible value for RV that would implement CBRM.

Meanwhile, one may suggest using a non-zero RV index for initial transmission. For this we simulated RV=1 for all interleave sizes and for the rate 0.5, 0.6, 0.7 and 0.8. We found that with rate 0.8, 0.7 and 0.6, using RV=1 the decoder almost cannot correct anything. The only rate works for RV=1 is 0.5. However, the corresponding performance is at least 0.5 dB worse than that of using RV=0, see Fig. 3.

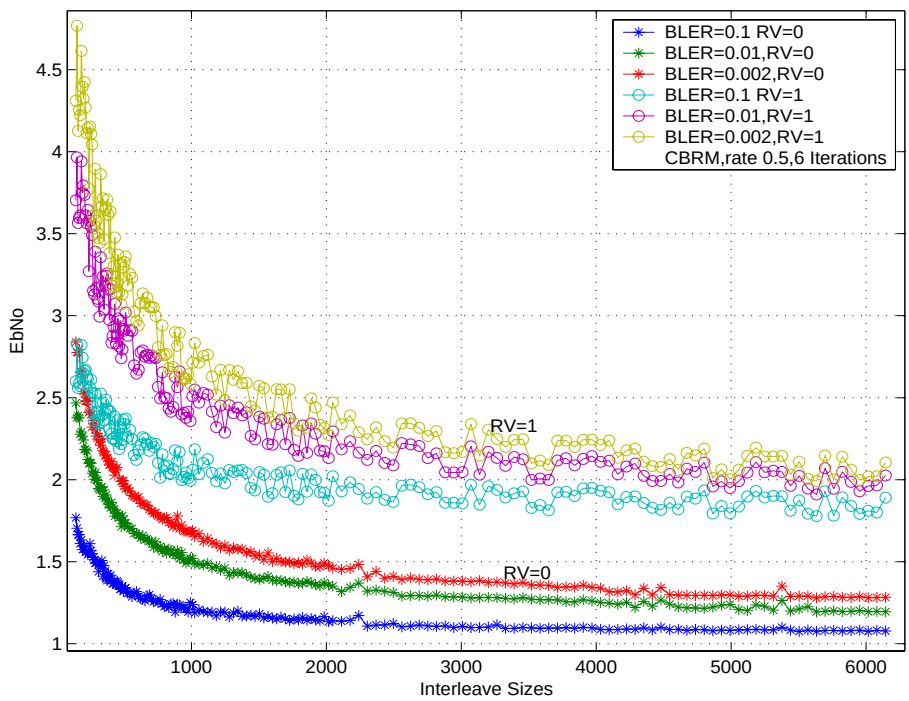

Figure 3 Initial transmissions with different RV values

Therefore, we propose the following change:

Modification Define RV as the index of re-transmission, i.e. RV=0 as the initial transmission, RV=1 as the first re-transmission, RV=2 as the second re-transmission, etc. Moreover, calculating starting point as follows:

Using the notation in TS36.212, we have K_{rm} denotes the rate matching output sequence length; K_z denotes the circular buffer size, and R is the number of rows of the matrix used to define the sub-interleave and σ is the skip index. Then, the pseudo code in 5.1.4.2.3 shall be modified as follows

```
set k0 = R×σ
set j=0
set w=0
while (w < RV_max)
        set i = 0
        while { i < Krm }
                if z(k0+j)%Kz ≠< NULL >
                        z'i = z(k0+j)%Kz
                        i = i +1
                        j = j +1
                else
                        j = j +1
                end if
        end while
        w := w+l
        kw=(k0+j) % Kz
end while
```

Thus we have

Table 1

RV	**0**	**1**	**2**	**3**
Starting point	k_0	k_1	k_2	k_3

Table 2 starting point comparison

Size		**Starting point defined in TS36.212**				**Starting point of the 1st re-transmission**			
Info.	**Codeword (mother)**	**RV=0**	**RV=1**	**RV=2**	**RV=3**	**rate=0.5**	**rate=0.6**	**rate=0.7**	**rate=0.8**
40	120	4	52	100	148	120	103	87	78
48	144	4	52	100	148	123	103	90	79
56	168	4	52	100	148	123	104	89	79
64	192	6	78	150	222	188	159	137	120
72	216	6	78	150	222	188	160	137	120
80	240	6	78	150	222	189	160	137	123
88	264	6	78	150	222	189	160	137	121
96	288	8	104	200	296	254	214	185	164
104	312	8	104	200	296	254	215	185	164
112	336	8	104	200	296	255	216	185	165
120	360	8	104	200	296	255	215	184	163
128	384	10	130	250	370	320	269	233	206
136	408	10	130	250	370	320	271	232	206
144	432	10	130	250	370	323	271	233	207
152	456	10	130	250	370	323	270	232	205
160	480	12	156	300	444	388	327	281	248

168	504	12	156	300	444	388	326	280	248
176	528	12	156	300	444	389	326	280	249
184	552	12	156	300	444	389	326	280	247
192	576	14	182	350	518	454	382	328	290
200	600	14	182	350	518	454	381	328	290
208	624	14	182	350	518	455	382	328	291
216	648	14	182	350	518	455	381	328	289
224	672	16	208	400	592	520	437	376	332
232	696	16	208	400	592	520	437	375	332
240	720	16	208	400	592	521	437	376	333
248	744	16	208	400	592	521	436	375	331
256	768	18	234	450	666	586	493	424	374
264	792	18	234	450	666	586	492	423	374
272	816	18	234	450	666	587	492	424	375
280	840	18	234	450	666	587	492	423	373
288	864	20	260	500	740	652	548	471	416
296	888	20	260	500	740	652	547	471	416
304	912	20	260	500	740	653	548	471	417
312	936	20	260	500	740	653	547	471	415
320	960	22	286	550	814	718	603	519	458
328	984	22	286	550	814	718	603	519	458
336	1008	22	286	550	814	719	603	519	459
344	1032	22	286	550	814	719	602	518	457
352	1056	24	312	600	888	784	659	567	500
360	1080	24	312	600	888	784	658	566	500
368	1104	24	312	600	888	785	658	567	501
376	1128	24	312	600	888	785	658	566	499
384	1152	26	338	650	962	850	714	615	542
392	1176	26	338	650	962	850	713	614	542
400	1200	26	338	650	962	851	714	614	543
408	1224	26	338	650	962	851	713	614	541
416	1248	28	364	700	1036	916	769	662	584
424	1272	28	364	700	1036	916	769	662	584
432	1296	28	364	700	1036	917	769	662	585
440	1320	28	364	700	1036	917	768	662	583
448	1344	30	390	750	1110	982	825	710	626
456	1368	30	390	750	1110	982	824	709	626
464	1392	30	390	750	1110	983	824	710	627
472	1416	30	390	750	1110	983	824	709	625
480	1440	32	416	800	1184	1048	880	758	668
488	1464	32	416	800	1184	1048	879	757	668
496	1488	32	416	800	1184	1049	880	758	669
504	1512	32	416	800	1184	1049	879	757	667
512	1536	34	442	850	1258	1114	935	805	710
528	1584	34	442	850	1258	1115	935	805	711
544	1632	36	468	900	1332	1180	991	853	752
560	1680	36	468	900	1332	1181	990	853	753
576	1728	38	494	950	1406	1246	1046	901	794
592	1776	38	494	950	1406	1247	1046	901	795
608	1824	40	520	1000	1480	1312	1101	949	836
624	1872	40	520	1000	1480	1313	1101	948	837
640	1920	42	546	1050	1554	1378	1157	996	878
656	1968	42	546	1050	1554	1379	1156	996	879
672	2016	44	572	1100	1628	1444	1212	1044	920
688	2064	44	572	1100	1628	1445	1212	1044	921
704	2112	46	598	1150	1702	1510	1267	1092	962
720	2160	46	598	1150	1702	1511	1267	1092	963
736	2208	48	624	1200	1776	1576	1323	1139	1004

752	2256	48	624	1200	1776	1577	1322	1139	1005
768	2304	50	650	1250	1850	1642	1378	1187	1046
784	2352	50	650	1250	1850	1643	1378	1187	1047
800	2400	52	676	1300	1924	1708	1433	1235	1088
816	2448	52	676	1300	1924	1709	1433	1235	1089
832	2496	54	702	1350	1998	1774	1489	1283	1130
848	2544	54	702	1350	1998	1775	1488	1282	1131
864	2592	56	728	1400	2072	1840	1544	1330	1172
880	2640	56	728	1400	2072	1841	1544	1330	1173
896	2688	58	754	1450	2146	1906	1599	1378	1214
912	2736	58	754	1450	2146	1907	1599	1378	1215
928	2784	60	780	1500	2220	1972	1655	1426	1256
944	2832	60	780	1500	2220	1973	1654	1426	1257
960	2880	62	806	1550	2294	2038	1710	1473	1298
976	2928	62	806	1550	2294	2039	1710	1473	1299
992	2976	64	832	1600	2368	2104	1765	1521	1340
1008	3024	64	832	1600	2368	2105	1765	1521	1341
1024	3072	66	858	1650	2442	2170	1821	1569	1382
1056	3168	68	884	1700	2516	2236	1876	1617	1424
1088	3264	70	910	1750	2590	2302	1931	1664	1466
1120	3360	72	936	1800	2664	2368	1987	1712	1508
1152	3456	74	962	1850	2738	2434	2042	1760	1550
1184	3552	76	988	1900	2812	2500	2097	1807	1592
1216	3648	78	1014	1950	2886	2566	2153	1855	1634
1248	3744	80	1040	2000	2960	2632	2208	1903	1676
1280	3840	82	1066	2050	3034	2698	2263	1951	1718
1312	3936	84	1092	2100	3108	2764	2319	1998	1760
1344	4032	86	1118	2150	3182	2830	2374	2046	1802
1376	4128	88	1144	2200	3256	2896	2429	2094	1844
1408	4224	90	1170	2250	3330	2962	2485	2141	1886
1440	4320	92	1196	2300	3404	3028	2540	2189	1928
1472	4416	94	1222	2350	3478	3094	2595	2237	1970
1504	4512	96	1248	2400	3552	3160	2651	2285	2012
1536	4608	98	1274	2450	3626	3226	2706	2332	2054
1568	4704	100	1300	2500	3700	3292	2761	2380	2096
1600	4800	102	1326	2550	3774	3358	2817	2428	2138
1632	4896	104	1352	2600	3848	3424	2872	2475	2180
1664	4992	106	1378	2650	3922	3490	2927	2523	2222
1696	5088	108	1404	2700	3996	3556	2983	2571	2264
1728	5184	110	1430	2750	4070	3622	3038	2619	2306
1760	5280	112	1456	2800	4144	3688	3093	2666	2348
1792	5376	114	1482	2850	4218	3754	3149	2714	2390
1824	5472	116	1508	2900	4292	3820	3204	2762	2432
1856	5568	118	1534	2950	4366	3886	3259	2809	2474
1888	5664	120	1560	3000	4440	3952	3315	2857	2516
1920	5760	122	1586	3050	4514	4018	3370	2905	2558
1952	5856	124	1612	3100	4588	4084	3425	2953	2600
1984	5952	126	1638	3150	4662	4150	3481	3000	2642
2016	6048	128	1664	3200	4736	4216	3536	3048	2684
2048	6144	130	1690	3250	4810	4282	3591	3096	2726
2112	6336	134	1742	3350	4958	4414	3702	3191	2810
2176	6528	138	1794	3450	5106	4546	3813	3287	2894
2240	6720	142	1846	3550	5254	4678	3923	3382	2978
2304	6912	146	1898	3650	5402	4810	4034	3477	3062
2368	7104	150	1950	3750	5550	4942	4145	3573	3146
2432	7296	154	2002	3850	5698	5074	4255	3668	3230
2496	7488	158	2054	3950	5846	5206	4366	3764	3314
2560	7680	162	2106	4050	5994	5338	4477	3859	3398

2624	7872	166	2158	4150	6142	5470	4587	3955	3482
2688	8064	170	2210	4250	6290	5602	4698	4050	3566
2752	8256	174	2262	4350	6438	5734	4809	4145	3650
2816	8448	178	2314	4450	6586	5866	4919	4241	3734
2880	8640	182	2366	4550	6734	5998	5030	4336	3818
2944	8832	186	2418	4650	6882	6130	5141	4432	3902
3008	9024	190	2470	4750	7030	6262	5251	4527	3986
3072	9216	194	2522	4850	7178	6394	5362	4623	4070
3136	9408	198	2574	4950	7326	6526	5473	4718	4154
3200	9600	202	2626	5050	7474	6658	5583	4813	4238
3264	9792	206	2678	5150	7622	6790	5694	4909	4322
3328	9984	210	2730	5250	7770	6922	5805	5004	4406
3392	10176	214	2782	5350	7918	7054	5915	5100	4490
3456	10368	218	2834	5450	8066	7186	6026	5195	4574
3520	10560	222	2886	5550	8214	7318	6137	5291	4658
3584	10752	226	2938	5650	8362	7450	6247	5386	4742
3648	10944	230	2990	5750	8510	7582	6358	5481	4826
3712	11136	234	3042	5850	8658	7714	6469	5577	4910
3776	11328	238	3094	5950	8806	7846	6579	5672	4994
3840	11520	242	3146	6050	8954	7978	6690	5768	5078
3904	11712	246	3198	6150	9102	8110	6801	5863	5162
3968	11904	250	3250	6250	9250	8242	6911	5959	5246
4032	12096	254	3302	6350	9398	8374	7022	6054	5330
4096	12288	258	3354	6450	9546	8506	7133	6149	5414
4160	12480	262	3406	6550	9694	8638	7243	6245	5498
4224	12672	266	3458	6650	9842	8770	7354	6340	5582
4288	12864	270	3510	6750	9990	8902	7465	6436	5666
4352	13056	274	3562	6850	10138	9034	7575	6531	5750
4416	13248	278	3614	6950	10286	9166	7686	6627	5834
4480	13440	282	3666	7050	10434	9298	7797	6722	5918
4544	13632	286	3718	7150	10582	9430	7907	6817	6002
4608	13824	290	3770	7250	10730	9562	8018	6913	6086
4672	14016	294	3822	7350	10878	9694	8129	7008	6170
4736	14208	298	3874	7450	11026	9826	8239	7104	6254
4800	14400	302	3926	7550	11174	9958	8350	7199	6338
4864	14592	306	3978	7650	11322	10090	8461	7295	6422
4928	14784	310	4030	7750	11470	10222	8571	7390	6506
4992	14976	314	4082	7850	11618	10354	8682	7485	6590
5056	15168	318	4134	7950	11766	10486	8793	7581	6674
5120	15360	322	4186	8050	11914	10618	8903	7676	6758
5184	15552	326	4238	8150	12062	10750	9014	7772	6842
5248	15744	330	4290	8250	12210	10882	9125	7867	6926
5312	15936	334	4342	8350	12358	11014	9235	7963	7010
5376	16128	338	4394	8450	12506	11146	9346	8058	7094
5440	16320	342	4446	8550	12654	11278	9457	8153	7178
5504	16512	346	4498	8650	12802	11410	9567	8249	7262
5568	16704	350	4550	8750	12950	11542	9678	8344	7346
5632	16896	354	4602	8850	13098	11674	9789	8440	7430
5696	17088	358	4654	8950	13246	11806	9899	8535	7514
5760	17280	362	4706	9050	13394	11938	10010	8631	7598
5824	17472	366	4758	9150	13542	12070	10121	8726	7682
5888	17664	370	4810	9250	13690	12202	10231	8821	7766
5952	17856	374	4862	9350	13838	12334	10342	8917	7850
6016	18048	378	4914	9450	13986	12466	10453	9012	7934
6080	18240	382	4966	9550	14134	12598	10563	9108	8018
6144	18432	386	5018	9650	14282	12730	10674	9203	8102

References

[1] Technical Specification Group Radio Access Network: Multiplexing and channel coding (release 8), 3GPP TS 36.212 V1.3.0 (2007-07)