组会报告

徐益

2018 年 10 月 28 日

1 工作内容

1. 修改 NR 单线程链路中的问题；
2. 性能测试。

2 NR 单线程链路问题修复

2.1 流不满时的信道估计问题

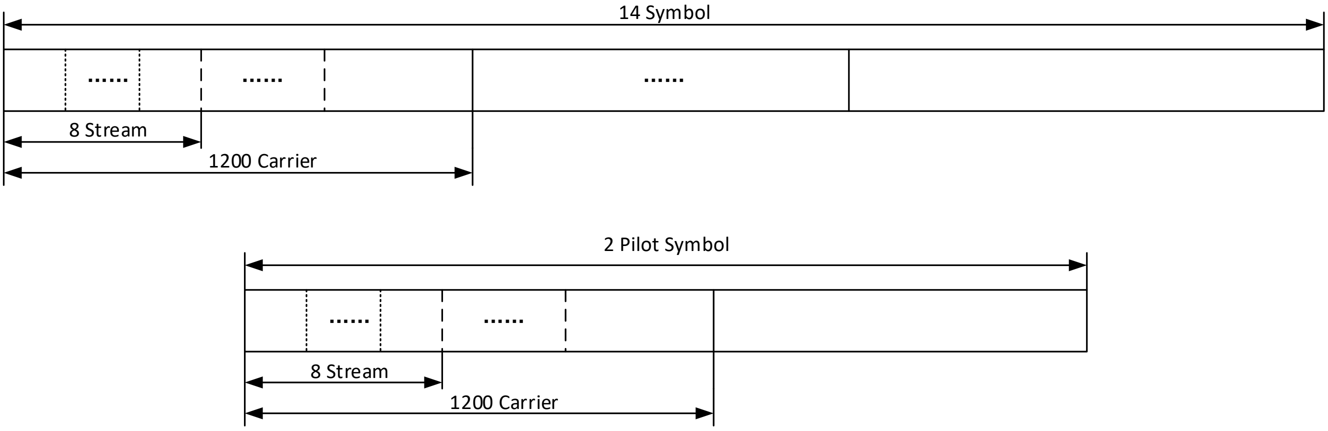
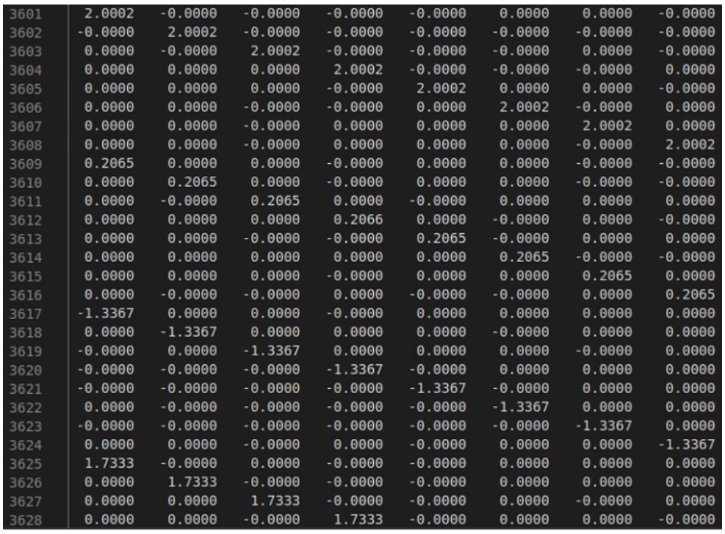


图 1: Tx 端数据子帧结构

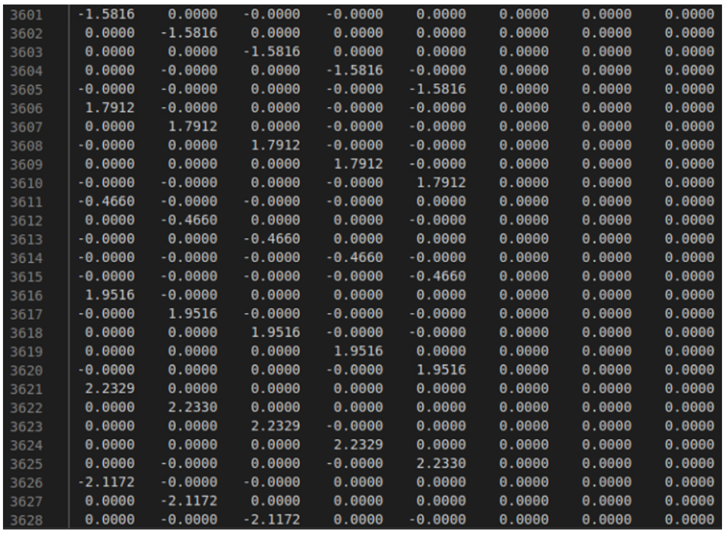
2.1.1 方案一：截取满流 (8 Stream) 时的导频

问题：
1. 信号估计前需要对导频进行截取，增加开销
2. 低流时无法使用更密集的导频



```
3601   2.0002  -0.0000  -0.0000  -0.0000  -0.0000   0.0000   0.0000  -0.0000
3602  -0.0000   2.0002  -0.0000  -0.0000  -0.0000  -0.0000  -0.0000  -0.0000
3603   0.0000  -0.0000   2.0002  -0.0000  -0.0000  -0.0000   0.0000  -0.0000
3604   0.0000   0.0000   0.0000   2.0002  -0.0000  -0.0000  -0.0000   0.0000
3605   0.0000   0.0000   0.0000  -0.0000   2.0002   0.0000   0.0000  -0.0000
3606   0.0000   0.0000  -0.0000  -0.0000   0.0000   2.0002  -0.0000   0.0000
3607   0.0000   0.0000  -0.0000   0.0000   0.0000   0.0000   2.0002   0.0000
3608   0.0000   0.0000  -0.0000   0.0000   0.0000   0.0000  -0.0000   2.0002
3609   0.2065   0.0000   0.0000  -0.0000   0.0000   0.0000  -0.0000  -0.0000
3610   0.0000   0.2065   0.0000  -0.0000   0.0000   0.0000  -0.0000  -0.0000
3611   0.0000  -0.0000   0.2065   0.0000  -0.0000   0.0000   0.0000   0.0000
3612   0.0000   0.0000   0.0000   0.2066   0.0000  -0.0000   0.0000  -0.0000
3613   0.0000   0.0000  -0.0000  -0.0000   0.2065  -0.0000   0.0000   0.0000
3614   0.0000   0.0000   0.0000   0.0000   0.0000   0.2065  -0.0000  -0.0000
3615   0.0000   0.0000   0.0000  -0.0000   0.0000   0.0000   0.2065   0.0000
3616   0.0000  -0.0000  -0.0000   0.0000  -0.0000  -0.0000   0.0000   0.2065
3617  -1.3367   0.0000   0.0000  -0.0000   0.0000   0.0000   0.0000   0.0000
3618   0.0000  -1.3367   0.0000   0.0000   0.0000  -0.0000   0.0000   0.0000
3619  -0.0000   0.0000  -1.3367   0.0000   0.0000   0.0000  -0.0000   0.0000
3620  -0.0000  -0.0000  -0.0000  -1.3367  -0.0000   0.0000   0.0000   0.0000
3621  -0.0000  -0.0000  -0.0000  -0.0000  -1.3367  -0.0000   0.0000   0.0000
3622   0.0000  -0.0000  -0.0000  -0.0000  -0.0000  -1.3367   0.0000   0.0000
3623  -0.0000  -0.0000  -0.0000  -0.0000  -0.0000  -0.0000  -1.3367   0.0000
3624   0.0000   0.0000  -0.0000   0.0000  -0.0000   0.0000   0.0000  -1.3367
3625   1.7333  -0.0000   0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000
3626   0.0000   1.7333  -0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000
3627   0.0000   0.0000   1.7333  -0.0000  -0.0000   0.0000  -0.0000   0.0000
3628   0.0000   0.0000  -0.0000   1.7333  -0.0000   0.0000   0.0000  -0.0000
```

图 2: 导频实部 (8 Stream)



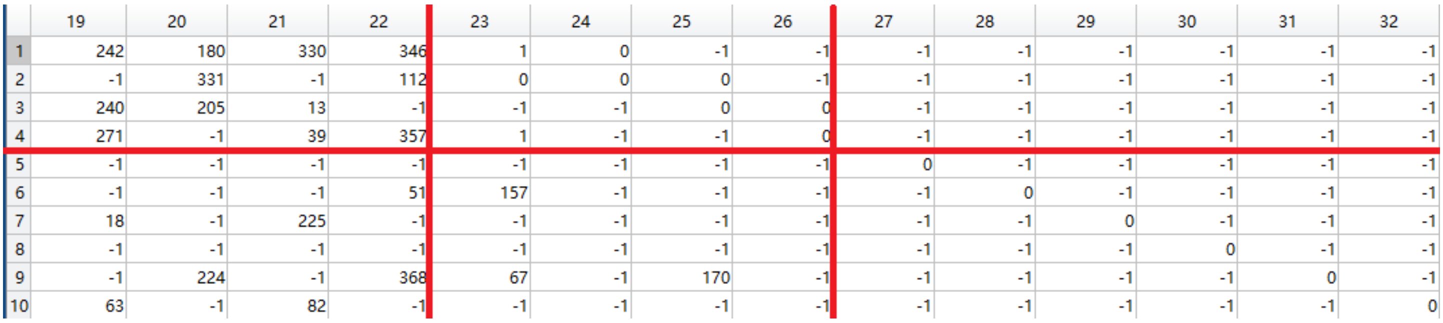
```
3601  -1.5816   0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000   0.0000
3602   0.0000  -1.5816   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3603   0.0000   0.0000  -1.5816   0.0000   0.0000   0.0000   0.0000   0.0000
3604   0.0000  -0.0000   0.0000  -1.5816  -0.0000   0.0000   0.0000   0.0000
3605  -0.0000  -0.0000   0.0000  -0.0000  -1.5816   0.0000   0.0000   0.0000
3606   1.7912  -0.0000   0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000
3607   0.0000   1.7912   0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000
3608  -0.0000   0.0000   1.7912  -0.0000  -0.0000   0.0000   0.0000   0.0000
3609   0.0000   0.0000   0.0000   1.7912  -0.0000   0.0000   0.0000   0.0000
3610  -0.0000  -0.0000   0.0000  -0.0000   1.7912   0.0000   0.0000   0.0000
3611  -0.4660  -0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000   0.0000
3612   0.0000  -0.4660   0.0000   0.0000  -0.0000   0.0000   0.0000   0.0000
3613  -0.0000   0.0000  -0.4660   0.0000   0.0000   0.0000   0.0000   0.0000
3614  -0.0000  -0.0000  -0.0000  -0.4660  -0.0000   0.0000   0.0000   0.0000
3615  -0.0000  -0.0000  -0.0000  -0.0000  -0.4660   0.0000   0.0000   0.0000
3616   1.9516  -0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3617  -0.0000   1.9516  -0.0000  -0.0000  -0.0000   0.0000   0.0000   0.0000
3618   0.0000   0.0000   1.9516  -0.0000  -0.0000   0.0000   0.0000   0.0000
3619   0.0000   0.0000   0.0000   1.9516   0.0000   0.0000   0.0000   0.0000
3620  -0.0000   0.0000   0.0000  -0.0000   1.9516   0.0000   0.0000   0.0000
3621   2.2329   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3622   0.0000   2.2330   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3623   0.0000   0.0000   2.2329  -0.0000   0.0000   0.0000   0.0000   0.0000
3624   0.0000   0.0000   0.0000   2.2329   0.0000   0.0000   0.0000   0.0000
3625   0.0000  -0.0000   0.0000  -0.0000   2.2330   0.0000   0.0000   0.0000
3626  -2.1172  -0.0000  -0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3627   0.0000  -2.1172   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
3628   0.0000  -0.0000  -2.1172   0.0000  -0.0000   0.0000   0.0000   0.0000
```

图 3: 导频实部 (5 Stream)

2.1.2 方案二：预先生成 8 类导频

```
int32_t inter_freq[MAX_BEAM] = {0, 0, 0, 0, 0, 0, 0, 0};
lapack_complex_float *pilot_symb[MAX_BEAM];
for (i = 0; i < MAX_BEAM; i++)
{
        pilot_symb[i] = (lapack_complex_float *)malloc(sizeof(lapack_complex_float) * (i + 1) * CARRIER_NUM * PILOT_SYM_NUM);
        k = i + 1;
        while (CARRIER_NUM % k != 0)
                k++;
        inter_freq[i] = k;
        CalPilotSymb(i + 1, CARRIER_NUM, PILOT_SYM_NUM, USER_NUM, inter_freq[i], pilot_symb[i]);
}
```

2.2 R=984 以及 R<342 时的译码问题



	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	242	180	330	346	1	0	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	331	-1	112	0	0	0	-1	-1	-1	-1	-1	-1	-1
3	240	205	13	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1
4	271	-1	39	357	1	-1	-1	0	-1	-1	-1	-1	-1	-1
5	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1
6	-1	-1	-1	51	157	-1	-1	-1	-1	0	-1	-1	-1	-1
7	18	-1	225	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1
8	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1
9	-1	224	-1	368	67	-1	170	-1	-1	-1	-1	-1	0	-1
10	63	-1	82	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0

图 4: BG1 部分数值

```
col_hbg_d = h->K_b * 1024 / h->R + 2;
col_hbg_d = col_hbg_d >= (h->K_b + 4) ? col_hbg_d : (h->K_b + 4);
col_hbg_d = col_hbg_d <= h->col_hbg ? col_hbg_d : h->col_hbg;
```

```
row_hbg_d = col_hbg_d - h->K_b;
```

2.3 实现有效载波长度的可变

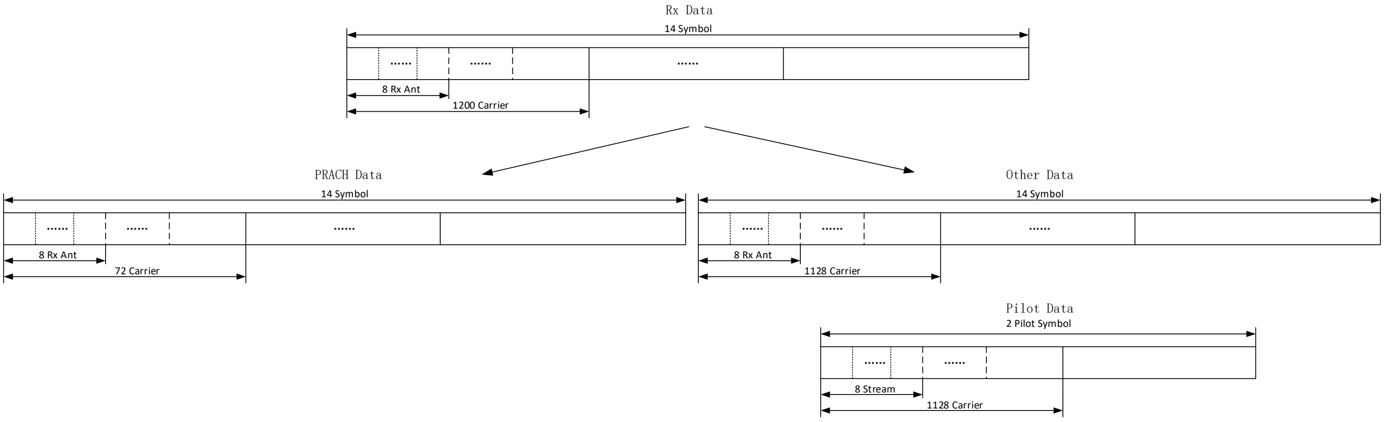


图 5: Rx 端数据子帧结构

```
const int32_t vld_carrier_num_table[VLD_CARRIER_TYPE_NUM] = {1200, 1128};
......
int32_t inter_freq[VLD_CARRIER_TYPE_NUM][MAX_BEAM] = {{0, 0, 0, 0, 0, 0, 0,
    0},{0, 0, 0, 0, 0, 0, 0, 0}};
lapack_complex_float *pilot_symb[VLD_CARRIER_TYPE_NUM][MAX_BEAM];
for (i = 0; i < MAX_BEAM; i++)
        for (j = 0; j < VLD_CARRIER_TYPE_NUM; j++)
        {
                pilot_symb[j][i] = (lapack_complex_float *)malloc(sizeof(
                    lapack_complex_float) * (i + 1) * CARRIER_NUM *
                    PILOT_SYM_NUM);
                k = i + 1;
                while (vld_carrier_num_table[j] % k != 0)
                        k++;
                inter_freq[j][i] = k;
                CalPilotSymb(i + 1, vld_carrier_num_table[j], PILOT_SYM_NUM,
                    USER_NUM, inter_freq[j][i], pilot_symb[j][i]);
        }
```

2.4 其他改进

1. 选择新的随机数生成方式;
2. 使用 fread 代替 fscanf 读取信道信息;
3. 增加最大许可 TBS 生成模块;

2.5 当前测试接口

```c
int32_t testNum = 8;
int32_t loopNum = 100;

float snr_list[MAX_TEST_TIMES] = {15.0, 15.0, 15.0, 15.0, 15.0, 15.0, 15.0, 15.0};
int32_t cqi_list[MAX_TEST_TIMES] = {20, 21, 22, 23, 24, 25, 26, 27};
int32_t tb_byte_len_list[MAX_TEST_TIMES] = {9162, 18327, 27492, 36657, 45823, 54988, 64153, 73318};
int32_t subcarrier_indx_list[MAX_TEST_TIMES] = {2, 3, 4, 2, 3, 4, 2, 3};
int32_t max_layer_num_list[MAX_TEST_TIMES] = {1, 2, 3, 4, 5, 6, 7, 8};
```

3 性能测试

3.1 Tx 单流耗时占比测试

表 1: Tx 耗时占比

Stream	1	8
CRC Attach	7.64%	9.65%
Code Blocks Segment	0.95%	2.48%
Encode	17.89%	23.31%
Rate Matching	38.31%	42.39%
Map	16.33%	16.25%
Pack	18.85%	5.90%

Throuput_Tx(Stream=1) = 94.32Mbps
Throuput_Tx(Stream=8) = 126.68Mbps

3.2 Rx 单流耗时占比测试

表 2: Rx 耗时占比

Stream	1	8
Channel Estimate	34.34%	12.86%
Signal Detect	10.98%	52.74%
Unpack	8.68%	1.52%
Demap	9.23%	10.19%
Rate De-matching	14.35%	10.70%
Decode	22.18%	11.67%
De-CBS	0.23%	0.30%
CRC Check	2.54%	1.74%

Throuput_Rx(Stream=1) = 34.70Mbps
Throuput_Rx(Stream=8) = 24.00Mbps

3.3 不同流的最大吞吐量对比

表 3: 最大吞吐量对比

Stream	Tx	Rx
1	94.3187Mbps	34.6968Mbps
2	110.1581Mbps	21.1701Mbps
3	117.0514Mbps	23.6051Mbps
4	119.7418Mbps	24.6373Mbps
5	124.8383Mbps	25.7432Mbps
6	120.0644Mbps	23.9620Mbps
7	125.5944Mbps	24.0412Mbps
8	126.6790Mbps	24.0002Mbps

3.4 不同 CQI 下的性能对比

表 4: 不同 CQI 下的性能对比 (SNR=15dB, Stream=8)

CQI	Q	R	Tx Throughput	Rx Throughput	BER	FER
0	2	120	19.1748Mbps	1.2977Mbps	0.00e+00(0/2472000)	0.00e+00(0/100)
1	2	157	24.8647Mbps	1.6720Mbps	3.09e-07(1/3235200)	1.00e-02(1/100)
2	2	193	30.3081Mbps	2.0258Mbps	1.01e-06(4/3977600)	4.00e-02(4/100)
3	2	251	38.0779Mbps	2.6368Mbps	1.55e-06(8/5174400)	8.00e-02(8/100)
4	2	308	44.8342Mbps	3.1302Mbps	3.15e-07(2/6349600)	2.00e-02(2/100)
5	2	379	53.1400Mbps	3.8364Mbps	2.30e-06(18/7814400)	1.60e-01(16/100)
6	2	449	62.0329Mbps	4.5721Mbps	7.56e-07(7/9257600)	5.00e-02(5/100)
7	2	586	69.5904Mbps	5.3592Mbps	5.21e-04(5648/10845600)	3.60e-01(36/100)
8	2	602	76.7437Mbps	6.1579Mbps	1.22e-02(151672/12413600)	8.10e-01(81/100)
9	2	679	83.4890Mbps	6.9832Mbps	7.36e-02(1030578/14001600)	1.00e+00(100/100)
10	4	340	55.8664Mbps	5.9989Mbps	1.23e-03(17220/14022400)	3.50e-01(35/100)
11	4	378	60.4923Mbps	6.6838Mbps	4.62e-06(72/15589600)	5.00e-01(50/100)
12	4	434	67.1290Mbps	7.6519Mbps	1.49e-02(266314/17900000)	7.90e-01(79/100)
13	4	490	74.0037Mbps	8.7083Mbps	2.21e-01(4471324/20209600)	1.00e+00(100/100)
14	4	553	79.8351Mbps	9.7716Mbps	2.07e-01(4718078/22808800)	1.00e+00(100/100)
15	4	616	87.1937Mbps	10.9847Mbps	1.46e-01(3714578/25407200)	1.00e+00(100/100)
16	4	658	91.3331Mbps	11.7369Mbps	1.23e-01(3350474/27140000)	1.00e+00(100/100)
17	6	438	72.5977Mbps	10.1401Mbps	2.45e-01(6644275/27098400)	1.00e+00(100/100)
18	6	466	76.2555Mbps	10.7902Mbps	2.23e-01(6430297/28831200)	1.00e+00(100/100)
19	6	517	83.7652Mbps	12.2214Mbps	2.05e-01(6543188/31986400)	1.00e+00(100/100)
20	6	567	89.6400Mbps	13.3132Mbps	1.98e-01(6933854/35080000)	1.00e+00(100/100)
21	6	616	94.9979Mbps	14.5417Mbps	1.93e-01(7371623/38112000)	1.00e+00(100/100)
22	6	666	101.6158Mbps	15.9313Mbps	1.97e-01(8124062/41205600)	1.00e+00(100/100)
23	6	719	107.3590Mbps	17.3358Mbps	1.90e-01(8441999/44485600)	1.00e+00(100/100)
24	6	772	112.6666Mbps	18.8440Mbps	1.89e-01(9018436/47764800)	1.00e+00(100/100)
25	6	822	111.5673Mbps	19.2854Mbps	1.89e-01(9610630/50858400)	1.00e+00(100/100)
26	6	873	108.4685Mbps	20.1055Mbps	1.93e-01(10419103/54014400)	1.00e+00(100/100)
27	6	910	114.9944Mbps	21.3412Mbps	1.93e-01(10868537/56303200)	1.00e+00(100/100)
28	6	948	116.7884Mbps	21.9075Mbps	1.89e-01(11105305/58654400)	1.00e+00(100/100)