Communication Systems Design

Lab 6: Cell Search and MIB Recovery

(Part 2)

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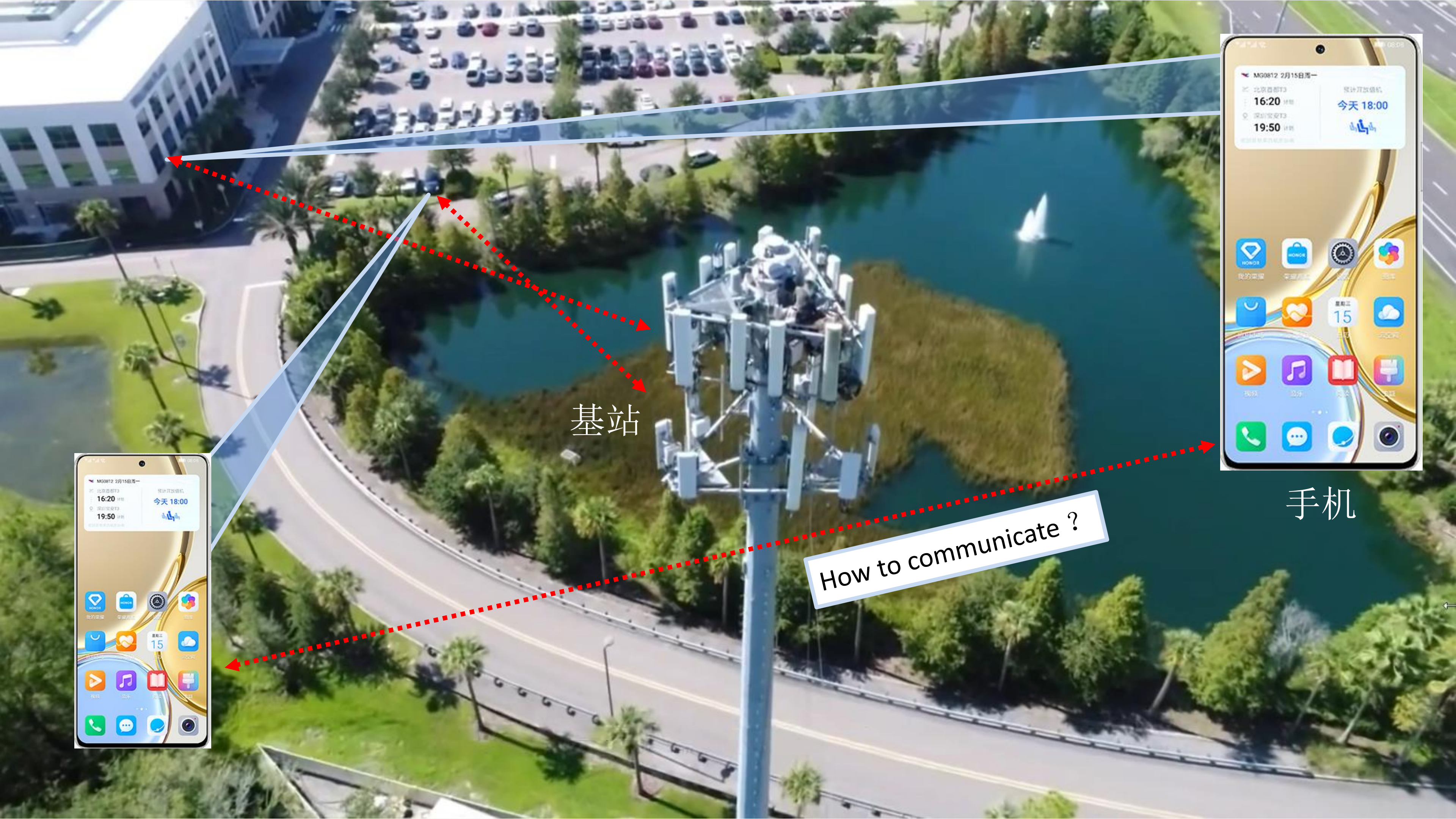
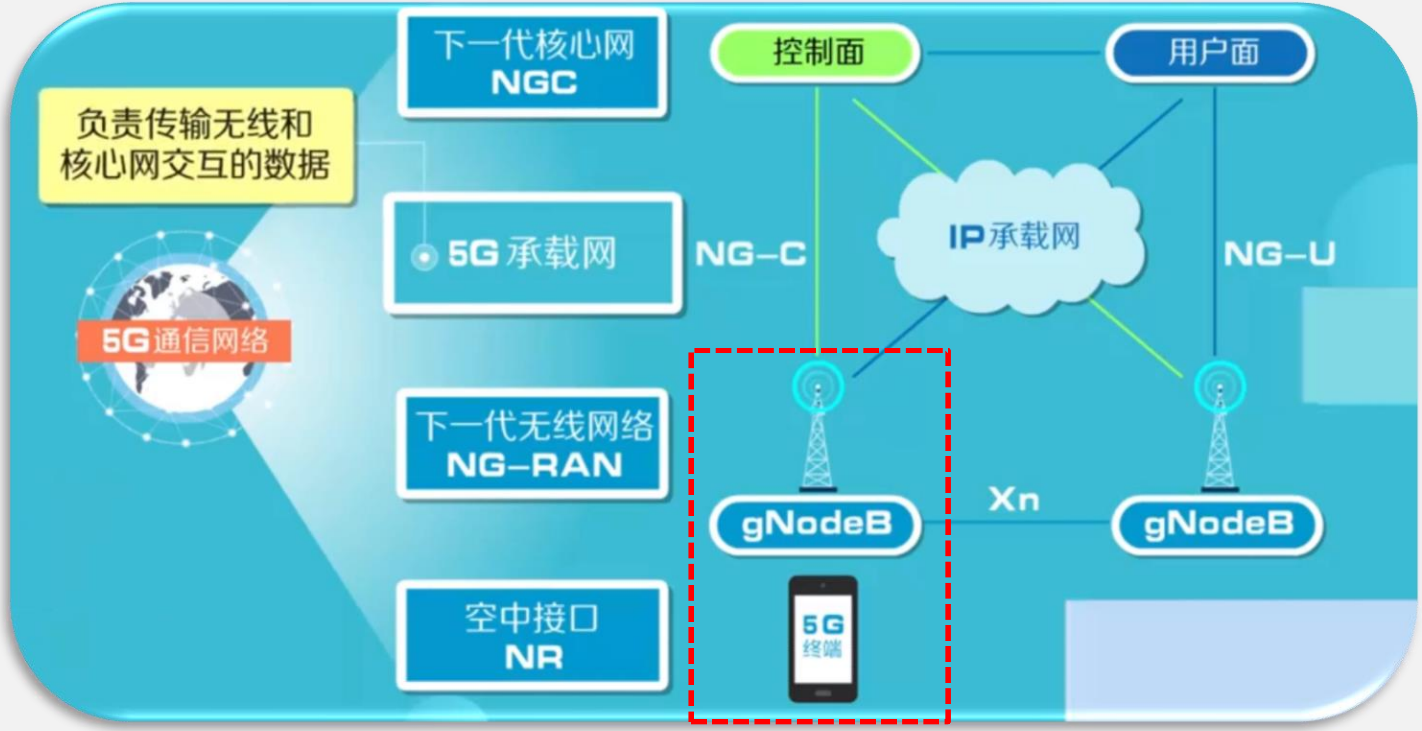
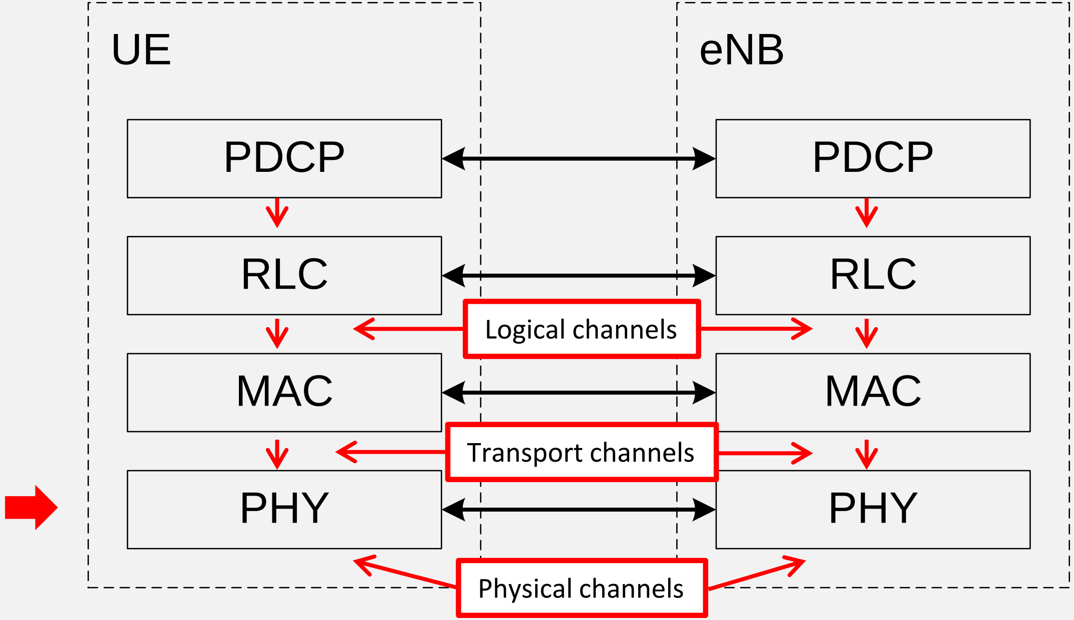
前沿通信系统设计（32学时）
1 WiFi通信系统（9周）
实验目标：利用USRP实现802.11a/n图像传输
软件：MATLAB, 硬件：USRP
授课内容：MATLAB通信编程、USRP文本传输、MIMO系统、802.11a/n仿真、802.11a/n图像传输
2 5G/4G-LTE系统（4周）
实验目标：利用USRP实现LTE图像传输
软件：MATLAB，硬件：USRP
授课内容：小区搜索过程、MIB/SIB解码过程、LTE图像传输、LDPC编解码过程、srsLTE系统
3 无线网络传输系统（2周）
实验目标：利用Telos实现无线多跳网络传输数据
软件：TinyOS、NesC
授课内容：TinOS编程、MICAZ平台介绍、无线多跳网络数据收集、无线信道建模、无线定位、路由和数据收集
4 雷达感知系统（1周）
实验目标：利用KerberosSDR实现测向
软件：MATLAB，硬件：KerberosSDR、树莓派
授课内容：MUSIC算法、空间谱估计、KerberosSDR原理，无线开源项目，课程Presentation


基站
How to communicate ?
手机


下一代核心网
NGC
控制面
用户面
负责传输无线和
核心网交互的数据
5G承载网
NG-C
IP承载网
NG-U
5G通信网络
下一代无线网络
NG-RAN
gNodeB
Xn
gNodeB
空中接口
NR
5G
终端


下午2:40
选取运营商
自动选择网络
自动选择首选网络
中国移动 4G
CMCC
中国移动 2G
CHINA MOBILE
中国联通 4G
CHN-UNICOM（禁用）
中国电信 4G
CHN-CT（禁用）

Understanding LTE: Physical layer

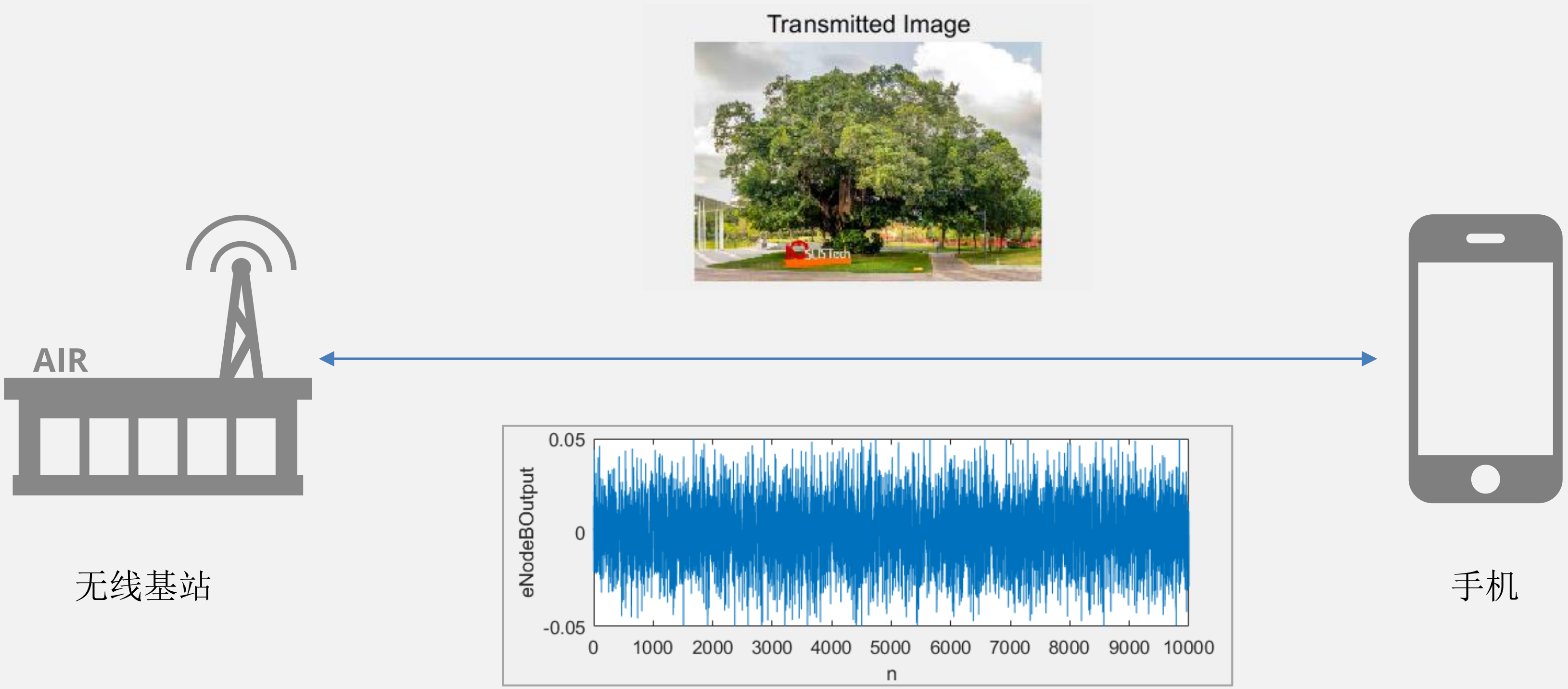


1. Frame structure

2. LTE Channel

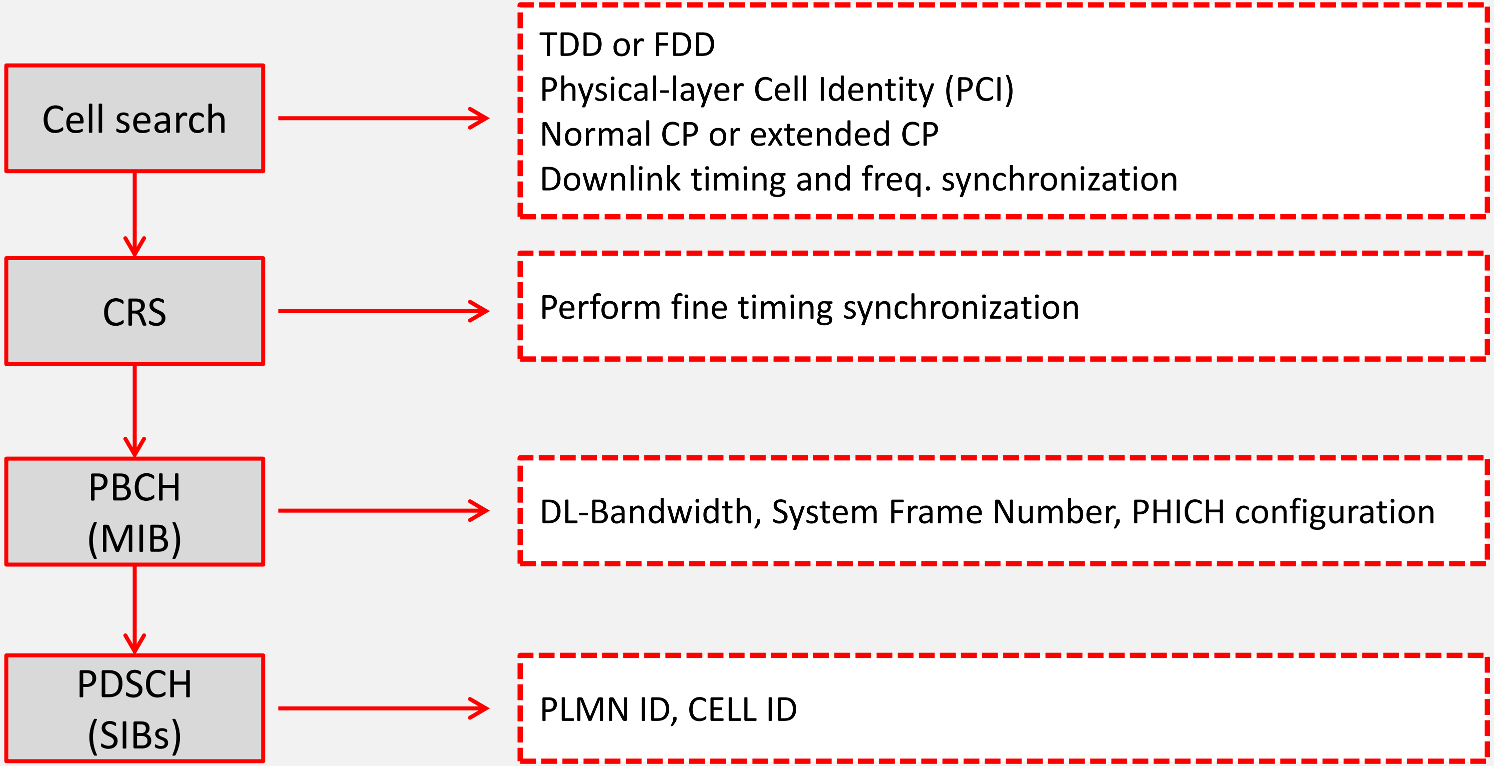
3. LTE downlink channel

4. LTE uplink channel

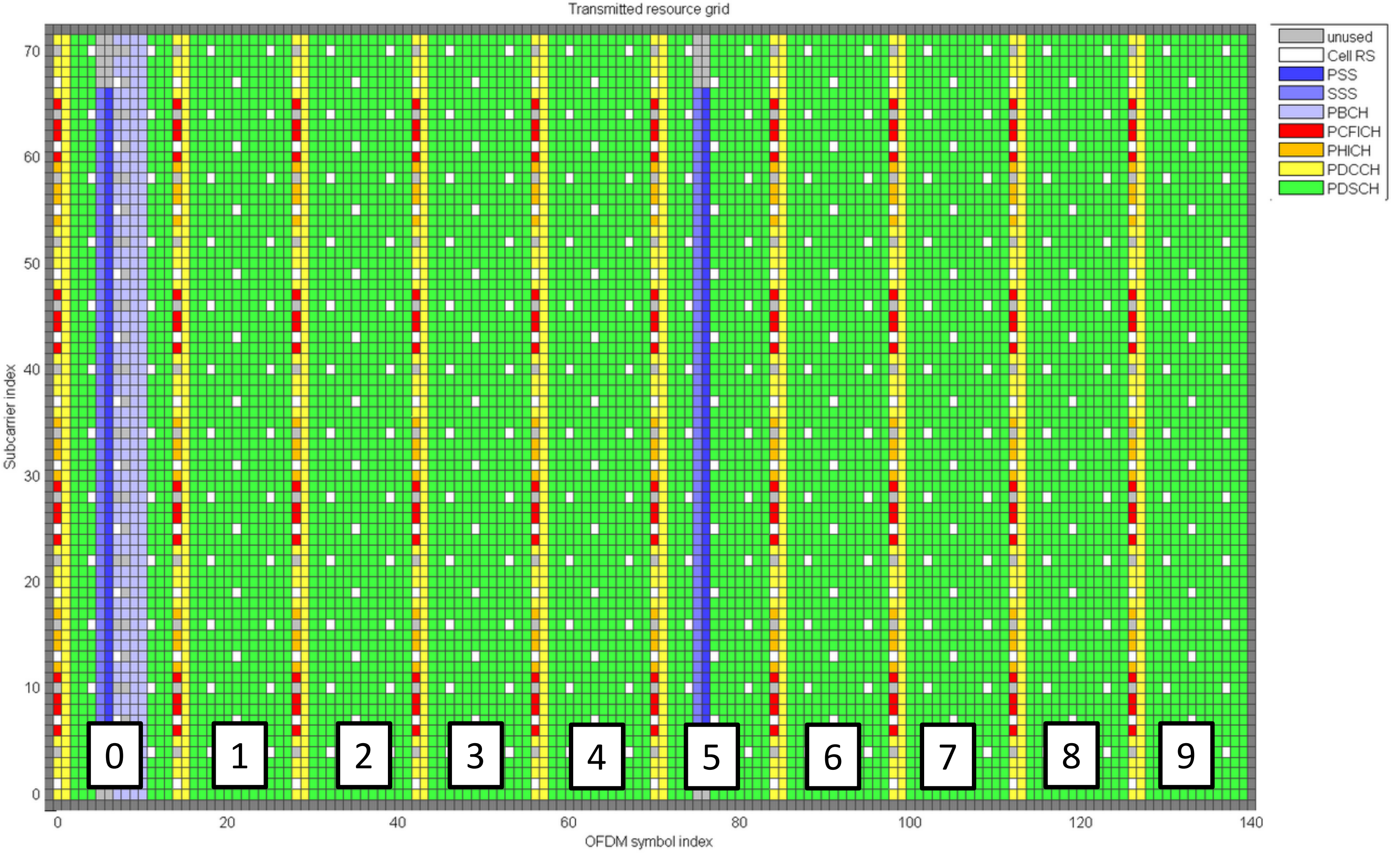


Transmitted Image
AIR
无线基站
手机
eNodeBOutput
0.05
0
-0.05
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
n

Flow chart of received signal processing



How to determine TDD or FDD ?


Transmitted resource grid
Subcarrier index
OFDM symbol index
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140
unused
Cell RS
PSS
SSS
PBCH
PCFICH
PHICH
PDCCH
PDSCH
0
1
2
3
4
5
6
7
8
9

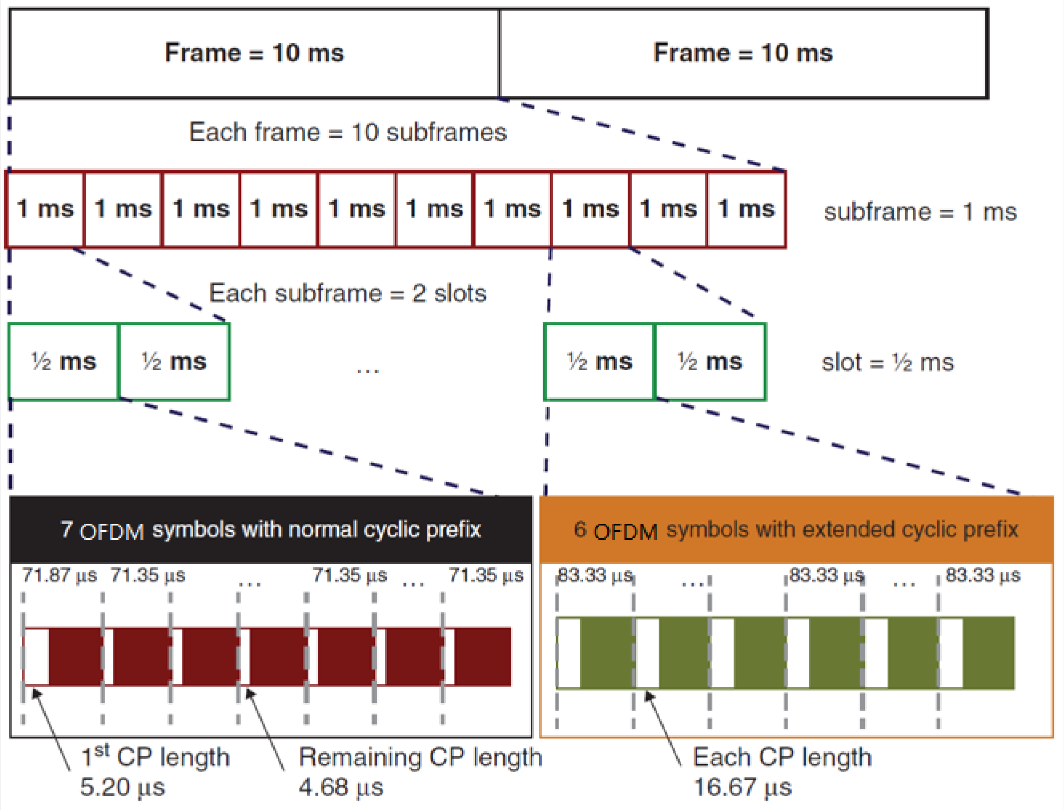
Frame Structure in physical layer

1 System frame →

1 Sub frame →

1 Time slot →

1 OFDM symbol →



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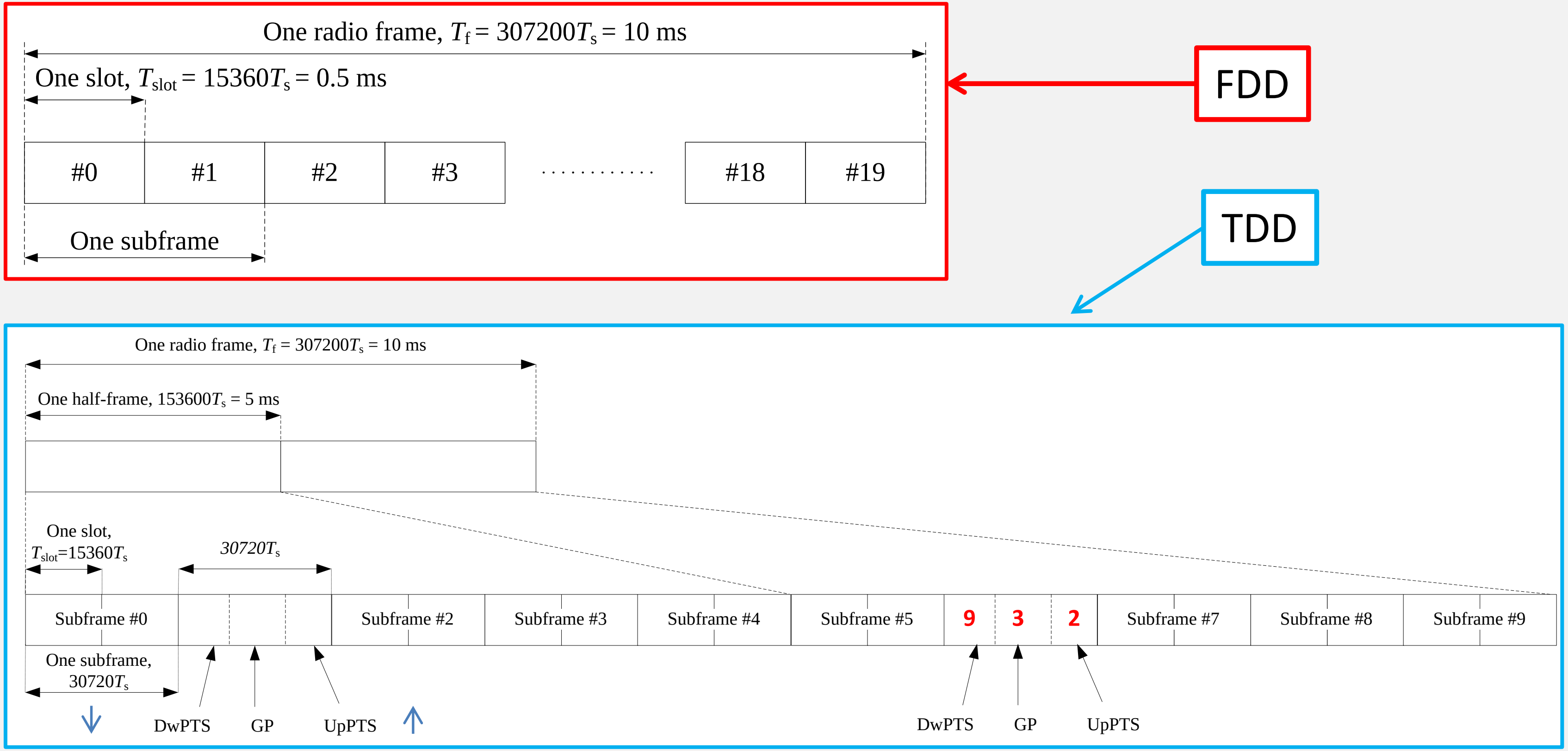
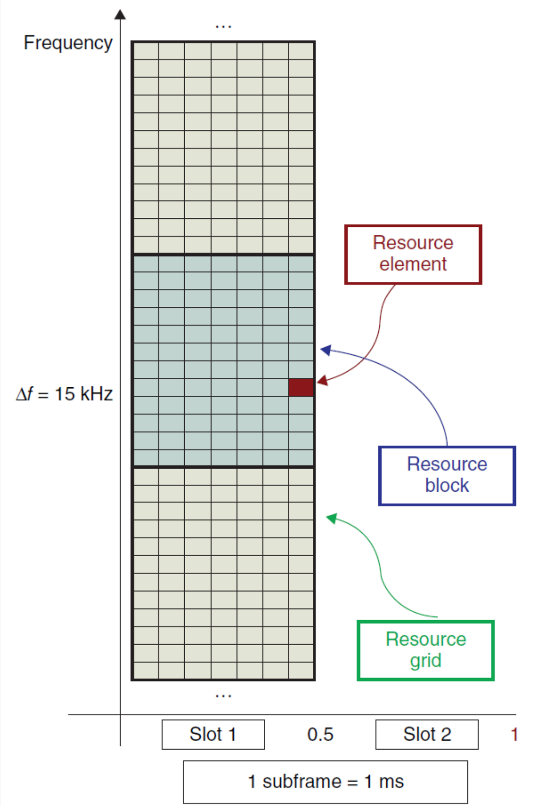
FDD/TDD Frame in time-domain

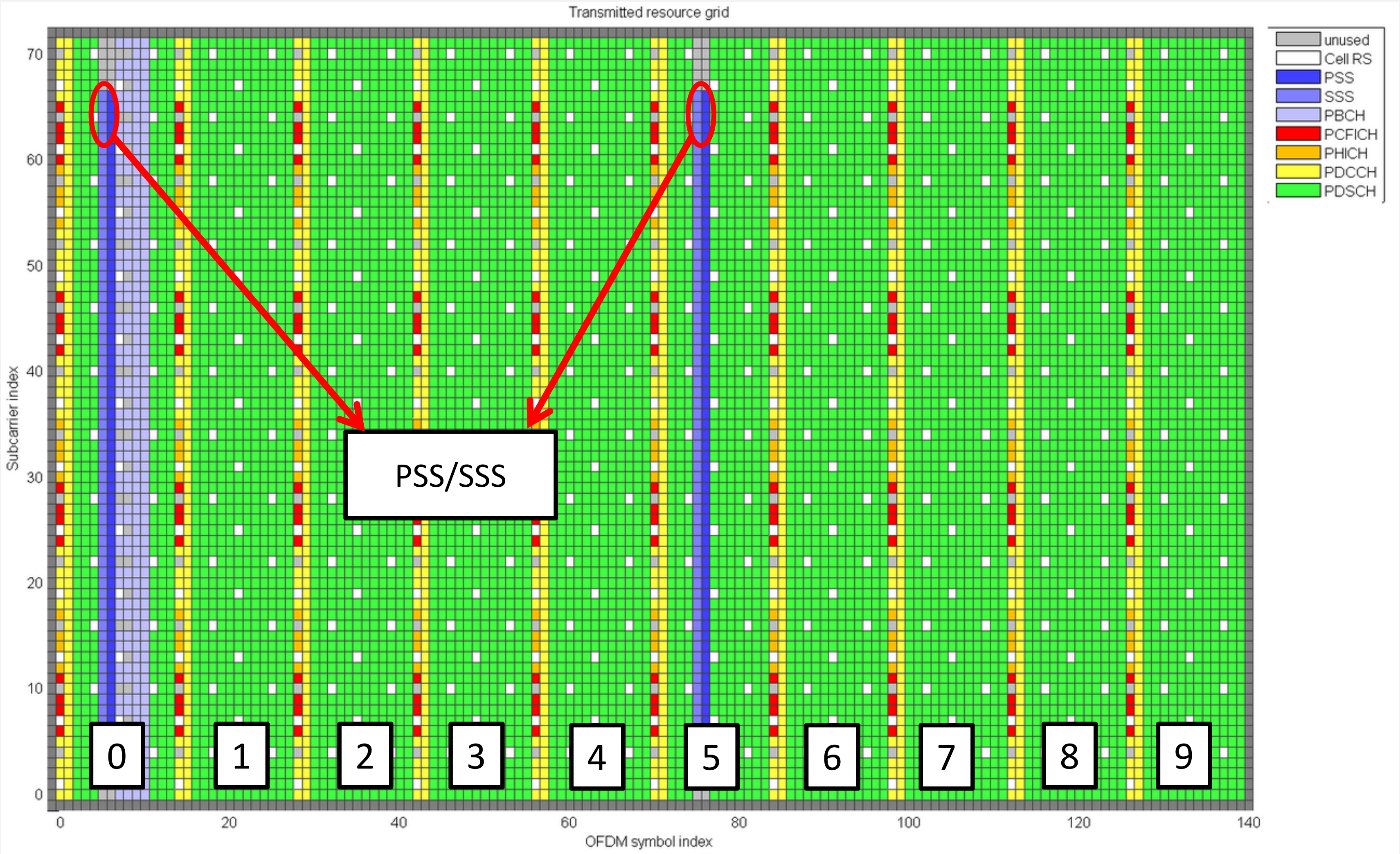


FDD/TDD Frame in freq.-domain



A resource block: a group of resource elements corresponding to **12 subcarriers** or 180 kHz in the frequency domain and **one 0.5ms slot** in the time domain.

OFDM parameters for downlink transmission subframe duration (1 ms) subcarrier spacing (15 kHz)						
Bandwidth (MHz)	1.4	3	5	10	15	20
Sampling frequency (MHz)	1.92	3.84	7.68	15.36	23.04	30.72
FFT size	128	256	512	1024	1536	2048
Number of resource blocks	6	15	25	50	75	100
OFDM symbols per slot			14/12		(Normal/extended)	
CP length			4.7/5.6		(Normal/extended)	


Transmitted resource grid
unused
Cell RS
PSS
SSS
PBCH
PCFICH
PHICH
PDCCH
PDSCH
PSS/SSS
0
1
2
3
4
5
6
7
8
9
Subcarrier index
OFDM symbol index
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140

```matlab
% *Signal Capture and Processing*
enbDefault = enb;

while rxsim.numBurstCaptures
    % Set default LTE parameters
     enb = enbDefault;
     rxWaveform  = eNodeBOutput;

    % Show power spectral density of captured burst
    hsa.SampleRate = rxsim.RadioFrontEndSampleRate;
    step(hsa,rxWaveform);

    % Perform frequency offset correction for known cell ID
    frequencyOffset = lteFrequencyOffset(enb,rxWaveform);
    rxWaveform = lteFrequencyCorrect(enb,rxWaveform,frequencyOffset);
    fprintf('\nCorrected a frequency offset of %i Hz.\n',frequencyOffset)

    % Perform the blind cell
    %   Use 'PostFFT' SSS detection method to improve speed
    cellSearch.SSSDetection = 'PostFFT'; cellSearch.MaxCellCount = 1;
    [NCellID,frameOffset] = lteCellSearch(enb,rxWaveform,cellSearch);
    fprintf('Detected a cell identity of %i.\n', NCellID);
    enb.NCellID = NCellID; % From lteCellSearch

    % Sync the captured samples to the start of an LTE frame, and trim off
    % any samples that are part of an incomplete frame.
    rxWaveform = rxWaveform(frameOffset+1:end,:);
    tailSamples = mod(length(rxWaveform),samplesPerFrame);
    rxWaveform = rxWaveform(1:end-tailSamples,:);
    enb.NSubframe = 0;
    fprintf('Corrected a timing offset of %i samples.\n',frameOffset)
```

How to perform cell search with PSS/SSS here ?

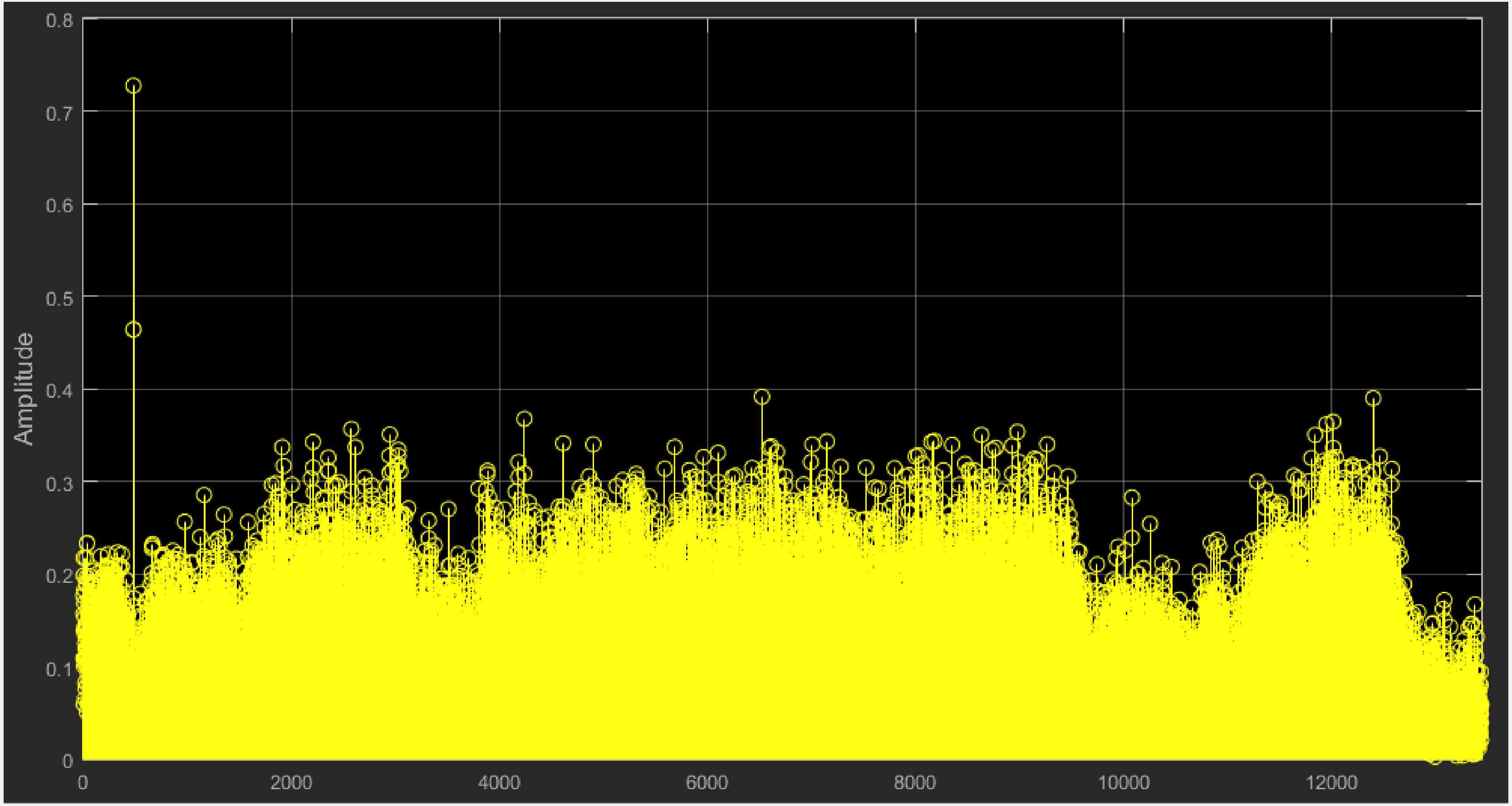
```
K>> enb

enb =

          PDSCH: [1x1 struct]
     DuplexMode: 'FDD'
   CyclicPrefix: 'Normal'
       CellRefP: 4
          NDLRB: 50
```

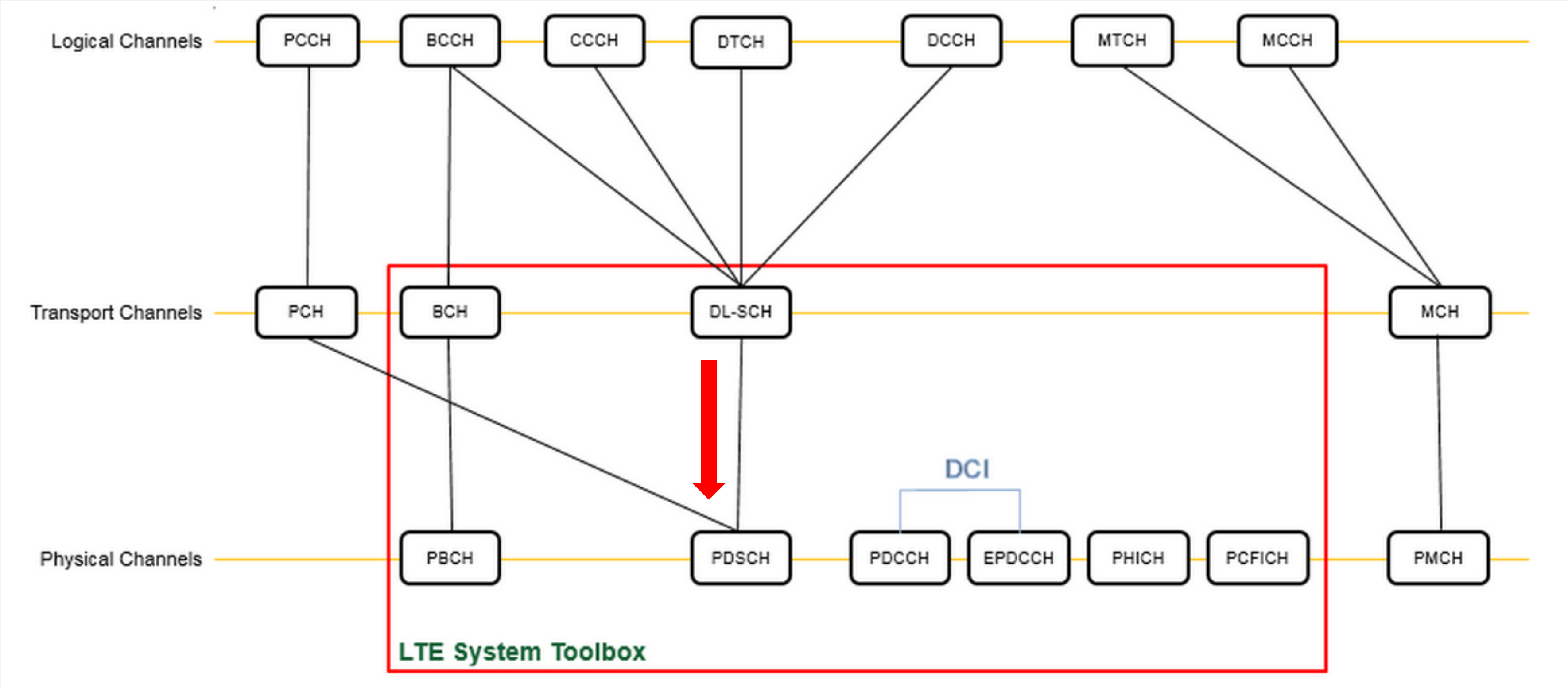
```
enb =

          PDSCH: [1x1 struct]
     DuplexMode: 'FDD'
   CyclicPrefix: 'Normal'
       CellRefP: 4
          NDLRB: 50
        NCellID: 88
```

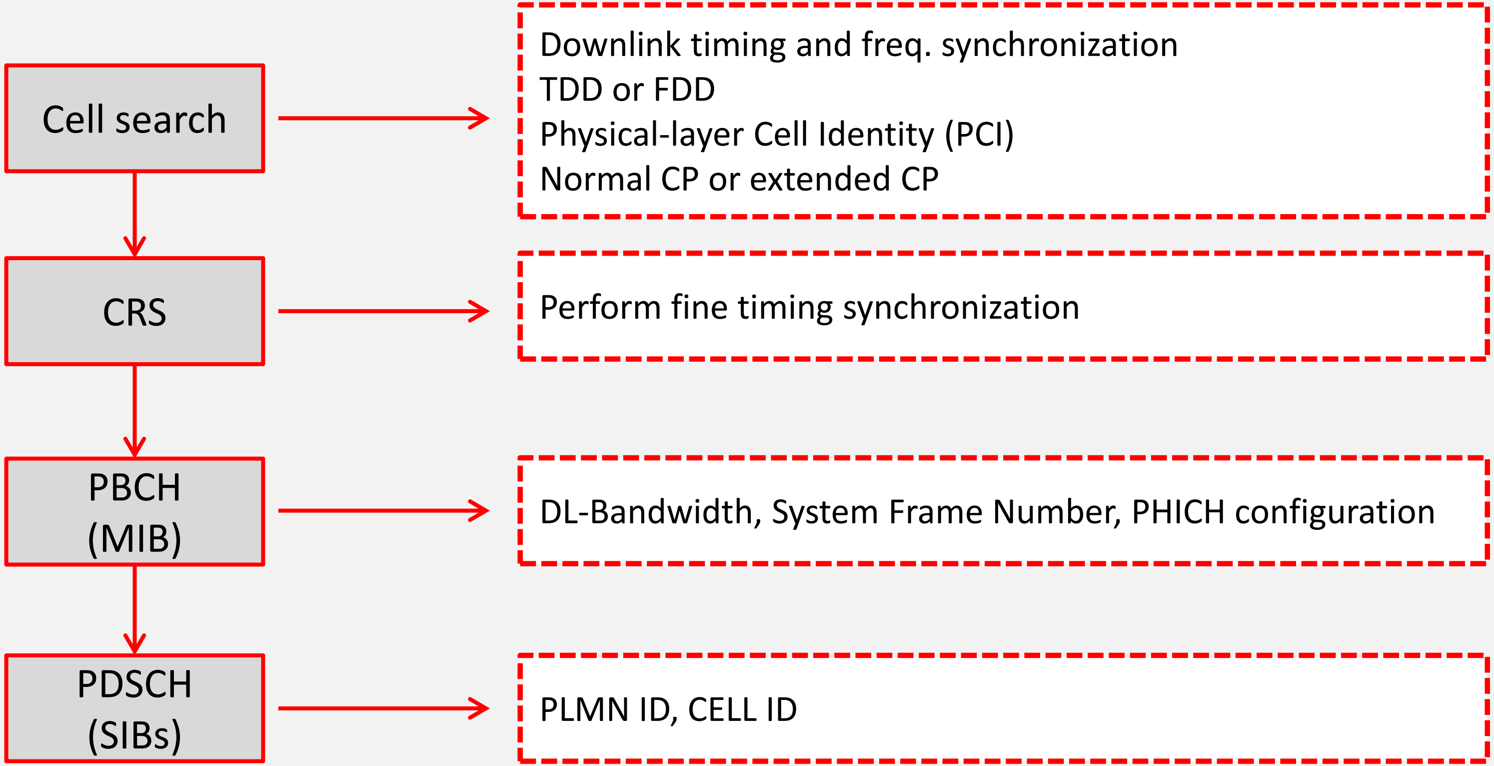


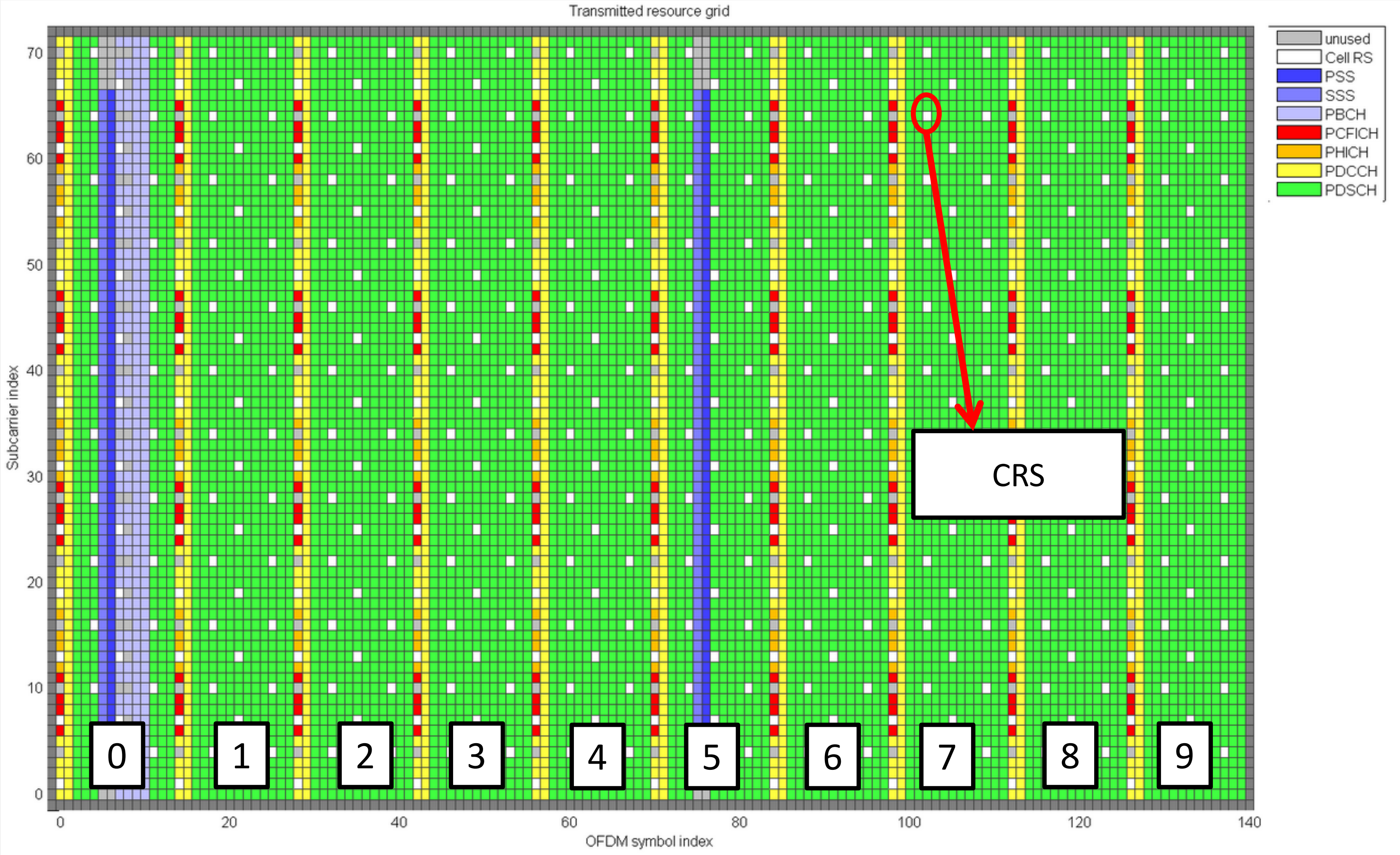
Amplitude
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2000
4000
6000
8000
10000
12000

Downlink channel model

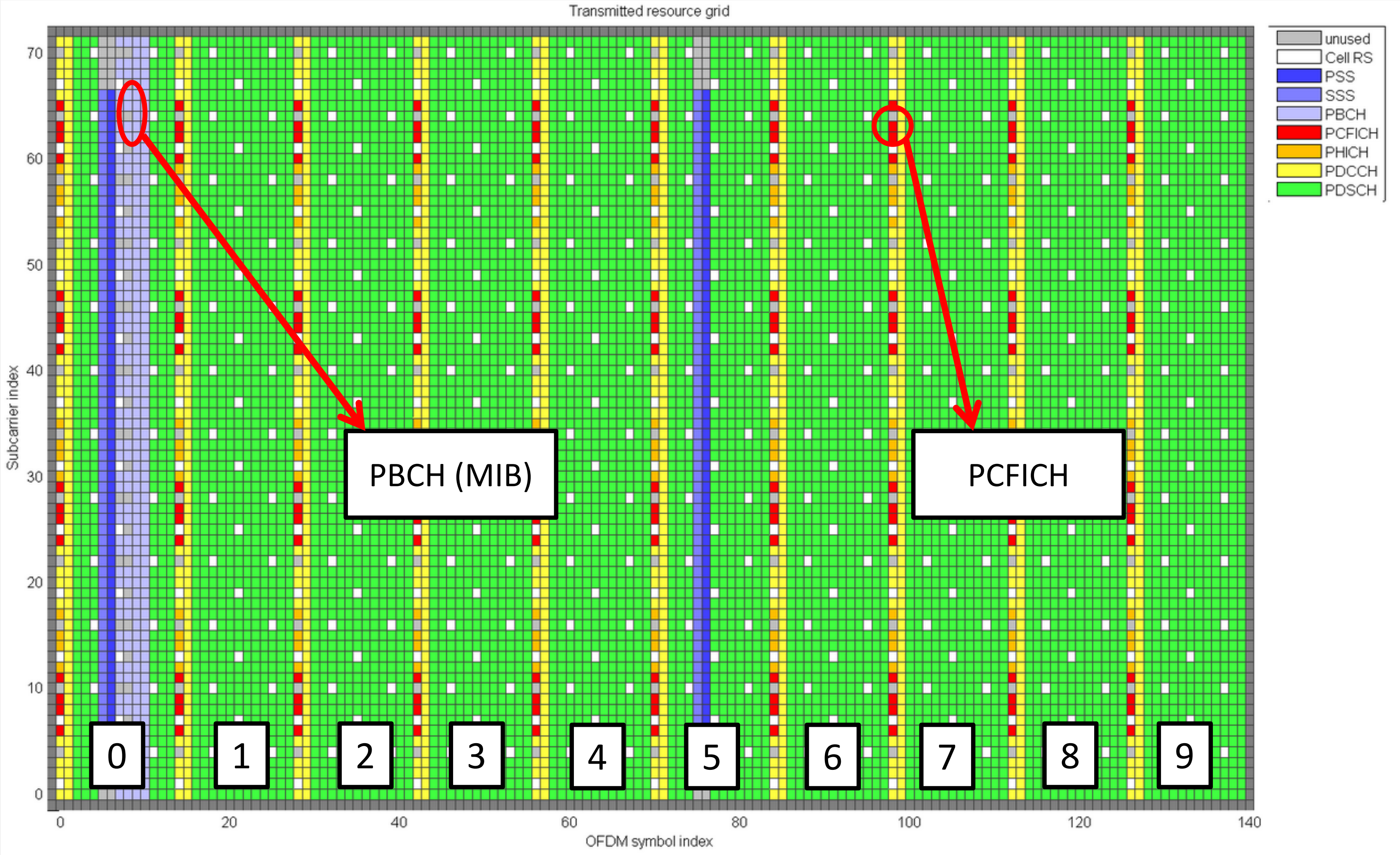


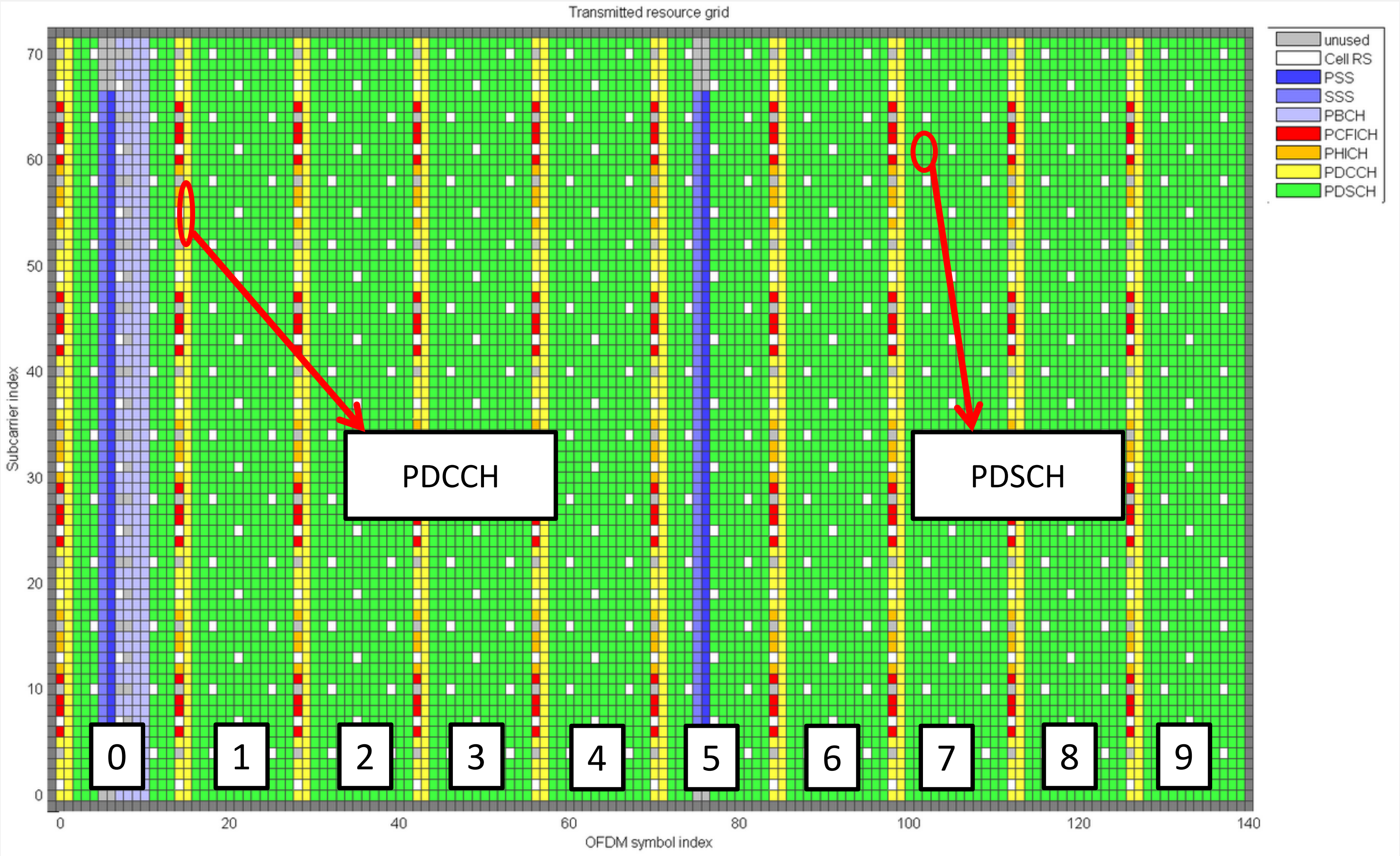
Cell search and synchronization





Transmitted resource grid
Subcarrier index
OFDM symbol index
unused
Cell RS
PSS
SSS
PBCH
PCFICH
PHICH
PDCCH
PDSCH
CRS
0
1
2
3
4
5
6
7
8
9


Transmitted resource grid
unused
Cell RS
PSS
SSS
PBCH
PCFICH
PHICH
PDCCH
PDSCH
Subcarrier index
OFDM symbol index
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140
PBCH (MIB)
PCFICH
0
1
2
3
4
5
6
7
8
9



Transmitted resource grid
unused
Cell RS
PSS
SSS
PBCH
PCFICH
PHICH
PDCCH
PDSCH
PDCCH
PDSCH
0
1
2
3
4
5
6
7
8
9
Subcarrier index
OFDM symbol index
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140

```
% For each frame decode the MIB, PDSCH and DL-SCH
for frame = 0:(numFullFrames-1)
    fprintf('\nPerforming DL-SCH Decode for frame %i of %i in burst:\n', ...
        frame+1,numFullFrames)

    % Extract subframe #0 from each frame of the received resource grid
    enb.NSubframe = 0;
    rxsf = rxGrid(:,frame*LFrame+(1:Lsf),:);
    hestsf = hest(:,frame*LFrame+(1:Lsf),:,:);

    % PBCH demodulation.
    enb.CellRefP = 4;
    pbchIndices = ltePBCHIndices(enb);
    [pbchRx,pbchHest] = lteExtractResources(pbchIndices,rxsf,hestsf);
    [~,~,nfmod4,mib,CellRefP] = ltePBCHDecode(enb,pbchRx,pbchHest,nest);

    % If PBCH decoding successful CellRefP~=0 then update info
    if ~CellRefP
        fprintf('  No PBCH detected for frame.\n');
        continue;
    end
    enb.CellRefP = CellRefP; % From ltePBCHDecode

    % Decode the MIB to get current frame number
    enb = lteMIB(mib,enb);

    % Incorporate the nfmod4 value output from the function
    % ltePBCHDecode, as the NFrame value established from the MIB
    % is the system frame number modulo 4.
    enb.NFrame = enb.NFrame+nfmod4;
    fprintf('  Successful MIB Decode.\n')
    fprintf('  Frame number: %d.\n',enb.NFrame);

    % The eNodeB transmission bandwidth may be greater than the
    % captured bandwidth, so limit the bandwidth for processing
    enb.NDLRB = min(enbDefault.NDLRB,enb.NDLRB);
```

```
enb =

            PDSCH: [1x1 struct]
       DuplexMode: 'FDD'
     CyclicPrefix: 'Normal'
         CellRefP: 4
            NDLRB: 50
          NCellID: 88
        NSubframe: 0
```

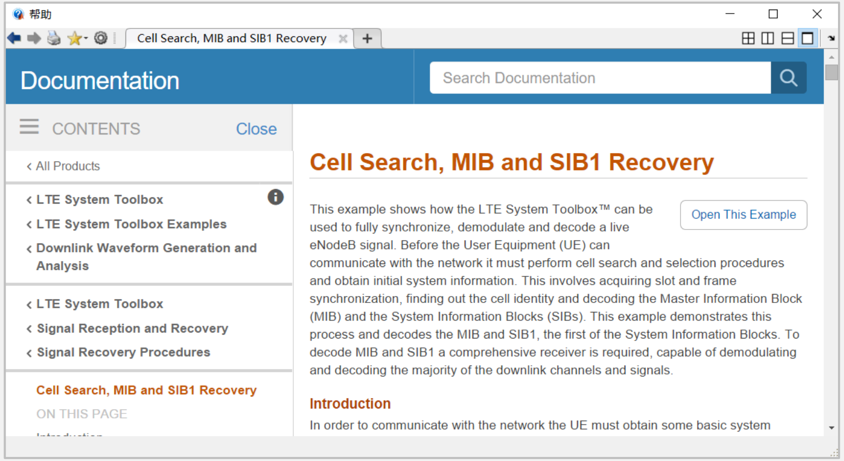
```
enb =

            PDSCH: [1x1 struct]
       DuplexMode: 'FDD'
     CyclicPrefix: 'Normal'
         CellRefP: 1
            NDLRB: 50
          NCellID: 88
        NSubframe: 0
    PHICHDuration: 'Normal'
               Ng: 'Sixth'
           NFrame: 700
```

Assignments

- Read the example '**Transmit and Receive LTE MIMO Using a Single Analog Devices AD9361/AD9364**' in LTE System Toolbox.

- Explain the functions of the following six subcomponents respectively,
  (1) lteCellSearch.m
  (2) ltePBCHDecode.m
  (3) lteResourceGridSize.m
  (4) ltePCFICHDecode.m
  (5) ltePDCCHDecode.m
  (6) ltePDSCHDecode.m



- Cell search and MIB/SIB decoding.

Reception Process

USRP Capture → Baseband Processing → Image Recover

Cell Search → MIB Recovery → PDSCH Decoding

Questions