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IP Design and Implementation of a LTE-A Cell Detect Scheme

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ABSTRACT

The current LTE-Advanced system architecture tends to flatten and the data transfer rate of mobile communication system continues to increase, which needs to complete cell blind detect more accurate and quick, and indicates that the design of the LTE-A system terminal need to be updated. Therefore, this paper will find a new cell blind detect scheme, then designing a corresponding IP which considers the hardware performance, area, power and scalability from the perspective of ASIC implementation, and using ASIC tools to verification and logic synthesis. Implementation results show that the designed IP can be used for a mobile terminal chip design.

Keywords: LTE-A, Frame synchronization and Timing.

1. INTRODUCTION

This paper describes the classification of the passive bistatic radar cross section (RCS) on ground moving target with simulation using Computer Simulation Technology (CST) Microwave studio. Passive biostatic radars used illuminators of Opportunity as transmitters. Illuminators of opportunity are transmitters that are already present in the environment, such as analog TV Transmitters, digital video broadcast terrestrial (DVB-T) TV transmitters, or mobile phone base transceiver stations (BTSs). We propose to use one or multiple illuminators of opportunity as source of radar illumination, as in (Willis and Griffiths, 2007). Different characteristics of the signals transmitted from illuminators of opportunity such as their location, modulation, polarization and frequency which could not be controlled. Hence, we choose to use of long-term evolution (LTE) as an illuminator of opportunity for passive radars investigation (Salahet al., 2014. The current LTE-Advanced system architecture tends to flatten and the data transfer rate of mobile communication system continues to increase, which indicates the previous cell blind detect implementations scheme of the LTE-A system terminal need to be updated. Therefore, it is very important to find a new cell blind detect implementation scheme. First of all, due to timing synchronization needs a lot of FFT and related calculations, this paper divides the algorithm into three steps: (1) coarse timing synchronization and detecting the sub cell ID; (2) fine timing synchronization; (3) frame synchronization and detecting the cell ID group. This above-divided we adopt can reduce the amount of fine timing synchronization calculation and accelerate to complete the cell blind detect considerably. Finally, this paper will design a corresponding IP which considers the hardware performance, area, power and scalability from the perspective of ASIC implementation, and use ASIC tools to verification and logic synthesis.

1.1 MOBILITY WITH SINGLE CONNECTIVITY

In this mode, the UE consumes radio resources from one cell at a time. Following the parameterization in [7], intra and inter-frequency handovers are triggered by the A3 event (neighboring cell becomes offset better than the serving cell). Intra-frequency events (macro-to-macro and pico-to-pico) are based on the Reference Signal Received Power (RSRP) Radio Resource Management (RRM) measurement while inter frequency handovers (macro-to-pico or vice-versa) are based on Reference Signal Received Quality (RSRQ).

2. RELATED ALGORITHMS

Physical Layer Protocol of LTE-Advanced system provisions, which has 504 physical layer cell IDs. Each physical layer cell ID (used c e l lID N to represent) could be formed by a physical layer cell ID group ID N and a physical layer sub cell ID N [1]:

(1) (2) = 3 +c e l l ID N (1) In the LTE-Advanced system, information associated with the cell ID is included in the PSS and the SSS. The PSS and SSS have a fixed position in the time-frequency domain. PSS which generation period is 5ms is decided by root index (2)
ID N; SSS which generation period is 10ms is decided by the root index (1)
ID N and (2) ID *N.*

Before the calculation, we need to process the received data with down-sampling rate 1/16, which still meets the Nyquist sampling theorem, and does not occur mixing. While Setting the sliding step is 16 Ts.

3. COARSE TIMING SYNCHRONIZATION AND SUB CELL ID DETECTION

It is quickly that getting the approximate location of the PSS and obtaining the sub cell ID (2) ID N by using coarse timing synchronization, so as to determine the sliding ranges of the fine timing synchronization. Therefore, this paper adopts a coarse timing synchronization scheme which bases on the symmetry-related of received PSS to reduce the amount of calculation [2]. Specific steps of the scheme are: receiving half frame data (assuming that the half frame data contained a complete PSS), with the first point of data as a starting point, followed by removing 2048 point, with r(n) representation and divided r(n) two portions. Then doing a sliding correlation calculation for the two parts of the data, the maximum value of calculation result is the approximate location of the PSS, the correlation function by the following formula (2):

$$|C(d) = \left|\sum_{n=0}^{N-1} r(d+n)r^{*}(2047-n+d)\right|$$

Which N represents the correlation window length, i.e., is the length of half OFDM symbol. When the down-sampling rate is set to 1/16, take 64. The position of PSS approximate can obtained from the formula (3):

$$\hat{d} = \arg\max_{d}\{C(n)\}$$

4. SIMULATION METHODOLOGY

Connected-mode mobility performance is evaluated by means of advanced simulations. The system level simulator implements the mobility mechanisms defined by the 3GPP for LTE, including physical-layer measurements, Layer-3 filtering and reporting events.

The RSRP, RSRQ and Signal to Interference plus Noise Ratio (SINR) for each user are calculated on each time-step, followed by the SINR to throughput mapping estimation. Effects of scheduling, link adaptation, Hybrid Automatic Repeat Request (HARQ) and Multiple Input and Multiple Output (MIMO) are included. The tool has been used in several standardization and research studies, such as [7], [12], [13].

More details on the simulator can be found in [14]. A total of 630 users are dropped in the simulations, divided into slow- and high-speed users. Ten slow-speed users per macro area are considered, moving at 3 kmph. Each of the users follow random directions thorough the whole scenario, shown in Figure 1. The purpose of these slow-users is to generate background interference. Additionally, 400 users moving at 130 kmph are dropped along the highway.

The stretch of the highway is modeled with two lanes per direction, and each high-speed user is randomly assigned to one lane. Among all simulated users, statistics are only collected from the highway users. All users in the network generate traffic according to a Poisson process. For the baseline case, a fast transition between small cells is favored by setting a Time-To-Trigger (TTT) of 40ms.

Macro to-pico handovers are set to a larger TTT to ensure that the signal from the small cells is stable for a longer time, thus avoiding Radio Link Failures (RLFs). For DC simulations, the SeNB events are also set to 40ms of TTT so that, results can be compared with the baseline case. Moreover, a fast transition between small cells is guaranteed by setting the SeNB change.

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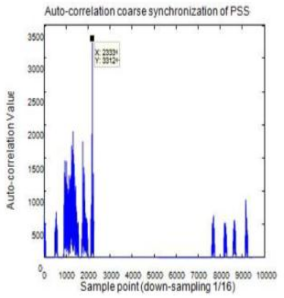


Figure 1. Simulation of Coarse Timing Synchronization Algorithm based on the Symmetry-Related of Received PSS

As we can observe in the Figure 1, the maximum value is very clear, the maximum value of the abscissa is 2333, which the position in the received data by converting is 35280. The actual location of the PSS is 35265, which has a 15 points difference with simulation results. As a result of down-sampling processing, which sampling rate is 1/16, 15-point difference can be accepted. After finding out the approximate location of the PSS, the group the maximum value located corresponding to u, which is the root index of the received PSS, and the value of (2) ID N can be obtained by correspondence between u and root index.

5. FINE TIMING SYNCHRONIZATION

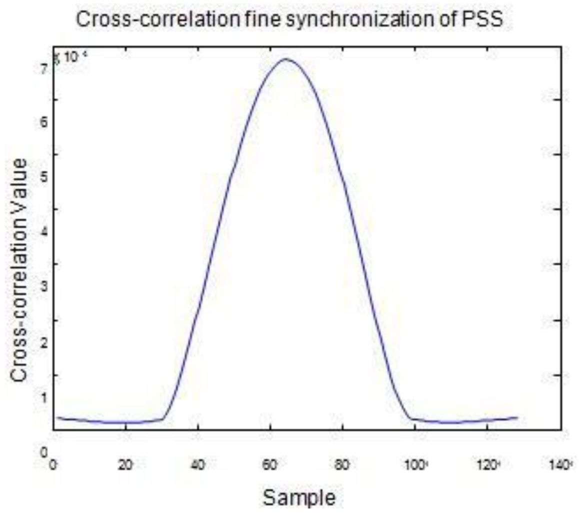
Coarse timing synchronization just has found the approximate location of the PSS, but synchronization accuracy does not meet the requirements; it also needs fine timing synchronization. In this case, the fine timing synchronization can be reduced to , represents the point of coarse timing synchronization. This paper adopts related algorithm [3] between the received PSS and the local PSS to fine timing synchronization. ^ ^ [* 1 6 6 4, * 1 6 6 3] First, we use the obtained from coarse timing synchronization to generate locale frequency-domain PSS, and then convert it to the time domain by IFFT. Then, making a sliding correlation calculation between the received data before down-sampling and the 128 point time-domain PSS in the range . Correlation function shown by the formula (4): (2) ID N ^ ^ [* 1 6 6 4 , * 1 6 6 3] d d

$$C(d) = \sum_{n=\hat{d}*16-64}^{\hat{d}*16+63} \left|r(d+n)s^{*}(n)\right|^{2}$$

The maximum value calculated by the formula (5) is the position of fine synchronization:

$$\hat{d}_{PSS} = \arg\max_{d}\{C(d)\}$$

Getting the exact location of the PSS indicates that we have completed the half-frame synchronization. Simulating the coarse timing synchronization scheme with MATLAB, simulation condition setting: channel is a Gaussian white noise channel, SNR is -10dB, CP for general CP, timing offset is set to 0, offset is set to 2000Hz, the (2) ID N used for PSS of send signal is 1. The simulation is shown in Figure 2:



6. IP DESIGN

To ensure the accuracy of cell blind detect module, the input and output data were chosen different accuracy for different functions of the module.

（1）The accuracy for the input and output data of FFT function is Q15, and its width is 32bit, which the high 16bit data represent the real part, and the low 16bit data represent the imaginary part.

（2）These two functions which produce local PSS sequence and local SSS sequence have no input data. The accuracy of their output data is Q15, width is 32bit, each of the real and imaginary part has 16bit.

（3）The input and output data of the function which finds the maximum values are real, which use 32bit width of data to represent.

（4）The accuracy for input data of calculating PSS sequence impulse response function is Q15 is Q15. The input and output data of the function are 32bit, and each of the real and imaginary part has 16bit.

（5）The accuracy for input data of M0 and M1 estimate function is Q15, which output data is real and width is 32bit, each of the real and imaginary part has 16bit.

The width of the data through calculation will be greater than the width of original data. To ensure a consistent between the input and output data, this module would make normalization with the maximum value of the above data.

Structure Description:

Hardware architecture of cell blind detect module be showed in Figure 3, by five components: input module, interface module, control module, memory module and function module. As we can see from the Figure 3, the interface bus of module Regif is ZSP, which can read and write data from memory or register, configure parameters, get the running status of the module by querying, and determine the end of the module operation by the interrupt flag; Module Mainctrl control the entire hardware flow and functional modules; Module Core is the core of the hardware, which complete specific functions of the hardware required to achieve; Module Mem completes ZSP bus and functional modules to access memory resources, including input and output data from memory.

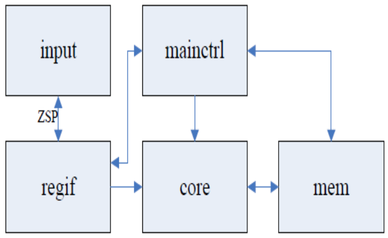


Figure 3. Cell Blind Detect Module Hardware Architecture

7. PERFORMANCE ANALYSIS

The number of events and the connectivity distribution that a UE experiences. As can be seen, this scenario is especially challenging due to the large number of mobility events. When using single connectivity, a UE at 130 kmph experiences an average of 4176 handovers per hour, corresponding to 1.16 events per second. The device is connected to the small cells 96.6% of the time, where intra-frequency handovers between the small cells dominate the statistics. For DC, the total number of events increases because each UE maintains two active links. However, MeNB handovers are reduced by 83%, with a total number of 0.2 events per second. In this case, SeNB changes are dominant with 1.3 events per second. The latter is expected because the mobility parametrization of 1 dB offset favors it. On average, a UE is operating in DC 95.7% of the time. No RLFs or HOFs are observed in the simulations for single and dual Connectivity. In general, results show how DC is able to reduce the overall experienced data interruption time. In real implementations, the interruption times will lay in between the presented numbers. For example, data forwarding between nodes may not always be available, resulting in larger delays for split bearer. On the other hand, results for SCG can be improved with some mobility enhancement techniques –like preparing cells as the UE moves along the highway to anticipate the mobility events and forward data towards the target cells– reducing the interruption times. Nonetheless, the presented numbers show that the improvement provided by split bearer may not be sufficient to deal with the 5 ms end-to-end latency required by the vehicular use-cases envisioned for the next generation of mobile networks [10]. Additionally, the cost in terms of signaling is also becoming a potential issue as the users experience a large number of mobility events.

8. CONCLUSION

This paper proposes a cell blind detect algorithm scheme, and designs a corresponding IP which has considered accuracy, area, and power consumption, scalability from the perspective of ASIC implementation. As future work, it is recommended to investigate solutions to reduce the interruption time and the signaling load towards fulfilling the requirements imposed by the envisioned use cases for the next generation of mobile networks.

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