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# Efficient Neighbour Cell Detection in LTE Systems

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**ABSTRACT**

This paper provides more prominence for the eNodeB to use reliable and robust algorithm for self configuration of the Neighbor Cell List (NCL). The novel NCL selection scheme is based on Potentially Worst case Carrier to Interference (PWCI) which, in contrast is more promising than the conventional Receive Signal Strength Indicator (RSSI) based cell identity detection of neighbor cells that maximizes the performance of the system. The proposed scheme utilizes the PWCI as a threshold for neighbor cell ID detection under high noise and interference scenario rather than the empirically generated RSSI threshold. Simulation results shows that proposed self configured NCL detection improves the performance rate by 7% and achieves the probability of right cell ID detection around 85% under noisy environment, moreover the success rate for the cell ID detection for fixed time offset and carrier frequency oscillation(CFO) at different cases also improved by about 20% based on the existing scheme.



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## INTRODUCTION

3GPP LTE is a new radio access technology to provide a smooth migration towards Fourth Generation (4G) network (Amirijoo *et al*., 2008). LTE is an advancement of Universal Mobile Telecommunication Systems (UMTS), the UMTS should educed from the management which simplifies auto configuration and optimization process (Sujuan Feng and Eiko Seidel, 2008). The system configuration is automated through E-UTRAN NodeB (eNB), where each eNB maintains a list of cells that are the targets for connecting the interface, and this list of cells is called Neighbor cell List (NCL). It is designed to increase the capacity, coverage and speed as compared to the earlier wireless systems (Kim *et al*., 2010 and Li and Jantti, 2007). LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) in the downlink and single carrier frequency division multiple access (SC-FDMA) in uplink multiple access scheme. It also configures and optimizes the NCL autonomously reducing human interaction (Nguyen and Claussen, 2010). eNB transmits signals directly among the cells and handover (HO) the signals between the neighboring cells. However, in reality the signals are not transmitted properly due to RF signal degradation in the limited scenario and in the mixed cell environment. Hence the delays occur during HOs. Thus the self configuration and optimization of the initial NCL is required for eNB by eliminating HO.

Initial work on NCL and eNB scanning methods was studied by Kim,Shin *et al*., 2010. The identification of cell currently in the NCL and ranking them based on the received signal quality was realized in (Guerzoni *et al*., 2005). The problem of missing neighbors was also addressed by (Guerzoni *et al*., 2005). (Soldani and Ore, 2007) Proposed an enhanced procedure for efficient identification of missing neighbor and setting of thresholds to filter and limit the pool. An automatic creation of NCL for newly installed cells was proposed in (Parodi *et al*., 2007). The neighbor cell relation and physical cell ID self organization in LTE was discussed in (Amirijoo *et al*., 2008). The existing methods dealt with the physical layer cell ID detection using RSSI (Received Signal Strength Indicator) and eNB scanning methods is used for collecting the information reflecting the real radio environment via SINR data transmitted from the adjacent cells (Kim,Shin *et al*., 2010). The signal strengthens more at center of the cell coverage area rather than the actual boundaries where the signal gets weaker and weaker due to HO (Amirijoo *et al*., 2008 and Marco Carvalho and Pedro Vieria 2011).

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***System model:***

Initial access procedure of a LTE system consist of three steps namely Cell search, System information receives and Random access. Cell search is used to identify a cell and the mobile obtain its physical layer cell identity and estimate the frame timing of the desired cell even during HO. It includes synchronization between UE and the cell, thus acquiring the information about cell. This can be achieved by using two synchronizing signal generations: the primary synchronization signal (PSS) and secondary synchronization signal (SSS) which broadcasts in each cell.

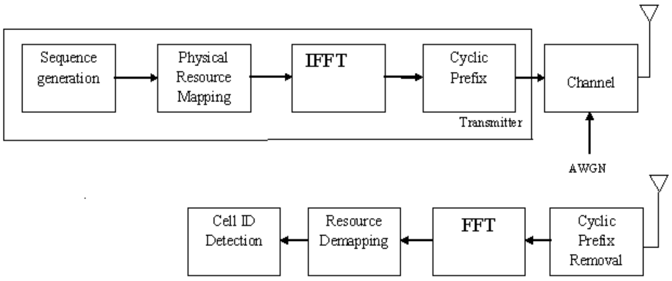


**Fig. 1:** Block diagram of signal transmission and reception.

According to 3GPP LTE specification (Sujuan Feng and Eiko Seidel, 2008), downlink transmission is organized into radio frames with duration of 10ms.Each radio frames consists of 10 sub-frames, each with two consecutive 0.5ms slots. A dedicated synchronization channel (SCH) is specified in LTE for transmitting two synchronization signals, the primary (P-SCH) and the secondary(S-SCH). Within the SCH, both synchronization sequences are mapped on 62 subcarriers located symmetrically around the DC-carrier. They are transmitted with the last two OFDM symbols of the first and sixth sub-frame (sub-frame index 0 and 5), that is every 5ms.

We generate PSS and SSS sequences for more than 8 neighbor cells with different signal powers. The PSS and SSS provide the UE with its physical layer identity with the cell. It supports 504 possible physical layer cell identities and is divided into three groups. Each has 168 layer identities for the formation of cell ID. These signal provide time and frequency synchronization within the cell.

Physical layer identity

$$N_{ID}^{cell} = 3\,N_{ID}^{(1)} + N_{ID}^{(2)}$$
$$N_{ID}^{(1)} = 1, \ldots, 167 \ and$$
$$N_{ID}^{(2)} = 0,1,2 \qquad (1)$$

The generated sequence (data's) and the filtered signal in the receiver are implemented using IFFT and FFT respectively. The performance analysis is estimated with respect to the probability of detection, the error rate of the cell ID detection and the success rate is measured with varying SNR scenario.

***Ncl optimizatoin approach:***

Optimization process collects the measured information from UE and eNB to select the neighbor cells from the NCL. It auto tunes the configured data to optimize the network. This is an operation state process which starts optimization and allows a more fast and accurate resolution of network problems. The optimization tasks includes Neighbor list optimization, Coverage and capacity optimization and Inter-cell interference coordination.

***RSSI Optimization Technique:***

In the existing optimization technique, a neighbor cell is dynamically added to the NCL if the percentage of handovers from the serving cell to the neighbor cell is above a predefined threshold. Test frequencies are added to the neighbor frequency list for the mobiles to measure the cells that are not in the current NCL but this fails at the weaker signal level (Kim *et al*., 2010).

The received signal is given by,

$$y(t) = X_m(t) + n(t) \qquad (2)$$

Where,

$X_m(t)$ is the input reference signal from current cell and adjacent cells and $n(t)$ is the Additive White Gaussian Noise.

The received signal strength can be achieved by

$$|y(t)|^2 = |y(\omega)|^2 \qquad (3)$$

Here

$$RSSI = 10 * log_{10}(|y(\omega)|^2) \quad (4)$$

Where, $|y(\omega)|^2$ is the received power level of the target cell. The RSSI can be measured in mW or dBM. Thus, the measurement of the signal strength of an LTE cell helps to rank between the different cells as input for handover and cell re-selection decisions. The RSSI is the average of the power of all resource elements which carry PSS and SSS signals over the 1.08MHz bandwidth.

***PWCI Approach:***

The objective of the proposed scheme is the neighbor list optimization to automatically reconfigure the NCL and to maximize the network performance. This should also eliminate the handovers and to set a threshold for cell reselection. We investigated the effect of various SINR by which neighbor are determined.

$$PWCI \leq \frac{|X_T(\omega)|^2}{\sum_{m=0}^{M}|X_m(\omega)|^2+\sum_{n=0}^{N}|X_n(\omega)|^2+R_{NN}(\omega)} \quad (5)$$

$|X_T(\omega)|^2$ Input signal strength of the target cell.
$|X_m(\omega)|^2$ Input signal strength of the neighbor cells which uses different cell IDs.
$|X_n(\omega)|^2$ Input signal strength of the neighbor cells which uses same cell IDs.
$R_{NN}(\omega)$ Noise spectral density

***NCL configuration scheme:***

1. Collect the information (cell identifier, CINR, and etc.) of adjacent cells utilizing eNB scanning.
2. Determine the neighbor cell of which measured SINR is higher than PWCI of the target cell among the detected cells.
3. Configure the initial NCL containing the determined cells as the neighbor cells.
4. Connect the direct interface between the newly deployed eNB and the eNBs of the neighbor cells (Kim *et al*., 2010).

After the completion of the NCL configuration procedure by the newly deployed eNB, further process should be followed by eNB of the neighbor cells. If there is a change in the network topology, new neighbor cell must be added to their NCLs by eNBs. Generally the networks demand to manually update neighbor cells from the operators, but in LTE systems a newly deployed eNB sends its identification information while establishing direct interface based on the NCL. Thus neighbor cells update their NCLs (Kim *et al*., 2010). The system parameters considered for the simulation of the LTE cell search environment are listed in Table I.

**Table I:** Simulation Parameters.

| Parameters | Value |
|---|---|
| PSS Sequence | Zadoff Chu Sequence $N_{ID}^{(2)} = 0,1,2$ |
| SSS Sequence | m-sequence based $N_{ID}^{(1)} = 0,1,2..167$ |
| Number of Neighbor cells | 6 |
| Bandwidth | 10MHz |
| Sampling Frequency | 15.36MHz |
| Centre Frequency | 2.4GHz |
| CP Type | Normal CP |
| Duplexing Mode | FDD |
| Channel Model | Extended Vehicular A Model |
| SNR | (-6dB to 12dB) |
| Timing Error | 10 µs |
| Frequency Error | 1 ppm |

## RESULT AND DISCUSSIONS

We had carried out simulations with respect to probability of detection and error rate under high noise with different channel scenarios and variation in SNR. Thus we can evaluate the performance analysis of the proposed PWCI based neighbor physical layer cell ID detection of the self optimizing network.

The conventional RSSI based detection schemes require empirically generated threshold for the right detection of the neighbor cell ID. The simulated results shows the Cell ID detection probability and false alarm probabilities of the conventional RSSI approach and the proposed PWCI approach under AWGN and high noise variance scenarios. The probability of the correct detection achieved is around 85% under such noise conditions. With this PWCI based approach, we can achieve improved detection probability under such scenarios which are clearly illustrated in Fig. 2.

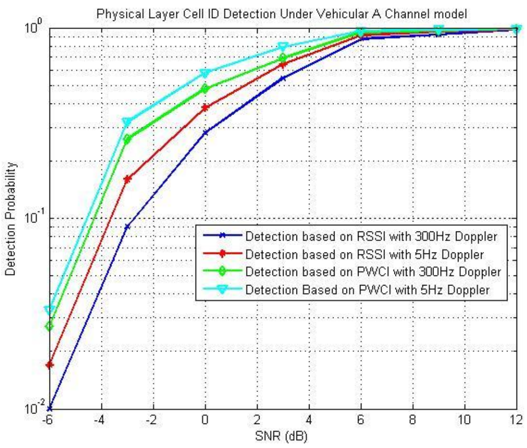


**Fig. 2:** Detection performance of $N_{CELL}^{ID}$ of NCL.

Fig.2 shows the detection probabilities of the proposed PWCI based Physical layer cell ID detection of the first neighbor cell under low (5Hz) and high (300Hz) Doppler scenarios as compared to the conventional RSSI based detection technique even when the SNR is -6dB. Also, PWCI based detector gives better performance under high Doppler and low Doppler conditions than the conventional detector and improved by about 7%.

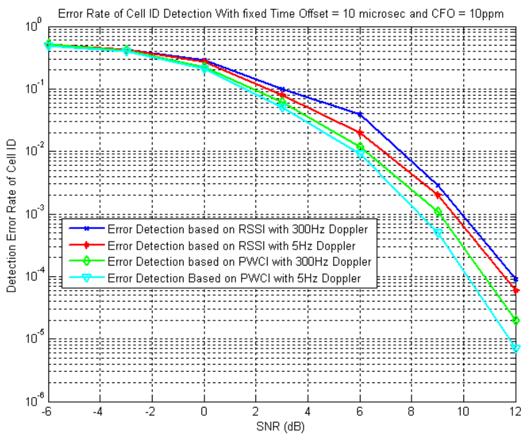


**Fig. 3:** Error performance of $N_{CELL}^{ID}$ of NCL.

Fig.3 shows the error probabilities of the PWCI and RSSI based methods under low and high Doppler scenarios with fixed timing error of 10 µs and frequency error of 2.4KHz and shows that the PWCI based detection provides around 30% improved error probability under Doppler scenarios as compared to the conventional RSSI based detection technique even when the SNR is 0dB.

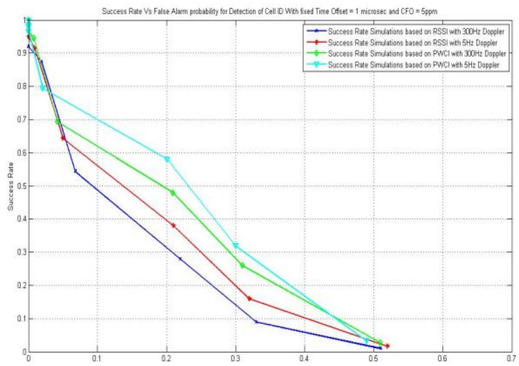

**Fig. 4:** Success rate of $N_{CELL}^{ID}$ of NCL with fixed time offset=1ms and CFO=5ppm

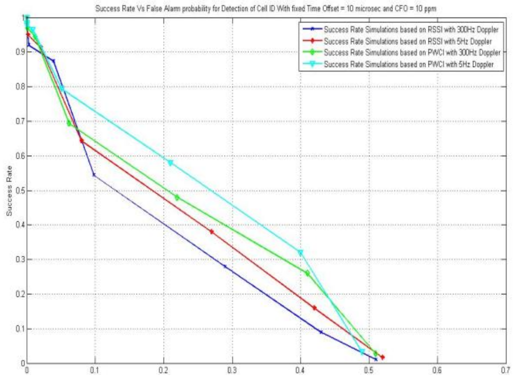


**Fig. 5:** Success rate of $N_{CELL}^{ID}$ of NCL with fixed time offset=10ms and CFO=10ppm .

Fig.4 and Fig.5 shows the success rate vs false alarm probability of cell ID detection of the PWCI and RSSI based method with fixed time offset and carrier frequency oscillation (CFO). The HO target searching success rate determines the quality of the NCL. At different scenarios of timing offset and CFO were measured and the graph shows the increase in the success rate by about 20% in the proposed method in the high noisy environment and thus the quality of NCL gets improved.

***Conclusions:***

The developed and proposed PWCI based PHY layer cell ID detection detects even under high noise and interference scenario. This has been captured under 3GPP specified EVA channel model which outperforms under high doppler condition. It also improves the error probability to around 35% to a great extent compared to the conventional empirically generated RSSI based detection even at SNR of 0dB. The performance rate and the probability of the right cell ID detection have been improved under noisy environment. The success rates of cell ID detection for fixed time offset and CFO at different cases are increased by 20% than the existing scheme. Therefore the proposed method is more reliable and robust towards the timing and frequency offsets and highly pertinent in the mixed cell environment.

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