

1. **Invention Title.**

Energy Efficient Handover Preparation in Cellular Networks

2. **Invention Summary.**

This invention describes a method to optimize the cellular handover process that requires the handset to only switch on GPS circuitry rather than full RF receiver most of the time, which results in an energy saving of 15x for the handset, compared to the approach in the current 3GPP specifications.

3. **Invention Description.**

a. Describe the invention in detail.

In the cellular environment, the handover process from one eNB (base station) to another is UE-assisted and network-controlled. In a nutshell, as long as a UE (e.g., cell phone, portable hotspot, tablet) is switched on, it continuously measures RSRP (reference signal received power), RSRQ (received quality), etc of its own cell, as well as that of the neighboring cells, at a fixed time interval. Once an event is triggered, such as a neighbor cell's RSRP is higher than serving cell's RSRP plus a threshold, the UE sends a measurement report to the eNB signaling the start of the handover process. The list of events is specified by the eNB.

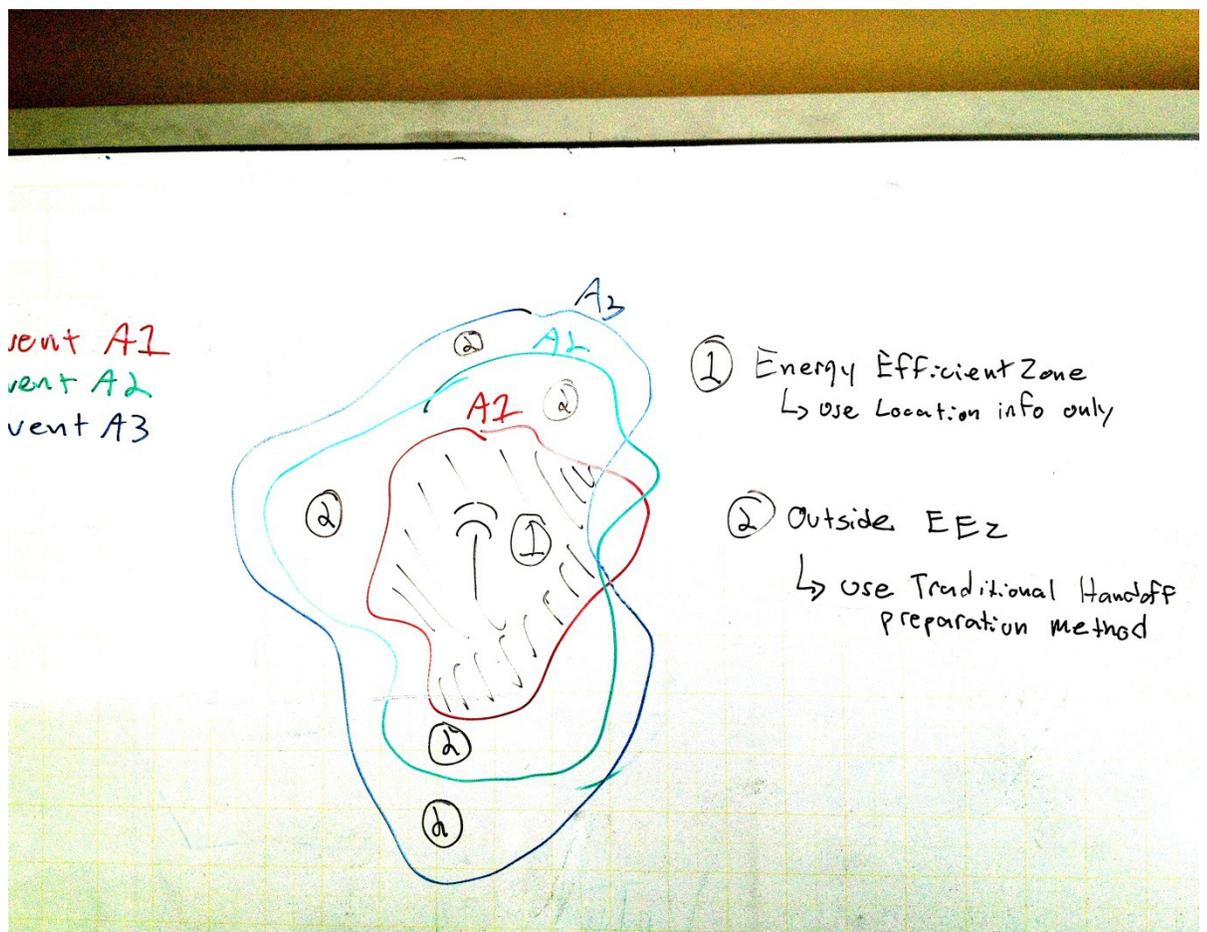
The problem with traditional approach is the high power consumption required of the UE for making the required measurements, for both current serving cell as well as all neighboring cells, for as long as a UE is switched on. The power consumption of an UE that is not actively transmitting and receiving (i.e., in IDLE state) is around 20mW. When UE is in non-IDLE state, and is receiving signals, it expands around 1000mW. And when UE is transmitting signals, it expands around 3000mW.

This invention disclosure proposes a method to use the motion and/or position of the UE to assist eNB to make handover decisions. When a new cell is switched on, all UEs currently served by the new cell perform measurements as currently specified in the cellular standards for a finite period of time. Based on measurement reports, the new cell builds an "Energy Efficient Zone" map (EEZ) (see Figure 1). To create this map, the cell tracks the UEs' locations at the time measurement reports were triggered, and creates a polygon for each event type whose the boundary corresponds to where the measurement reports are made.

Once the EEZ map is built, it is sent to the UEs. Instead of requiring the UE to constantly perform traditional measurements even if UE is nowhere near a cell's coverage boundary, UEs can turn on only its GPS receiver and use location information and the EEZ map to determine if handover preparation procedure is necessary, i.e., switching on the entire receive radio circuitry and perform a full spectrum measurement of the reference signals transmitted by UE's serving cell and neighboring cells. In other words, UEs within the EEZ do not need to turn on the receive radio and make measurements on reference signals.

A typical GPS expends 62mW when it is active. Today's smartphones typically implements A-GPS (assisted GPS) that uses the cellular network to acquire initial lock to the GPS signal quickly, then transitions to traditional GPS mode. Therefore, when location measurements are made at the same periodicity as what the traditional method requires for measuring received signal power, a minimum of 15x reduction (i.e., $1000\text{mW} \div 62\text{mW}$) in power consumption can be achieved once the device has locked on to the GPS. This saving continues for as long as the UE remains in the EEZ. The power savings will be especially pronounced for UEs staying within the EEZ for significant period of time, e.g., home, office, or shopping center locations within the EEZ.

Figure 1: Coverage map for event 1 is red, coverage map for event 2 is green, and coverage map for event 3 is blue. The intersection of the 3 maps is the Energy Efficient Zone (EEZ).



- b. **Why was the invention developed? What problem(s) does the invention solve? How is it better?**
 This invention greatly reduces the energy consumed is the general consumption of power by cellular devices, i.e. using less is always better.

c. **Briefly outline the potential commercial value and customers of the invention.**

This invention will benefit UE component and UE vendors by reducing power consumption during normal operations. Reduced power consumption will increase battery life, which benefits end users.

4. **HOW is your invention different from existing products, processes, systems?**

Current solutions use periodic measurement of the multiple base station reference signals. This requires the UE to turn on the receiver circuitry for an extended period of time and scan multiple channels. After scanning, processing is done to calculate the relevant parameters and evaluate them against the network-configured thresholds.

The proposed invention allows the UE to use a lower power method during stationary times within a good reception area that we call the Energy Efficient Zone.