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# Technology Offer

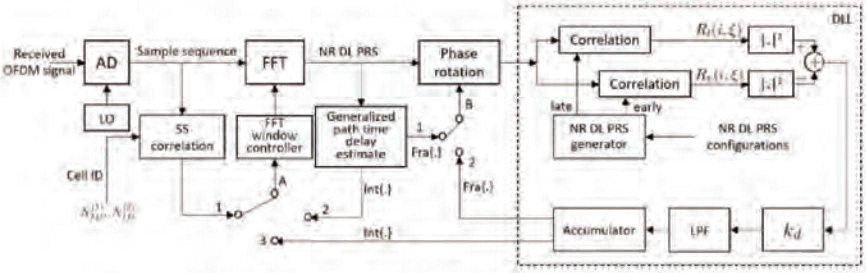
# 5G Positioning Using Code Phase and Carrier Phase Receiver

## Technology Overview

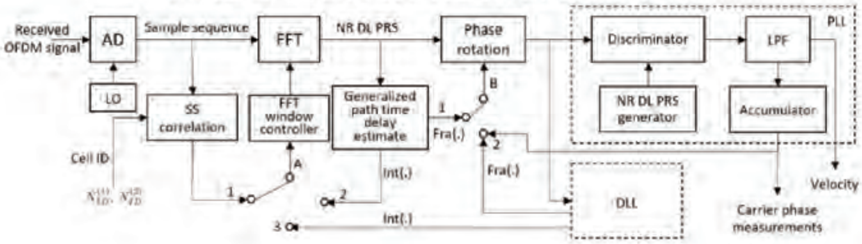
The fifth generation of mobile technology (5G) is designed to provide enhanced mobile broadband (eMBB), ultra reliable low latency communications (URLLC) and massive machine type communications (mMTC). According to IMT-2020, 5G is supposed to perform ten to hundred times better in terms of peak data rate, latency and connection density. Due to the ubiquity of communication network, it also provides an added value on positioning services even in some GNSS-denied or constrained environments, e.g., indoors, urban canyon. The fundamental positioning techniques of cellular networks are classified as trilateration, triangulation, proximity, scene analysis and hybrid. Among which, time of arrival (TOA) based trilateration is one of the common methods utilized from 2G to 5G.

Positioning Reference Signal (PRS) is first defined in Long-Term Evolution (LTE) to perform TOA measurement as pilot signals. Another candidate of pilot signals in LTE for TOA measurement is the cell-specific reference signals (CRS). In 5G standards, the CRS is removed. Taking on the legacy of LTE, 5G utilizes Orthogonal Frequency Division Multiplexing (OFDM) waveform with flexible numerology. The first commercial 5G network was launched in 2019 based on the Release 15 specifications. Only since Release 16 forwards, 5G new radio (NR) downlink (DL) PRS was defined in 3rd generation partnership project (3GPP) Technical Specification (TS) 38.211 and TS 38.214. Until March 2020, corresponding positioning procedures and 5G NR DL PRS configurations were finalized in TS 37.355. These specifications pave the way for further verifying the performance of 5G PRS based positioning services. 5G NR PRS has flexible configurations and patterns, which are different from that of LTE CRS or other pilot signals adopted in OFDM system. There is a requirement of having proper timing recovery solution for 5G standard-compliant pilot signals, e.g., 5G NR PRS, thus, obtaining accurate timing estimate.

The proposed code-phase timing recovery solution is suitable for generalized pilot signal pattern including 5G NR DL PRS. It can be integrated with current 5G NR commercial network directly. The positioning process complies with that of 3GPP 5G standards. The proposed 5G carrier phase receiver provides more accurate carrier phase measurements and additional velocity estimate. The proposed 5G code phase receiver and 5G carrier phase receiver could potentially provide a more accurate localization service in 5G networks. The technology owner is interested in seeking technology licensing collaborator or manufacturing partner.




**Block diagram of the proposed 5G NR DL PRS code phase-based receiver**

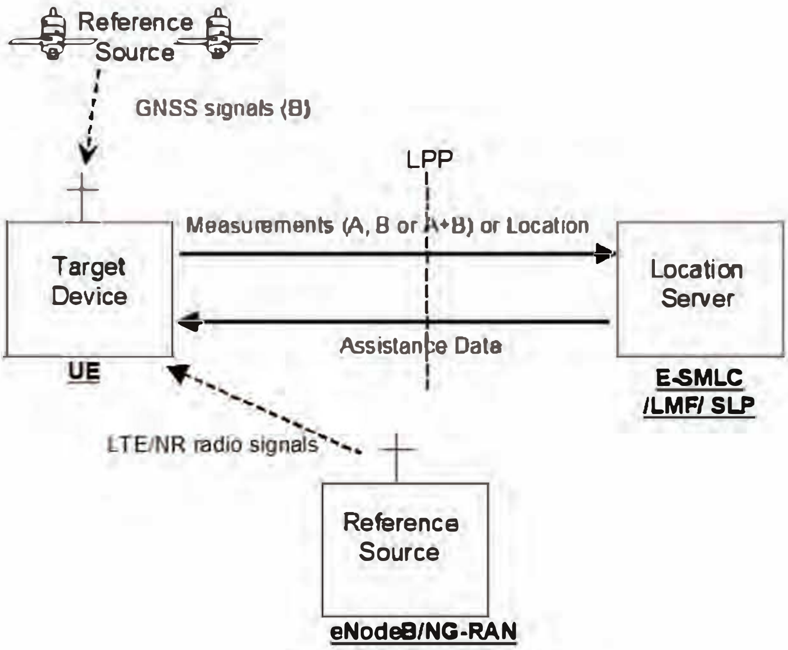



5G Carrier Phase Receiver

## Potential Applications

As shown in clause 4.3.1, 3GPP TS 38.305 (V16.0.0), the current 5G network supports downlink time difference of arrival (DL-TDOA) positioning method for localization services. 5G NR DL PRS is the potential reference signal adopted by 5G standards for measuring reference signal time difference (RSTD) in DL-TDOA. In addition, 5G NR DL PRS is defined in Release 16 (3GPP TS 38.214 (V16.1.0) and TS 37.355 (V16.0.0)). In the near future, the commercial 5G networks will support NR DL PRS based positioning method.

According to 3GPP TS 37.355 (V16.0.0), LTE Positioning Protocol (LPP) is used as point-to-point between a location server (E-SMLC, LMF or SLP) and a target device (UE or SET) to position the target device using position related measurements obtained by one or more reference sources. Internal LPP positioning methods and associated signalling content include NR DL-TDOA. The timing recovery scheme described in this invention aims at implementing user equipment (UE) localization using the NR DL PRS signals in the actual 5G commercial network through NR DL-TDOA positioning method.




LPP Configuration [TS 37.355]

The figure above illustrates the positioning protocol in LTE and 5G NR networks. Our invention conforms to the 5G NR standards and positioning protocol in the following way:

1. Once the localization service is initiated, the UE will NR DL PRS configuration of multiple base stations, i.e. NG RAN, through assistance data defined in 3GPP TS 37.355 (V16.0.0) including but not limited to NR-DL-TDOA Assistance Data.

2. With NR-DL-TDOA Assistance Data, UE obtains NR DL PRS reference signal configuration and pattern, together with other system information including frequency bandwidth, UE could receive and demodulate the expected NR DL PRS signals from expected gNodeB.

3. After sampling the received NR DL PRS carried by CP-OFDM waveform, UE could apply the proposed three stage code and carrier phase receiver to have an accurate estimate of timing error, the resulting time of arrival (TOA) will be obtained.

4. Multiple gNodeBs result in multiple TOA at the UE, which can be used to calculate the NR DL TDOA on either UE or location server side. The measurements or location results could send back to location server.

It illustrates that the proposed code and carrier phase receiver can be integrated with the current 5G NR commercial network directly. The positioning process complies with that of 3GPP 5G standards. The proposed method could potentially provide a more accurate localization service.

## Benefits

By applying this technology, the 5G-based positioning performance can be improved due to the introduction of phase-locked loop and corresponding carrier-phase based measurements, which play a similar role with that in GNSS positioning applications. The proposed method can be compatible with current 5G standards and commercial networks, which results in a more efficient and cost-effective positioning solution.

Please contact A/Prof. Tay Wee Peng (NTU) for further discussions on this technology.



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