RAN-R18-WS-non-eMBB-DanKook_University - Version 0.0.2
RAN

3GPP TSG RAN Rel-18 workshop RWS-210563

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.2

Source: Email discussion moderator (DanKook University)

Title: Email discussion summary for [RAN-R18-WS-non-eMBB-DanKook_University]

1 Introduction

This document is to provide opportunity for comments , Q&A on DanKook Unversity contibution

RWS-210285 Motivation for new SI: Study on Carrier Phase Positioning, DanKook University

to help better understanding of the proposals among companies.

Note: there will be two rounds in this Q&A session.

Round 1: Questions: June 14 08:00 UTC – June 17 8:00 UTC; Answers: June 17 8:00 UTC – June 18 23:59 UTC

Round 2: Questions: June 21 08:00 UTC – June 23 8:00 UTC; Answers: June 23 8:00 UTC – June 24 18:00 UTC

A summary will be provided by the moderator before June 25, 18:00 UTC.

2 Carrier Phase Positioning Round #1 Q&A

2.1 Round #1 Questions (Locked)

Feedback Form 1: Comments or Questions

1 – CATT

Comments:

1) CATT shares the similar view of DanKook Univ that we should study the NR carrier phase positioning in R18 (CATT actually tried to promote NR carrier phase positioning since R16 (e.g., R1-1812615).

2) For the frequency range for carrier phase positioning, DanKook proposes to include FR2. Our concern is that the wavelength of FR2 is very short (e.g., wavelength is only 1cm when frequency is 30GHz). With the impact of the phase noise, it would be difficult to have reliable carrier phase measurements and very difficult to have the correct integer ambiguity resolution even the carrier phase measurements are correct.

Will DanKook explain the motivation to support NR carrier phase positioning for FR2?
2 – Intel Corporation (UK) Ltd Thanks a lot for contribution and interesting proposal. Overall, we agree that carrier phase based positioning has potential, but it requires more feasibility + benefits study and this study does not seem to be a small piece of work across multiple WGs. In particular, carrier phase positioning is sensitive to various types of impairments including synchronization in time/frequency at network and UE side (strict sync requirements are implied), phase continuity assumptions at gNB / UE side, phase noise impact, impact on RF, NLOS/multi-path propagation issues, impact from parallel data transmission by gNB, UE/gNB power consumption, etc. In addition, we will need to compare performance with the baseline R16/R17 solutions. Therefore, we would like to clarify whether you have comparison with the R16/R17 frameworks considering above practical aspects and in which propagation scenarios + for which KPIs do you expect significant benefits (e.g. NLOS and/or LOS environment)?
3 – Huawei Tech.(UK) Co.. Ltd Carrier phase based positioning requires high-accuracy sync between gNBs. Phase-based ranging method may require the motion of the gNB or UE to resolve integer ambiguity, such as the satellite, so this method can be applied to only limited scenarios.
4 – LG Electronics Inc. Q1: What's the difference between the proposed phase based positioning and the existing GPS positioning?

2.2 Round #1 Answer

Table 1:

Answer to CATT
1) Thank you for your comment. We appreciate CATT's pioneering proposals in the past for Carrier Phase, and we hope to work together with other companies for the improvement of 5G positioning in Release-18. 2) We believe the Carrier Phase or Subcarrier Phase technology can improve the 3GPP system function in three points. First, it can improve positioning precision, second, it can improve resolution of AoD (Angle of Departure), and the third, it can improve gNBs synchronization. In terms of angular resolution, carrier phase based method can significantly improve the performance of downlink AoD by transmitting an orthogonal signal via multiple antennas. This method has already been commercialized on Bluetooth or WiFi, and Qualcomm also has proposed a similar approach in (R1-2103172, R1-2101470). This technique can be applicable in both FR1 and FR2 bands, depending on the application scenario. Especially when applied to FR2 patch antennas, the carrier phase based method can be more accurate and efficient than the beam-sweeping method.

Table 2:

Answer to Intel Corporation (UK) Ltd

Thank you for the comments. As you said, I understand that you agree with the need for study on the feasibility and benefit of carrier phase-based method in Release-18. While the Phase Based measurement method is generally very precise, it is true that it is sensitive to RF impairments, multipath or phase noise. Nevertheless, technologies have evolved to overcome these effectively, especially when you design the signal structure well, you can overcome most of the difficulties. Hence, we argue that new design for phase based PRS signal may necessary. We have experiences, data and know-hows obtained from years of research. We also have results achieving centimeter grade accuracy with consuming narrow bandwidth. We would like to share our tips and experiences with companies through study item in Release-18. We hope to present detailed data on rel-18 studies when they are launched.

Table 3:

Answer to Huawei Tech. (UK) Co.. Ltd
As you mentioned, Integer Ambiguity is a very important issue in determining the performance of Carrier Phase. However, unlike satellites, 5G NR systems may offer a variety of ways to solve the problem of the Integer Ambiguity by designing the new reference signaling well. CATT also proposed potential solutions to this problem (R1-1901980, R1-21003642). We have also successfully applied a method to effectively solve this problem by exploiting subcarrier wavelengths that are longer than carrier wavelengths, and if this topic is selected as an important study item topic in Release-18, we hope to propose some solutions.

Table 4:

Answer to LG Electronics Inc.
Although the baseline approach is the same as GPS carrier phase technology, carrier phase in 5G NR may differ in that both the subcarrier wave signal that constitutes the OFDM signal and the carrier wave signal. The carrier wavelength is tens of centimeters long depending on the carrier frequency used, but the subcarrier wavelength of 5G NR can vary from meters to hundreds of meters depending on the subcarrier spacing. In 5G NR, both carrier phase difference and subcarrier phase difference are combined to achieve significantly better performance than GPS carrier phase. It can also be applied to a much broader use case than the GPS carrier phase, such as for sidelink application, angular positioning, vertical positioning, gNB synchronization, etc.

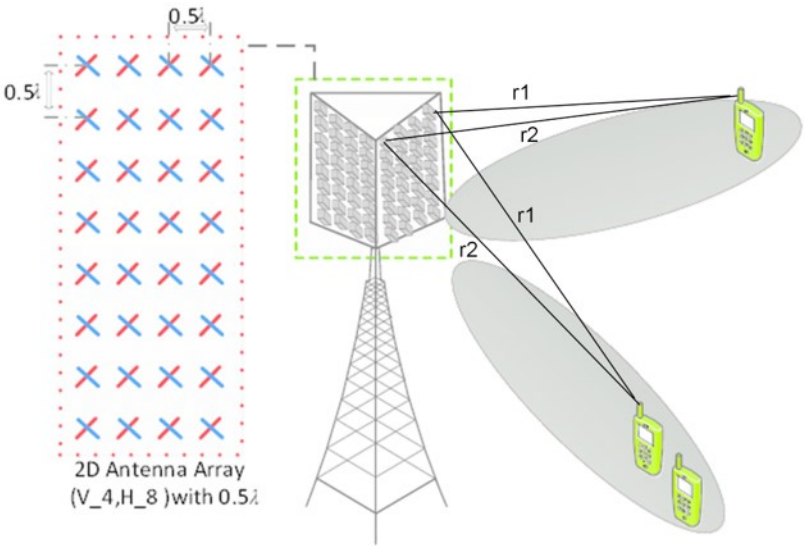

Figure 1: Carrier Phase Based DL-AoD Measurement using FR2 patch antenna

3 Carrier Phase Positioning Round #2 Q&A

3.1 Round #2 Questions (Locked)

Feedback Form 2: Comments or Questions (Round 2)

1 – KT Corp. KT fully supports introducing Carrier Phase Positioning in Release-18. Positioning enhancements has been continuously done in 3GPP RAN and this will also happen in Release-18. In terms of performance, we would like to find out the estimated positioning accuracy for both FR1 and FR2 (e.g. within 50cm outdoor?). Also, we would like to find out whether vertical (or 3D) positioning supported.
2 – LG Electronics Inc. Thank you for clarification. Q1: Considering multiple panel can be used for positioning especially in FR2 band, do you think the positioning performance can be improved if carrier-phase based positioning is combined with multiple panels mounted on a UE?

3.2 Round #2 Answers

Table 5:

Answer to KT Corp.

Thank you for KT supporting our Carrier Phase Positioning study proposal. We've already tested carrier phase technology in the FR1 band. In our outdoor experiment, we achieved less than 0.5m accuracy only using 30Mhz bandwidth. In particular, we have successfully demonstrated vertical positioning using this technology achieving less than 1m resolution. You can find the video of this demonstration at the link below. https://www.youtube.com/watch?v=Gj2Wzfh39So We believe 3GPP positioning accuracy can be further enhanced if carrier phase technology is introduced. This will not only satisfy requirements such as US E911 but it will also save countless lives.

Table 6:

Answer to LG Electronics Inc.
Thank you for LG question. As we have answered your questions in Section 2.2 above and in Figure 1, carrier phase technology can be applied in FR2 using a patch antenna. By allowing different subcarrier sets to be sent per vertical column or horizontal row of antenna elements, it can obtain a high angular resolution of DL-AoD by simple conjugate computation between the subcarriers. Qualcomm also presented a similar approach in (R1-2103172, R1-2101470). This method is not only accurate but it also consumes less resource compared to beamweeping methods.

4 Conclusion

Four companies asked questions in Round #1 and two companies questioned in Round #2.

The question is about the applicability of carrier phase in FR2, stability, practical feasibility of the phase measurement method, and there is also a question about Integer Ambiguity and the solution.

In response, DanKook University answered that the carrier phase method was already tested in our field experiment, and we believe it is matured and efficient method to achieve centimeter grade positioning accuracy.

We would like to note that many companies are supporting this method.

As for Integer Ambiguity issues, a number of solutions were already proposed in the past

and we strongly suggest that this issue should be studied further in release-18.

In our view, many company's support on carrier phase positioning is clear, hence we suggest this subject must be included as a key item in the study of positioning enhancement in release-18.