TSG-RAN Working Group 1 #17 R1-00-1389

November 13-17, Stockholm, Sweden

Agenda Item: Adhoc 29 (Positioning)

Source: **Panasonic**

Title: Simulation results for the OTDOA-PE positioning method

Document for: **Discussion**

Introduction

In R1-001186 the OTDOA-PE method was summarized, simulation conditions were described in detail, and initial results involving a single PE transmitting within IPDL idle slots were given. This paper presents further simulation results showing the performance of this method when additional PEs are deployed and also when it is used in normal operation, i.e. without idle periods. Qualitative answers are also provided on system level questions that were raised during WG1#16.

System issues

The main point made was the potential for the transmissions from PEs to confuse the initial synchronization process. The reasons that will prevent this from happening are the use by the PEs of codes that are not used elsewhere in the system, and the fact that PE transmissions could be configured so that at all possible UE positions PE code reception does not overlap with the beginning of the slots from the serving base station and if possible with none of the sync codes from the surrounding base stations.

Another important factor is that PE transmissions occur a maximum of once per frame so they can easily be distinguished from the system synchronization codes transmitted at the beginning of each slot. So, even if PE codes are received with high power and significant cross correlation products are generated with system codes, the synchronization procedure will not be affected.

Simulation conditions

One of the main differences from the initial simulations is that there are now simulation results whereby OTDOA measurements are made with the serving base transmitting (no idle periods). There is now a measurement slot, which has the same duration as the idle slot had in the IDPL simulations, i.e. 5 symbols of 256 chips. This means that even when more than one PEs become active within the same frame their reception will partially overlap the same 5 symbols in the serving Node B's frame that would have been power off to generate an idle slot. Although this introduces interference between PEs reducing the C/I for the detection of each PE code, it guarantees that the deterioration brought to the downlink of other users is always less than it would have been with IPDL.

The UE attempts to detect other Node Bs within these 5 symbols as well as the PEs. With the serving Node B always on the UE could use more than 5 symbols from the target CPICH in order to increase the processing gain. In the interest of UE complexity though we have assumed that the same small number of symbols is used. This reduces the contribution – in terms of OTDOA measurements - made by Node Bs and leaves room for implementation dependent improvement.

In the simulations with 6 PEs in a cell these transmit in alternate 'measurement periods' of which there are 10 in one second. This results in 3 PEs signals being contained in any 5 symbol period. Results show that the loss in diversity is more than compensated by the increased reliability of the detection process.

Simulation results

When the serving base station does not employ idle periods, the PEs constitute the main source of OTDOA measurements as was expected. With 6 PEs the percentage of measurement instances that result in position calculation – at least 2 OTDOA measurements – is by a large margin in excess of the equivalent figure for BTS CPICH measurements only. At the same time the positioning accuracy is significantly improved.

The overall result is that by employing a number of PEs in a cell we can achieve much better accuracy than by making only Node B based measurements. The improvement is possible not only with idle slots but also when Node Bs transmit continuously.

In most cases there are already enough OTDOA measurements from the PEs to calculate the UE position and these are usually more accurate than Node B measurements. Hence utilizing the Node B measurements tends to reduces the accuracy at the 67% point of the radial error CDF. The positive side of using the Node B measurements is that we end up with fewer instances where less than 2 OTDOA measurements are made.

Positioning results are now not only more accurate but there is also a much higher percentage of measurement periods that result in a calculation of position as opposed to an assumption being made that the UE is at the center of the cell. The practical consequence is there will be far fewer positioning related measurements that will need to be made as most first time measurements will produce a position fix. This then reduces loss in the downlink with fewer idle periods or fewer PE transmissions and also helps conserve UE power.

Conclusion

Simulations results have been presented that show significant increase in positioning accuracy when PEs are used in conjunction with IPDL. These improvements in accuracy are also possible with the OTDOA–PE procedure used as a stand alone method removing the need to frequently switch Node Bs off for very short periods.

Further refinements are possible and simulations will be used to investigate other PE configurations. However the potential of the PE method has been demonstrated and this could now be indicated to RAN WG2 via a liaison statement.

Appendix A

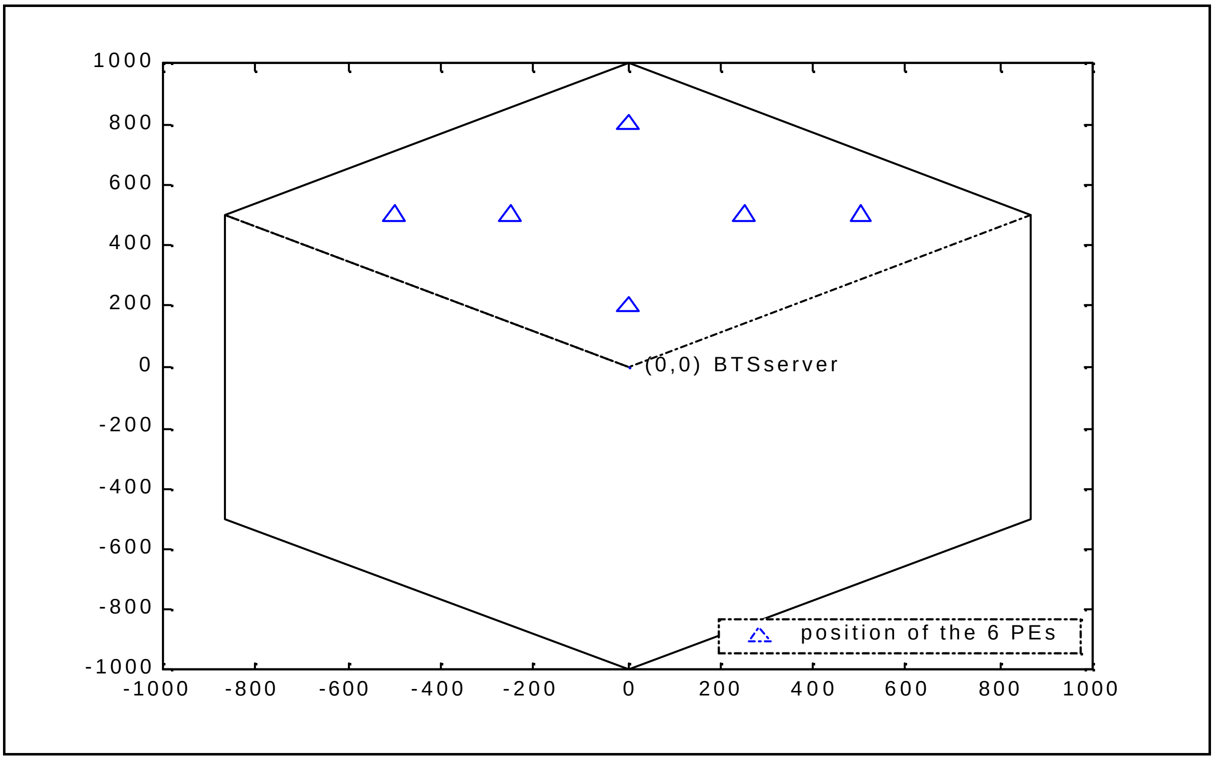

Figure 1: PE positions used in the simulation

Appendix B - Results for UrbanA environment

Table 1 : Summary of simulation results with 6 PEs

PEs power	Serving BTS status	References used for position estimation	Percentage of simulations in which the UE made at least 2 OTDOA measurements	67% error: at least 2 OTDOA measurements	67% error: all results	90% error: at least 2 OTDOA measurements	90% error: all results
1W	ON	BTSs	57.5%	420m	422m	676m	721m
		BTSs +PE	84.4%	193m	198m	590m	590m
		PE only	78.2%	188m	196m	556m	603m
2W		BTSs + PE	88.9%	160m	163m	536m	543m
		PE only	85.3%	148m	153m	542m	543m
0.75W	OFF	BTSs	70.3%	285m	299m	652m	684m
		BTSs + PE	99.3%	128m	128m	369m	369m
		PE only	93.8%	102m	106m	306m	320m

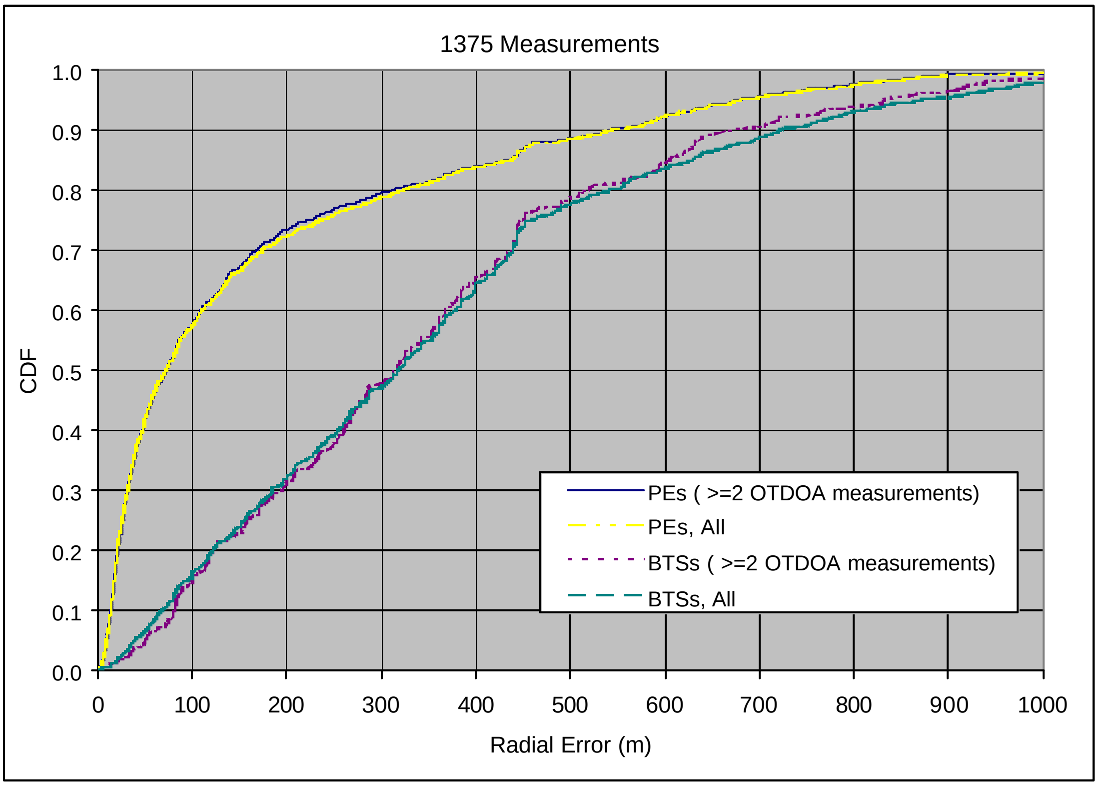

Figure 2: CDF of radial error for 6 PEs with no idle periods, PE power =2W. PEs signals only are used for detection

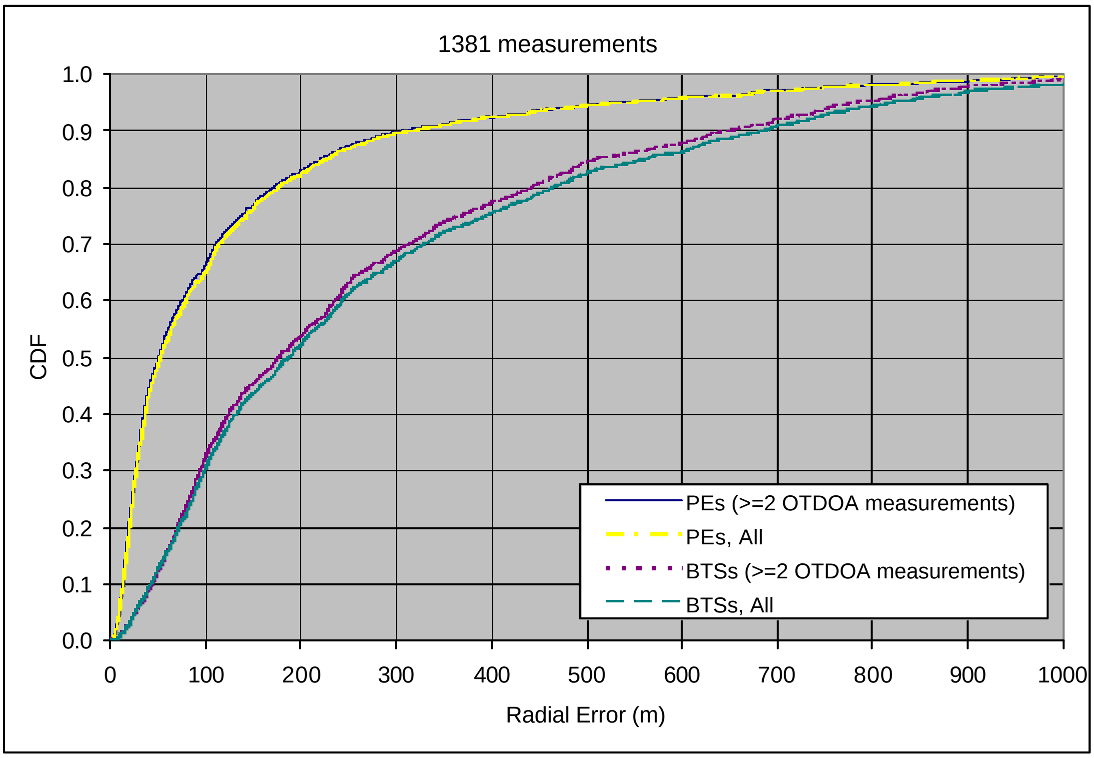

Figure 3: CDF of radial error for 6 PEs with idle periods, PE power =0.75W. PEs signals only are used for detection

The following figures shows groupings of three bar types. Each bar type corresponds to the type of reference points used for position calculation, BTS only, BTS and PE, PE only. The figure under each grouping shows the total number OTDOA measurements available. The height of each bar – and the number on the top – show in how many simulations runs the number of OTDOA measurements given by the number under the bar grouping was available for position calculation using the type of reference points associated with this bar type.

When considering BTSs or PEs the maximum number of references points is 6 and when considering both PEs and BTSs there is a total of 12 reference points. The maximum number of OTDOA measurements made was 8, this happened only once and constituted of measurements of PEs as well as BTSs. Cases whereby one Node B and one PE were detected would add to the tally for 1 OTDOA with BTS only (first bar type) and for 1 OTDOA for PE only (third bar type) but not for to the tally for 1 OTDOA with BTS and PE (second bar type) because in that case there are 2 OTDOA measurements available and it would fall under the third bar grouping (2 OTDOA measurements with BTS and PE as reference points).

So Figure 4 shows that without idle periods and PE power of 2W there are 504 simulations out of 1375 where not a single OTDOA measurement was based on Node B signals. For the PEs the number is 41 and there were 40 instances where neither PE nor Node B signals were detected. It should be noted here that the small number of BTSs measured is due to the interference from the serving base station that is not idling and not affected by PE signals. The figures for BTS only refer to signal detection before the PE transmissions are added.

The second grouping of bars in the same figure shows that there 493 times with 1 OTDOA measurement when looking only at Node B signals, 112 instances of a single measurements when both PE and Node B detections are taken into account, and 162 times that there was a single reference point when only taking into account PE signals..

When idle periods are used the contribution of Node Bs grows significantly as can be seen in Figure 5. The trends are very similar for the Urban A and the BadUrban environments (Figure 8 and Figure 9)

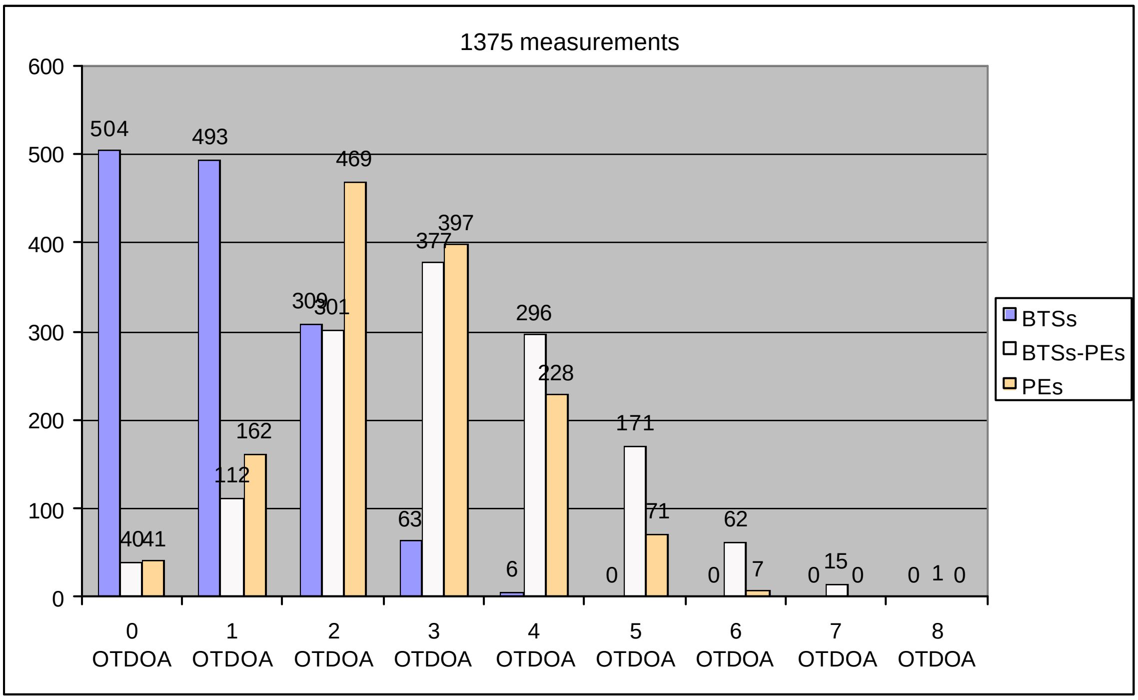

Figure 4: Breakdown of visibility of reference points for OTDOA measurements for 6 PEs with no idle periods, PE power =2W

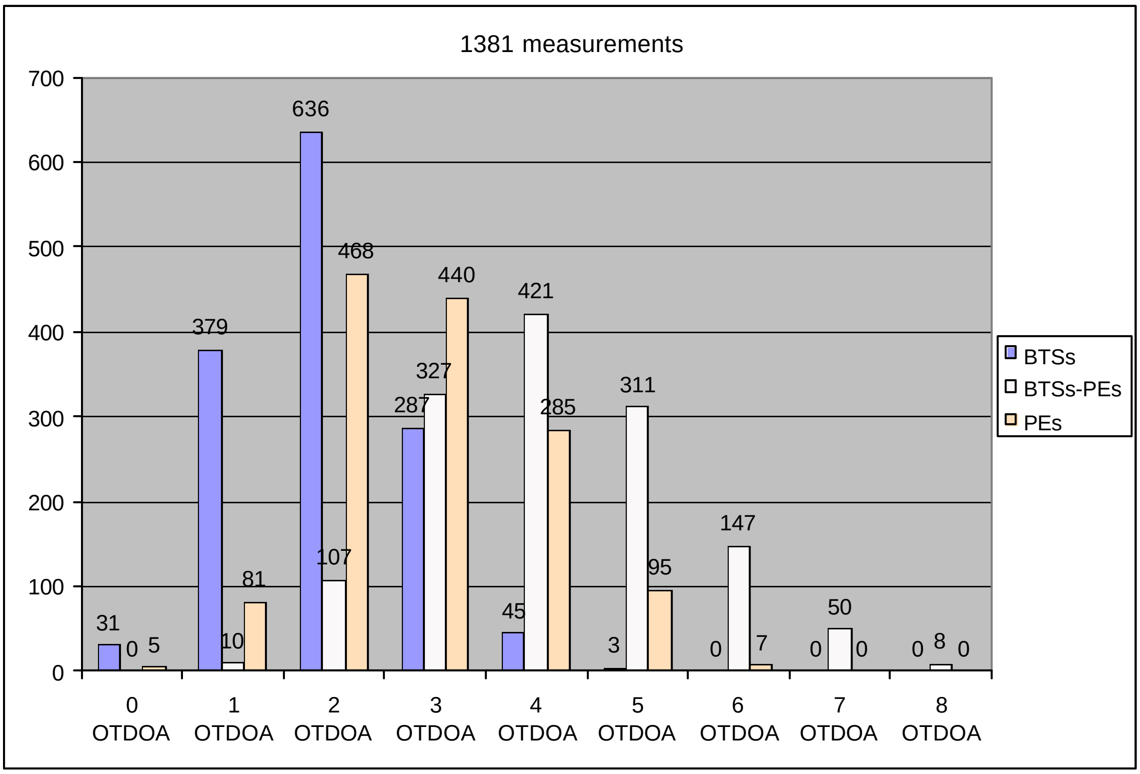

Figure 5: Breakdown of visibility of reference points for OTDOA measurements for 6 PEs with idle periods, PE power =0.75W

Appendix C Results for BadUrban environment

Table 2: Summary of simulation results with 6 PEs

PE power	Serving BTS status	References used for position estimation	Percentage of simulations in which the UE made at least 2 OTDOA measurements	67% error: at least 2 OTDOA measurements	67% error: all results	90% error: at least 2 OTDOA measurements	90% error: all results
2W	ON	BTSs	19.6%	446m	446m	747m	737m
		BTSs + PE	85.1%	287m	287m	667m	652m
		PE only	81.4%	258m	253m	644m	630m
0.75W	OFF	BTSs	52.4%	451m	467m	762m	788m
		BTSs + PE	97.7%	219m	219m	568m	566m
		PE only	89.2%	182m	179m	611m	611m

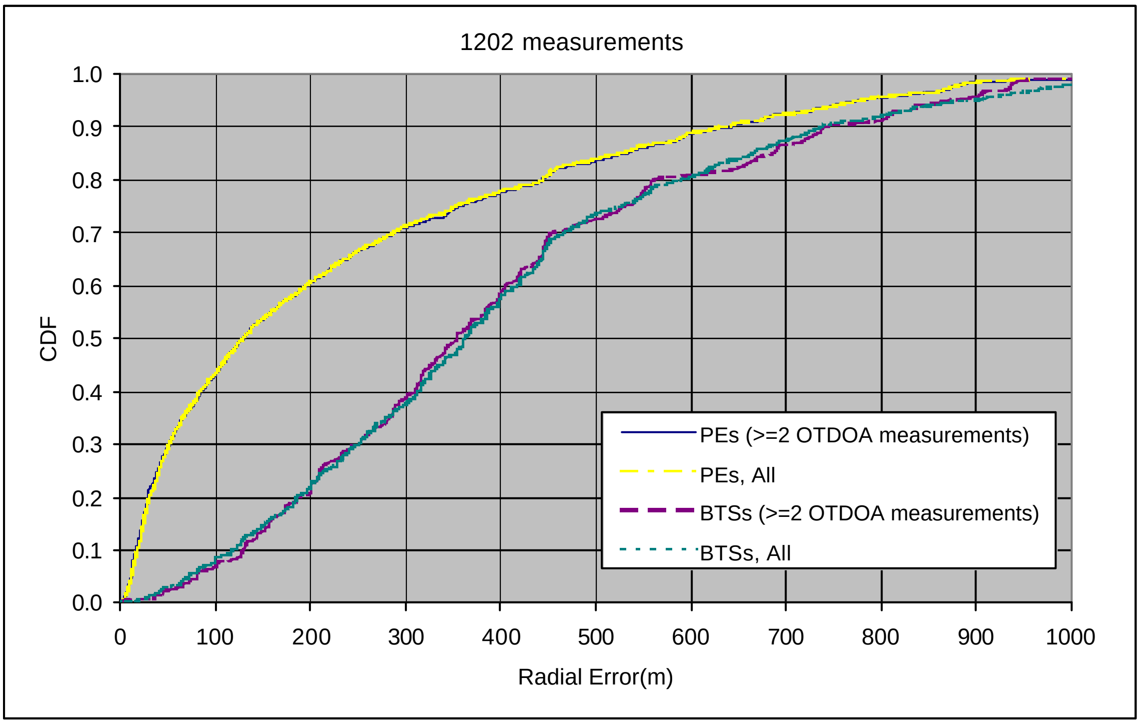

Figure 6: CDF of radial error for 6 PEs with no idle periods, PE power =2W. PEs signals only are used for detection

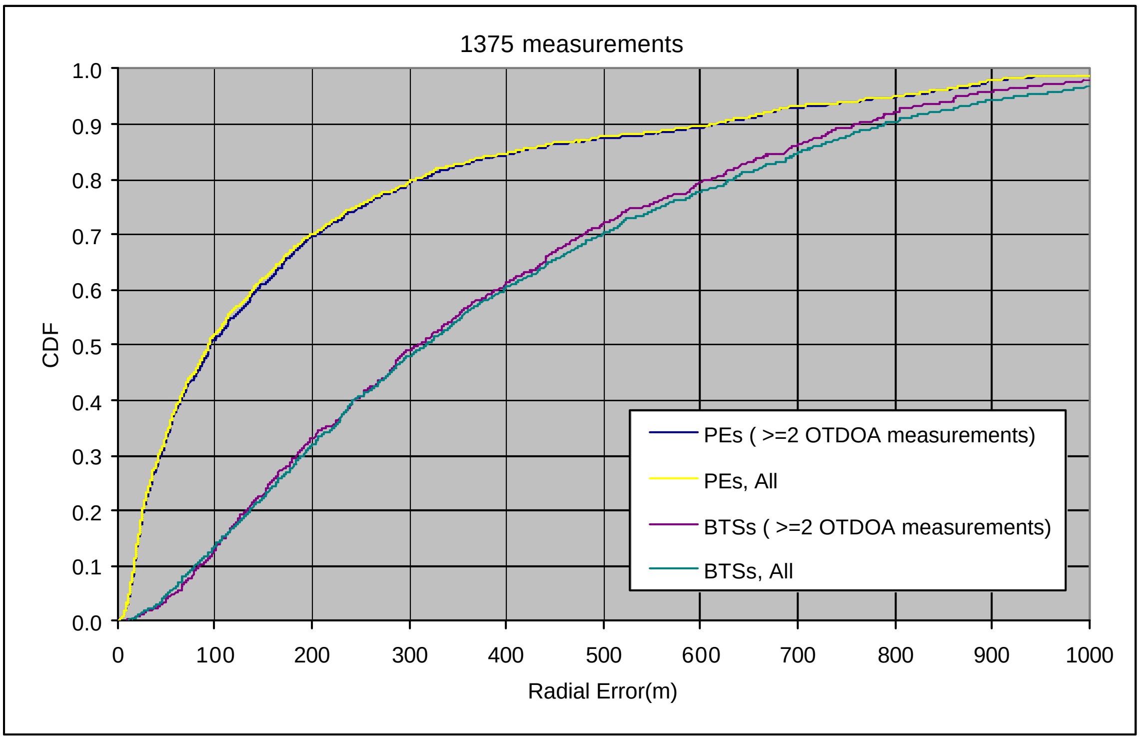

Figure 7: CDF of radial error for 6 PEs with idle periods, PE power =0.75W. PEs signals only are used for detection

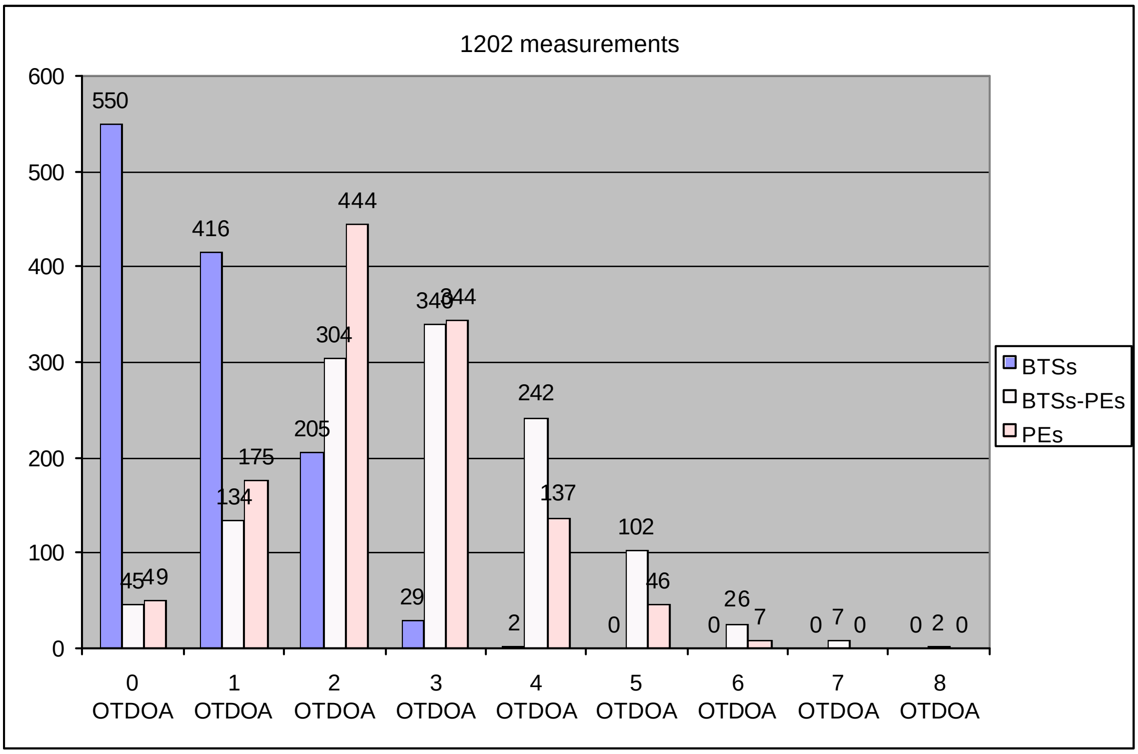

Figure 8: Breakdown of visibility of reference points for OTDOA measurements for 6 PEs with no idle periods, PE power =2W

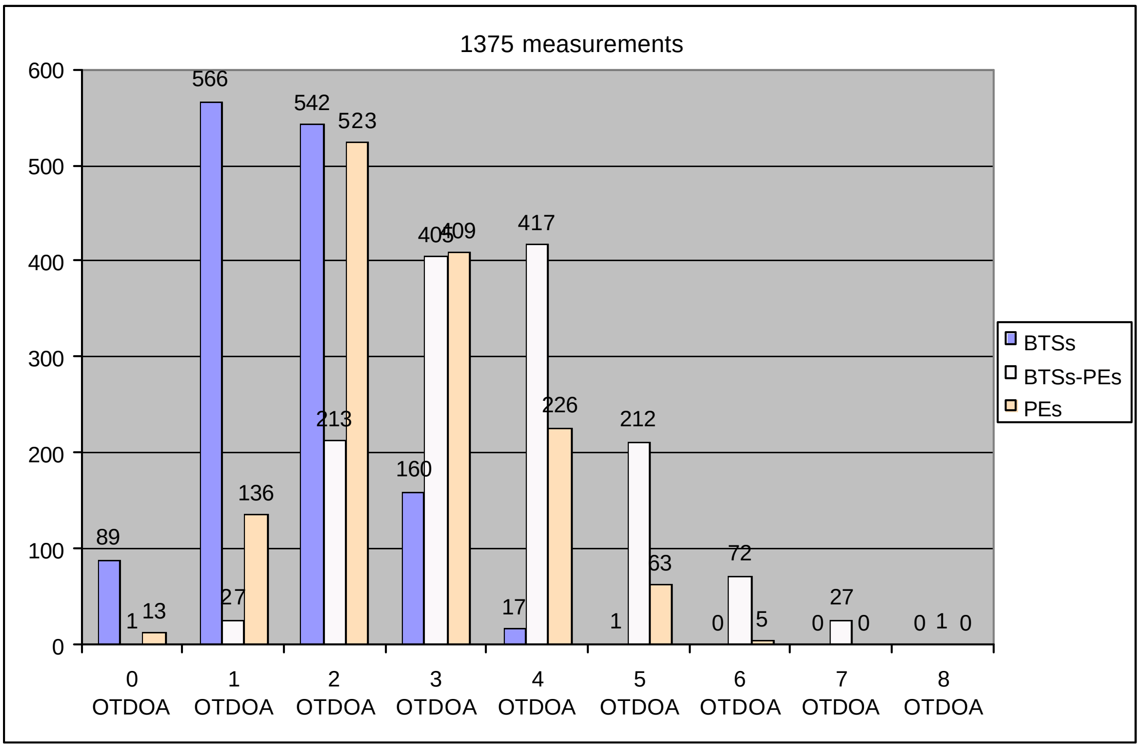

Figure 9: Breakdown of visibility of reference points for OTDOA measurements for 6 PEs with idle periods, PE power =2W