Chapter 15 solutions

1. An RFID positioning system typically involves two steps, i.e. location sensing and positioning processing. The location sensing step senses the tag location in terms of range and/or DOA using proper location metrics. The purpose of the positioning processing step is to find the location of an RFID tag or reader based on the information obtained from the location sensing step.

2. RSS-, phase-, and time-based techniques. For RSS-based techniques, the fusion of tag detection rate and RSS measurement, multiple measurements, and frequency hopping can be utilized to improve range estimation accuracy. For phase-based techniques, averaging over multiple frequency pairs or/and multiple estimation results may improve the accuracy. For time-based techniques, the use of wide signal bandwidth improves the range estimation accuracy.

3. In a real system, the observed phase difference falls into the range of $[0, 2\pi)$ due to phase wrapping. When the actual phase difference is larger than 2π, the observation differs from the true one in the form of an unknown integer of 2π, which leads to the phase ambiguity and thereby results in range ambiguity.

4. Carrier-based UWB RFID systems can achieve frequency diversity to alleviate the impact of multipath fading, since wideband signals contain many different frequency components and it is highly likely that some of them can go through or around obstacles. On the other hand, due to high time-domain resolution, impulse-based UWB RFID systems can resolve multipath components to eliminate the effect of reflection and scattering paths. Thus, the range and thereby the positioning estimation accuracy can be improved.

5. The accuracy of DOA estimate can be improved by increasing SNR and the number of snapshots. The use of a larger number of antennas results in enhanced DOA

estimation.

6. $n+1$.

7. At least five positioning techniques can be used, namely, trilateration/multilateration, triangulation, hybrid direction/range methods, radio map matching, and proximity.

8. The tag is located at $p(6.2, 5.3)$.

9. The tag is located at $p(5.8, 7.3)$.

10. The radio map matching methods are also known as "scene analysis" approaches. They are composed of two distinctive steps. In the first step, the radio scene information or RF fingerprints in the environment are collected to form the radio map. In the second step, the unknown tags are localized by matching the measured data corresponding to the unknown tags with an appropriate subset of fingerprints recorded in the radio map. Two major fingerprinting-based matching methods are the k-nearest-neighbor (kNN) and the probabilistic methods.

[BT]In reality, the RSS measurement often suffers from multipath propagation and shadowing. By taking these factors into account in the pre-stored radio map, their effects on the location estimation can be mitigated. In addition to the RSS, the spatial signatures can also be used into map matching. The primary advantage of map matching methods lies in the corporation of the environment effect, such as NLOS propagation and multipath. However, the radio map should be constructed based on dense reference tags to represent the current environment and should be periodically updated to reflect the environmental dynamics.

11. Better location sensing and better positioning processing. The form can be

achieved by collecting more and diversified information in terms of time, frequency, space, and polarization. The latter can be achieved by fusing the collected data in an optimal or suboptimal way.