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Case ID:M20-099P
Published: 9/23/2020

Hyper-Precise Positioning and Communications for Radio Networks: Leveraging Time-of-Flight Estimations

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Vehicle positioning systems assist operators in travel and operation of air and ground vehicles. For example, aircraft positioning systems assist operators in critical tasks such as landing and takeoff, particularly in low-visibility conditions. Aircraft positioning systems are also key components of remotely controlled tasks such as drone operation. Traditionally, vehicle positioning systems have contended with tradeoffs between accuracy of measurement and spectral efficiency, where higher-bandwidth signals are required for increased position resolution. Use of positioning technologies in increasingly cluttered environments only furthers technical challenges. In addition, vehicle positioning signals have traditionally been segregated from communications signals, requiring dedicated bands for each. Thus, legacy radio systems do not support modern performance requirements or user densities.

Researchers at Arizona State University have developed a distributed radio frequency (RF) communications system which provides users with simultaneous communication and high-precision positioning capabilities with minimal spectral requirements. The system facilitates high-precision estimations of positions, orientations, velocities, and acceleration of network nodes in a distributed RF network (e.g., including base stations and vehicles, such as aircraft or unmanned aerial systems (UASs)). This system specifically addresses the issue of spectral congestion by employing an extremely efficient positioning strategy and using a joint waveform that simultaneously enables both tasks. This efficiency in turn supports more users in a given frequency allocation. The positioning task is performed using advanced time-of-arrival (ToA) estimation techniques and a synchronization algorithm that measures time-of-flight (ToF) between all pairs of antennas between two nodes. The communications task provides an encrypted data link between RF nodes in the network, which enables phase-accurate timing synchronization and secures the positioning system against cyberattacks such as spoofing. Some examples use multi-antenna RF platforms which additionally enable orientation estimation and multiple-input, multiple output (MIMO) communications

Potential Applications:

- Communication-based location services
- Aircraft position detection

- Ground vehicle position detection
- Navigation for automated air and ground vehicles

Benefits and Advantages:

- Efficient – Produces high-precision position estimates with significantly fewer spectral resources than comparable techniques such as radar and global positioning systems (GPS)
- Self-Contained – Does not require external infrastructure (such as a mesh of satellites)
- Secure – Features encrypted communication to guard against spoofing and adversarial interference
- Versatile – Compatible with existing platforms and standard, consumer-grade software-defined radios