High-Resolution Detection of Direction of Arrival of a Transmitting Source

THE EXISTING PROBLEM OR ISSUE
Direction of Arrival (DOA) estimation is the determination of the bearing of any transmitting source at a receiving location. The problem has been investigated for 80 years for numerous applications in radio communications, radio navigation, and radar. A radio signal transmitted from an unknown source and received at two locations can be used to determine the location of the source with high precision, using trilateration. The error in the estimated source location is highly dependent on the accuracy of the bearing estimation. The accurate determination of transmitter location is extremely important in multiple channel reuse within cells in future 4G and 5G communication networks involving microcells and direct device-to-device communications. This enables a tremendous increase in network capacity and generated revenue with a small increase of equipment investment.

OUR SOLUTION
The invention introduces a technologically disruptive signal-processing solution that achieves extremely high accuracy, rapidly computed, low computational complexity determination of the direction of arrival (DOA) from a transmitting source. Signals at the output of an antenna array are processed with the new technique to obtain DOA accuracy which achieves the Cramer-Rao Lower Bound on estimation error. No other approach can obtain superior performance to this new signal processing solution.

Unlike previous techniques, the DOA with this innovation is obtained from a single time sample of the antenna array output. The computational complexity required for the signal processing for this invention is much less than for other techniques. The new invention includes the optimal antenna array geometry. Since the Cramer-Rao Lower Bound decreases with an increasing number of antenna elements and the new invention achieves the performance of the Cramer-Rao Lower Bound, arbitrarily good DOA estimation performance can be achieved with a sufficient number of antenna elements and sufficient computational capability for the digital signal processing.

APPLICATIONS
- Efficient resource allocation in 4G and 5G cellular communications
- Beam-forming and spatial multiplexing of users in 5G cellular communication
- Location of interference generators and jammers
- Defence communication systems and tracking
- Cognitive radio networks
- Radar
- Wireless sensor networks
- Radio-location of objects

In defence communications, accurate transmitter location is crucially important to identify enemy transmissions which emulate friendly signals, to locate enemy transmitters, and to locate malicious jammers. In the rapidly developing Internet of Things, the locations of wireless sensor network nodes may be established without the use of GPS. Since the nodes are very low-cost units and are numerous, this capability is significant. An additional application is the accurate location of objects, such as expensive portable equipment in a hospital environment.
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ADVANTAGES | BENEFITS
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Achieves the Cramer-Rao Lower Bound on DOA estimation error at relatively low signal-to-noise ratio | High-accuracy direction of arrival and transmitter position determination
Low computational complexity | Suitable for a wide range of applications and requires only low-cost digital signal processing
Performance improves for an increasing number of antenna elements and increasing computational complexity | Capable of providing any required level of position determination accuracy

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INTELLECTUAL PROPERTY POSITION
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