A Novel Synchronization Signal Swarm Array Beamforming

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We propose to use synchronization signal for high accuracy and robust swarm array beamforming. The method is a significant permissive technology since it can provide beamforming without swarm array positioning information and array calibration. In addition, the sync signals are not affected by transmitter/repeater Doppler, propagation delays, or data that is modulated onto the signal.

We use the Advanced Television Systems Committee (ATSC) Digital television (DTV) signal to demonstrate the swarm array beamforming performance. The synchronization DTV signals are designed for channel modeling and multipath mitigation, and consequently can be used for accurate beamforming. Our proposed method may apply to other sync signals. The DTV signal uses 8-level Vestigial Sideband Modulation (8 VSB). The symbol rate of the signal is 10.762237 MHz which is derived from a 27.000 000 MHz clock. The frame consists of two fields, each has 313 segments. The field synchronization segment is for DTV signal timing. It has a total of 832 symbols, starts with 4 data segment sync symbols, followed by a pseudo noise (PN)511, three PN63 and 128 symbols for VBS (variable block size) mode reserved pre-code. We choose to use PN511 for signal timing.

The synchronization signal swarm array beamforming system consists of *N* mobile repeaters that receive signal from a DTV signal source and relay identical element signals at slightly different frequencies to avoid self-interference and FCC policy violation. In the purposed architecture, swarm array elements act as relay nodes, the element signals may be viewed as multipath signals in a typical TV signal propagation environment. The approach doesn't require to obtain the element positions and precise system synchronization, nor does it need real-time array calibration. It is a simple, robust, and efficient way to recover the desired signal sent by the target. Since the proposed swarm array beamforming is performed at the destination rather than the elements, the great reduction of hardware and computation burden on the swarm drones is expected.

The procedure starts with a rough search using cross correlation of PN511 and the received signals to estimate the time of arrival of each signal from individual drone. Then a smooth search will be performed to accurately estimate the time of arrival of signals within one symbol.