Poster: Radar-CA: Radar-Sensing Multiple Access with Collision Avoidance

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ABSTRACT

We propose a practical and efficient radar interference mitigation system, Radar-CA. Radar-CA overcomes the limitations of requiring any additional equipment or resources. Radar-CA transfers the access time estimation problem to a frequency estimation problem, enabling interference mitigation through a central controller, and our preliminary result shows that Radar-CA is capable of mitigating interference efficiently in a dense radar network.

CCS CONCEPTS

• **Hardware** → *Wireless devices*; • **Computing methodologies** → **Model development and analysis**.

KEYWORDS

Millimeter Wave (mmWave), Interference Mitigation

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1 INTRODUCTION

In recent years, automotive vehicles have gained increasing attention. Automotive radars are crucial components of most automotive vehicles, as they can detect objects at a distance of several hundred feet [2]. Frequency-modulated continuous wave radars (FMCW) are commonly used today.

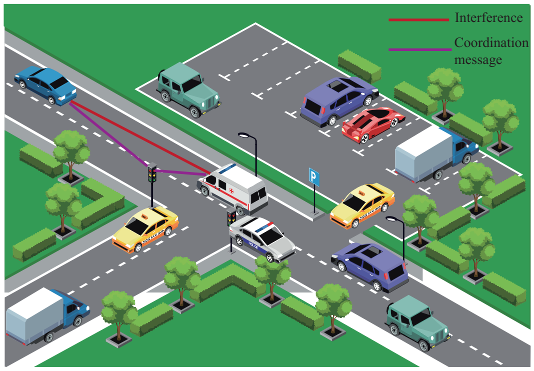

Figure 1: A scenario for Radar-CA.

Automotive radar provides the vehicle with location and velocity information about the surrounding area, allowing the vehicle to act accordingly in a timely and reliable manner. However, radar-to-radar interference can compromise high localization sensitivity and robustness.

Existing works dynamically adjust their own parameters in order to mitigate interference [3]. After adjusting parameters, radars may still be subject to interference, and the parameters will need to be changed again, which is a very time-consuming process. A radar coordination system that is capable of working once and for all is therefore essential for a dense radar network.

As a solution to radar coordination once and for all, we propose Radar-CA, a radar-sensing multiple access system with collision avoidance. Such a system requires that we detect and rearrange the access time for each radar in the network, and inform them of the change. Fig.1 illustrates a Radar-CA scenario in which existing traffic radars are used as a central controller to detect and coordinate radar interference within their detection areas.

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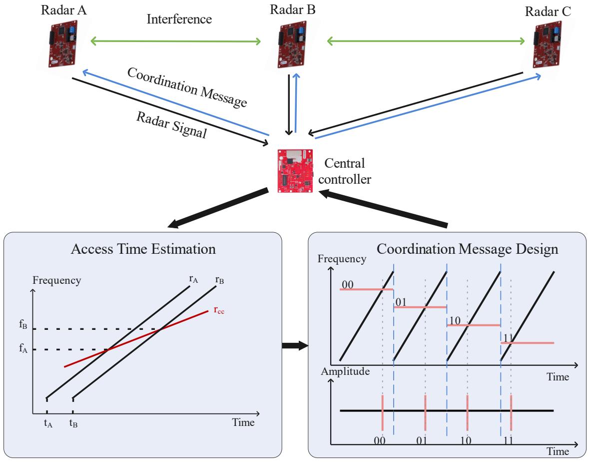

Figure 2: System overview.

Obtaining the radar's access time without synchronization is the first challenge. In existing work, each radar is required to be equipped with a synchronizer and to actively transmit its access time [1]. Secondly, how can other radars be informed about the access time adjustment? In existing work, either additional devices are required for communication [4], which would suffer from communication-to-radar interference, or nanosecond synchronization is required between transmitter and receiver [5].

The difference in radar access times can be determined passively and asynchronously by detecting a particular frequency component within different chirp signals. Based on the radar access time, the central controller is able to determine whether interference exists and adjust each radar accordingly.

To inform the target radar about the adjustment, we propose an asynchronous carrier frequency modulation scheme. Information is encoded on carrier frequencies and broadcast over the air. By estimating the carrier frequency, the receivers decode the information. Because information is encoded in frequency, and a chirp period only carries one frequency, the transmitter, and receiver do not need to be synchronized.

We want to highlight the advantages of our radar-CA system: (1) Radar-CA can mitigate possible interference in a radar network once and for all, which is an efficient process. (2) Radar-CA does not sacrifice any bandwidth for communication or adjustment, allowing each radar to maximize its sensing capabilities. (3) Radar-CA does not require any additional device for synchronization or communication. All functions are built into the radar itself.

2 SYSTEM DESIGN

Fig.2 illustrates the architecture of the coordination system. In the proposed architecture, there are two modules: **Access Time Estimation** and **Coordination Message Design**. The first module determines whether interference exists as well as the source of the interference. The latter one schedules the access time for each radar in a radar network for interference avoidance and notifies the target radar of the change in access times.

We estimate access times of different radars by transferring access times to frequency points. As shown in Fig. 2, suppose two radar signals r_A and r_B have different access times t_A and t_B. It is challenging to directly estimate their access times, but we can transmit another known frequency slope S_{cc} radar signal r_{cc}. **We define the *Crossing frequency points* as a frequency point that multiple signals sweep to at the same time**. When two radar signals sweep to a certain frequency point, it is able to observe a peak in the time domain of the intermediate frequency signal, enabling us to determine their crossing frequency points, and further estimate the access time by $t_i = f_i/S_{cc}$, i = A or B. Once the access time is estimated, we can determine whether there exists interference and how to coordinate these radar's access times.

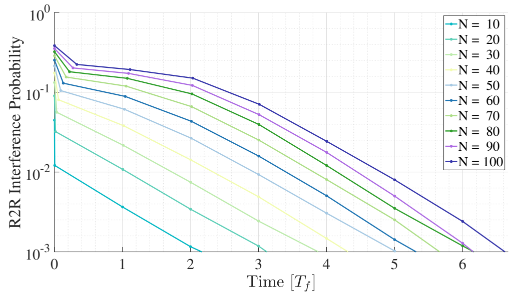

Figure 3: Preliminary result.

To inform the change of access time to each radar, we propose an asynchronous carrier frequency modulation scheme as shown in Fig. 2. Specifically, we encode the information on the carrier single frequency, once the target radar receives the signal, it can detect the code by estimating the crossing frequency points. Each adjustment is encoded with its previous access time, and the coordination message is broadcast to all radars. Each radar decodes the coordination message and makes necessary adjustments according to the message, then the interference can be mitigated.

3 PRELIMINARY RESULT

We evaluate the performance of Radar-CA through simulation and experiment. We use three TI AWR1843 radar platforms to evaluate the interference detection rate and the bit-error rate (BER). Then we feed these parameters into a large radar network by simulation. The overall performance is shown in Fig. 3. When there are 100 radars, the radar-to-radar (R2R) interference probability will drop to 10^{-3}% within seven frame periods (37 ms).

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