LIDAR AND RADAR INTERFERENCE AND SYNCHRONIZATION USING SHORT RANGE COMMUNICATION

PACCAR

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FMCW Radar and Flash LiDAR Interference

- LiDAR and Radar sensing applications are becoming attractive for automated driving systems; mutual interference between adjacent sensors is expected
- There are two types of radar interference: (1) Crossing interference and, (2) Parallel interference.
- Time of Flight (ToF) LiDAR provides an accurate imaging in a single infrared light pulse.
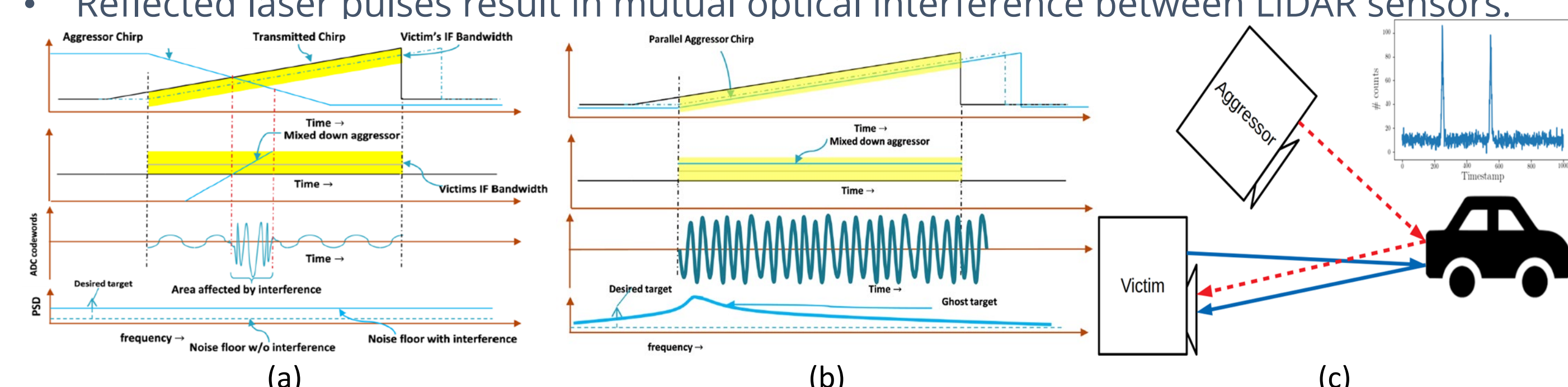- Reflected laser pulses result in mutual optical interference between LiDAR sensors.

Figure 1: Simple Interference illustrations for FMCW Radar and Flash LiDAR. (a) shows the effect of crossing interference in hiding detections, (b) shows the effect of parallel interference in creating 'ghost' detections and, (c) shows a scenario where the victim imager detects reflected laser pulses from both its own imager and the aggressor imager in the case of a Flash LiDAR system.

Radar Interference Testing

- AWR1843BOOST (right sensor, with DCA1000 module attached) and IWR1443BOOST (left sensor) modules are used.
- AWR module is operated using mmWave Studio (2.0); IWR module is operated using Demo Visualizer (1.2) with the sensor FPS set to 15.
- The middle point corresponds to the detection of the reflector whose distance is about 4 meters away.
- The left point in the plot appearing 90% of the time, slightly varying across frames, corresponds to the detection of a stabilized object through the reflector.
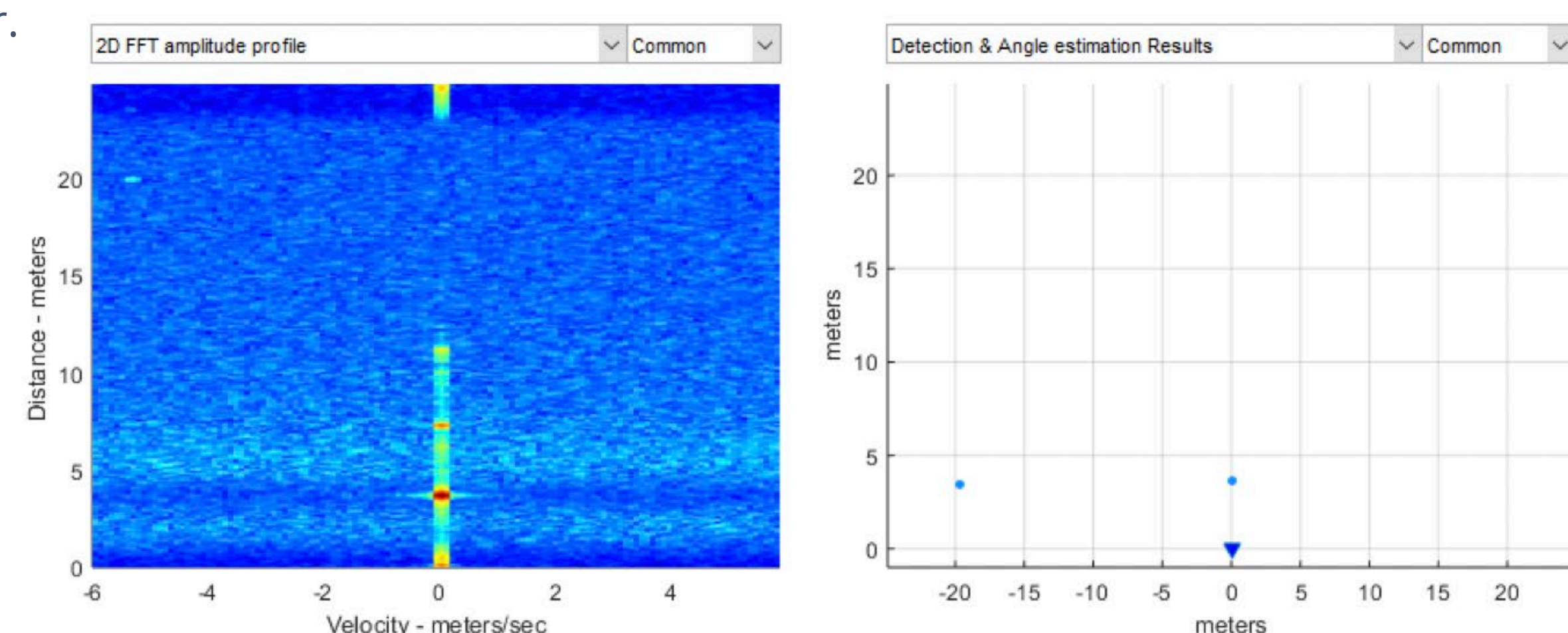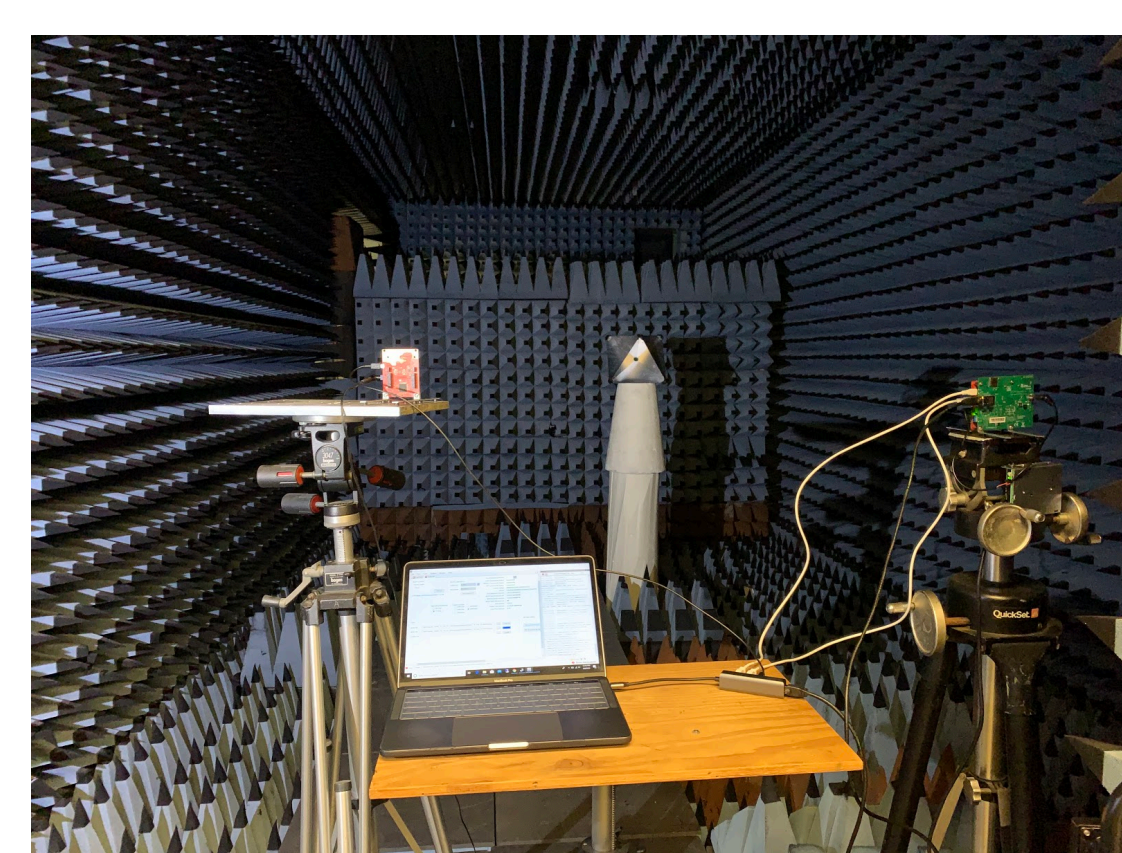

Figure 2: (Top) Lab setup in anachronic chamber for measurement of target with two radar modules adjacent to each other and, (Bottom) Detection results were obtained from the primary module.

Interfacing with External Sensors

- Different sensor modules from Texas Instruments (TI) and Leddartech were used to capture and store data.
- Radar modules used (TI): AWR1843BOOST and IWR1443BOOST for producing the FMCW radar and, the DCA1000 evaluation module for data recording.
- Flash LiDAR module used (LeddarTech): LeddarVu 8-Segment Solid-State LiDAR.

Embedded Platform

- Each sensor module to be synchronised is connected to a Raspberry Pi 4B (R-Pi) to form a connected embedded platform with each module being part of a 'node'.
- The R-Pi is used to trigger both radar modules and LiDAR modules to collect data at the intended number of frames per second.
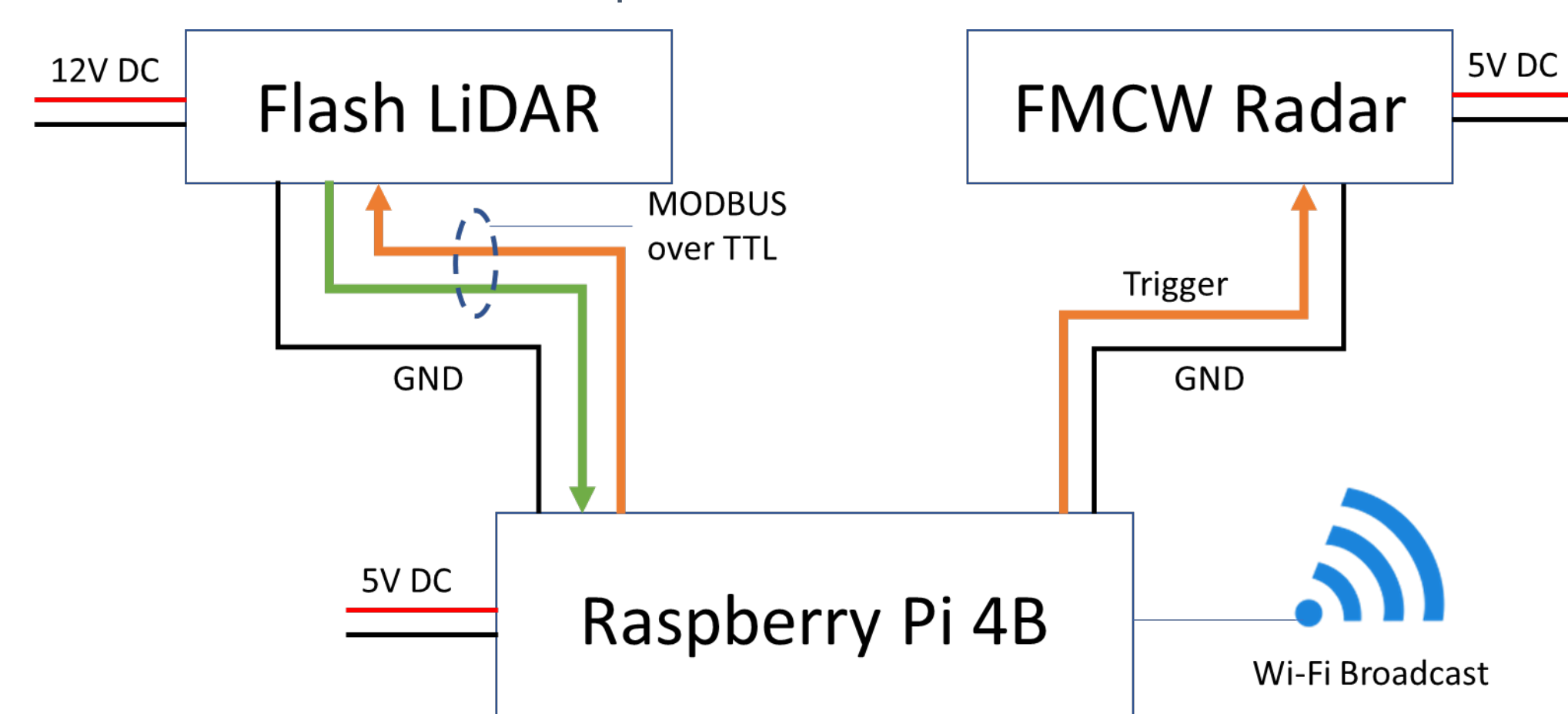

Figure 3: Schematic of the embedded platform. Each node features the R-Pi as well as the required sensor modules.

- The LiDAR module is triggered by using the MODBUS protocol to write the register values for a single frame capture.
- Data acquisition of a single detection frame, also obtained through serial communication, provides 8 segments for each captured image.

- The radar module is triggered by sending a rising edge pulse onto the special input SYNC_IN pin present.
- Data from the radar module is collected and displayed using the separate TI mmWave Studio software on the computer.
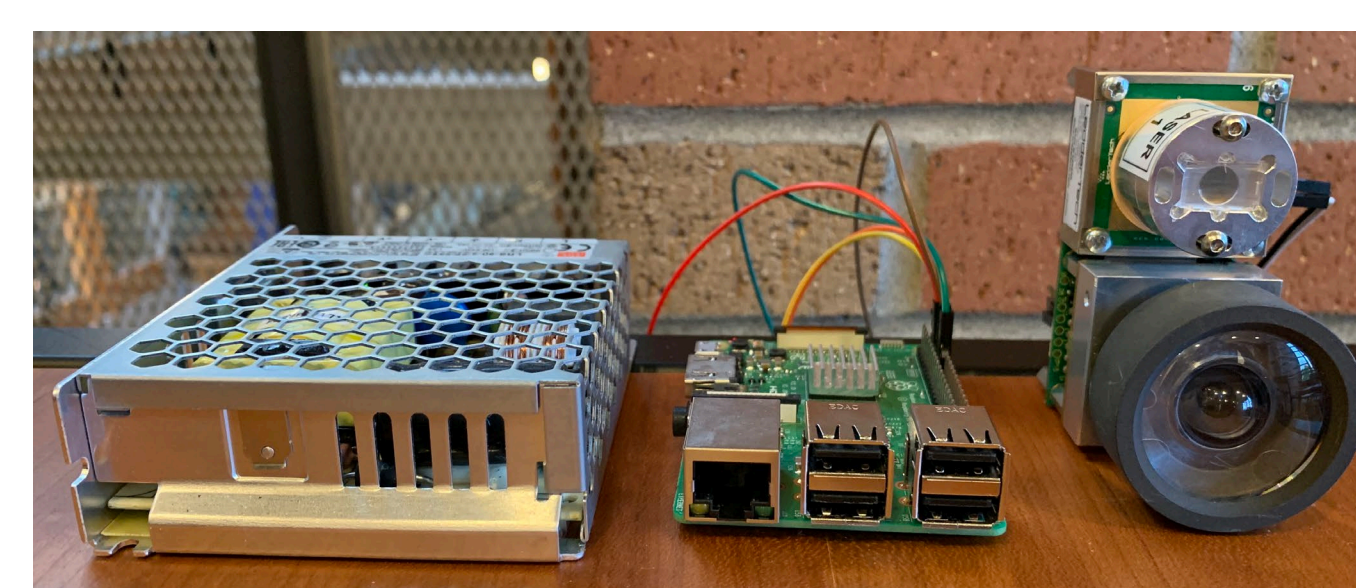

Figure 4: R-Pi connected to the LiDAR module during testing.

Figure 5: R-Pi connected to the LiDAR module as well as the radar module. Currently, the platform only supports triggering of a single sensor and the R-Pi can be switched over to trigger either of the module.

Short Range Communication

- In automotive scenarios, communication typically occurs over DSRC or possibly through C-V2X in the future.
- To simplify the problem, 5GHz Wi-Fi was used as the side-channel.
- To emulate the broadcast-based communication of DSRC, all communication was done using UDP broadcasts.
- All devices to be synchronized are connected to a single network.

Synchronization

- Synchronization using side-channel communication is one solution to reducing interference.
- Multiple sensors are dynamically scheduled to prevent overlapping measurements.
- All R-Pi nodes to be synchronized are connected to a single 5GHz network.
- Each node continuously broadcasts its MAC ID and timing requirements - time required for each measurement and intended Frames Per Second (FPS).
- Each node is dynamically evaluated with the other nodes present in the network to obtain a Group Leader (GL) based on MAC ID.
- The GL is responsible for scheduling the devices connected to the network based on the requirements broadcast by each node.
- Node broadcasts occur every 200ms and a node is removed from the node list if it doesn't broadcast for 500ms. GL assignment is re-calculated every second to ensure there is no overlapping of GLs amongst the network.
- If the timing requirements of all connected nodes exceeds the possible allocation (cumulative sum greater than one second), allocated frequency is decreased for all nodes until scheduling is possible.
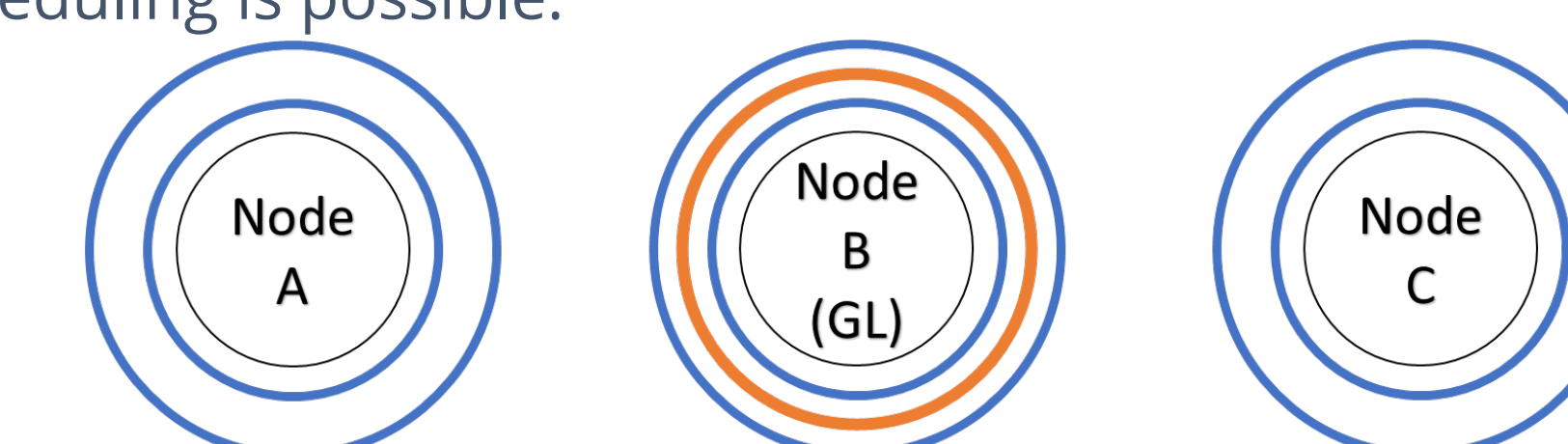

Figure 6: Representation of three synchronized nodes with Node B as GL. Each Blue ring indicates a node broadcast and the orange ring indicates a trigger broadcast.

Future Work, References, and Acknowledgments

- Further radar interference testing should be conducted to better understand possible scenarios and factors to be considered.
- The developed system should be evaluated in laboratory as well as in real-world conditions with analysis of collected data to verify efficacy.
- Adding an added implementation for interference management such as 'Sensing and Avoidance' would be helpful as a failsafe.

[1] Texas Instruments, "Interference Mitigation For AWR/IWR Devices", Application Report SWRA662, January 2020

[2] Lucio Carrara and Adrian Fiergolski, "An Optical Interference Suppression Scheme for TCSPC Flash LiDAR Imagers", Appl. Sci. 2019, 9 (11), 2206; doi:10.3390/app9112206

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