ECE 480 Scooter Proximity Alert System

Ayush Chinmay, Vigneshwer Ramamoorthi, Shayna Wilson, Kattie Romero-Otero, Pradnya Ghorpade

Sponsor: RCPD, Tyler Smeltekop **Facilitator:** Dr. Hayder Radha

RCPD
Resource Center for Persons with Disabilities

Abstract

Scooter Proximity Alert System (SPAS) tackles safety problems for visually impaired individuals on college campuses, concentrating on the challenges posed by fast and silent electric scooters. The initiative, developed by Michigan State University's Resource Center for Persons with Disabilities (RCPD), makes use of Ultra-Wideband (UWB) technology for scooter identification.

SPAS focuses on providing real-time distance computations and prioritizes safety through timely notifications by using wearable tags for visually impaired individuals and scooter-mounted transceivers. The project follows a tiered strategy spanning hardware setup, software development, integration, testing, and documentation, with an emphasis on minimal human contact, user-friendly interfaces, and seamless connection with current scooter systems. The planned output is a proactive alert system that will allow visually impaired persons to traverse campus areas securely.

SPAS, which is aligned with the RCPD's mission of establishing an inclusive campus, uses innovation and technology to improve the safety and mobility of the visually impaired.

Introduction

In the 1970s Michigan State University (MSU) created the Resource Center for Persons with Disabilities (RCPD) in response to equal access to a university education for all students. Since then, they have expanded their services to students with mobility and visual disabilities, as well as deaf or hard of hearing, any learning disabilities, brain injuries, psychiatric, and other chronic health conditions. RCPDs mission is to lead MSU in maximizing ability and opportunity for full participation by persons with disabilities.

One of the major challenges that visually challenged people face is the fact that these scooters are incredibly quiet and fast. This makes travelling around campus dangerous as they can neither hear the scooters nor have time to avoid these if they are aware of them. MSU RCPD has a goal of allowing the visually impaired to travel safely around campus without fear and threat the scooters present.

To help with RCPDs mission, our project will focus on assisting the visually impaired with the increased usage of electric scooters on the university's campus. Our goal is to provide an alert system that will effectively notify the visually impaired of scooters in a way that is conventional for campus. We also want to have the environment accommodate the visually impaired, instead of vice versa. The goal is that these scooters provide audible cues to alert them of any scooter present, the danger that the scooters present the visually impaired can be prevented.

Design Requirements

Goal: Develop an alert system that can effectively notify visually impaired pedestrians of scooters

Objectives:

- Active Alert System
  - Scooters in proximity will alert the pedestrians through sonic alerts
  - Allow enough time for the pedestrian to react
  - Supports interactions with multiple scooter and tag units
- Compact Form-Factor
  - Small form-factor allows the tags to be hassle-free carriable item
- Accommodating Environment
  - The burden should be upon the environment rather than the persons with impairments
  - Allow persons with impairments to roam safely, unhindered by the risks posed by the scooters.

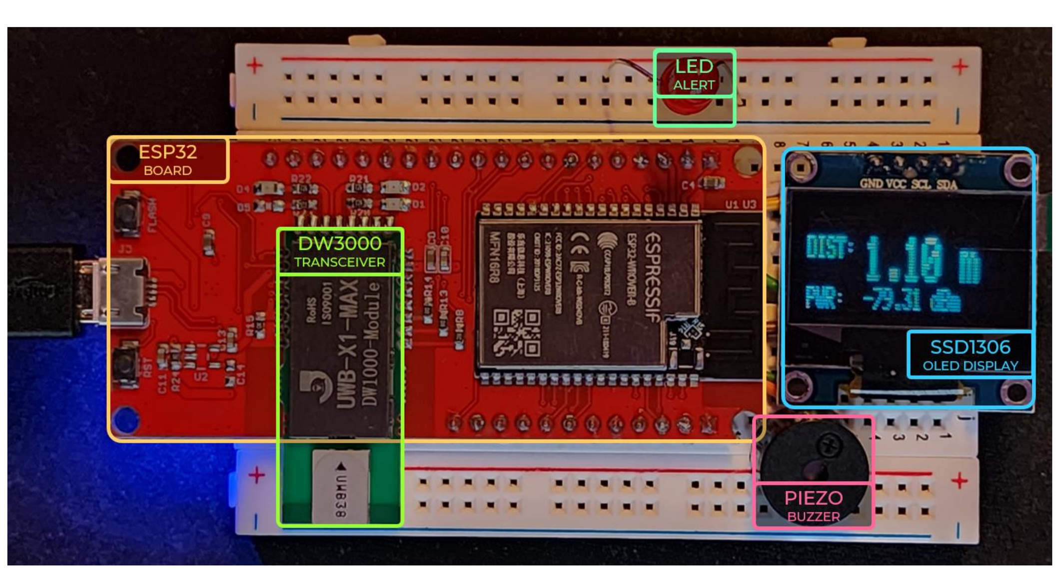

FIG 1: Prototype of the ESP32-UWB based Tag Unit

Technology

Ultra-Wideband, or UWB, is a short-range RF technology for wireless communication, employed for precise location tracking. It utilizes short nano-second pulses across an expansive frequency spectrum. This technology proves advantageous for portable ranging applications, facilitating high-data rate transmission over short distances while consuming minimal power, thereby enabling cost-effective and efficient hardware solutions. UWB operates by detecting ranges between two nodes through time-of-flight, calculating the duration for radio wave pulses to travel between devices.

For the purposes of this project, in the absence of fixed indoor positioning anchors, Two-Way Ranging (TWR) technology is employed to calculate distances between two devices. UWB can accurately determine the location of a device within a range of under 200 meters, with optimal performance observed within shorter ranges of 1-50 meters and under conditions of line of sight between devices or anchors. The time taken for a signal to traverse this distance is multiplied by the speed of light, forming the basis for determining their relative positions. The measured distance is then used to establish alert priorities conveyed to users.

The central communication and control unit for this project is the ESP32-UWB Pro board, manufactured by Maker-Fabs. This board integrates the ESP32-WROOM board with an on-board Decawave DW1000 UWB module. The ESP32 microcontroller manages data reading, initiation of communication events, calculation of alert priorities, and activation of the piezo-buzzer alerts. The dual-core architecture of the ESP32 facilitates concurrent execution of UWB communication and distance calculation, ensuring a reliable system without processing-related delays.

A compact piezoelectric buzzer is employed to generate sonic alerts due to its capacity to produce a sharp tone without requiring additional circuitry. While speakers offer enhanced fidelity, their use introduces increased power consumption, computational demands, and design complexity. The buzzer generates audible beeps at regular intervals, with the timing influenced by UWB distance measurements, resulting in shorter intervals between beeps at closer ranges. A 0.96" OLED display is incorporated to showcase tag-ID, distance data, and signal strength.

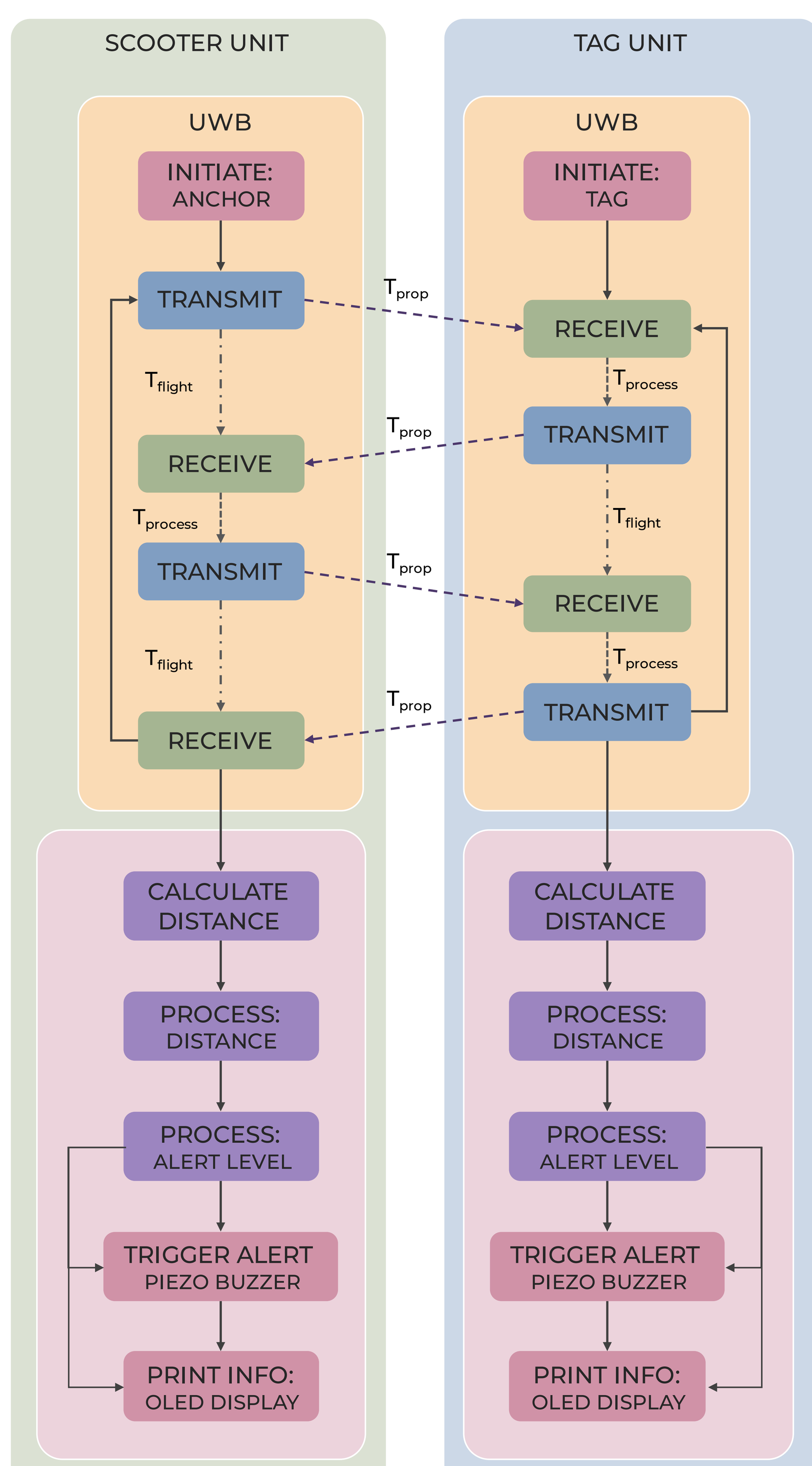

FIG 2: Proximity Alert system --Block Diagram

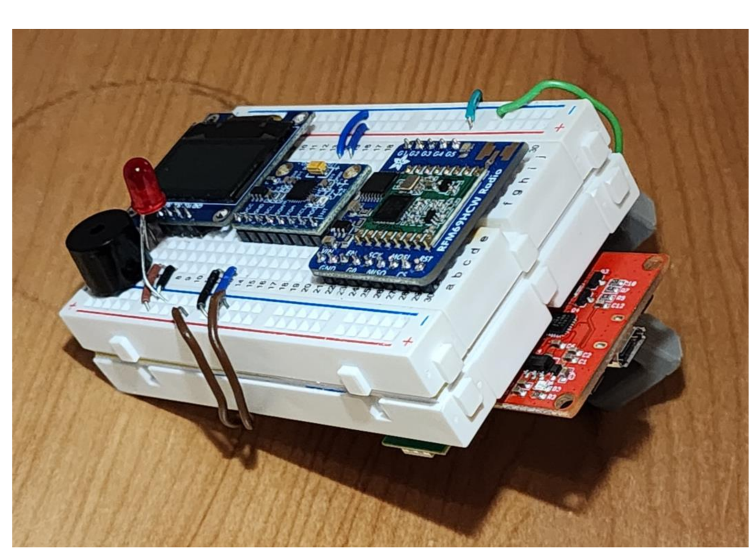

FIG 3: Prototype of the Scooter Unit

Budget

Within the $500 budget allotted for this attempt, we concentrated on acquiring the most crucial components that underlie the efficacy and quality of our product. Detailed budgeting has been critical for a variety of reasons, including:

1. Financial prudence: By methodically preparing and managing our budget, we've drawn out a clear roadmap of our spending, ensuring that every dollar is spent wisely.
2. Proactive Approach: The budgeting method allowed us to foresee and plan for contingencies. This proactive approach guarantees that we are ready to face unanticipated obstacles without sacrificing product quality or exceeding our budgetary limits.

Table 1: Bill of materials

Part Description	Cost Each	Qty	Total
ESP32 UWB DW3000 (Ultra-Wideband)	$43.80	2	$87.60
ESP32 UWB PRO (Ultra-Wideband)	$51.84	2	$103.68
RFM69HCW 433 MHz Transceiver Radio Module	$9.95	2	$19.90
RFM69HCW 915 MHz Transceiver Radio Module	$9.95	2	$19.90
USB A/Micro Cable	$4.95	2	$9.90
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Dupont Jumper Wires Set	$6.98	1	$6.98
Misc Electrical/Hardware Items	~$50.00	1	~$50.00
Shipping	~$50.00		~$50.00
	Total		$370.93

Final Product and Results

The system successfully established a connection, measured distances between the scooter and tag units through two-way ranging. Verification involved commencing tests from the same point in a hallway, moving away while accurately measuring the distance traveled, and closely monitoring signal integrity. Another test, starting with the units out of range and then moving closer, demonstrated swift initial pairing once within range. The measured distance accuracy reached up to 20 cm at its best. Appropriate sonic-alerts were triggered at the programmed distance intervals.

The initial plan was to incorporate a 915MHz radio system for redundancy in scenarios where line-of-sight might be obstructed. However, this plan was abandoned, as in cases of line-of-sight blockades, the connection promptly restores upon receiving even a single ping.

Future Directions

RCPD aims to extend its support for the visually impaired by translating technological advancements into real-world benefits. In this project, RCPD is hoping to propose our concept to scooter companies, urging them to integrate our design for a safer environment catering to individuals of diverse backgrounds.

Despite the limited development time, the prototype serves as a functional proof of concept. Further development holds the potential for significant improvement. For example, many features of the ESP32, contributing to its footprint, are unnecessary for this project. Substituting it with a more compact microcontroller, like the Arduino Pro Micro, can yield a tag with similar functionality, but notably smaller in size and power consumption.

Exploring renewable energy sources, such as small-form factor solar panels for the tag unit, may significantly extend battery life, enhancing the product's eco-friendliness.

Team

Left to Right: Vigneshwer Ramamoorthi, Pradnya Ghorpade, Shayna Wilson, Kattie Romero-Otero, Ayush Chinmay

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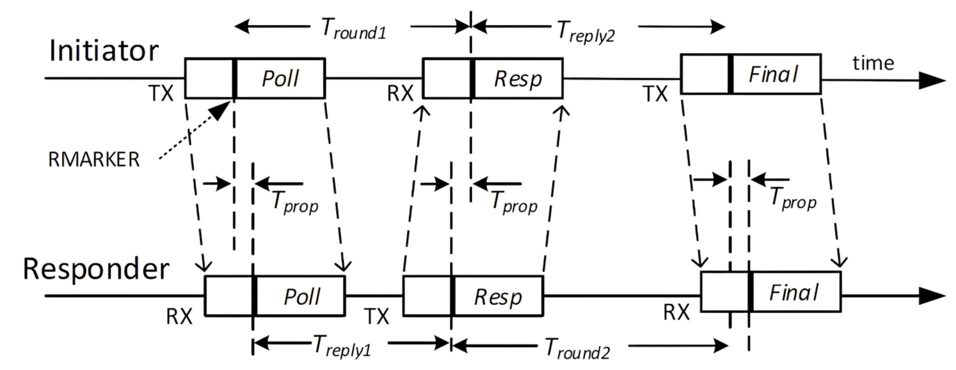
Components

Table 1: List of components

Component	Manufacturer	Functionality
ESP32 UWB Pro Module	Makerfabs	Processing & UWB communication
SSD1306 0.96" OLED Display	Adafruit	Display relevant information
Piezoelectric Buzzer	Adafruit	Create sonic alert at intervals
LED Indicator	-/-	Blink during signal reception

Technology



The *Final* message communicates the initiator's T_{round} and T_{reply} times to the responder, which calculates the range to the initiator as follows:

$$T_{prop} = \frac{T_{round1} \times T_{round2} - T_{reply1} \times T_{reply2}}{T_{round1} + T_{round2} + T_{reply1} + T_{reply2}}$$

FIG 1: Asymmetric Two Way Ranging ToF Formula

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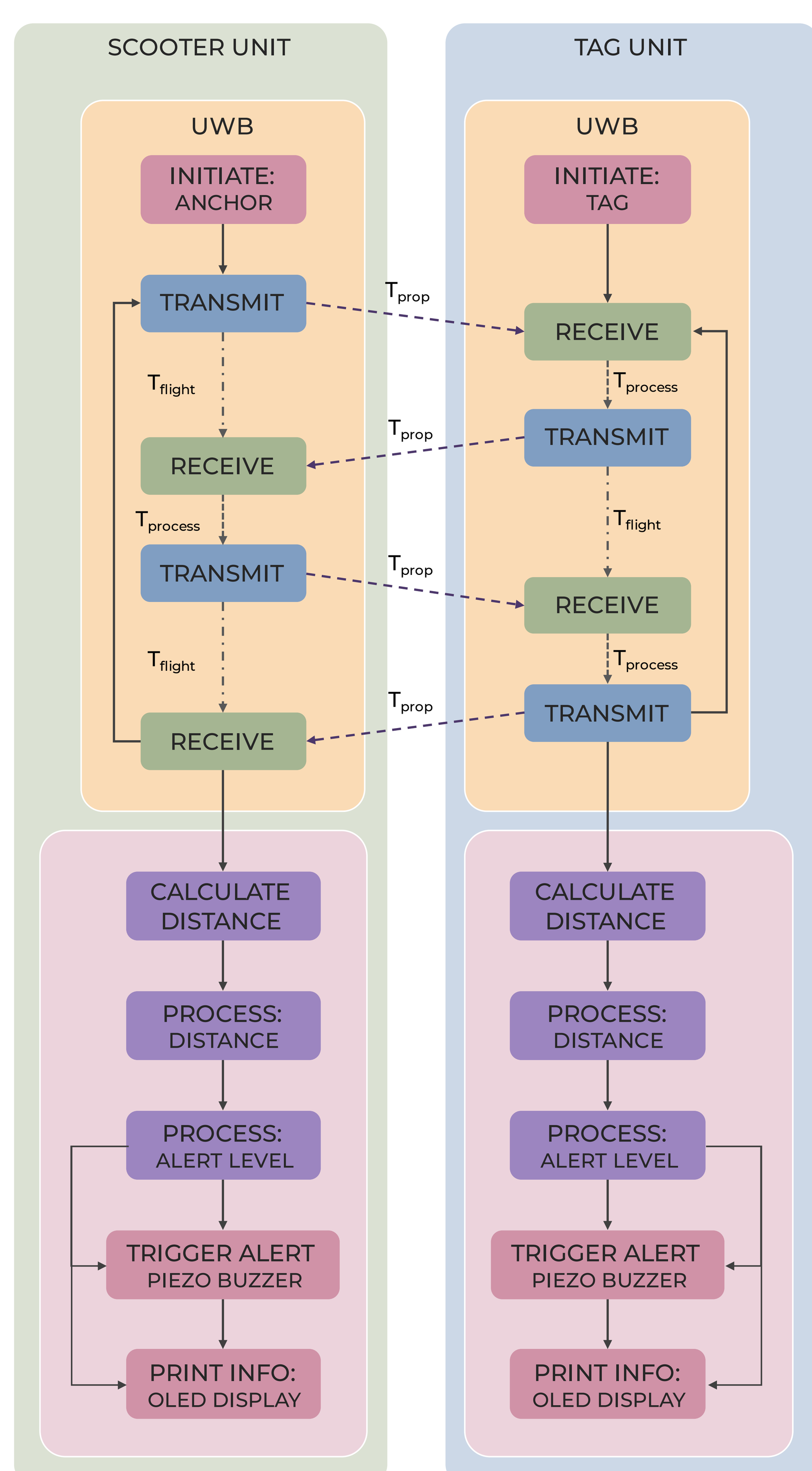

FIG 2: Proximity Alert system – Code Block Diagram

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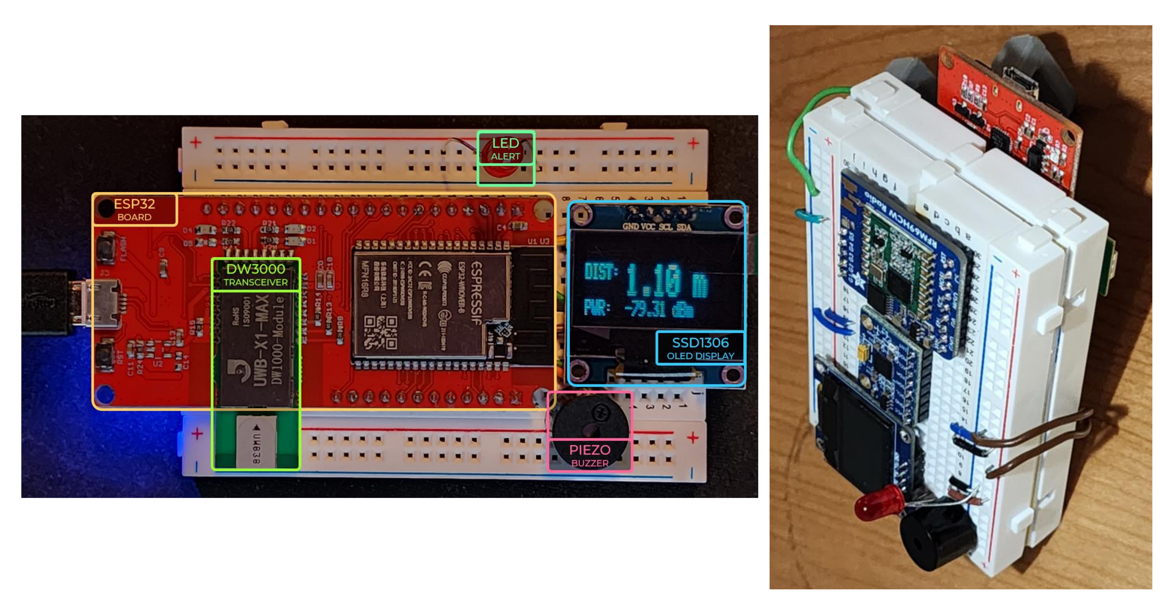

FIG 3: Final Proximity Alert system prototype Tag-Unit (left) & Scooter Unit (right)

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