Archangel Protocol for Pedestrian to Vehicle Communication via 5G Networks

DR, GT, PSz, SzL, TV

Eötvös Loránd University

archangel@inf.elte.hu

November 17, 2021

Overview

Introduction

- Autonomous driving has a growing interest
  - More self-driving cars
  - Less human control
- Pedestrians are the potential victims
  - Exposed to traffic dangers
  - No protection
- Smartphones
  - Share location
  - Increase safety
- Huge amount of data
  - 5G networks

State of the art – Communication

- V2X – Vehicle to everything
  - Direct communication within short distances ($\sim$1km)
  - WiFi technology in the licenced 5,9 GHz bandwidth
- C-V2X – Cellular vehicle to everything
  - Prerequisite: Long-Term Evolution (LTE)
  - Two operational modes:
    - Direct communication over PC5 interface
    - Indirect communication over Uu-interface
  - Long distance, latency-tolerant warnings
  - Problem: LTE not fast enough for life-critical systems
- C-V2X over 5G mobile-network
  - Designed to deliver peak data rates up to 20 Gbps
  - Beamforming technology

State of the art – Prediction & Scoring

- There were several attempts in this area
  - neural networks, decision trees and clustering algorithms
  - Prediction time concidered to be optimal: $>$0,5s and $<$2s
- Most accurate former attempt
  - Based on Mixed Markov-Chain Model (MMM)
  - Accuracy score: 97% with average delay of 783 ms
  - With a new protocol via 5G this time can be reduced
  - Reaction time: 500 ms (new developments are about to reach 10 ms)

speed($\frac{km}{h}$)	**speed($\frac{m}{s}$)**	**distance(m)**
30	8,3	6,5
50	13,8	10,8
70	19,4	15,2
90	25	19,6

Table: Distance traveled during delay time

The Archangel protocol – Intro

- P2V – Pedestrian to Vehicle
- Prerequisites:
  - 5G coverage
  - Smartphone with 5G and Archangel-protocol capability
- High reliability and fault tolerance
- Prediction, Scoring system, Warning messages
- Handles the case of street corners with thick walls

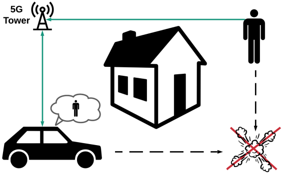
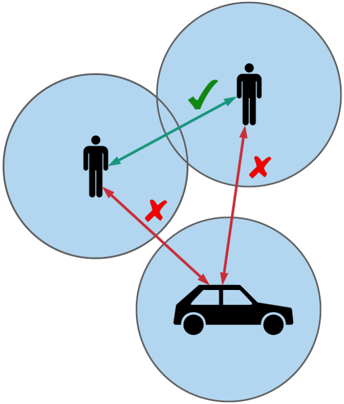


Figure: Direct signaling blocked by a building

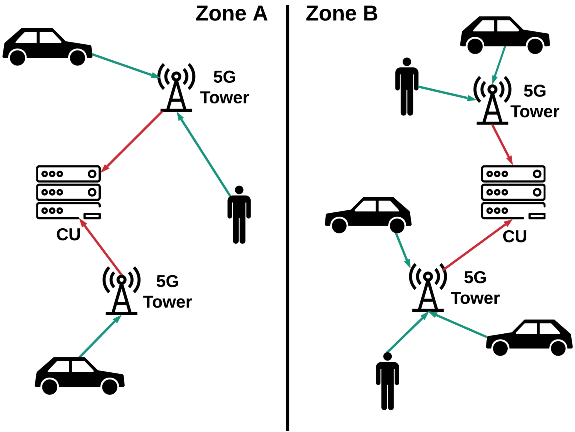
Computational units

- Endpoints cannot process large amount of data
- Border coverage is needed
- Centralized points
- High computing capacity
- Computations within critical time constraints
- Precision



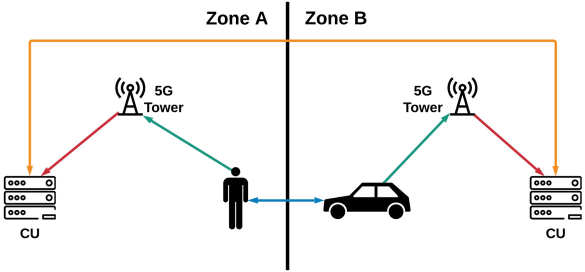
Communication

- Node → 5G Tower → Computational unit
- Area described by a given computational unit is a zone



Edge case

- Pedestrian and a car in a separate computational zone
- The car's computational unit needs to know the pedestrian's data
- Which of the two CUs should calculate the data for the car?
    1. Optimal case → The CU which is in the zone of the car
    2. Network round trip to save time in case when the car's CU is already critically loaded

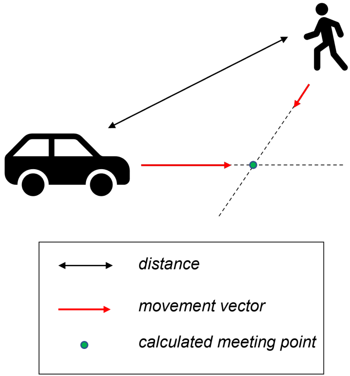


Scoring system

- Analysis of the situation
- Define the order of urgency between the notifications

Calculations - key points

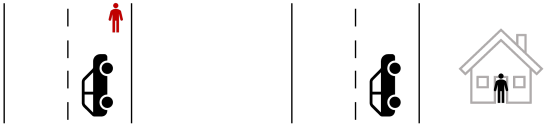
- movement
  - speed
  - direction
- position



Scoring system

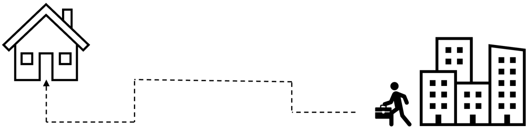
Environment

If data is available about the environment, it can increase or decrease the score.



Predictions

The last part of the score calculation is to assess the possibility of certain routes and to predict movements.



Package structure

- UUID
  - Number of UUIDs
  - For example: 123e4567-e89b-12d3-a456-426614174000
- Serial number
- Data type code
- Actual data
  - Coded
  - Compressed

Conclusion

- Future = self-driving cars
- Our work
- Future plans

The End