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Collision Avoidance Mechanism Based on V2V Communications in Container Terminal

Objective

This contribution aims to propose a cooperation mechanism based on networked autonomous vehicles in seaport container terminal to improve productivity. Using inter-vehicles communications, autonomous vehicles can cooperate together to avoid collision and deadlock problems that may occur in the intersections located at the yard. The preliminary results give a better performance when the proposed mechanism is applied.

V2V COMMUNICATION SYSTEM

The explosive growth in the freight volumes has put enormous pressure on seaport terminals to improve their management and find better ways of doing daily operations It has been demonstrated by several recent research studies that "landside operations" strongly influence the overall performance of a container terminal. In particular, containers transportation in the yard requires necessarily multiple autonomous vehicles which can cause challenging issues due mainly to their deployment and mobility.
Collisions at the intersections in the yard are one of these major problems which require a serious support. Our aim is to present a mechanism that involves several vehicles to establish cooperation between them through the exchange of messages to avoid collisions in intersections. Simulation study is conducted using two realistic scenarios,

Communication elements in an Intelligent Transportation System (ITS) dedicated to a Port Container Terminal Management: :

- Autonomous vehicle (V),
- Containers
- Confined base stations (CBS).

WAVE Technology

V2V communication enables the cooperation among autonomously driving vehicles. Each vehicle has a radio communication device. It will be able to share their information state (current position, speed, etc) with neighbors based on the distributed short messages. In the WAVE system, vehicles periodically broadcast beacon messages which are used for cooperative awareness applications

Collision Problem

The problem of detection and avoidance collisions is one of the first things that should be addressed in controlling and designing ITS. In general, this type of problem can be solved relatively by communication protocol.
A conventional intersection collision detection system based on V2I communication has performance limitations owing to the real-time limitations and the cost of installing the infrastructure. Kim & al (2014) propose cooperative intersection collision detection system using V2V communication which will solve the inaccuracy of the conventional system based on V2I communication.

***Table 1**. Defined trajectories in the layout for 10 vehicles*

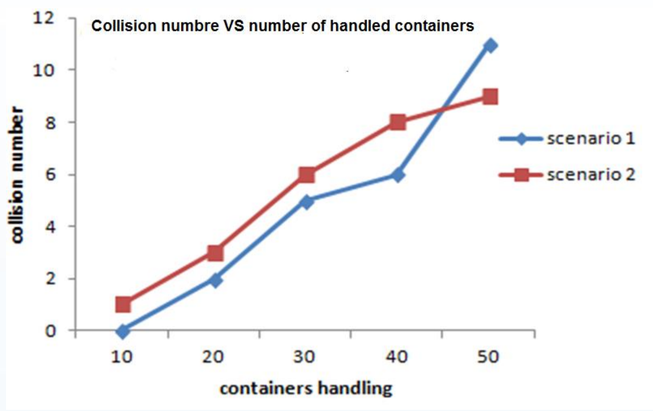
	Trajectory1 *[N1,N2,N11,N12]*	Trajectory 2 [N1,N2,N3,N4,N9, N10,N11,N12]	Trajectory 3 [N1,N2,N3,N4,N5,N6,N7 ,N8,N9,N10,N11,N12]
scenario 1	veh1, veh2, veh8	veh4, veh6, veh10	veh3,veh5, veh7, veh9
Scenario 2	veh1, veh2, veh5	veh3, veh4, veh6, veh8	veh7, veh9,veh10

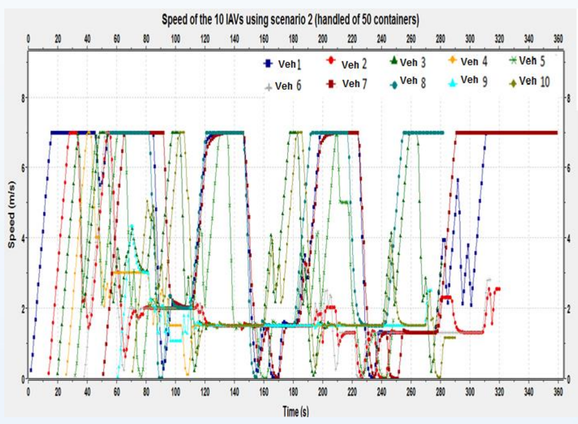
Simulation and results

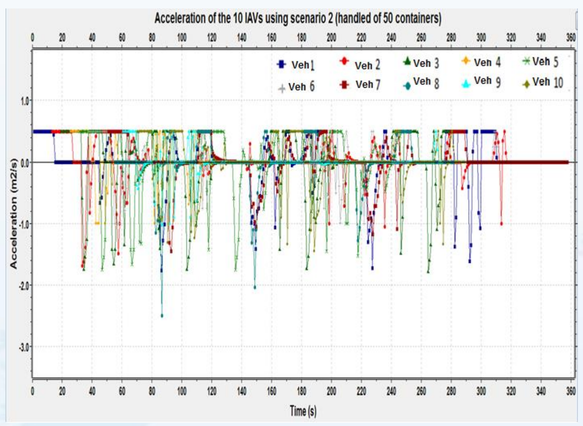
In our simulations, we assume that the horizontal trajectories have more priority then the vertical ones. We affect for each vehicle node a predefined trajectory as summarized in table 1. Parameters of simulation are listed in table 2.
Simulation steady has been made using Veins simulation framework. The latter provides some modules which can be used for TraCI interaction with SUMO simulator.

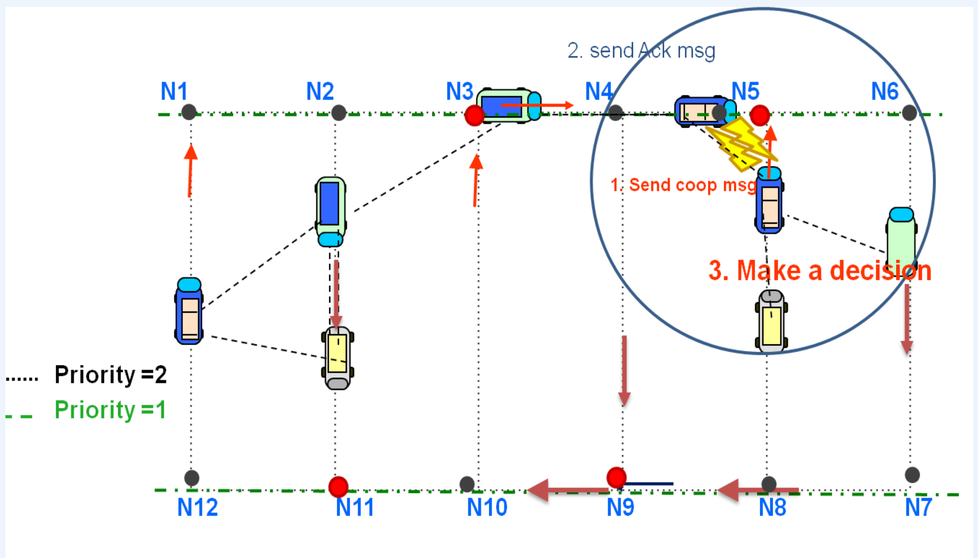
***Table 2**. Simulation parameters*

Parameter	Value
Layout dimension	100 m x 50 m
Inter-V distance (minGap)	2 m
Radio communication	64 m
IntervalBoadcast	1 sec
Vehicles Number	10
Containers Number	10*a / a=1 ..5
Vehicle max Speed	7 m/s
Vehicle max acceleration	0.5 m^2/s
Vehicle max deceleration	2.5m^2/s









COOPERATION FOR COLLISION AVOIDANCE

1. "**HELLO_Msg**":Each vehicle periodically advertises its presence along with its position and operational state to other vehicles located in its surrounding.

   Vehicles receiving "hello messages" can update their neighbor table accordingly.

1. "**Coop_Msg**": when a vehicle is moving in the vertical lane and it will be near to the intersection area, it must communicate with their neighbors in the horizontal lane to determine the priority. It models cooperation between concurrent vehicles and serves to verify the charge of the horizontal lane.
2. "**ACK_Msg**": vehicle approaching to the intersection will confirme the reception of the "Coop_Msg" by sending an "ACK_Msg". All the receivers of "ACK_Msg" in the vertical lane are being informed to reduce their deceleration, which can pass in order to avoid intersection blocking.