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Improvised algorithm to Avoid rear End collision

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Abstract: In Metropolitan Cities, the normal functioning of Vehicle to vehicle communicationrequires sophisticated control and coordination to ensure that traffic moves as smoothly and safely as possible. With the increasing no. of automobiles on the road, the problem with collision between vehicles in increasing. For a sustainable improvement of traffic condition, it is important to have some kind of automation to avoid the possible collision between vehicles. As far as today, the solution for vehicle to vehicle communication is not completely available, it is necessary to improvise the available algorithms for collision avoidance.

1. Introduction:

There exists a no. of techniques for inter vehicular and vehicle to infrastructure communication for important message exchange between the two entities. When the leading vehicle in road is breaking due to some environmental conditions like obstacles, Snowfall or any other vehicle taking the lane change and passes through the lane in which leading vehicle is travelling. At that time, driver in leading vehicle applies the brake and communicates the same message to the following vehicles through the brake light switch glow. The glow of the Brake light switch will confirm the rate at which brake shall be applied by

the driver. Then driver in following vehicle applies the brake by himself so that following vehicle comes to standstill.

In this way, the avoidance of rear end collision was performed. The driver was awaken by some buzzer sound inside the vehicle and driver applies the break thereafter once he listens to the sound if he did not noticed that leading vehicle is breaking.

2. Problems with Current Model of Rear End collision avoidance:

With the available technology of rear end collision avoidance, when the driver in leading vehicle applies the brake, leading vehicle brakes and the information is transferred to the vehicle through the Brake Light. In case the driver has applied the brake in emergency situation, the glow of the light will be very bright so that the driver in following vehicle decides the ramp at which he should apply the brake.

With this technology, there are following limitations.

1. Driver's interpretation on judging the Brake light (BLS) intensity will be not constant. For Example, Driver 'A' may consider intensity of Brake Light as Emergency brake whereas Driver 'B' will treat it as a Normal braking.

2. Though 'N' no. of drivers treat intensity of Brake Light as emergency request, how much brake shall be applied and in what ramp may keep varying from one driver to another.

3. In case of foggy environment, the light intensity may not be convincing which may lead to the misinterpretation of Brake Light Intensity.

4. As the amount of brake that shall be applied depends on different parameters of vehicle under consideration, this shall be considered to calculate the brake that shall be applied.

In the proposed system, the following advantages can be observed.

1. The dependency of light intensity and driver's interpretation will influence the action of driver to brake the vehicle. This may be dangerous in some situations when driver interprets the high intensity as low intensity and applies the brake partially. Because of this still there is a possibility of collision at the rear end of leading vehicle.

2. In the proposed idea, the actual brake applied by the driver in the leading vehicle is transmitted to the following vehicles. This information is being communicated through the intervehicular communication to the following vehicles. Along with the Brake pressure/force applied, the information of vehicle who is sending it must be shared like physical parameters of vehicle mass, wheel information. This information shall be received by the following vehicles and it shall be processed by comparing the vehicle parameters that has sent the information and vehicle parameters of the receiving vehicle.

3. After having the comparison result, driver in following will take a call whether the brake force applied by the leading vehicle is necessary or enough for the following vehicle to brake. The additional force shall be applied in case driver force applied by the leading vehicle is not enough for the following vehicle or excessive force shall be removed so that excessive braking shall be avoided to reduce the frictional damage to the vehicle components.

3. Methodology of the proposed system:

In the proposed idea, dependency on Brake light is removed and the vehicle to vehicle communication is applied. The information is being transmitted over wireless communication media in a certain bandwidth decided and regulated by authorized government body.

When the leading vehicle applies the brake in order to avoid any of the emergency situation located in front of it, driver brake pressure will be calculated. This brake pressure is used to calculate the brake force that is needed to bring the leading vehicle to standstill.

Once the leading vehicle calculates the sufficient amount of brake pressure, the ECU responsible for calculating the brake pressure /force will send it to the communication module through which the pressure/force generated by ECU will be communicated to external world. Along with this other vehicle parameters are also communicated in order to successfully retrieve the complete information about breaking.

After receiving the needed information from the ESP ECU, communication module does the needed modulation and error checking of the information that needs to be transmitted. If the communication module is capable of multiplexing the information shared by different ECUs that has to be communicated, communication module does the same to avoid any misuse of the bandwidth or latency in the message being transmitted.

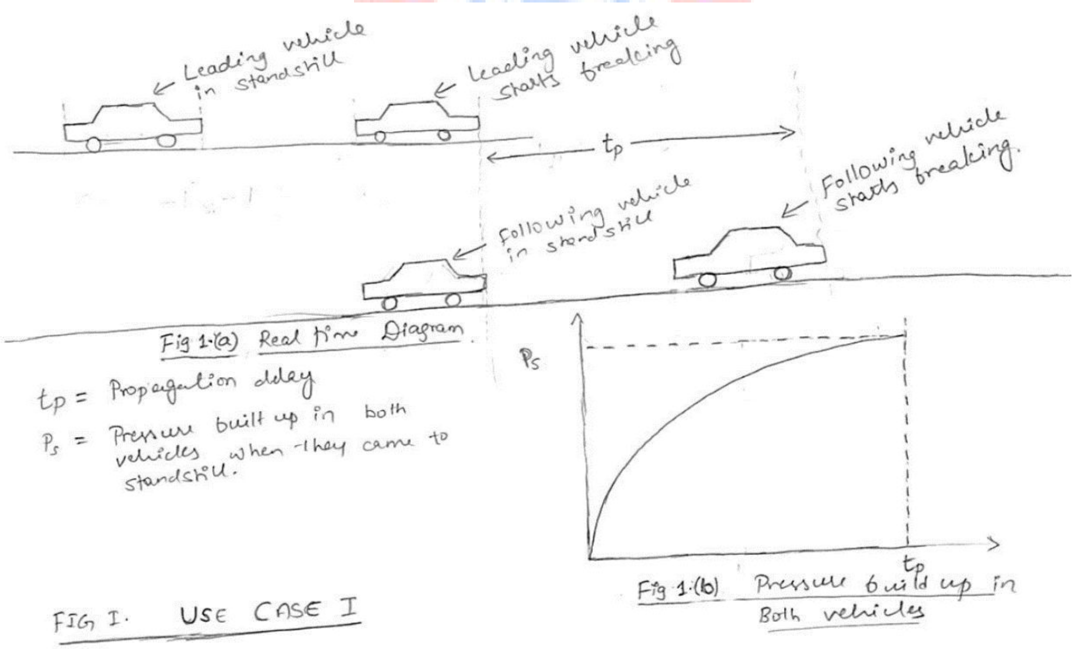
The receiver module available in the following vehicles shall be receiving the information sent by the leading vehicle. It demodulates the information being communicated and reads the information like brake pressure/force, vehicle parameters that has been communicated. The read brake force from the communication module is taken as reference and other vehicle parameters are checked to see if the vehicle parameters are matching with the leading vehicle. In case of very less tolerance of the vehicle parameters are there, the brake force sent by the leading vehicle is realized in the trailing vehicle also.

The communication time from leading vehicle to following vehicle shall be calculated by making use of propagation delay slot of the communication protocol. This time is kept as the reference time within which the following vehicle shall be brought into the standstill. So the brake pressure/ force gradient in the following vehicle must be adapted in such a way that, vehicle shall come into the standstill within the value specified by the propagation delay.

There are 3 use cases which one should take care of while applying this method.

1. Leading and following vehicle has the same parameters.

If the leading vehicle has the same physical parameters like vehicle mass, tyre size, brake calipers/disk size, gross weight of the vehicle, then the brake force applied by the leading vehicle shall be taken as the required brake force by the following vehicle. This brake force shall be applied in the following vehicle within the time specified by the propagation delay (t_p). As both vehicles are having same physical parameters, the brake pressure should build up within the time t_p.



2.Leading vehicle has lesser physical parameters than following vehicles.

In this case, the brake force calculated by the leading vehicle will not be sufficient enough to rake the following vehicle within the propagation delay tp. So when the following vehicle receives the EBR from leading vehicle, it should realize the brake force well within the propagation delay (tp), which means trF has to be less than tp. In case the following vehicle doesn't come to standstill within trF, the brake application shall be continued in the same gradient so that following vehicle comes to standstill within tp. The difference between tpand trFhas to be realized in such a way that, following vehicle comes to standstill within trF andtp.

When the following vehicle has higher parameters than leading vehicle, then the equation follows from 7 to 9.

$$P_{FVS} = P_{LVS} + P_{offset} \longrightarrow (7)$$

$$P_{offset} = \frac{F_{off}}{A} = \text{Extra pressure needed to bring vehicle to standstill}$$

$$P_{offset} = \frac{m_F (0 - V_F)}{A_F t} \longrightarrow (8)$$

$$P_{offset} = \frac{-m_F V_F}{A_F t} \longrightarrow (9)$$

For a given car, m and A are constant, Equation 10 follows.

$$P_{offset} = \frac{-m_F}{A_F} \int \frac{V_F}{t} \, dV_F \cdot dt. \longrightarrow (10)$$

As the target is to reduce the vehicle velocity from V_F to zero, within the time $t_{pF,}$ then Equation 11 follows.

$$P_{offset} = \frac{-m_F}{A_F} \int_{v_F}^{0} \int_{0}^{t_{PF}} \frac{v_F}{t} \, dv_F \, dt \rightarrow (11)$$

Hence equation 7 follows the equation 12.

$$\boxed{P_{FVS} = P_{LVS} + \left[\frac{-m_F}{A_F} \int_{v_F}^{0} \int_{0}^{t_{PF}} \frac{v_F}{t} \, dv_F \, dt \right]} \rightarrow (12)$$

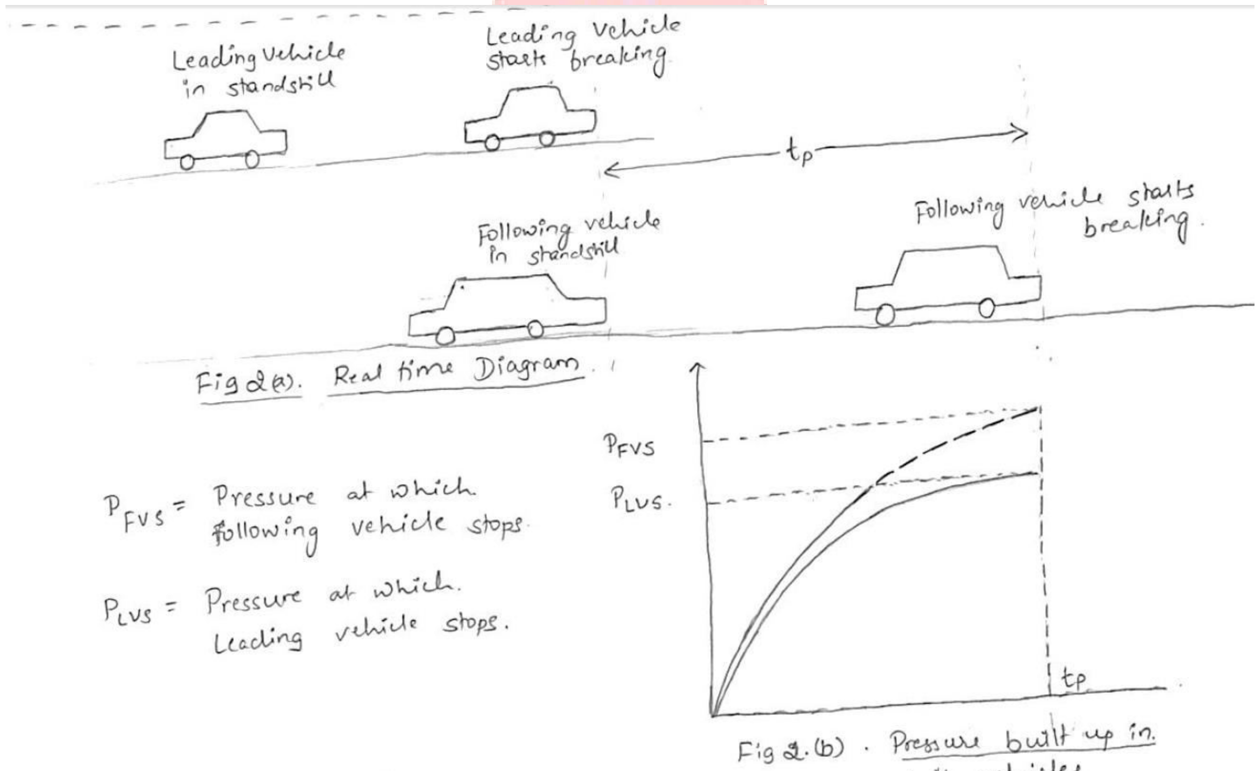


FIG II. USE CASE II

4. . Leading vehicle has higher physical parameters than following vehicles

In this case, the brake force calculated by the leading vehicle is more than required by the following vehicle, that means the gradient with which brake force shall be built up in the following vehicle is not necessarily as high as leading vehicle that means same pressure from leading vehicle should be realized in the following vehicle with time $t_p+t_{offset.}$.

All relation of Use case 2 holds well for use case 3 and these equations are shown in equation 13 and equation 14.

$$P_{FVS} = P_{LVS} - \left[\frac{-m_F}{A_F} \int_{V_F}^{0} \int_{0}^{t_{PF}} \frac{V_F}{t} \, dV_F \, dt \right] \longrightarrow (13)$$

$$P_{FVS} = P_{LVS} + \left[\frac{m_F}{A_F} \int_{V_F}^{0} \int_{0}^{t_{PF}} \frac{V_F}{t} \, dV_F \, dt \right] \longrightarrow (14)$$

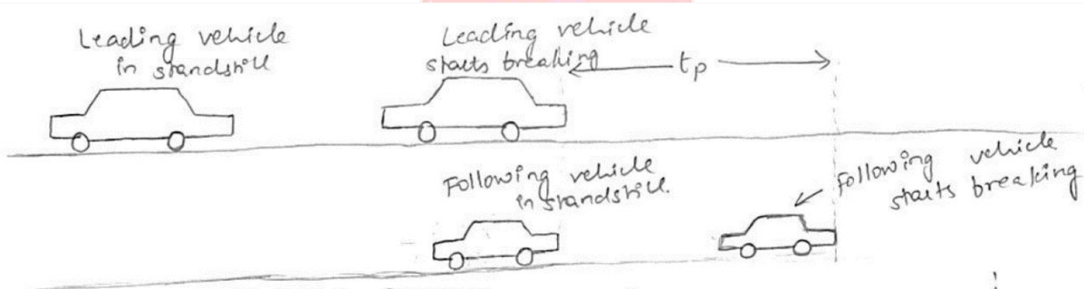


Fig 3(a) Real time Diagram

P_{FVS} = Pressure at which following vehicle stops.

P_{LVS} = Pressure at which leading vehicle stops.

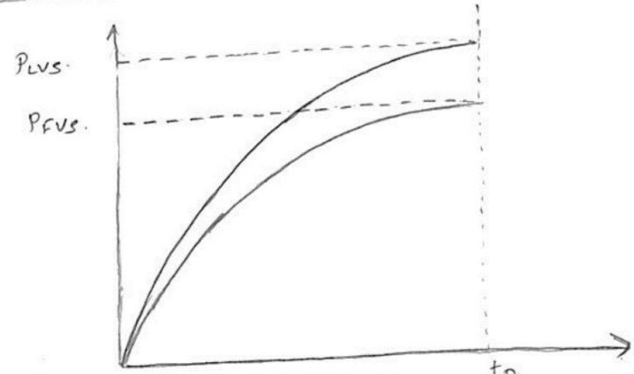


Fig 3(b). Pressure build up in both vehicles

In all three use cases, velocity of the following vehicle should be monitored & when it comes to standstill, brake pressure application should be turned off. In case, in all three use cases, driver is applying the pedal in a better way to build up the needed pressure, DBR has to be prioritized over EBR. (Normal use case, where driver is capable to build up the pressure to bring the vehicle to standstill).

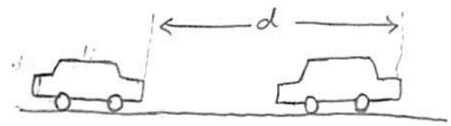
So in all three cases, P_{FVS} is the target pressure (or Expected pressure) that needs to be built up in the following vehicle in order to avoid any collision between leading vehicle and following vehicle. This target pressure shall be built up in the following vehicle within the time t_{pF}(calculation shown below) which also considers the Doppler Effect between two movable vehicles.

Calculating propagation delay t_{pF} by considering the Doppler Effect:

If two vehicles are stationary with a in between distance of d and leading vehicle communicates a data frame with a speed v, then time taken for data frame to reach following vehicle is according to equation 1.

If two vehicles are moving with a same velocity, equation holds good.

$$t_p = \frac{d}{V} \longrightarrow (1)$$



In case two vehicles (leading and following) vehicles are moving with different velocity, then equation 2 follows.

$$t_{pF} = t_p + \int \left(\frac{d_L}{V_L} - \frac{d_F}{V_F} \right) dV \cdot dd \longrightarrow (2)$$

Where d_L, d_F are the distance of leading and following vehicles respectively from a single point of reference and V_L and V_F are he velocities of leading and following vehicles respectively.

In this method, the calculation of $t_p$is done at following vehicle, reference point can be taken as the following vehicle and reference points can be taken as d_F=0. Hence equation 3 follows.

$$t_{pF} = t_p + \int \frac{d_L}{V_L} dv_L \cdot dd_L \longrightarrow (3)$$

As the maximum propagation delay will be taken from reaching the distance of (d_L-d_F) to 0 and velocity V_F to zero, Equation 4 and Equation 5 follows.

$$t_{pF} = t_p + \int_{d_L - d_F}^{0} \int_{V_L}^{0} \frac{d_L}{V_L} \, dv_L \, dd_2 \longrightarrow (4)$$

$$t_{pF} = t_p + \int_{d_L}^{0} d_L \cdot dd_L \int_{V_L}^{0} \frac{1}{V_L} \, dv_L \longrightarrow (5)$$

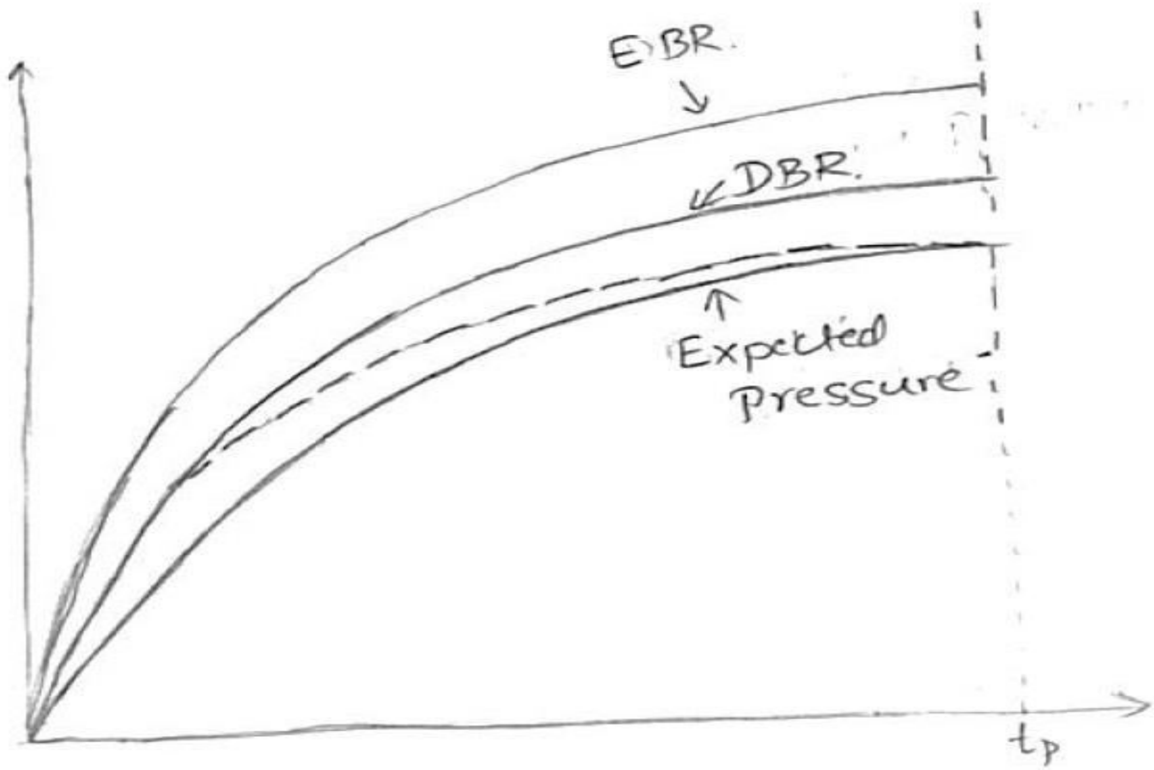
As the length of the vehicle needs to be taken care while calculating tpF then equation 6 follows.

$$\Rightarrow t_{pF} = t_p - \frac{d_{lL}}{V} + \int_{d_L}^{0} d_L \, dd_L \int_{V_L}^{0} \frac{1}{V_L} \, dV_L \longrightarrow (6)$$

d= Continuous distance between two vehicles

t_{PF} = Final propagation delay

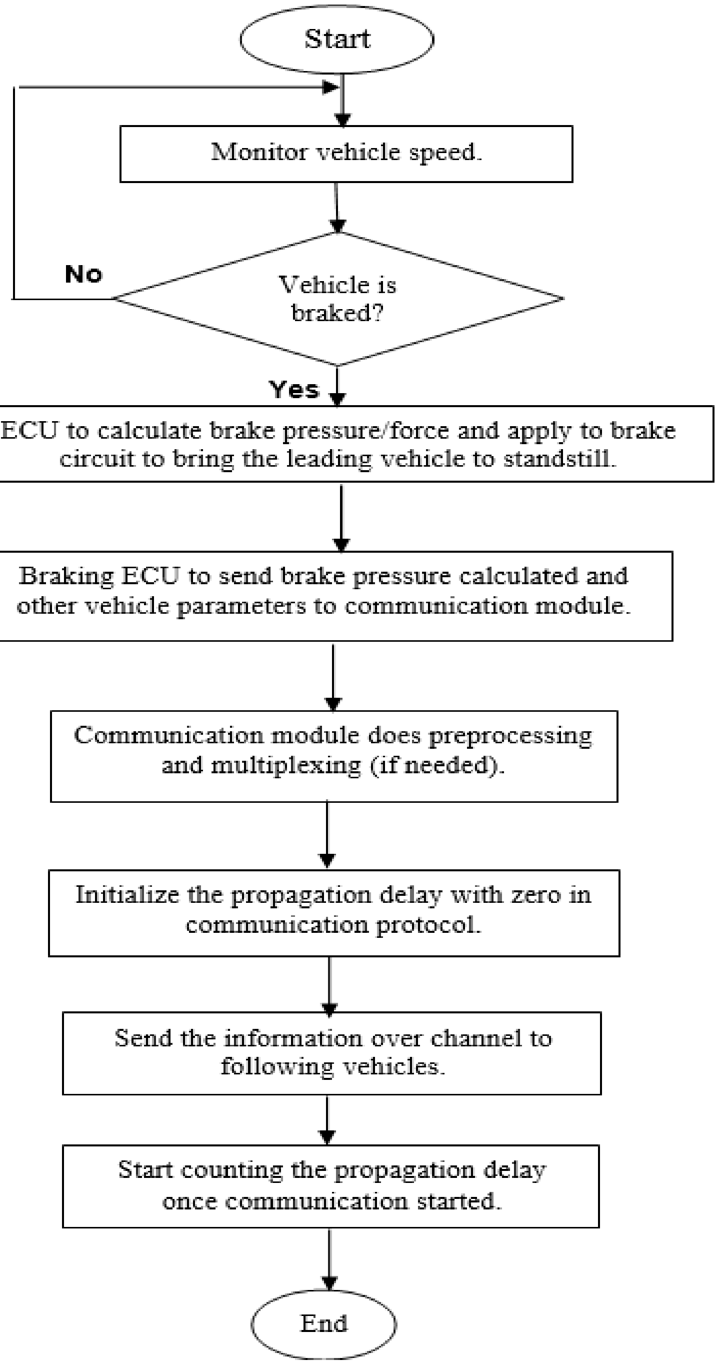
V_F, V_L = Velocity of following vehicle and leading vehicle respectively



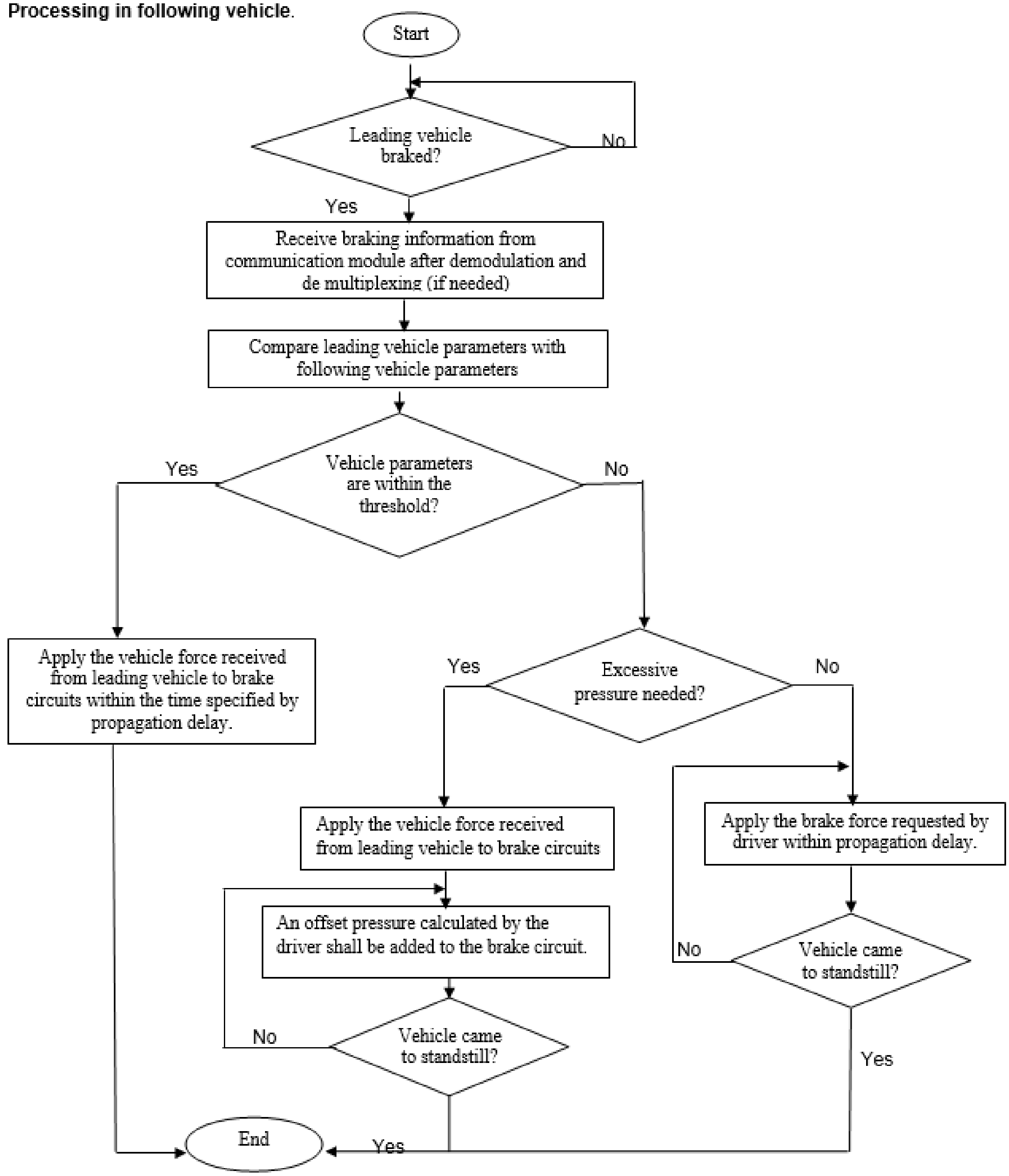
So because of this, the dependency on the driver's interpretation to reduce the vehicle velocity will come down. Along with that driver's intention to brake in the needed ramp will be executed.

Flowchart:

Processing in Leading Vehicle.



Processing in following vehicle.



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