Chapter 5:
Information Propagation Probability on Intersections in VANETs

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Information Propagation Probability on Intersections in VANETs

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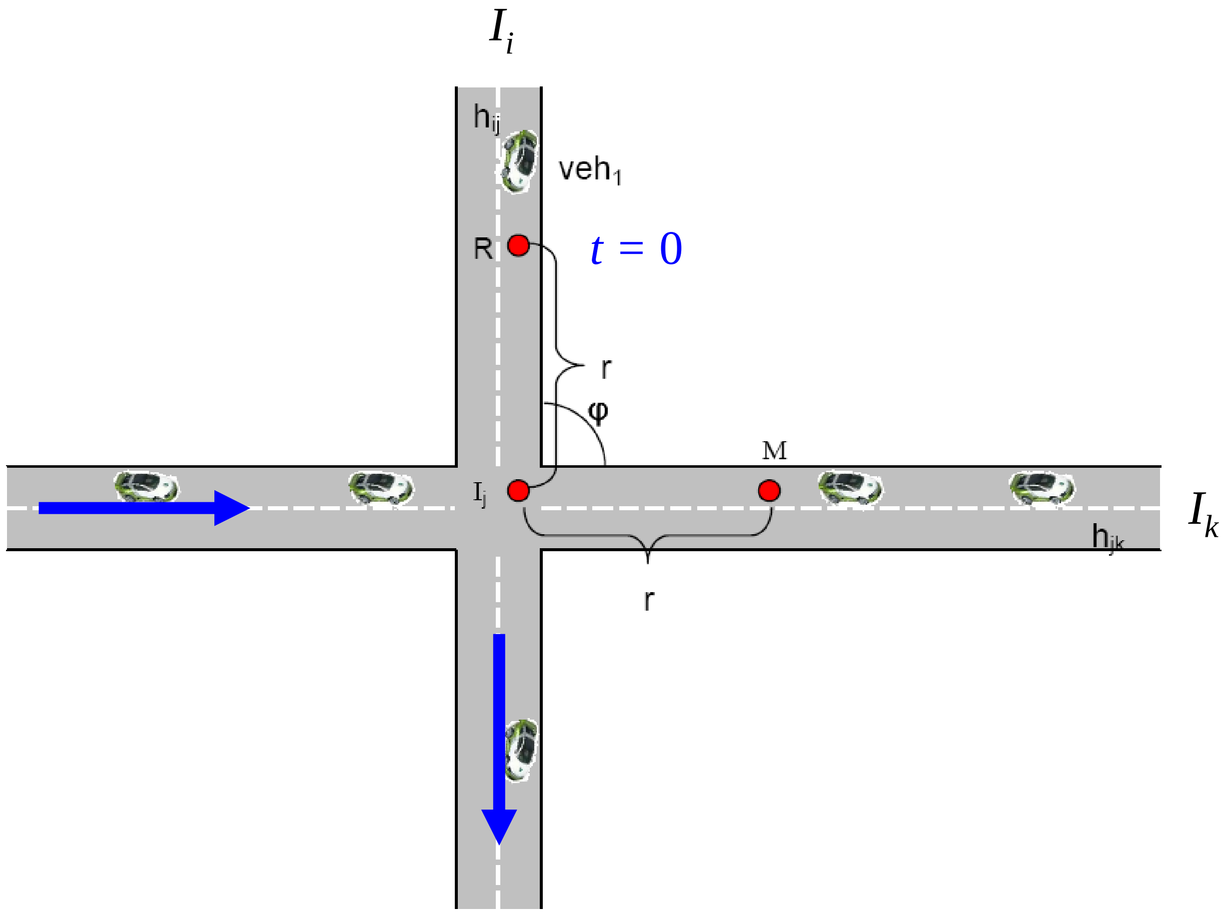
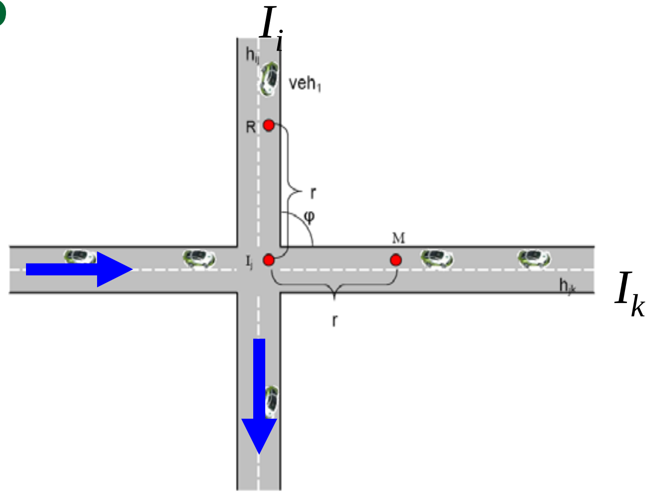
Vehicle-to-Vehicle Communications 2007 (V2VCOM 2007)

Environment



PDF of Arrival Process



Mean arrival rate at h_{jk}

$$P_z^{h_{jk}}(t) = \frac{(\lambda_{jk} t)^z}{z!} e^{-(\lambda_{jk} t)}$$

PDF of arrival process at h_{jk}

The number of arrivals from 0~t

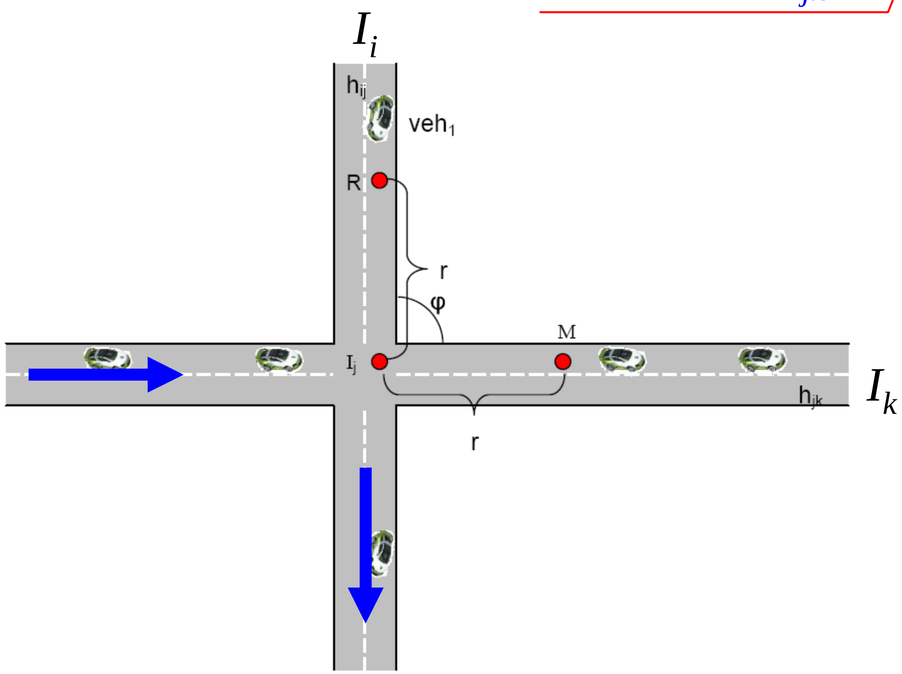
Erol A. Peko"z and Nitindra Joglekar, "Poisson traffic flow in a general feedback queue," Journal of Applied Probability, Volume 39, Number 3 (2002), 630-636

Information Propagation Probability

$$p_{h_{ij}h_{jk}} = \underline{p_{tr}^{h_{ij}h_{jk}}} + (1 - p_{tr}^{h_{ij}h_{jk}}) * \underline{p_{dr}^{h_{ij}h_{jk}}}$$

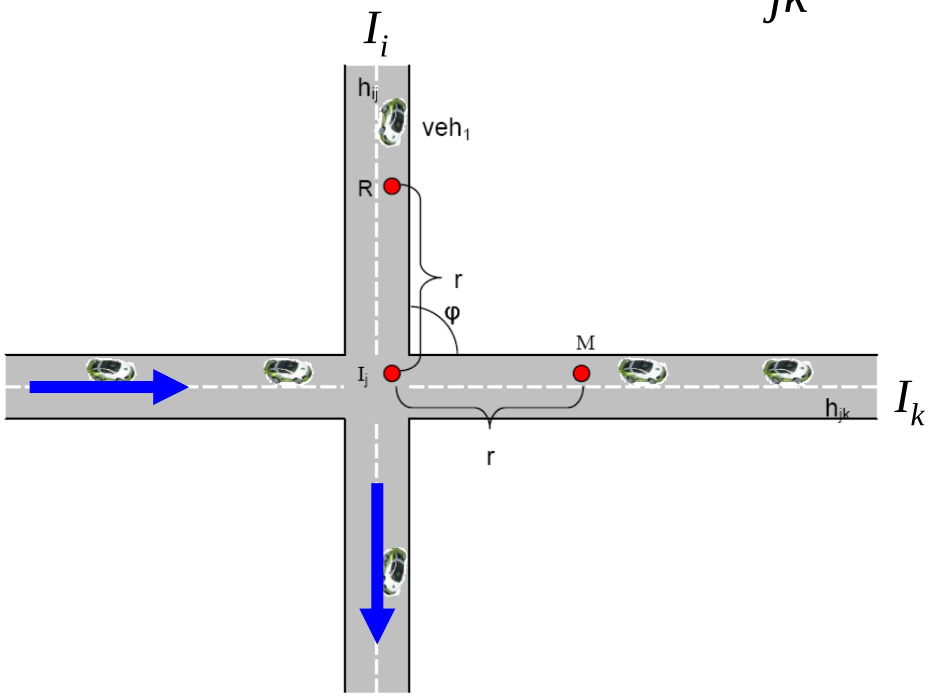
By transmitting information form h_{ij} to h_{jk} directly

By having the veh_1 driving into h_{jk}



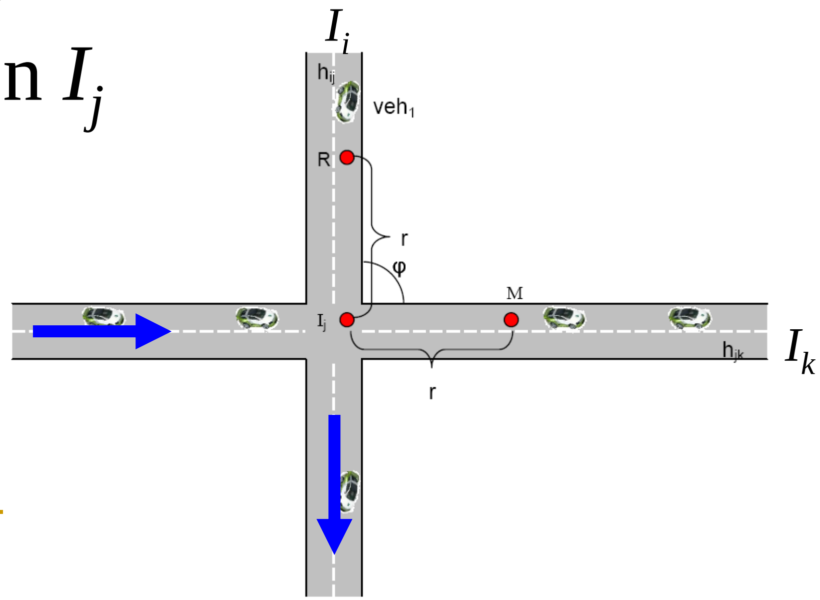
Probability of Information Transmission form h_{ij} to h_{jk} Directly ($p_{tr}^{h_{ij}h_{jk}}$)

- p_e: a vehicle entering h_{jk} during time interval$[0,y]$
- p_c: veh_1 transmits information to the vehicle at h_{jk} directly



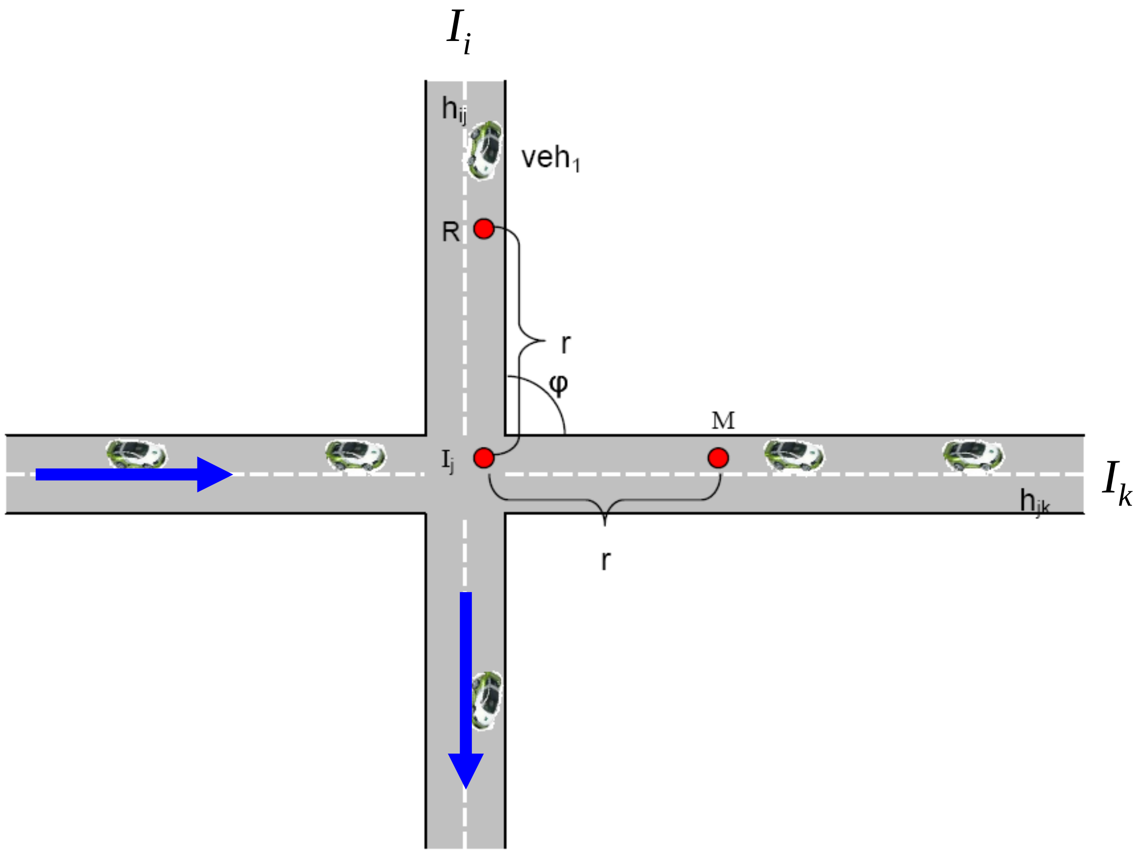
Probability of Information Transmission form h_{ij} to h_{jk} Directly ($p_{tr}^{h_{ij}h_{jk}}$)

- Case 1: veh_1 has the information when it passes from point R
- Case 2: veh_1 passed point R without carrying the information and it got informed before reaching intersection I_j



Case 1:
veh_1 has the information when it passes from point *R*

p_e: a vehicle entering h_{jk} during time interval[0,y]



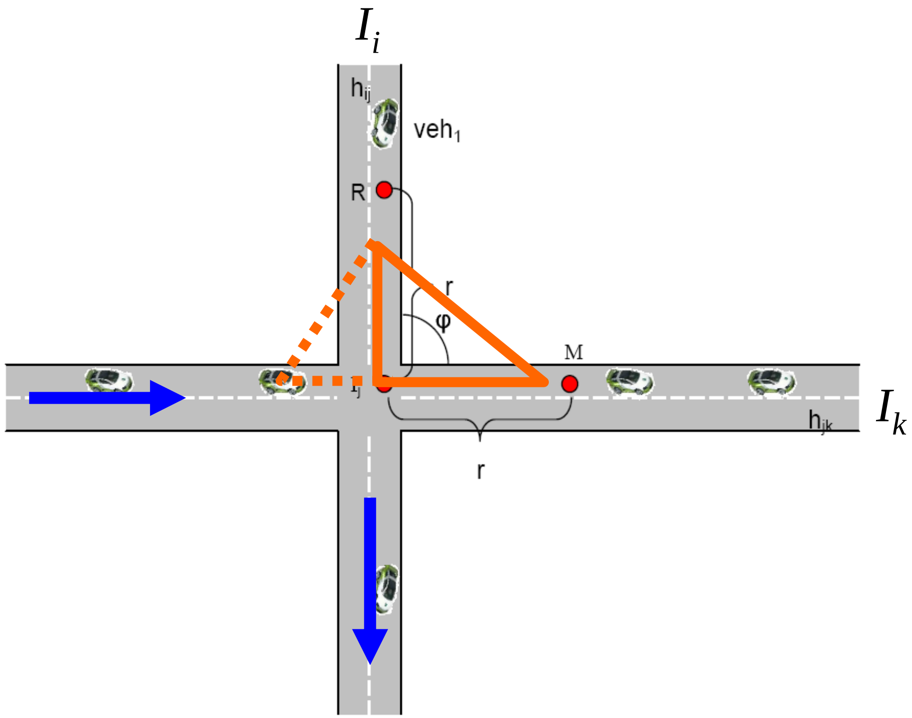
$$y \leq \frac{r}{V_{max}(h_{ij})}$$

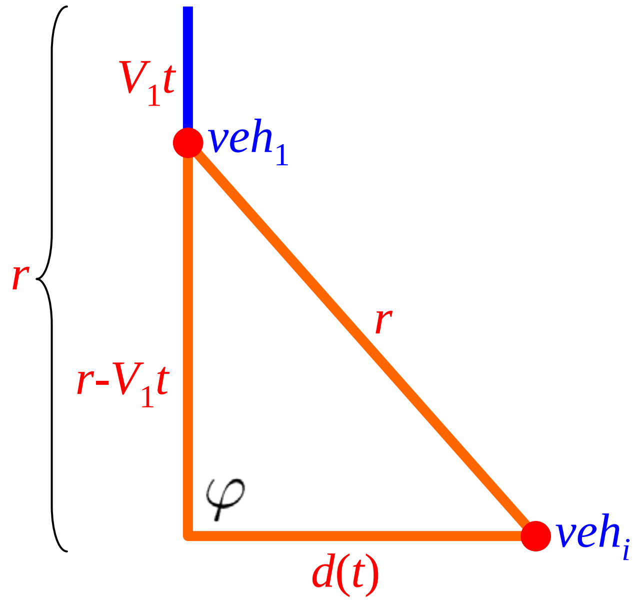
$$p_e = 1 - P_0^{h_{jk}}(y)$$

p_c: veh_1 transmits information to the vehicle at h_{jk} directly

$$d(t) = (r - V_1 t)cos\varphi + \sqrt{r^2 - (r - V_1 t)^2 sin^2\varphi}$$

The furthest away point
where veh_1 can cover in time t





$$d(t) = \sqrt{r^2 - (r - V_1 t)^2}$$

p_c: veh_1 transmits information to the vehicle at h_{jk} directly

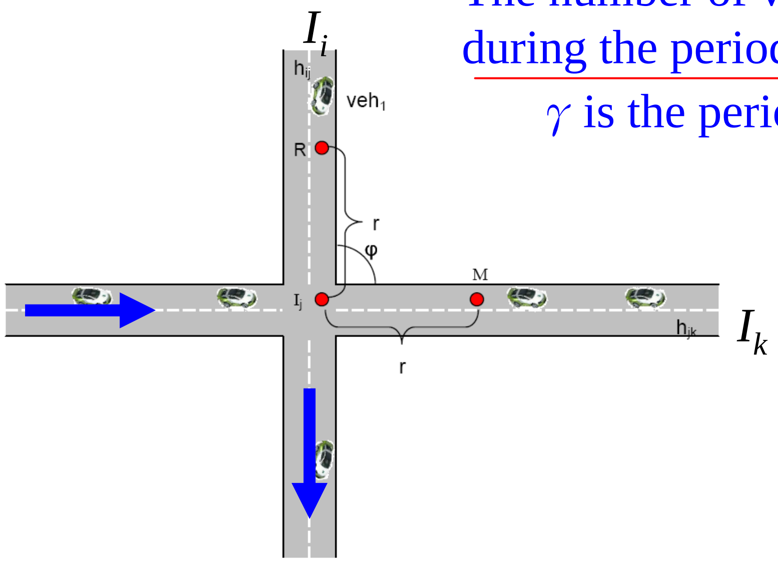
T_i is the time when vehicle i passed I_j

$$X(t) = min(V_i' * (t - T_i)) \ i = 1, 2, ..., Z(\gamma)$$

The distance that a vehicle closest to I_j

The number of vehicles that have entered h_{jk} during the period $(-\gamma, 0)$

γ is the period of time before $t = 0$



p_c: veh_1 transmits information to the vehicle at h_{jk} directly

The function distribution of $X(t)$

$$F_{X(t)}(d(t)) = \sum_{z=0}^{\infty} P[X(t) < d(t)|Z(\gamma) = z] * P[Z(\gamma) = z]$$

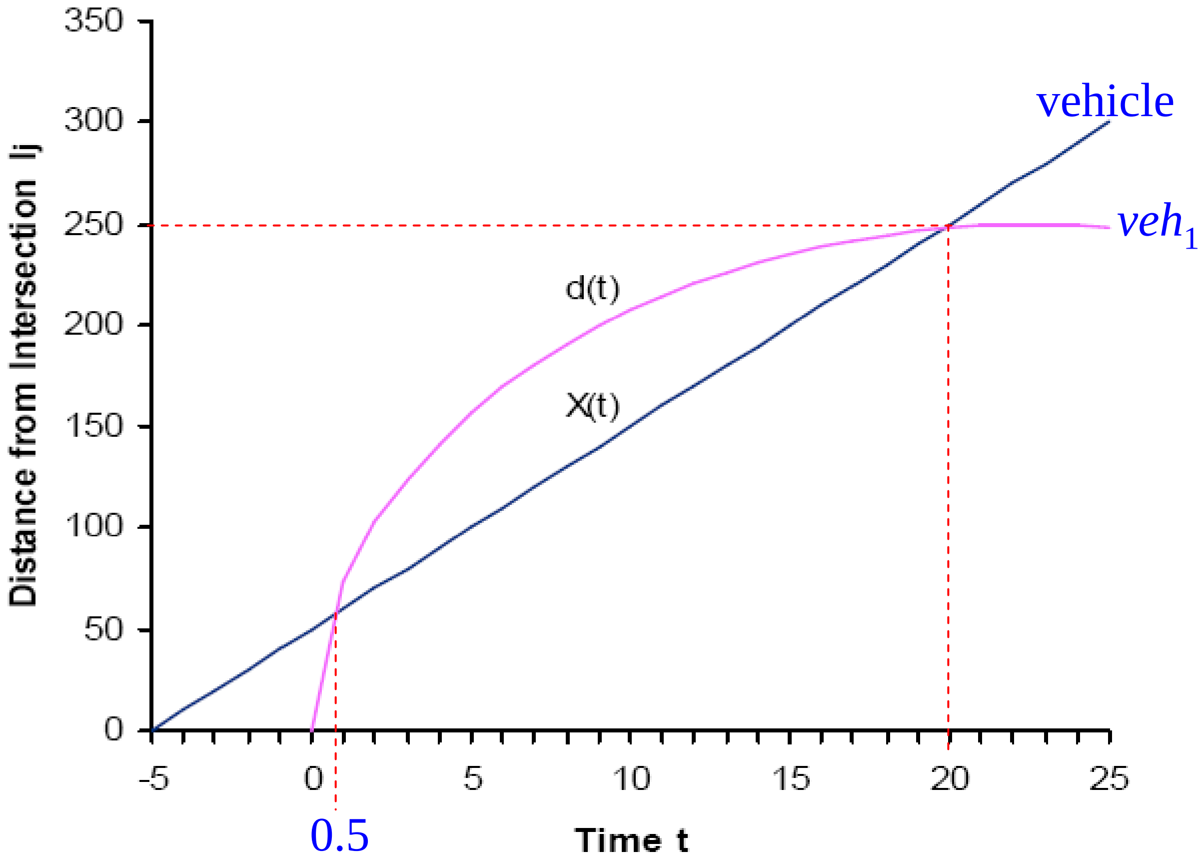
$$P[X(t) \leq d(t)|Z(\gamma) = z] =$$
$$1 - P[X(t) > d(t)|Z(\gamma) = z] =$$

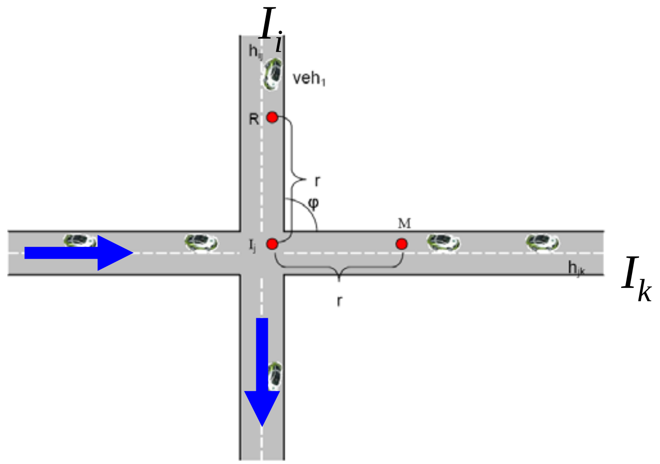
$$X(t) = min(V_i' * (t - T_i)) \qquad 1 - P[V' * (t - T) > d(t)]^z$$

$$p_c = \int_0^y F_{X(t)}(d(t))dt$$

Example of Catching Up Case

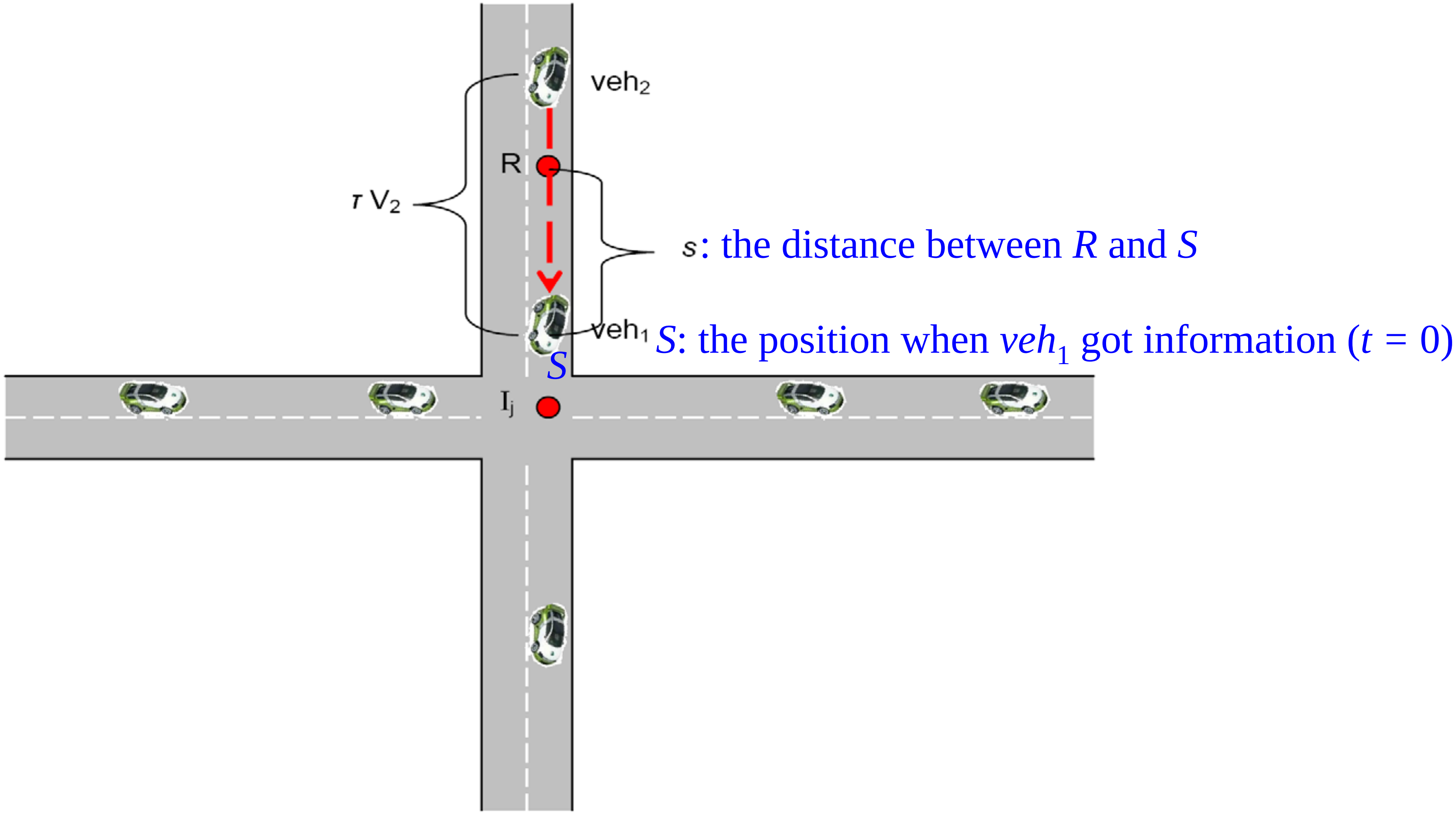
Transmission range = 250m



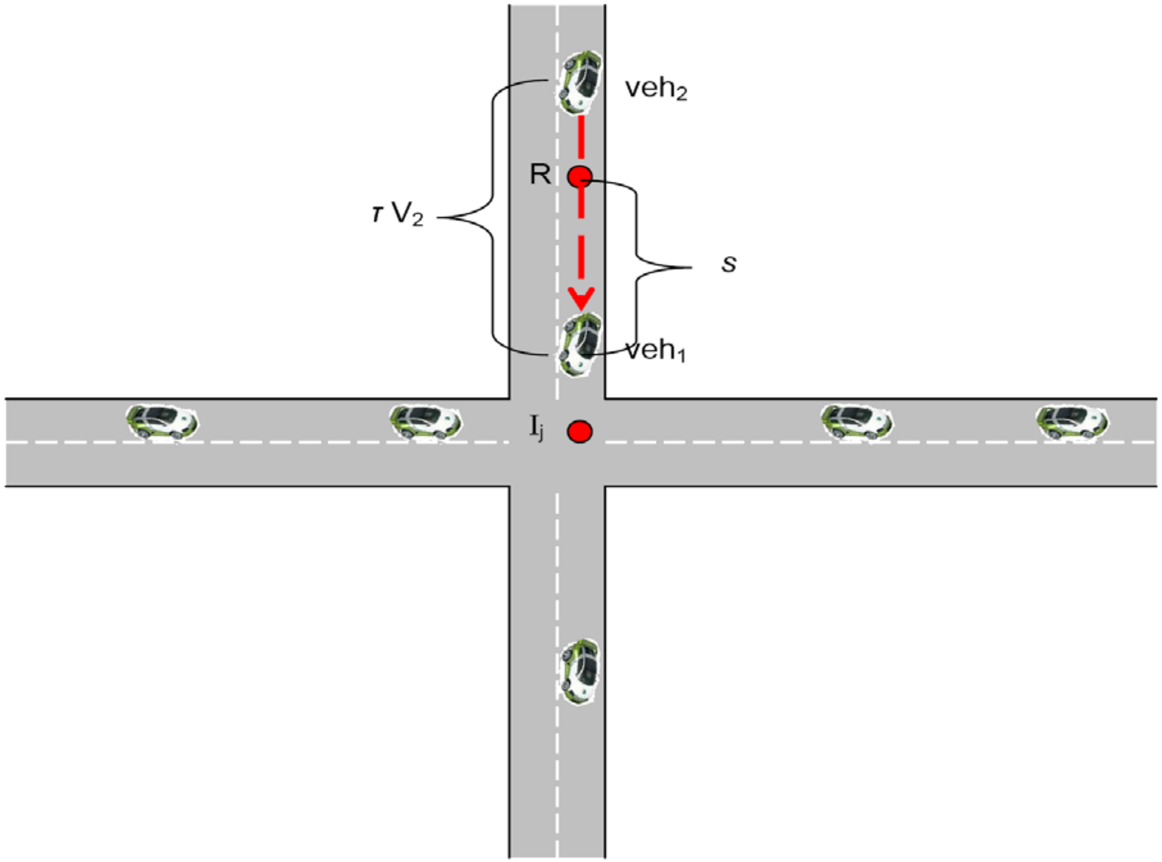


Case 2:
veh_1 passed point R without carrying the information and it got informed before reaching intersection I_j

Environment of Case 2



p_e: a vehicle entering h_{jk} during time interval[0,y]



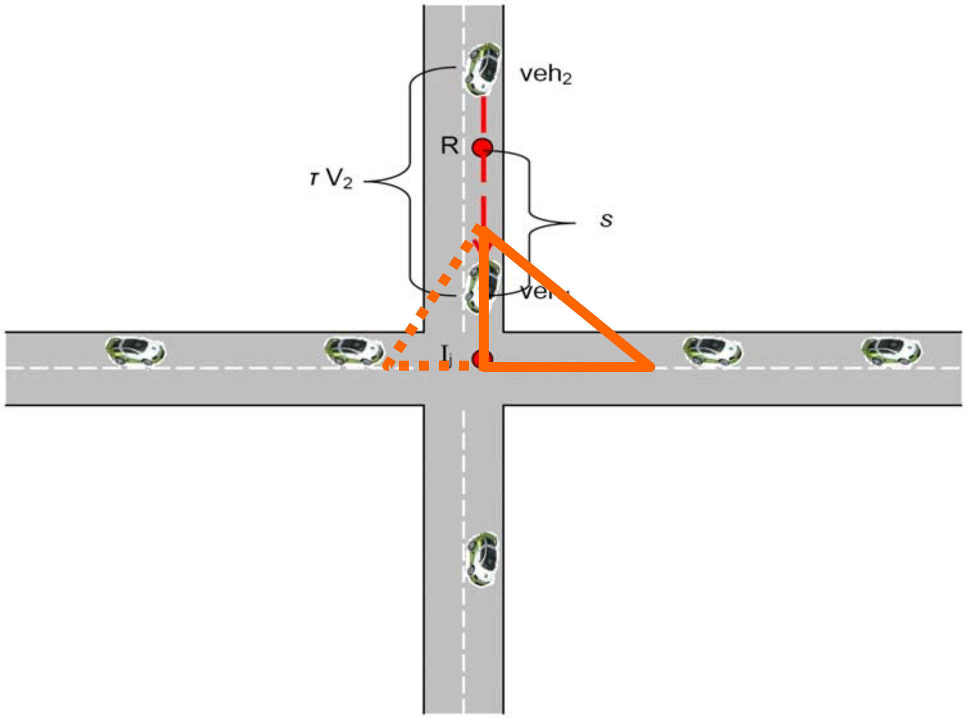
$$y \leq \frac{r-s}{V_1}$$

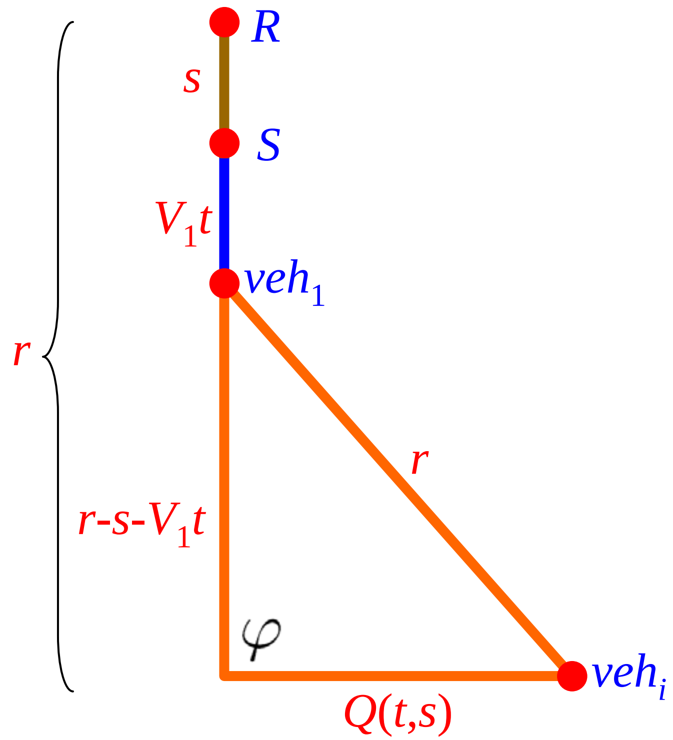
$$p_e = 1 - P_0^{h_{jk}}(y)$$

p_c: veh_1 transmits information to the vehicle at h_{jk} directly

$$Q(t,s) =$$

$$(r - s - V_1 t)cos\varphi + \sqrt{r^2 - (r - s - V_1 t)^2 sin^2\varphi}$$





$$\sqrt{r^2 - (r - s - V_1 t)^2}$$

p_c: veh_1 transmits information to the vehicle at h_{jk} directly

$$
\begin{aligned}
&F_{Q(t,s)-X(t)}(0) = \\
&\quad \int_0^r \sum_{z=0}^{\infty} P[Q(t,s) - X(t) > 0 | Z(\gamma) = z] \\
&\quad * P[Z(\gamma) = z] * f_s(s) ds
\end{aligned}
$$

$$
p_c = \int_0^y F_{Q(t,s)-X(t)}(0) dt
$$

Probability of Information Transmission form h_{ij} to h_{jk} Directly ($p_{tr}^{h_{ij}h_{jk}}$)

- Combining case 1 and case 2 to calculation $p_{tr}^{h_{ij}h_{jk}}$
- We need to find the probability for each case to happen separately
- Time gap distribution

pdf of time gap distribution between veh_1 and veh_2

$$p_\tau(\tau) = \lambda e^{-\lambda\tau}$$

The time gap between veh_1 and veh_2

PDF of time gap distribution between veh_1 and veh_2

$$P_\tau(\tau > T) = e^{-\lambda T}$$

M. Rudack, M. Meincke, M. Lott, "On the Dynamics of Ad Hoc Networks for Inter Vehicle Communications (IVC)," ICWN 2002

Probability of Information Transmission form h_{ij} to h_{jk} Directly ($p_{tr}^{h_{ij}h_{jk}}$)

$$P_{cs_1} = P_\tau(\tau > \frac{r}{V_1}) = e^{-\lambda\frac{r}{V_1}}$$

$$P_{cs_2} = 1 - P_{cs_1}$$

$$p_{tr}^{h_{ij}h_{jk}} =$$

$$P_{cs_1} * (p_e^{cs_1} + (1 - p_e^{cs_1}) * p_c^{cs_1}) +$$

$$P_{cs_2} * (p_e^{cs_2} + (1 - p_e^{cs_2}) * p_c^{cs_2})$$

Probability of having the veh_1 driving into h_{jk} ($p_{dr}{}^{h_{ij}h_{jk}}$)

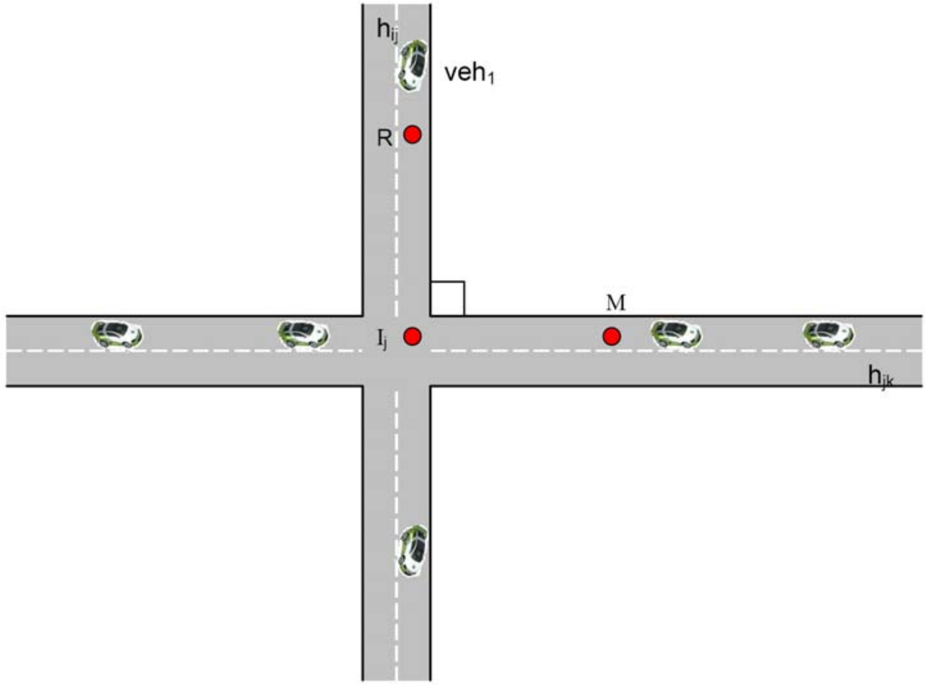
Mean arrival rate at h_{jk}

$$p_{dr}^{h_{ij}h_{jk}} = \frac{\lambda(h_{jk})}{\sum \lambda(h_{jb})}$$

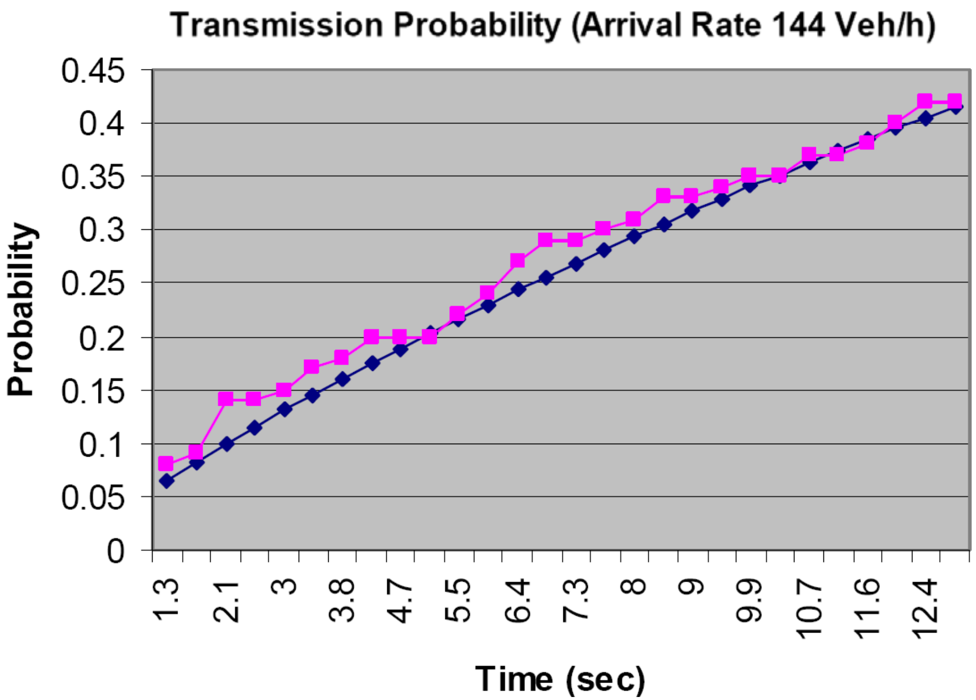
Mean arrival rate at h_{jb}

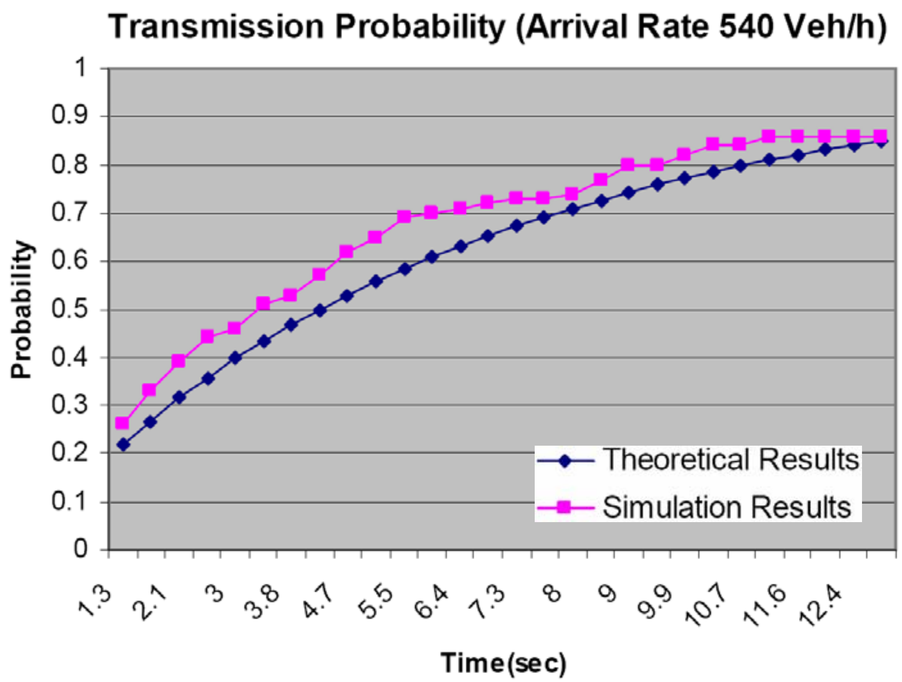
Simulation

- Simulation on VISSIM
- Transmission range is 250m
- Speed range is 60~8



Simulation


Transmission Probability (Arrival Rate 144 Veh/h)
Probability
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1.3
2.1
3
3.8
4.7
5.5
6.4
7.3
8
9
9.9
10.7
11.6
12.4
Time (sec)


Transmission Probability (Arrival Rate 540 Veh/h)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.3
2.1
3
3.8
4.7
5.5
6.4
7.3
8
9
9.9
10.7
11.6
12.4
Time(sec)
Theoretical Results
Simulation Results

Conclusions

- Provide a measure of the probability to propagate information on intersection roads
- Present a lower bound on the probability to propagate information between vehicles of two roads