



Study of A Geo-Multicast Framework for Efficient Message Dissemination at Level Crossings

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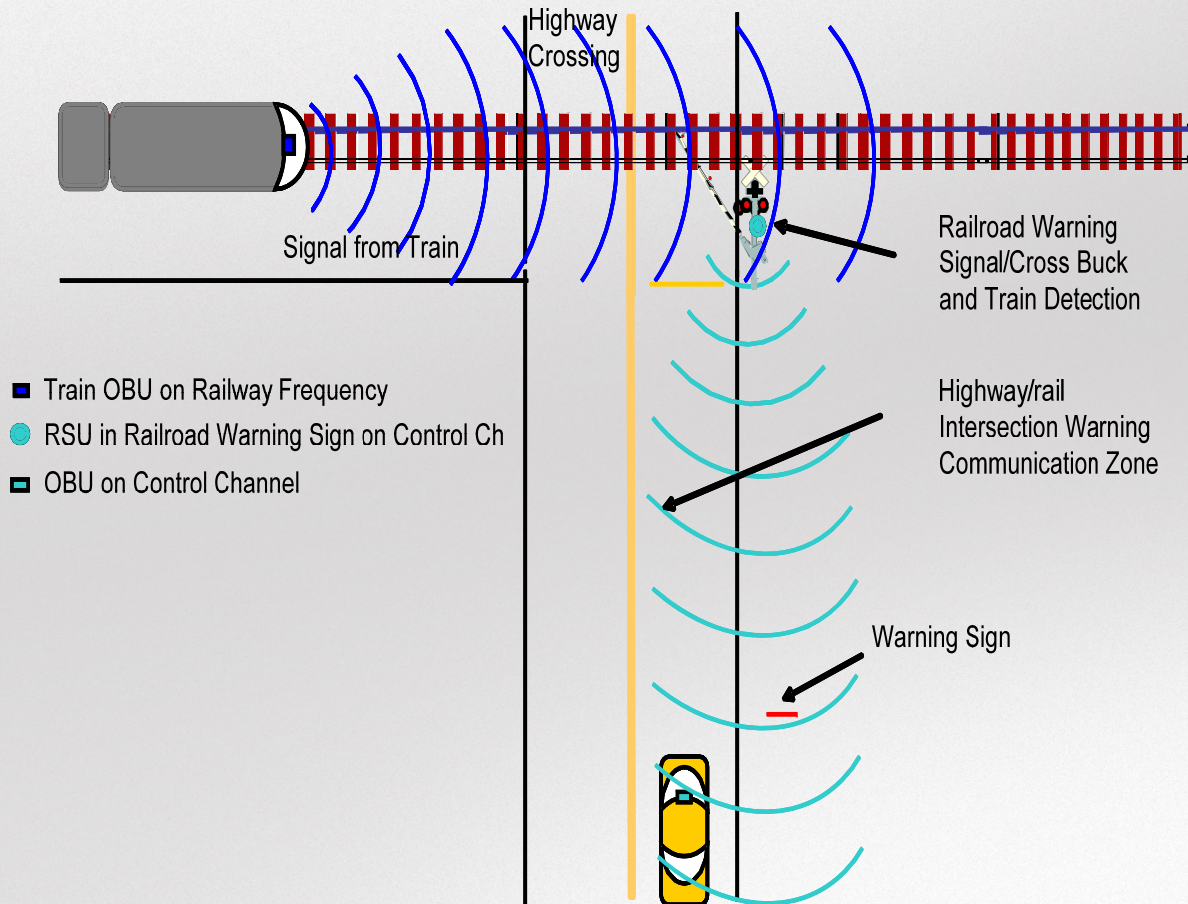


Outline

- CLX Safety System
- Geo-Multicast Framework
- The Framework Essentials
 - Communication Model
 - Statistical Model
- Geo-Determination Model
- RBGM Routing Protocol
- Geo-Determination Model Behavior
- Geo-Determination Model Performance
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- Discussion



Cooperative Level Crossing (CLX)



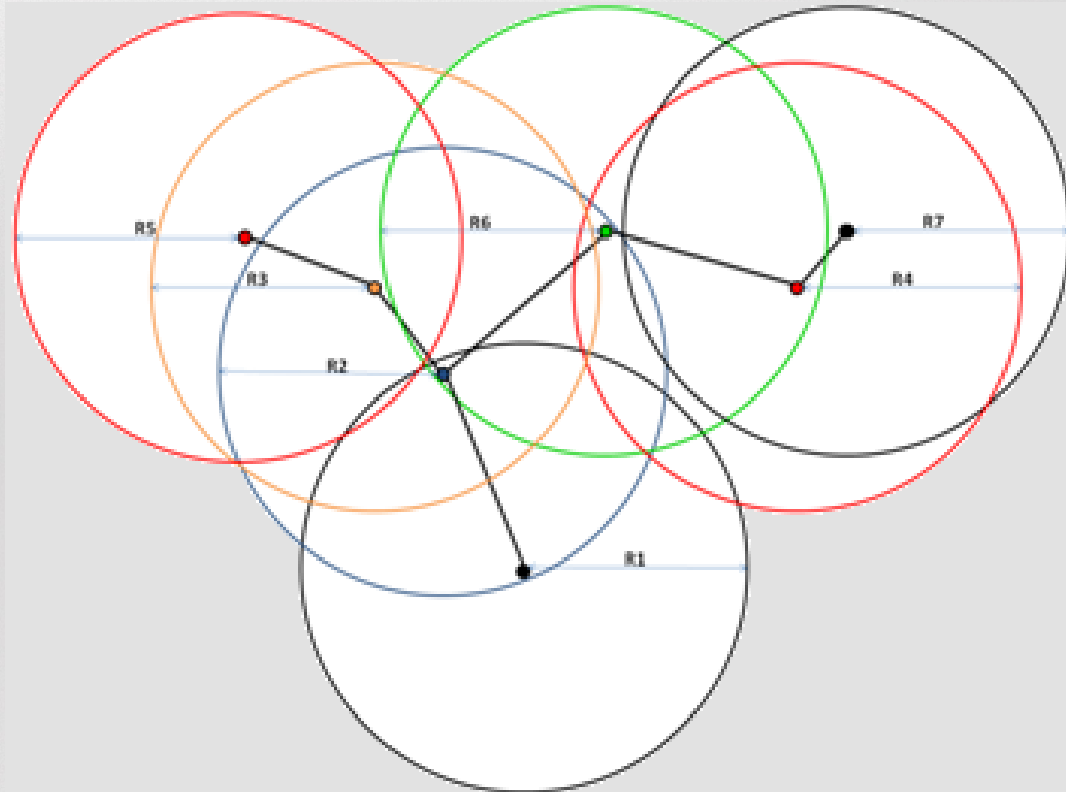
Source: Centre for Technology Infusion

<http://www.latrobe.edu.au/tech-infusion/activities/AutoCRC.htm>



The Framework Essentials

- **Communication Model - Unit Disk Graph**



Huson, Mark L.; Sen, Arunabha (1995), "Broadcast scheduling algorithms for radio networks", in *IEEE Military Communications Conference, MILCOM '95*, 2, pp. 647–651

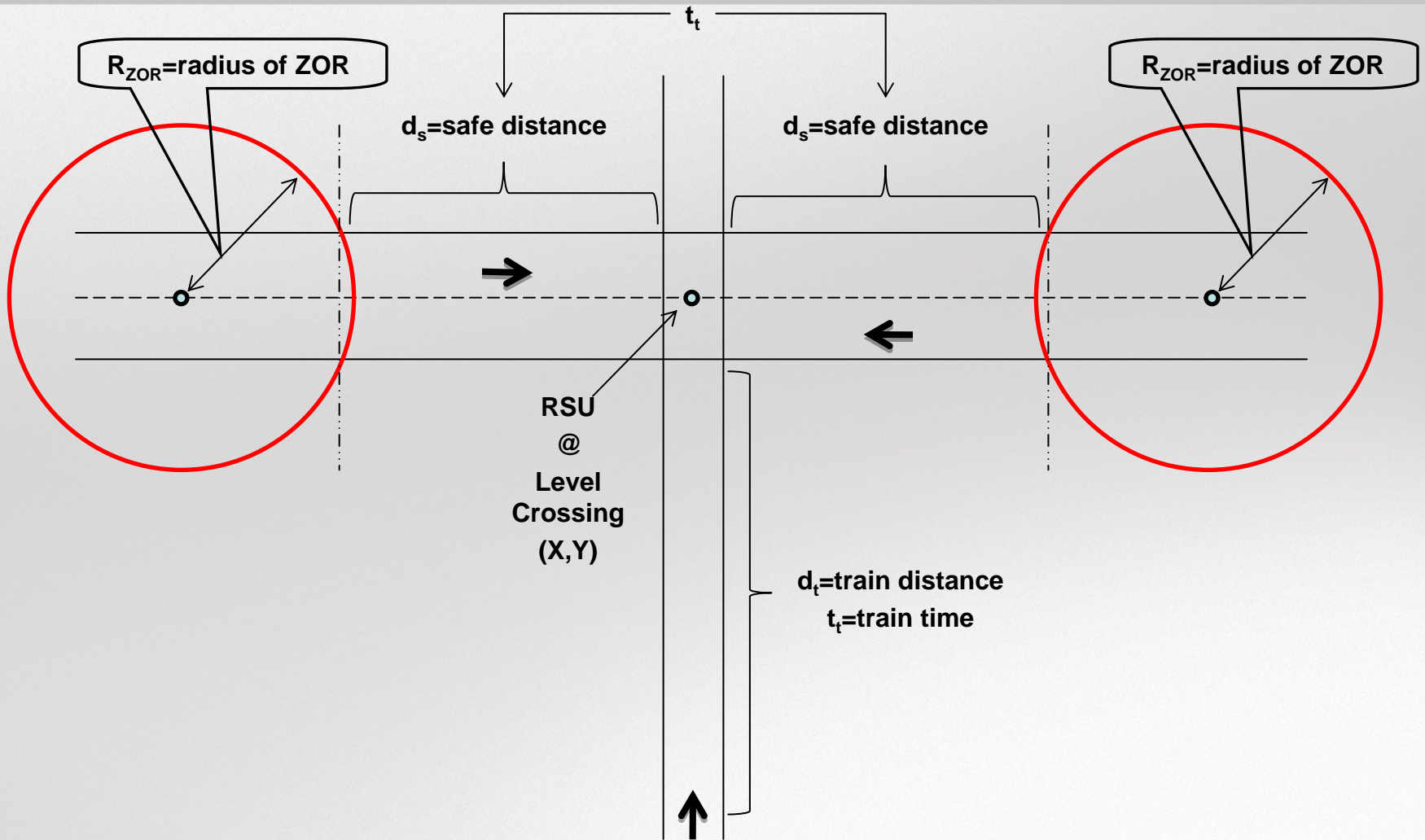


The Framework Essentials (Cont.)

- **Statistical Model - Packet Delay Variation**
 - The delay time difference between two successive packets:
$$J(k) = D(k) - D(k-1)$$
 - where $D(k)$ indicates the delay of k^{th} packet.



Geo-Determination Model





Geo-Determination Model (Cont.)

- Level Crossing Properties
 - Crossing Road's Angle (θ)
 - The angle of each road than the level crossing rail tracks
 - Level Crossing Degree
 - The number of crossing roads

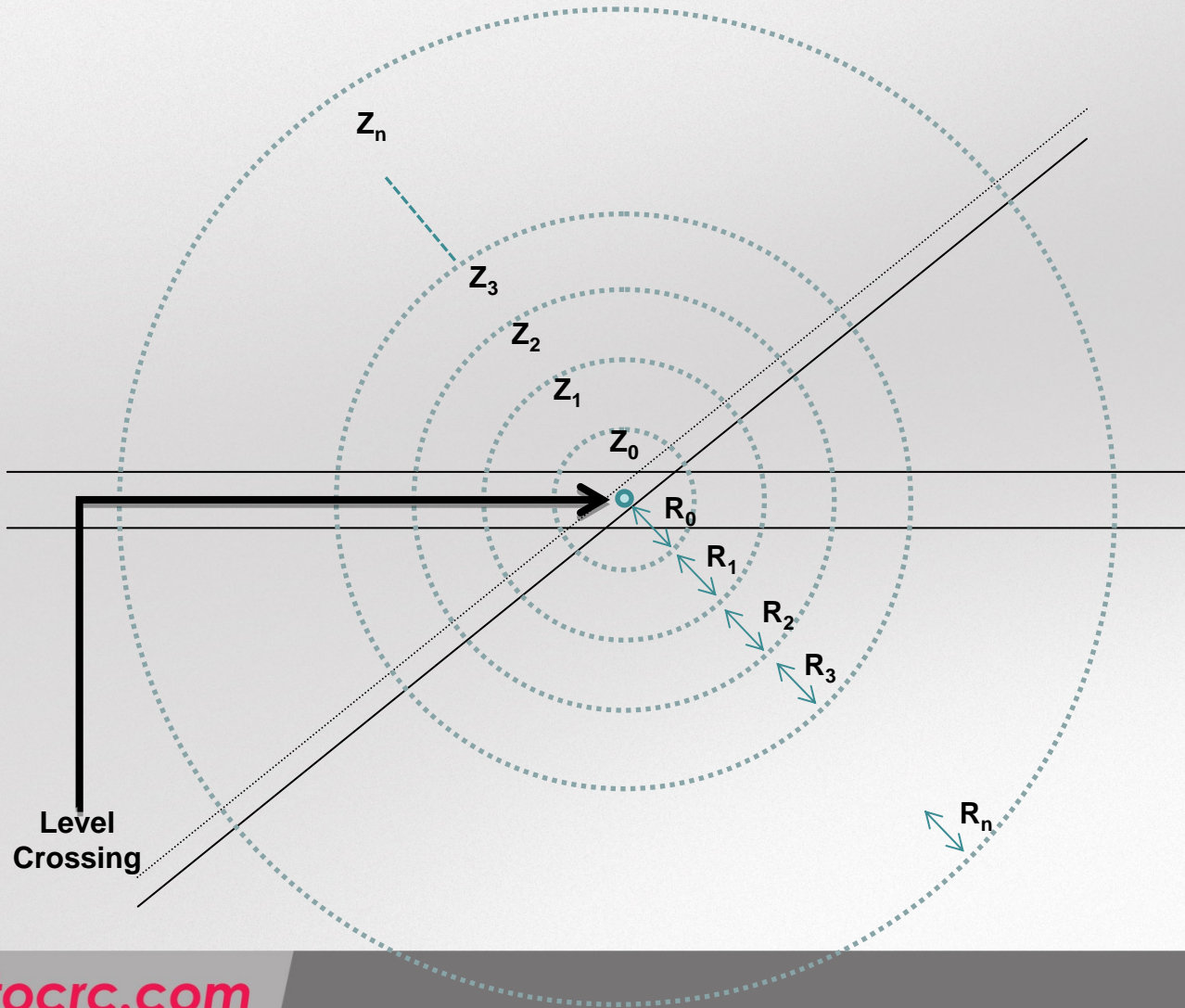
- Geo-Determination Formula:

ZORi Centre Point =

$$((\sin(\theta_i) \times (ds + Rz_{or})) + X, -((\cos(\theta_i) \times (ds + Rz_{or})) + Y))$$



Level Crossing Vicinity Fragmentation





Algorithm 1: RBGM Send

- The sender node (sn) checks its coordinates against the ZOR
- If $sn \notin ZOR$ // the sender is not in the ZOR
 - The sender sends a Request-to-Send (RS) packet including the location information of itself and the ZOR centre point
 - All the receivers calculate their suitability (rank) for forwarding and send Ready-to-Forward (RF)/Received packet back to the sender after a certain delay
 - The delay is calculated based on various parameters such as the distance to the destination, availability of relaying nodes, network traffic at the node, node movement pattern, etc.
 - The first node sending the RF packet back is selected as the relaying node
 - The sender transmits the data packets to the selected node
- Else // $sn \in ZOR$ - the sender is inside the ZOR)
 - If the packet is received previously
 - Discard the data packet
 - Else
 - Rebroadcast the data packet
 - Run the RBGM receiver algorithm



Algorithm 2: RBGM Receive

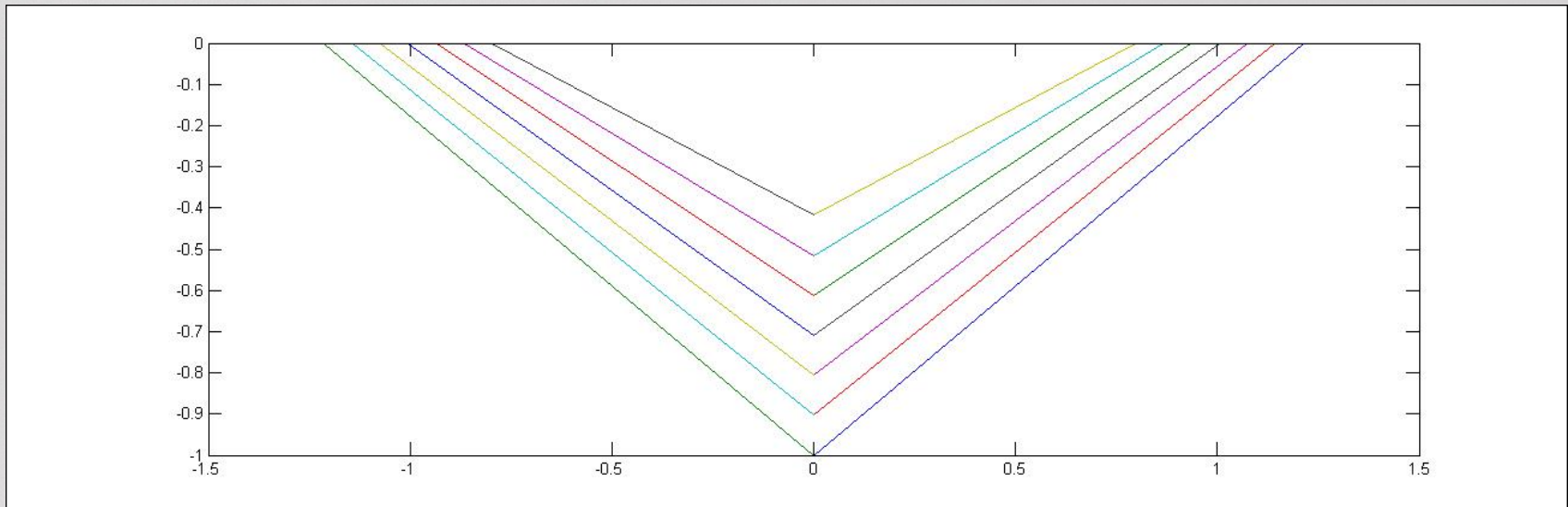
- The receiver node (rn) obtains its direction
- If $rn \in groupL$ // the receiver does not approach the level crossing
 - Discard the data packet
- If $rn \in groupA$ // the receiver approaches the level crossing
 - The receiver checks its coordinates against the ZOR
 - If $rn \notin ZOR$ // the receiver is not in the ZOR
 - Discard the data packet
 - Else // $rn \in ZOR$ - the receiver is inside the ZOR
 - Process the data packet



Geo-Determination Model Behavior

Scenario 1 : LX of degree 2 with $\theta_1=90^\circ$ and $\theta_2=270^\circ$

- $s_t=70\text{Km/h}$ (The train travels 0.097 Km per 5 seconds.)
- $s_r=50\text{Km/h}$
- $d_t=1\text{Km}$ at $t_0=0$,

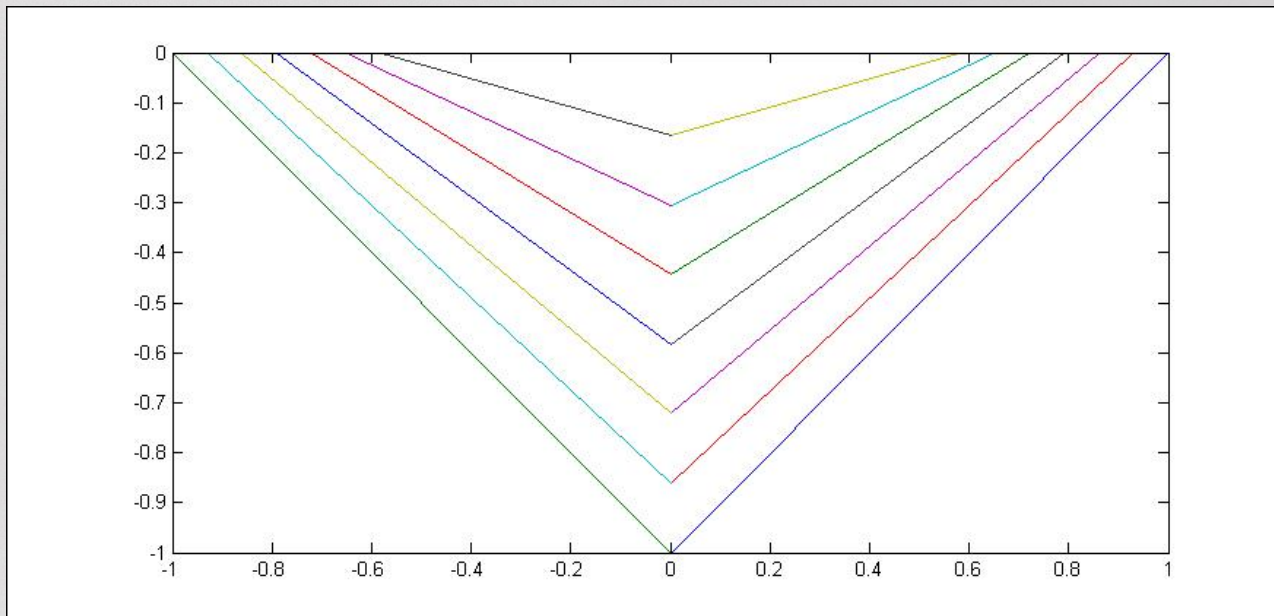




Geo-Determination Model Behavior (Cont.)

Scenario2 : LX of degree 2 with $\theta_1=90^\circ$ and $\theta_2=270^\circ$

- $s_t=100\text{Km/h}$ (The train travels 0.139 Km per 5 seconds.)
- $s_r=50\text{Km/h}$
- $d_t=1\text{Km}$ at $t_0=0$,

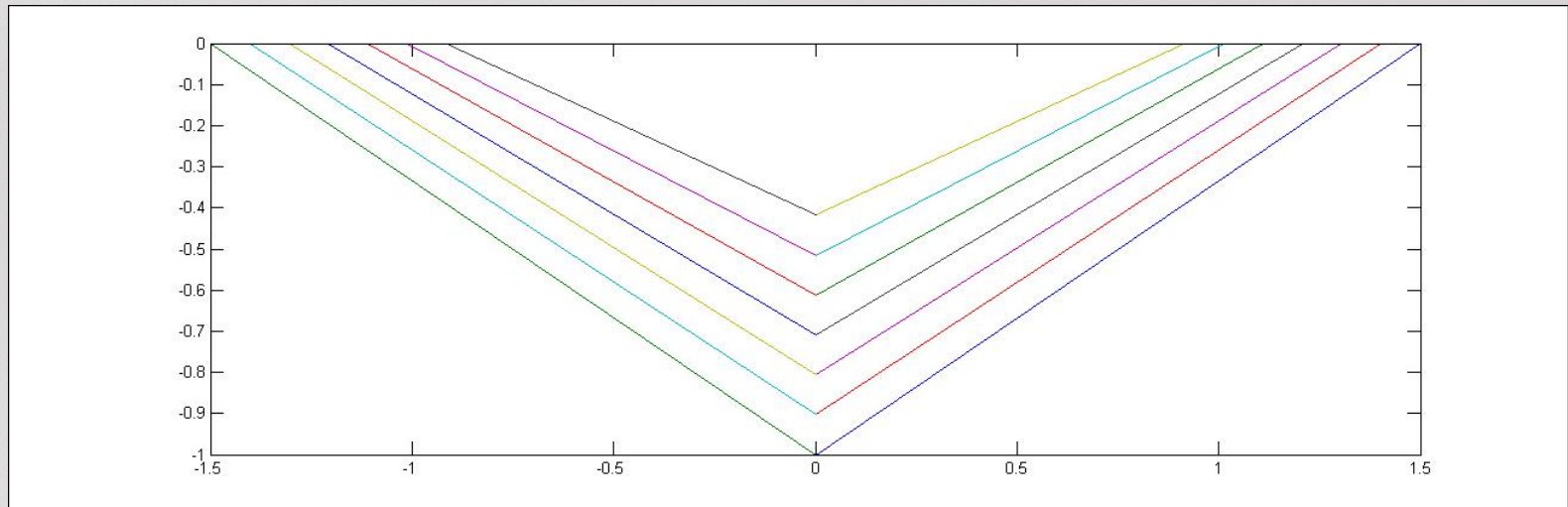




Geo-Determination Model Behavior (Cont.)

Scenario3 : LX of degree 2 with $\theta_1=90^\circ$ and $\theta_2=270^\circ$

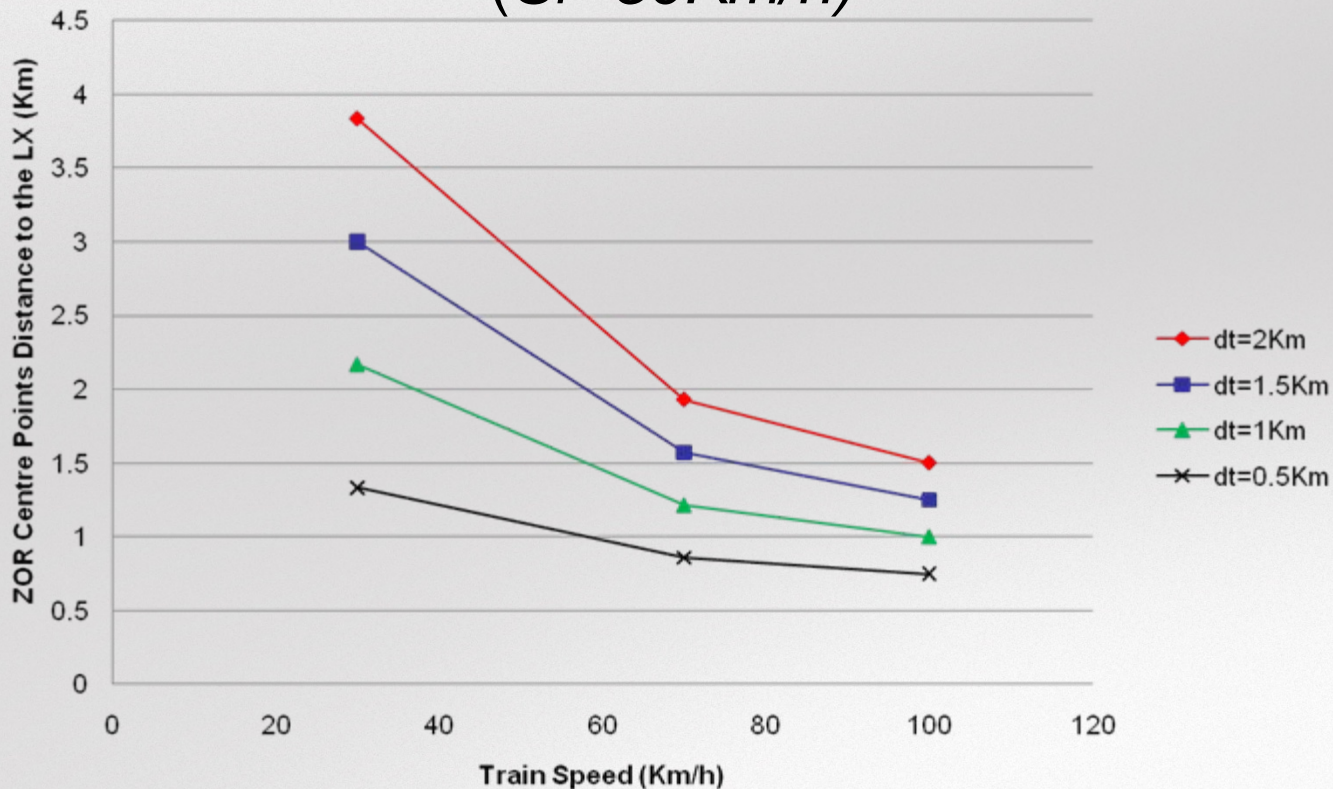
- $s_t=70\text{Km/h}$ (The train travels 0.097 Km per 5 seconds.)
- $s_r=70\text{Km/h}$
- $d_t=1\text{Km}$ at $t_0=0$,





Geo-Determination Model Performance

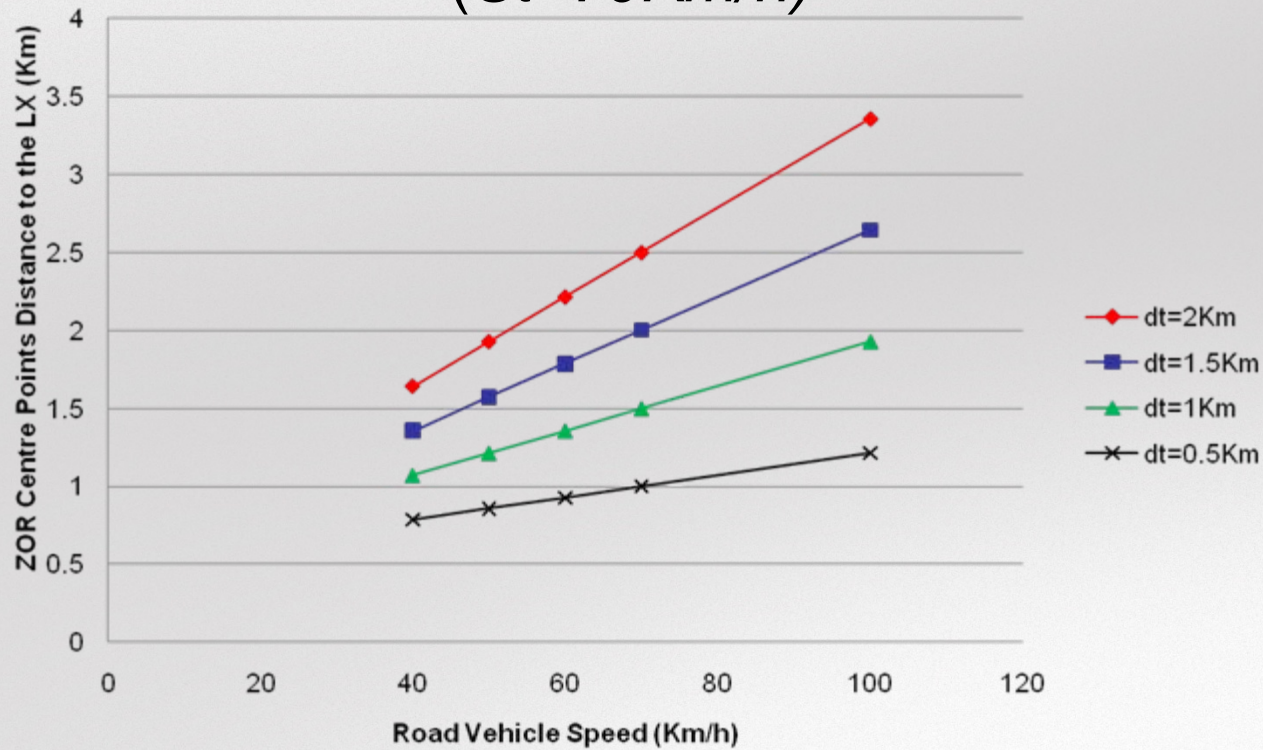
ZOR Centre Point vs. Speed For Train Movement ($S_r=50\text{Km/h}$)





Geo-Determination Model Performance (Cont)

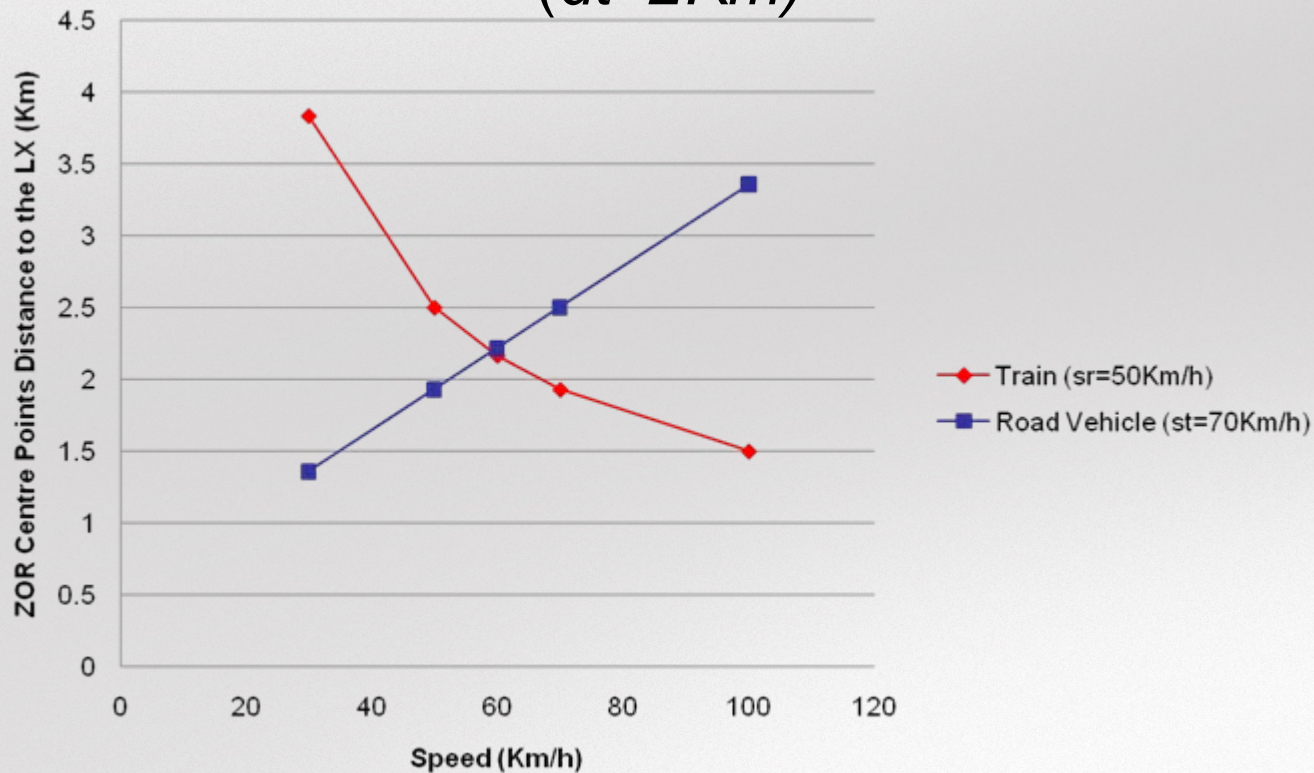
ZOR Centre Point vs. Speed For Road-Vehicle Movement ($St=70\text{Km/h}$)





Geo-Determination Model Performance (Cont)

ZOR Centre Point vs. Speed ($dt=2Km$)





Research Direction & Future Works

