Managing Moving Objects on Dynamic Transportation Networks

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Outline

- Motivations
- MODTN model
- Location update strategies of MODTN
- Querying location of moving objects
- Relation to our project
- Strong and weak points

Motivations

- Existing DBMS's can not handle continuously changing data
- MOD researches do not treat the interaction between MOs and the underlying transportation networks
- Only consider the static transportation networks
- None dealling with the relationship between the discrete presentation of MOs and the location update policies
- None discussion of the uncertainty management issues

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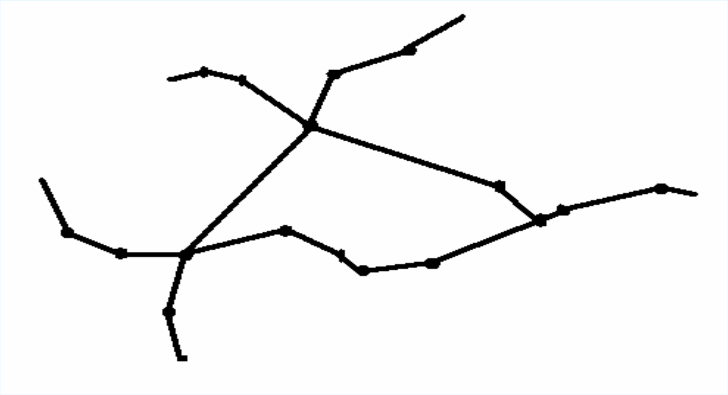
Basic Idea

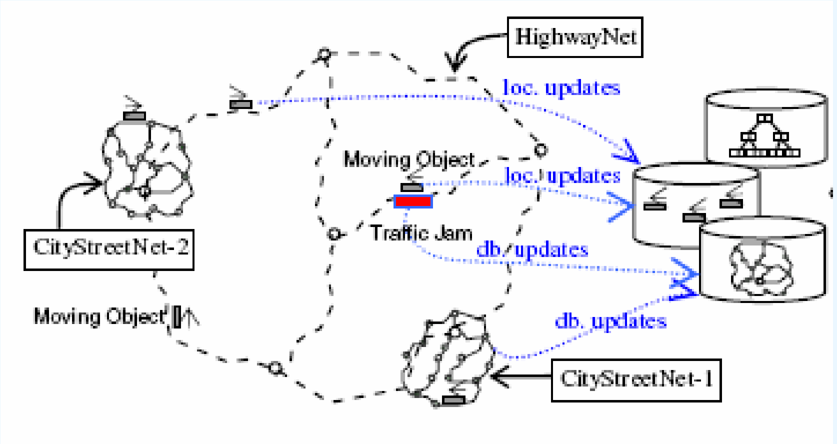
- Modeling the transportation network as graph system instead of modeling nodes, links .
- Advantage: reduce the complexity of modeling



Overview of System Architecture

Modelling the dynamic transportation network *as dynamic graphs*
express states,toplogy changes, traffic jam, road works...
Modelling the MOs *as moving graph points*

example:



Support queries:
"tell the location of car No.10 at 2pm yesterday"
"find all the cars which are now at abc street"
"find the position of car No.1 10 minutes later"

"find the routes which are currently blocked by traffic jam and the vehicles affected by it"

Data Types

- **dynamic graph system GS**

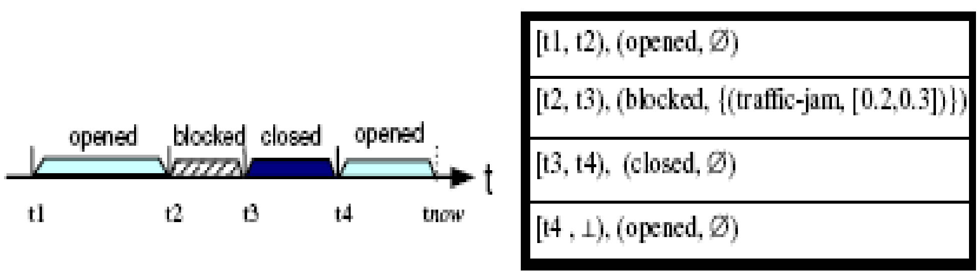
  a set of dynamic graphs and inter-graph junctions

  $GS = \{G_1, G_2, \ldots, G_n, j_1^*, j_2^*, \ldots j_m^*\}$
- **dynamic graph G :** $G = (R, J)$

  R,a set of dynamic routes; J , a set of dynamic in-graph junctions.

- **dynamic route *r***, $r = (gid, rid, route, len, fdr, tp)$
- **dynamic in-graph junction** and **inter-graph junction**
- **state s** of a junction or a route, $s = (\sigma, (br_i, BP_i)_{i=1}^{n})$
- **temporal attribute *tp* :** $tp = ((I_i, s_i))_{i=1}^{n}$

example:



a) state changes of a route b) the corresponding temporal units

Modelling of Moving Objects

- graph points GP:
- moving graph point *mgp*:

  $$mgp = f: T \rightarrow GP$$

  can be descreted and represented as a set of moving unit.
- discrete presentation of moving graph point:

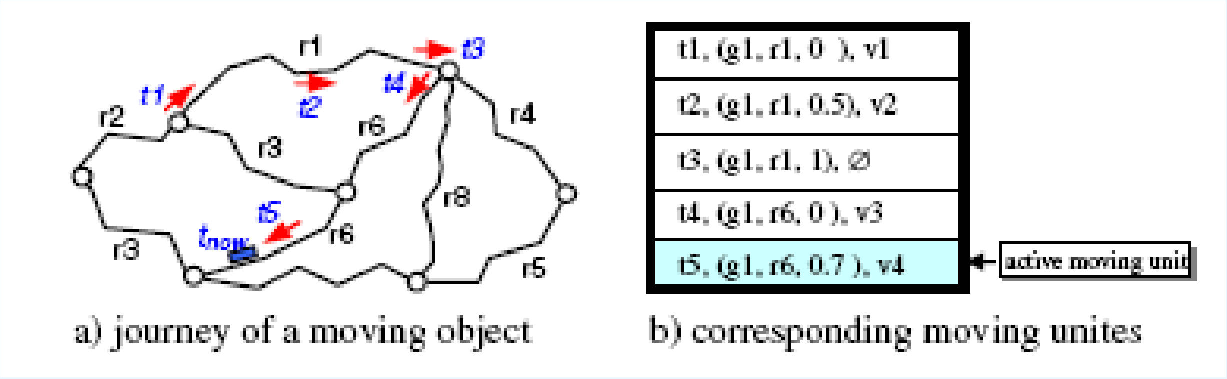
  $$dmgp = ((t_i, (gid_i, rid_i, pos_i), vm_i))_{i=1}^{n}$$

  where t_i: *time instant*

  (gid_i, rid_i, pos_i): gp_i

  $(t_i, (gid_i, rid_i, pos_i), vm_i)$: *the* $_i$*th moving unit of dmgp*

example:



a) journey of a moving object
b) corresponding moving unites

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Basic Idea of Location Update in MODTN

update of transportation networks is trivial
In MOD system, principle of ”predict and compare”
optimize to model MOs in predefined transportatin networks

In MODTN

- milemeter + sensors

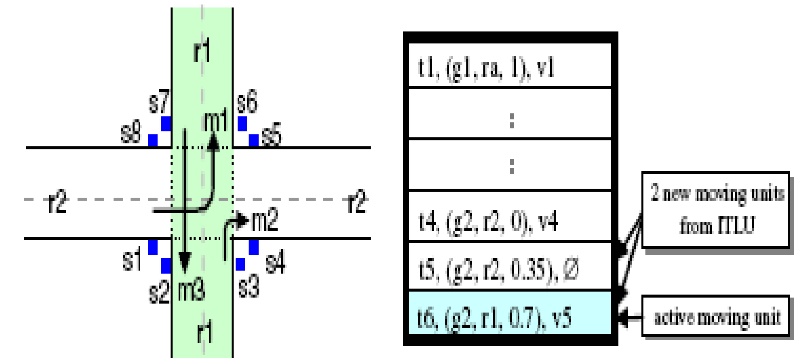
  sensors can send rid, location of junction ,speed direction
- When MO begins its journey from a junction

  send $msgu = (mid, t_u, (gid_u, rid_u, pos_u), vm_u)$
- server generate a moving unit & save as active moving unit
- MO compare actual rid, location, speed with that in active moving unit, if conditions met, update triggered
  1. id triggered location update ITLU
  2. distance-threshold triggered DTTLU
  3. speed-threshold triggered STTLU

ID-Triggered Location Update (ITLU)

ITLU is triggered to refect the changes of rid when MO move from one route to another

Example:



a) ID-triggered location update   b) corresponding moving unites of m1

m1:

passby s1,s6

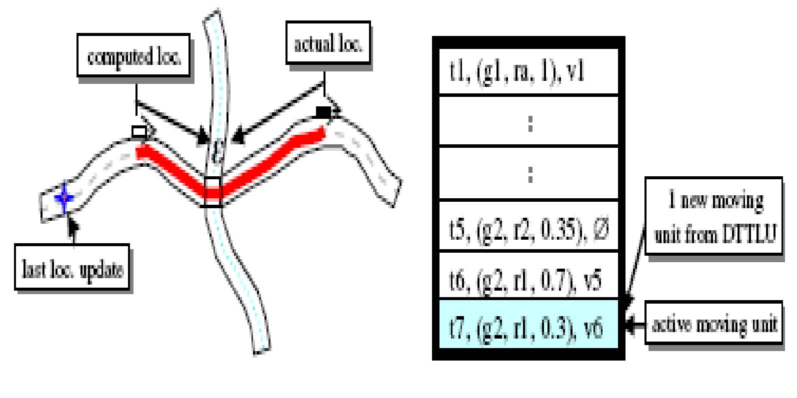
ITLU at t6

msgu sent

Distance-Threshold-Triggered Location Update (DTTLU)

MO compare its ***actual positon*** with the ***computed position*** derived from the active moving unit

DTTLU triggered if difference >distance threshold β



a) distance-threshold-triggered loc. update b) corresponding moving unites

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Computing Locations of MO through Interpolation

"where is *MO* at time t_q?" → graph point gp_q = (gid_q, rid_q, pos_q)

case 1: t_q is a location update time t_i

$gp_q = (gid_i, rid_i, pos_i)$

Case 2: t_q is between two consecutive location update time, $t_i < t_q < t_{i+1}$

if route(gid_i, rid_i) =route(gid_{i+1}, rid_{i+1}):

$gp_q = (gid_i, rid_i, pos_q)$

where $pos_q = pos_i + \frac{pos_{i+1} - pos_i}{t_{i+1} - t_i} \times (t_q - t_i)$

if route(gid_i, rid_i) !=route(gid_{i+1}, rid_{i+1}):

ITLU,

gp_q = getjunct(gp_i, gp_{i+1}).

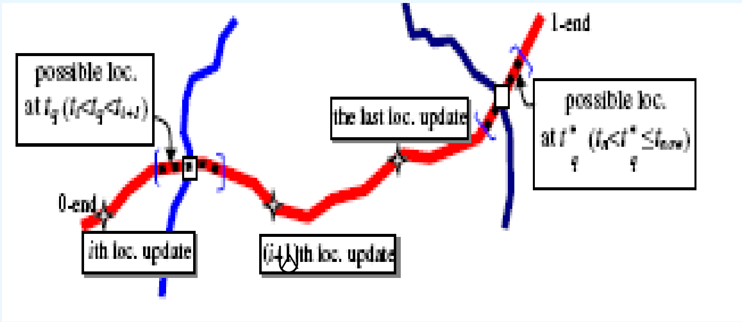
Case 3: t_q is bigger than the last location update time, $t_n < t_q < t_{now}$

$gp_q = (gid_n, rid_n, pos_q)$

where $pos_q = pos_n + v_n \times (t_q - t_n)$

Querying MO with Uncertainty Considered

Inherent imprecision
Graph route section grs_q = (gid_q, rid_q, seg_q) instead of graph point without validating update policy



Case 1: $t_q = t_i$, $gp_q = (gid_i, rid_i, pos_i)$
Case 2: $t_n < t_q < t_{now}$

route(gid_n, rid_n) =route(gid_q, rid_q):

$grs_q = (gid_n, rid_n, seg_q)$

where $seg_q \subseteq [0, 1]$ $\cup$

$seg_q \subseteq [pos_q - \beta, pos_q + \beta]$ $\cup$

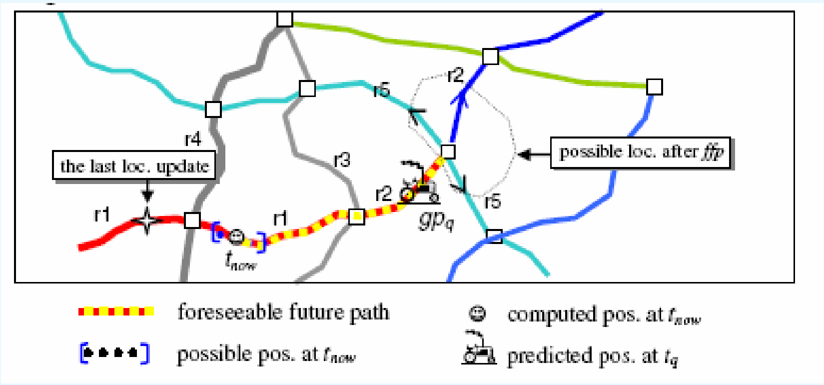
$seg_q \subseteq [pos_n + v_{min}^n \times (t_q - t_n), pos_n + v_{max}^n \times (t_q - t_n)]$

$(pos_q = pos_n + vm_n \times (t_q - t_n))$

$v^i_{\max} = vm_i + \varphi \quad v^i_{\min} = vm_i - \varphi$

Future Locations Prediction

tell me the location of moving object *mo* at *tq* (*tq*> *tnow*)?



1, search the "foreseeable future path" *ffp*

2, predict a future speed for MO

- the speed in nth moving unit
- average speed by $\bar{v} = \frac{\sum_{i=1}^{n-1}(|vw_i| \times (t_{i+1} - t_i)) + |vw_n| \times (t_{now} - t_n)}{t_{now} - t_1}$

3, predict the distance

$d = \bar{v} \times (t_q - t_{now})$

4, get graph point value from *d* and *ffp*

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Goals of our project

- modeling road network and MOs using oracle spatial
- tracking MOs in advanced network tracking policy
- efficiently perform range query and NN-query on MOs

Common with our project

- segment policy
- inertia priciple

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Strong points

- Propose a model for MODTN
- Consider uncertainty
- Easy to understand with graphs

Weak points

- Not a realistic solution
- Not fit for NN qurey
- No related works
- Too many definitions