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Oracle Spatial Users Conference

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Logistics Methodologies Using Oracle Spatial's Network Data Model and Linear Referencing Features

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Agenda

- Logistics Lifecycle
- Role of Network Data Model (NDM)
- Role of Linear Referencing System (LRS)
- LRS examples
- Demonstration
- Q&A

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Nominal Logistics Lifecycle

- Pre-trip planning and analysis
  - Optimal path determination
  - Report time/distance to features on/near path
- Trip execution and situational awareness
  - Real-time reporting of time/distance to landmarks/events
  - Route adherence
  - Dynamic re-routing
- Post-trip analysis
  - Mining intelligence from historical trip data

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Roles of Spatial Components for Logistics

- Network Data Model (NDM)

  generates paths based on network, costs, and constraints
- Linear Referencing System (LRS)

  supports along-path distance determination, drive times and situational awareness ***(i.e., more than just dynamic segmentation!!)***
- Application Server Mapviewer

  generates dynamic data-driven maps for inclusion into business applications

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Path Determination

- Network Data Model (NDM)
- Link/Node/Path model
- PL/SQL and Java APIs
- NDM versus ‘Oracle Route Server’

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Core NDM Tables

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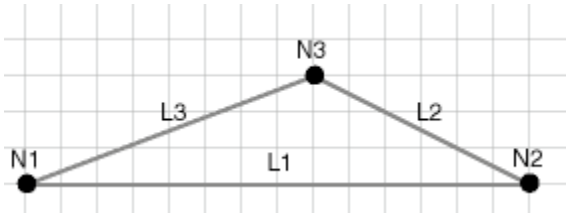
```
SQL> desc user_sdo_network_metadata
 Name
 ----------------------------------

 NETWORK
 NETWORK_ID
 NETWORK_CATEGORY
 GEOMETRY_TYPE
 NETWORK_TYPE
 NO_OF_HIERARCHY_LEVELS
 NO_OF_PARTITIONS
 LRS_TABLE_NAME
 LRS_GEOM_COLUMN
 NODE_TABLE_NAME
 NODE_GEOM_COLUMN
 NODE_COST_COLUMN
 LINK_TABLE_NAME
 LINK_GEOM_COLUMN
 LINK_DIRECTION
 LINK_COST_COLUMN
 PATH_TABLE_NAME
 PATH_GEOM_COLUMN
 PATH_LINK_TABLE_NAME
 PARTITION_TABLE_NAME
```




```
SQL> desc [network]_node$
 Name                                      Null?    Type
 ----------------------------------------- -------- ------------------
 NODE_ID                                   NOT NULL NUMBER
 NODE_NAME                                          VARCHAR2(200)
 NODE_TYPE                                          VARCHAR2(200)
 ACTIVE                                             VARCHAR2(1)
 PARTITION_ID                                       NUMBER
 GEOMETRY                                           MDSYS.SDO_GEOMETRY
 COST                                               NUMBER

SQL> desc [network]_link$
 Name                                      Null?    Type
 ----------------------------------------- -------- ------------------
 LINK_ID                                   NOT NULL NUMBER
 LINK_NAME                                          VARCHAR2(200)
 START_NODE_ID                             NOT NULL NUMBER
 END_NODE_ID                               NOT NULL NUMBER
 LINK_TYPE                                          VARCHAR2(200)
 ACTIVE                                             VARCHAR2(1)
 LINK_LEVEL                                         NUMBER
 GEOMETRY                                           MDSYS.SDO_GEOMETRY
 COST                                               NUMBER

SQL> desc [network]_path$
 Name                                      Null?    Type
 ----------------------------------------- -------- ------------------
 PATH_ID                                   NOT NULL NUMBER
 PATH_NAME                                          VARCHAR2(200)
 PATH_TYPE                                          VARCHAR2(200)
 START_NODE_ID                             NOT NULL NUMBER
 END_NODE_ID                               NOT NULL NUMBER
 COST                                               NUMBER
 SIMPLE                                             VARCHAR2(1)
 GEOMETRY                                           MDSYS.SDO_GEOMETRY
```

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Flexible Path Constraint Methods

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SystemConstraint Class

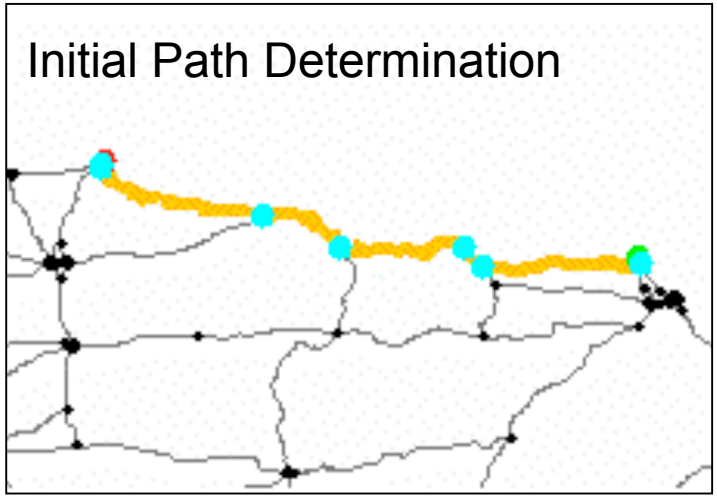
- Limit the network search space

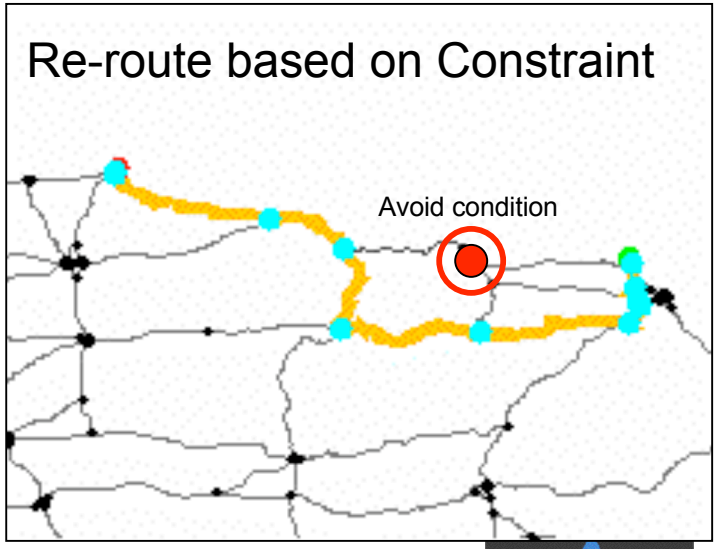
NetworkConstraint Interface

- Implement complex business logic

Link/node tables updates

- Link/node ACTIVE flag field
- Custom/programmatic cost fields





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Role of LRS

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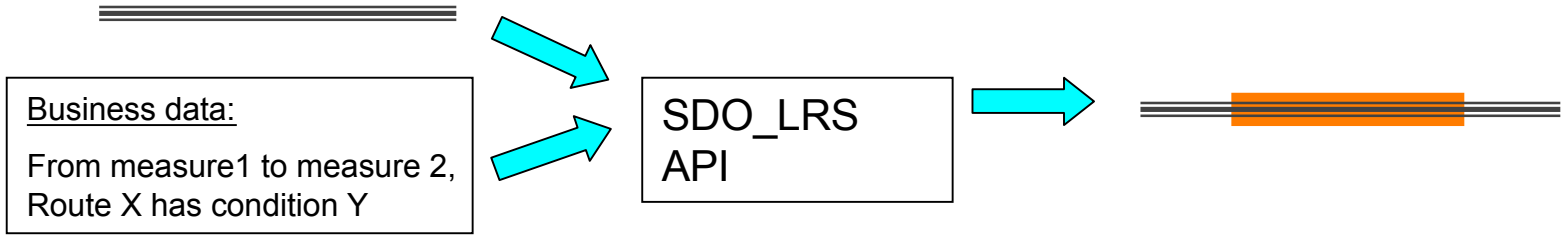
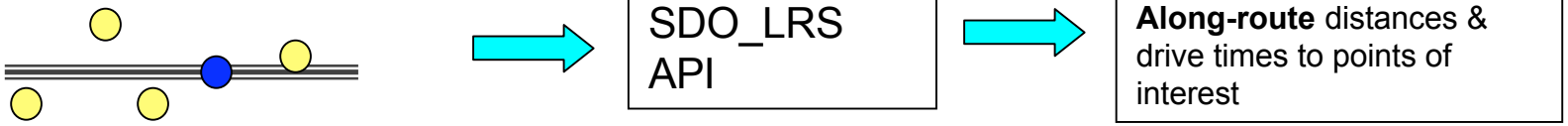
While we associate LRS with dynamic segmentation:



... we may also use LRS for 'situational awareness' for logistics:



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Example

Simplified case where LRS measure represents distance:

```
SQL> select a.laname as landmark,
  2         sdo_lrs.find_measure(b.geometry, a.geometry) as dist_along_path
  3  from landmark a, persist_path b
  4  where b.path_id=1
  5  and a.laname='Pershing Grade School';


LANDMARK                       DIST_ALONG_PATH
------------------------------ ---------------
Pershing Grade School                     20.5
```

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Example

Simplified case extended to report all landmarks within 5 miles of path:

```
SQL> select a.laname as landmark,
  2         sdo_lrs.find_measure(b.geometry, a.geometry) as dist_along_path
  3    from landmark a, persist_path b
  4    where b.path_id=1
  5    and sdo_within_distance(a.geometry,b.geometry,
  6                'distance=5 unit=MILE')='TRUE'
  7*   order by dist_along_path

LANDMARK                       DIST_ALONG_PATH
------------------------------ ---------------
Hospital                                 18.96
Mount View School                        19.25
Wyoming State Penitentiary               19.57
Pershing Grade School                    20.47
Wyoming Tech School                     115.49
Invinson Memorial Hospital              120.22
Platte County Memorial Hosp             233.32
Libby School                            233.87
Johnson County School District          404.15
Johnson Co Memorial Hospital            448.76
```

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Example

Impedance (i.e., speed limit) LRS business data enables time calculations:

```
SQL>  select a.laname as landmark,
  2     pkg.getTravelTime(1, 0, sdo_lrs.find_measure(b.geometry, a.geometry)) as time_hrs
  3   from landmark a, persist_path b
  4   where b.path_id=1
  5   and sdo_within_distance(a.geometry,b.geometry,
  6              'distance=5 unit=MILE')='TRUE'
  7*  order by time_hrs

LANDMARK                         TIME_HRS
-------------------------------- ----------
Hospital                              .34
Mount View School                     .35
Wyoming State Penitentiary            .36
Pershing Grade School                 .37
Wyoming Tech School                   2.1
Invinson Memorial Hospital           2.19
Platte County Memorial Hosp          3.84
Libby School                         3.85
Johnson County School District       5.98
Johnson Co Memorial Hospital         6.54
```

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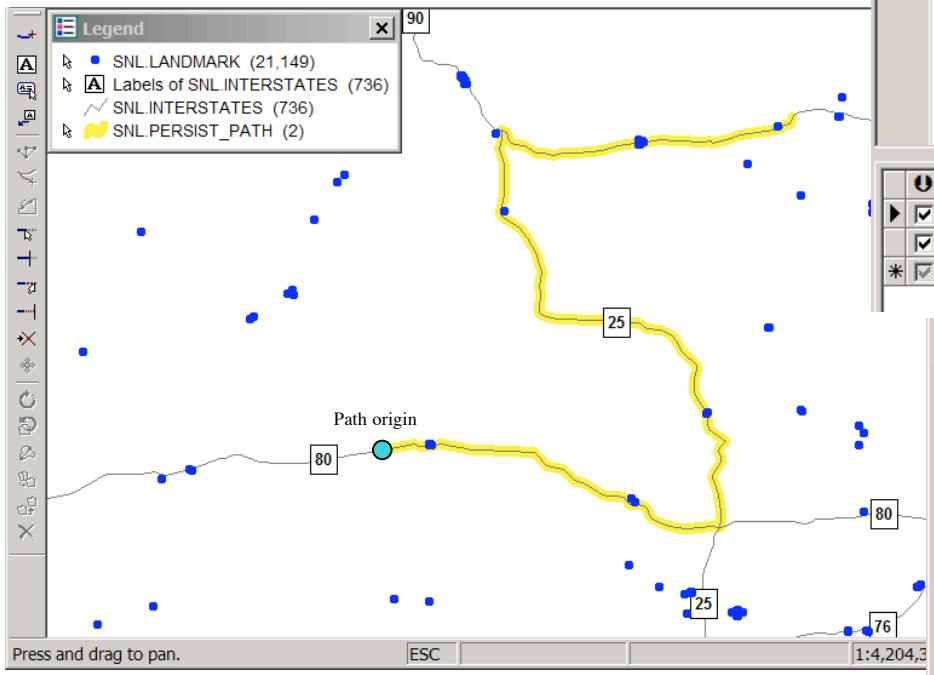
Pre-trip Analysis

Representative requirements:

- Report features on/near path
- Report expected drive times to POIs along path




```
begin
  -- Call the procedure
  pkg.locsalongpath(pathid => :pathid,
                    refcur => :refcur);
end;
```

	Variable	Type	Value
▶	pathid	Float	1
	refcur	Cursor	<Cursor>
*			

	ID	LANAME	DIST	TIME
▶ 1	59277	Hospital	19	0.29
2	37410	Mount View School	19.3	0.3
3	39971	Wyoming State Penitentiary	19.6	0.3
4	37406	Pershing Grade School	20.5	0.31
5	59254	Wyoming Tech School	115.5	1.78
6	37383	Invinson Memorial Hospital	120.2	1.85
7	39996	Platte County Memorial Hosp	233.3	3.34
8	37777	Libby School	233.9	3.34
9	59766	Johnson County School District	404.2	5.35
10	39995	Johnson Co Memorial Hospital	448.8	5.87

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Trip Execution

Representative requirements:

- Positioning & tracking
- Dynamic along-route distances/time reporting
- Alerts
  - Proximity (along-route & ‘as the crow flies’)
  - Route adherence
  - Geofence

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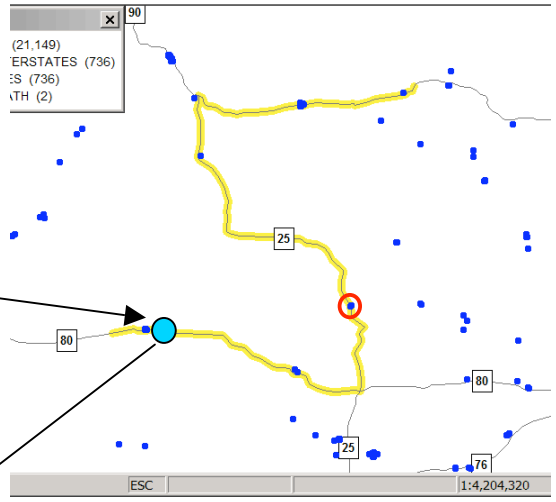
Distance/Time to Landmarks and Dynamic Events

Streamed positioning coordinate insert

Triggered geometry constructor and integrity rules

Determine LRS position

Analyze against LRS positions of POI and real time events




```
begin
  -- Call the procedure
  pkg.disttimetolandmark(pathid => :pathid,
                         longin => :longin,
                         latin => :latin,
                         landmarkid => :landmarkid,
                         disttolandmark => :disttolandmark,
                         timetolandmark => :timetolandmark);
end;
```

Variable	Type	Value
pathid	String	1
longin	Float	-104.9517
latin	Float	41.9641844
landmarkid	Float	59766
disttolandmark	Float	176.77
timetolandmark	Float	2.08

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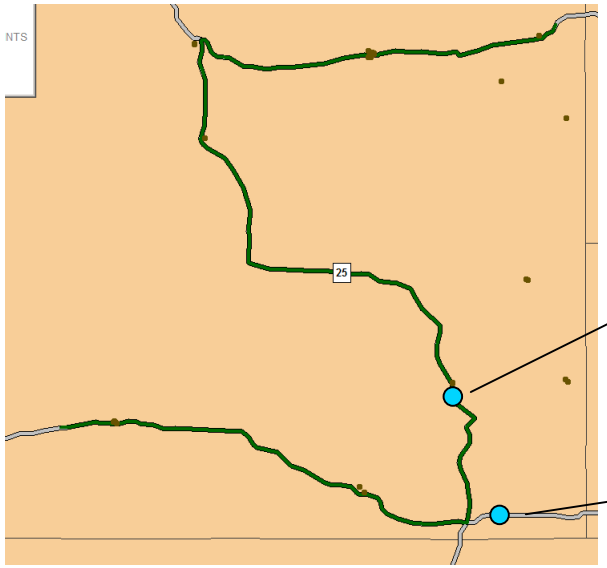
Route Adherence




```
SQL> select pkg.routeAdherence(1, geometry)
  2  from fake_avl;

PKG.ROUTEADHERENCE(1,GEOMETRY)
------------------------------------------

OK
```

```
SQL> /

PKG.ROUTEADHERENCE(1,GEOMETRY)
----------------------------------

ALERT
```

- Implemented using sdo_within_distance
- Geofence uses sdo_within_distance for ‘as the crow flies’, or LRS approach for along-path distance/time alerts

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Deployment Scenarios

In-House:

- Institutional requirements (i.e., network constraints)
- Security over institutional data
- Use what you own

Commercial service:

- Common industry requirements
- Commodity service
- Integration with commercial business apps

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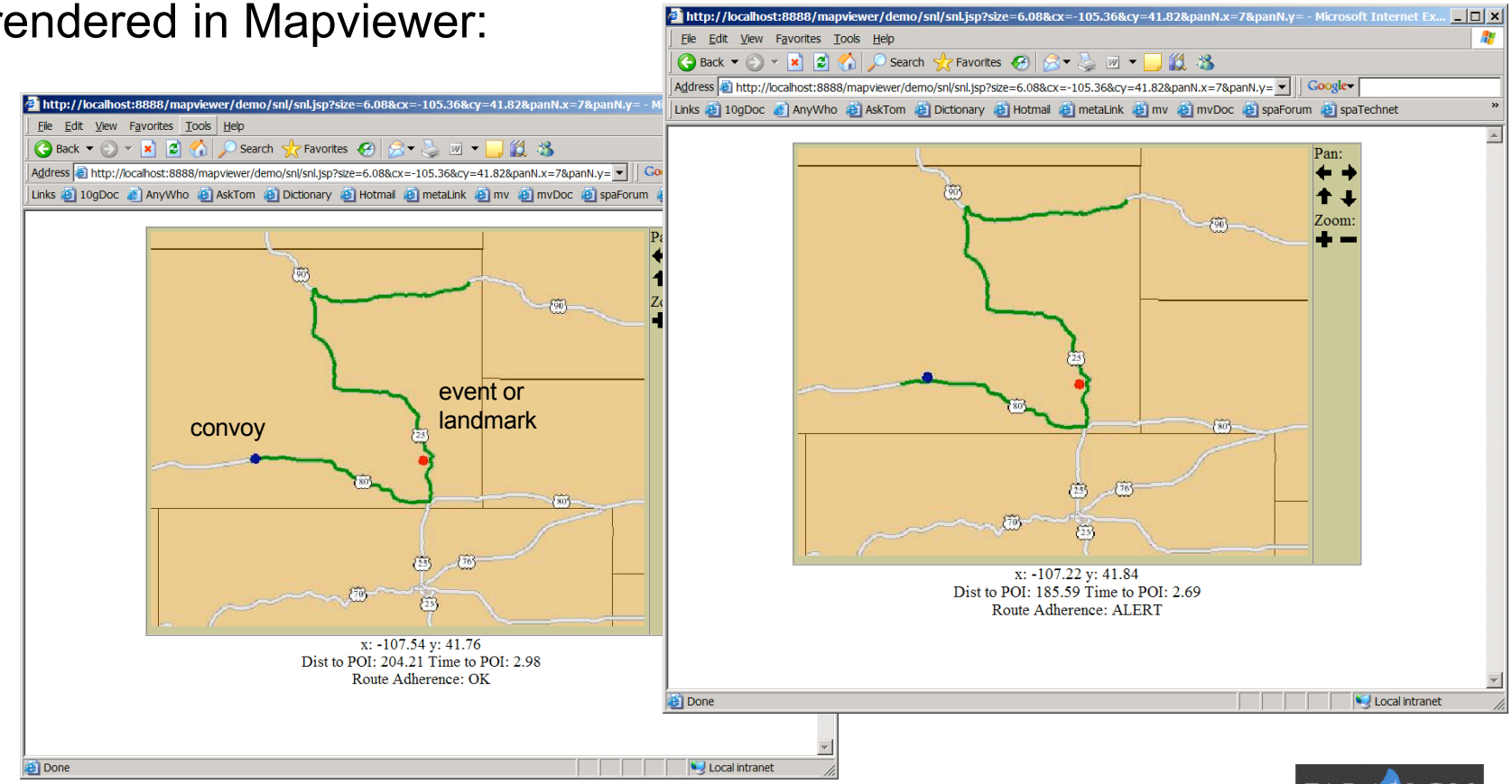
Demonstration

Positioning, dynamic along-path reporting, route adherence, rendered in Mapviewer:



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Thanks for attending!

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