March 2008

Oracle Spatial User Conference
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March 13, 2008
Sheraton Seattle Hotel
Seattle, Washington USA
Giovanni Corcione
Principal Sales Consultant
Oracle Italia
Automatic Vehicles Monitoring System at Cotral
Agenda

• Who’s COTRAL S.p.A?
• Functional Requirements
• Bus Data communication process
• Time and Location Info approach
• Cotral Spatial Data Infrastructure: AVM db-Schema
• The near-realtime process
• The Bus/route Monitoring
• SDI Leverage: Next steps
• Demo
• Q&A
Who’s COTRAL S.p.A…

Public Limited Company
Responsible for Public ‘tire’ Transportation in Lazio Region

Surface of Lazio: 17,000 kmq
Municipalities served: 376 In Lazio
18 Out Lazio
394

<table>
<thead>
<tr>
<th>Buses*Km</th>
<th>80,500,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>n° Lines</td>
<td>220</td>
</tr>
<tr>
<td>n° Routes</td>
<td>4,550</td>
</tr>
<tr>
<td>Lenght of the Net (km)</td>
<td>8,370</td>
</tr>
<tr>
<td>n° Annual Trips</td>
<td>2,614,500</td>
</tr>
<tr>
<td>n° Daily Trips</td>
<td>8,800</td>
</tr>
<tr>
<td>Buses</td>
<td>1,600</td>
</tr>
<tr>
<td>n° Operating Business Units</td>
<td>50</td>
</tr>
<tr>
<td>Bus Drivers</td>
<td>2,500</td>
</tr>
<tr>
<td>n° Employees</td>
<td>3,600</td>
</tr>
</tbody>
</table>
Functional Requirements

DEMO
Linear representation of buses and their schedule (route, time, alerts, etc...)

Bus details and tools to check/modify their status or send them informations

Bus position and status on the Lazio map

Functional Reqs: **Home page**
Functional Reqs: *Linear detail*

- Existing alerts (if any)
- Departure
- Route length
- Bus position related to the programmed route
- Bus detailed info
- Distance
- Destination
- Send a message to the bus

[Diagram showing bus position and route details]
## Functional Reqs: Bus details

<table>
<thead>
<tr>
<th>AUTOMEZZO</th>
<th>STATO</th>
<th>DATA STATO</th>
<th>ALLARMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>5849</td>
<td>FC - Fuori Corsa</td>
<td>29/09/2006 08:31:15</td>
<td></td>
</tr>
<tr>
<td>9201</td>
<td>NC - Non Classificato</td>
<td>29/09/2006 00:01:09</td>
<td></td>
</tr>
<tr>
<td>9204</td>
<td>NC - Non Classificato</td>
<td>29/09/2006 11:15:55</td>
<td></td>
</tr>
<tr>
<td>9207</td>
<td>FP - Fuori Programma</td>
<td>29/09/2006 10:46:00</td>
<td></td>
</tr>
<tr>
<td>9209</td>
<td>FP - Fuori Programma</td>
<td>29/09/2006 09:31:10</td>
<td></td>
</tr>
<tr>
<td>9210</td>
<td>NC - Non Classificato</td>
<td>29/09/2006 09:13:00</td>
<td></td>
</tr>
<tr>
<td>9211</td>
<td>NC - Non Classificato</td>
<td>29/09/2006 08:23:26</td>
<td></td>
</tr>
<tr>
<td>9214</td>
<td>FP - Fuori Programma</td>
<td>29/09/2006 04:26:06</td>
<td></td>
</tr>
<tr>
<td>9215</td>
<td>FP - Fuori Programma</td>
<td>29/09/2006 05:14:16</td>
<td></td>
</tr>
</tbody>
</table>

- **The bus has an alert**
- **Find the appropriate schedule starting from the bus sent positions**
- **Show the assigned schedule**
- **Recalculate all the schedule from scratch**
Functional Reqs: Map details

The bus is late
The bus is on time
Bus managed by the connected user, but not performing a schedule
Other buses
Functional Reqs: *Bus status details*

Detail of bus position and status
Functional Reqs: *Bus details*

Detail of all events sent by the bus and mapped on the cartography
Functional Reqs: *Route and bus details*

Details from the performed schedule:

- Positions
- Bus stops
- Different route colors for different bus status
- Bus position on the route
Bus Data TeleCommunication Process

**Main System**
- Mobility-DB
- Bus Mission Info
- TCU: Telematic Control Unit

**AVM System**
- Mobility-DB
- AVM-DB
- AC-TM043
  - 5636
  - 1
  - 10
  - 21
  - 0
  - @
  - A
  - 3
  - /

**RealTime Bus Info**
- Event: (X,Y), Time
- Msg: outOfRoute

**Route**
- Start: X,Y,0
- End: X,Y, 23km
Cotral has defined a clear and readable protocol data exchange to avoid TCU proprietary dependence.
Time & Location info approach

AVM system manages bus-events in relation of *Time* and *Location* info.
It controls “where” and “when” a bus event is happened.

TCUs send to the AVM informations about:

- dashboard bus: speed, kilometers, lights on/off, air conditioned system on/off, etc...
- Informative events: such as number of passengers, bus stop reached, etc...
- Alerts: high oil temperature, low fuel, etc...

*complete of X, Y and Time*
Relating Location&Time Event_Info

1) **Motion Monitoring**, to track bus automation in real-time
   idBus, **idStop**, **nameStop**, (X,Y), scheduleTime, TCU-timestamp_realtime
   *check/monitor if BUS is late for foreseen connections*
   idBus, **3min-Interrupt**, water, fuel, nPassengers, (X,Y), TCU-timestamp_realtime
   *check/monitor BUS: be out of route, delay, current condition ...*

2) **Motion Management** for trips/routes planning
   On the basis of collected “**Realting Location&Time Events**”:
   - Recompute connected routes
   - RePlan trip on the basis of seasons/dailyTime/location provided by historical
     BusStop Events,
AVM and Cotral SDI: Setting up Workflow

1 - TeleAtlas StreetNetwork Import in OracleSpatial

2 - Process based on PlanningData & Spatial Aggregation

The process assures db consistence as geoData are updated
AVM DB: basic schema input

Basic Tables input for setting up the AVM schema

<table>
<thead>
<tr>
<th>BUS_STOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BusStop_ID</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROUTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route_ID</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Route_Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route_ID</td>
</tr>
</tbody>
</table>

Sequences of same route_ID and different arcs define a Route

CoTraL LRS-based Routes

... `SDO_AGGR_CONCAT_LINES(c.geom) FROM routes c` WHERE c.route_ID = `myCurrent_Route_ID`;

`LRS_Geom := SDO_LRS.CONVERT_TO_LRS_GEOM(aggrGeom)`

`startM... SDO_LRS.FIND_MEASURE(LRS_Geom, geom of BusStopStart)`

`endM... SDO_LRS.FIND_MEASURE(LRS_Geom, geom of BusStopEnd)`

`LRS_Route := SDO_LRS.DYNAMIC_SEGMENT(LRS_Geom, startM, endtM)`

`SDO_LRS.REDEFINE_GEOM_SEGMENT (LRS_Route)`
LRS Linear Referencing System

Dynamic Segment from measure 5 to 18

Locate Point

Project Point
Get M and Offset

LRS Design

LRS-Routes Table

<table>
<thead>
<tr>
<th>SID</th>
<th>LRS Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LRS-Routes Table

- Sign #
- Stop #
- Link
- Condition

Road Sign
Bus-Stop
Link BusStop
Pavement Condition
The (Near) Real-Time Process

**TCU interrupts:**
- Transit BusStop
- Every 3-min

**SEND:** RealTime BUS_Info

**DBMS interrupts:**
- Read TCU-mess
- Insert *realtime BUS_Info* into EVENTS table
- Scheduled x-sec DBMS Job
- Execute BUS_MONITORING PROCEDURE

**EVENTS**
- Bus
- busStop
- Location (X,Y)
- Schedule time
- RealTime timestamp
- # passenger
- Fuel
- ....

**RelatTime_Info**
Bus Monitoring Procedure: what

MOTION Model

MOTION STATUS

- **NT**: Not Transmitting
- **T**: Transmitting
- **N.M**: No Motion
- **O.M**: Out of Mission
- **O.R**: Out of Route
- **R**: Regular: On shift
- **EOT**: End of trip
Bus Monitoring Procedure: how

**EVENTS**
- Bus
- busStop
- Location (X,Y)
- Schedule time
- RealTime timestamp
- # passenger
- Fuel
- ...

**BUS STATUS**
- Bus
- Status
- Location (X,Y)
- ROUTE
- timestamp
- LATE +/-
- ...

**BUS MONITORING**

Stack Fifo

```
SDO_GEOM.SDO_DISTANCE(LRS_route, location(X,Y), GPS_tollerance)
```

Out Of Route

LRS APIs: SDO_LRS.FIND_MEASURE, SDO_LRS.DYNAMIC_SEGMENT ....

Location&Time => LRS_Measure&Time

```
3 min 3 min rTime ScheduleTime
```

Stop1 Stop2 Stop

**Delay? ... Recompute!**

T1-M1 T2-M2 T3-M3

**Speed, Forecast, ...**
Bus Monitoring Web Application

Oracle 10g Spatial

Predefined MapViewer Themes derived from TeleAtlas dataSet and LRS_Routes

JDBC Theme mapRequest based on LRS_API Queries on Events, BusStatus and LRS_Routes tables
CoTral SDI leverage: next services

Cotral SDI data models:
- LRS Network Data Model: BusStop costs based on collected events
- Private Transport TeleAtlas-based network and geocoding services
- LOGICAL Graph: multiModal costs routing service
- Oracle Maps (on progress) more map interactive browser Apps
- SOA context to integrate (and orchestrate) internal and external processes
Oracle Technology Stack

- Oracle DBMS 10g rel.2
- Spatial Option
- Oracle Application Server 10g
- MapViewer - OracleMaps
- Oracle Jdeveloper
- J2EE standards
- Oracle Italia Consulting

<table>
<thead>
<tr>
<th>Node type</th>
<th>Nodes</th>
<th>OS</th>
<th>Processors</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Tier</td>
<td>2</td>
<td>Linux RedHat AS 4.0</td>
<td>2 AMD Dual Core Opteron 275 2.2 Ghz</td>
<td>8 Gb RAM</td>
</tr>
<tr>
<td>Database Server</td>
<td>2 (RAC)</td>
<td>Linux RedHat AS 4.0</td>
<td>2 AMD Dual Core Opteron 275 2.2 Ghz</td>
<td>8 Gb RAM</td>
</tr>
</tbody>
</table>
How to contact us

http://search.oracle.com

Paolo.Castagno@oracle.com
Giovanni.Corcione@oracle.com
Diego.Ponzi@cotralspa.it