Network Modeling and Analysis Using Oracle Spatial Network Data Model

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Overview

- Introduction to Oracle NDM
- Design Goals and Architecture
- Approach
- NDM Schema & APIs
- NDM Usage
- Metabolic Pathway Modeling and Analysis
- Q & A
A network (or graph) is a representation for modeling objects of interest and their relationships. It usually contains the following elements:

- Nodes: objects of interests
  Chemical Compounds and Enzymes in Bio-chemical Pathways
- Links: relationship between nodes (directional)
  Chemical Reactions and Protein Interactions
- Paths: an ordered list of connected links
  Chemical Reaction Paths

• A spatial network has spatial information associated with its elements. A logical network does not.
Introduction (contd.)

What is Oracle Network Data Model?

- A modeling and analysis platform for network applications
- Managing network information in database and analyzing networks in client or application tier
- It is NOT a network application! It provides support for building network applications.
- Available in Oracle 10g (database + Java Jar files)
Design Goals and Architecture

Design Goals Of Oracle Network Data Model

- Provide an open and generic network data model for network applications
- Separate application information from network data model
- Simplify network data management and analysis
- Enable spatial information support
- Enable hierarchical modeling
- 2-tier or n-tier architecture
Architecture

Persistent Network Data Management (SQL and PL/SQL Package)

Network Loading/Analysis (Java API)

Queries and GUI (NDM Editor)
Approach

- Network Modeling
- Network Analysis
Network Modeling involves the following steps:

1. Map application features into network elements: nodes, links, and paths
2. Analyze networks using network elements
3. Map the analysis results back to application features
Network Analysis

- Shortest Path/All Paths
- Tracing (Accessibility)
- Within-Cost
- Nearest-Neighbors
- Minimum Cost Spanning Tree
- Traveling Salesman Problems (TSP)

Above Analysis With Constraints (Depth, Cost, Distance or any application related constraints)
Network Constraints

- **Network Constraint**
  - A mechanism to guide network analysis based on application Information and logic
  - Implemented as a Java Interface
  - Can be passed in all supported network analysis functions
  - Two types of constraints:
    - **System Constraints:**
      - Path Length, Path Cost, Minimum Bounding Rectangle (MBR)
    - **Application Constraints:**
      - Certain Types of Nodes/Links to Avoid/Traverse
NDM Network Schema

Network Schema contains:

- **Network Metadata**
  - Name, Type, Node/Link/Path Table Information

- **Network Tables**
  - **Node Table**
    - Node_ID, Node_Type, Geometry,…
  - **Link Table**
    - Link_ID, Link_Type, Start_Node_ID, End_Node_ID, Cost, Geometry, …
  - **Path Table (Path-Link Table)**
    - Path_ID, Start_Node_ID, End_Node_ID, Cost, Geometry,…
  - **Path Link Table**
    - Path_ID, Link_ID, Seq_No
NDM Network Schema (contd.)

Application Information can be added to network schema in the following ways:

- Add additional columns in node, link, and path tables directly
- Add foreign key(s) to node, link, and path tables to refer to other application tables
NDM APIs

• PL/SQL Package:
  – Database Network Data Query and Management
  – Referential Integrity and Validation

• Java API:
  – Network Loading/Storing
  – Network Analysis
  – Network Creation/Editing
NDM APIs (contd.)

Network Java Representations can be extended:
- Network, Node, Link, Path are Java Interfaces

Network Analysis Functionality can be extended:
- Specific analysis functionality can be added
NDM Usage

• Create Network Schema (network tables and metadata)
  – Using SQL/PLSQL (SQL/Loader)
    Populate network metadata, node table, link table and path tables
  – Using Java API
    Build a Java network object incrementally and write to the database

• Perform Network Query and Analysis
  – Query Using SQL or Network PL/SQL package
  – Analysis Using Network Java API
Oracle NDM Editor

Oracle Spatial Network Data Model Editor
• A visualization and editing Java stand-alone application for Oracle Network Data Model
• Shipped with 10g database as a demo program
  – 10g database and some Java jar files
• Support most network analysis functions
• Currently only support spatial networks (networks with spatial information)
Citrate cycle (TCA cycle)  
Chemical Reaction Network