

# Modelo de Dados de Rede



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# Roteiro



- Introdução
- Conceitos de Modelo de Rede
- Oracle Network Data Model
- Estrutura dos Dados
- Implementação de uma Rede
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# Introdução



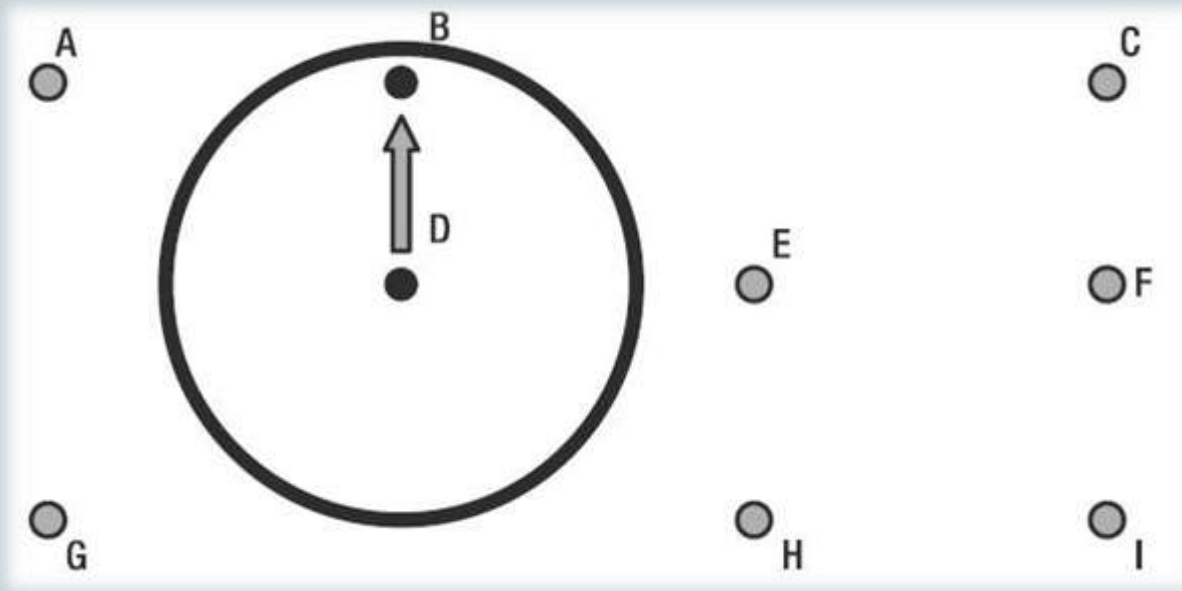
- No geoprocessamento o conceito de rede está associada a:
  - Serviço de utilidade pública: água, luz e telefone;
  - Rede de drenagem (bacias hidrográficas);
  - Rodovias;
  - entre outros.

# Introdução

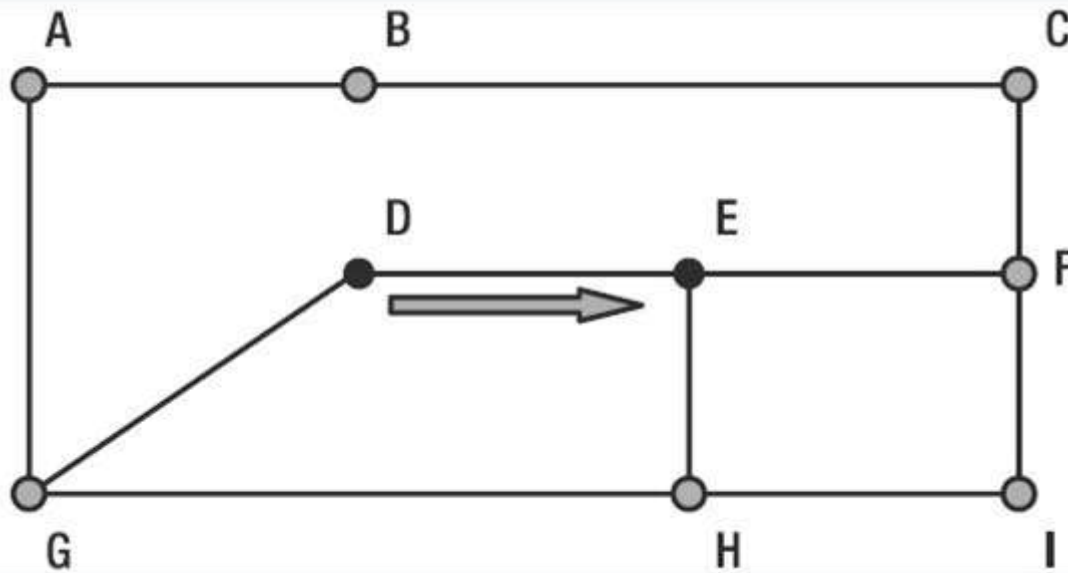


- Algumas situações que podem ser utilizada uma rede de dados:
  - Qual é o caminho mais curto ou mais rápido entre duas cidades?
  - Qual é o hotel mais próximo de um aeroporto?
  - Quais clientes moram a menos de 30 minutos de uma determinada loja?
  - Como redirecionar o tráfego de uma estrada que está fechada para obras?
  - Encontrar um ponto mais próximo de um determinado lugar.

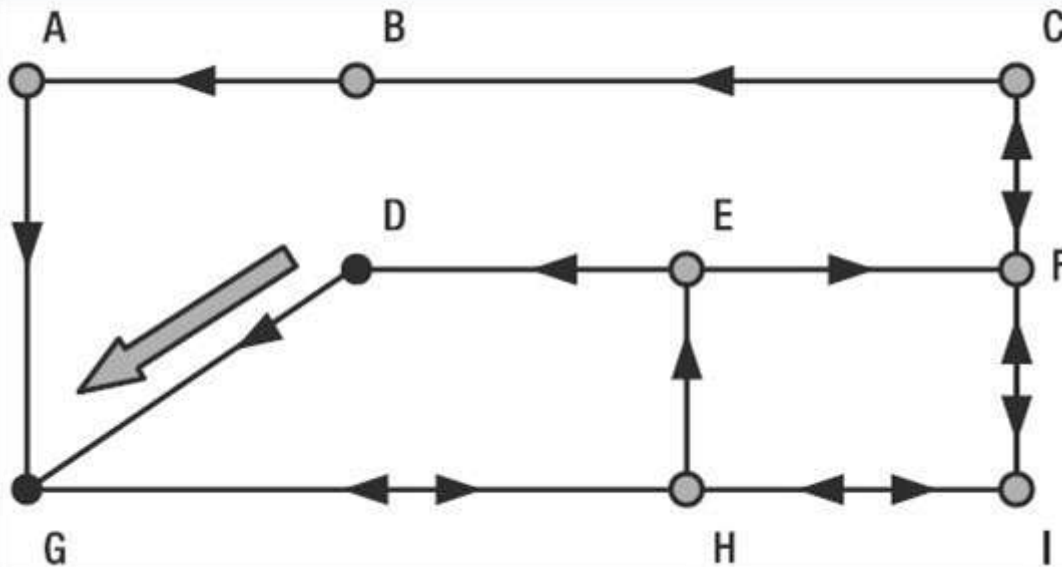
# Introdução



# Introdução



# Introdução



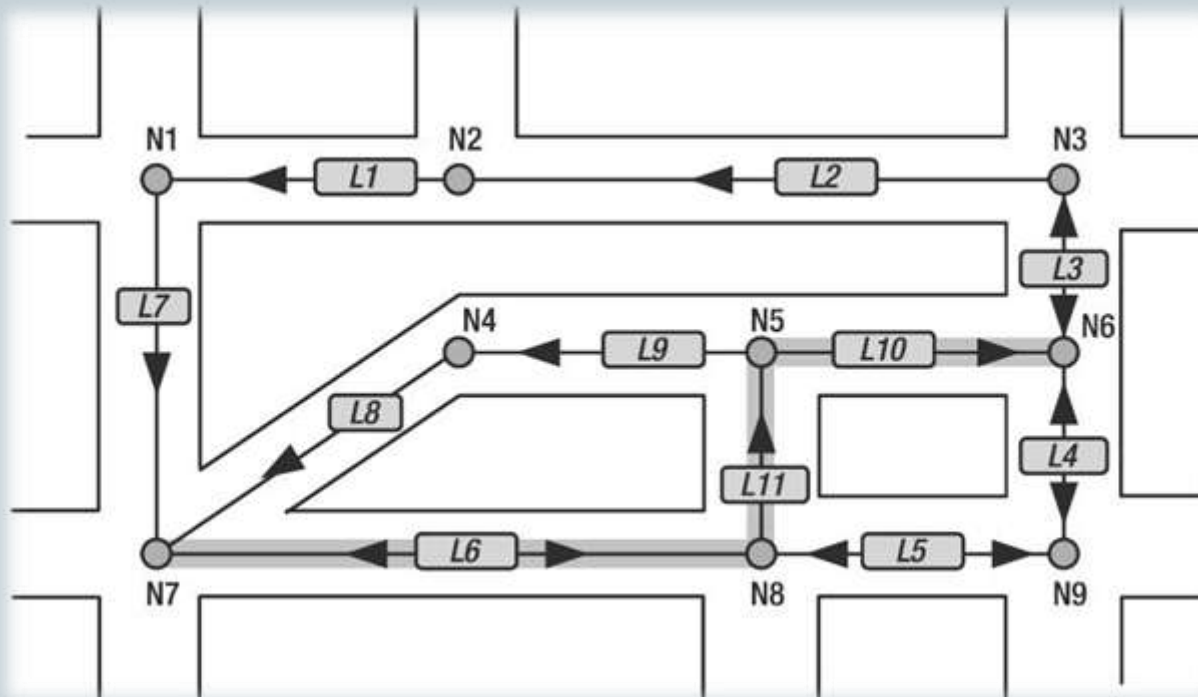
# Conceitos de Modelo de Rede



- **Rede** (*network*): é um gráfico matemático que captura as relações entre objetos. São formado por *links* e *nos*.
- **Nó** (*node*): representa um objeto de interesse em uma rede;
- **Link**: representa a relação entre dois objetos;
- **Caminho** (*path*): corresponde a um percurso através da rede formado por *links* e *nos*;
- **Custo** (*cost*): um atributo que pode ser associado a um link ou no;
- **Constantes** (*constraints*): são restrições definidas para um rede de busca.



# Conceitos de Modelo de Rede

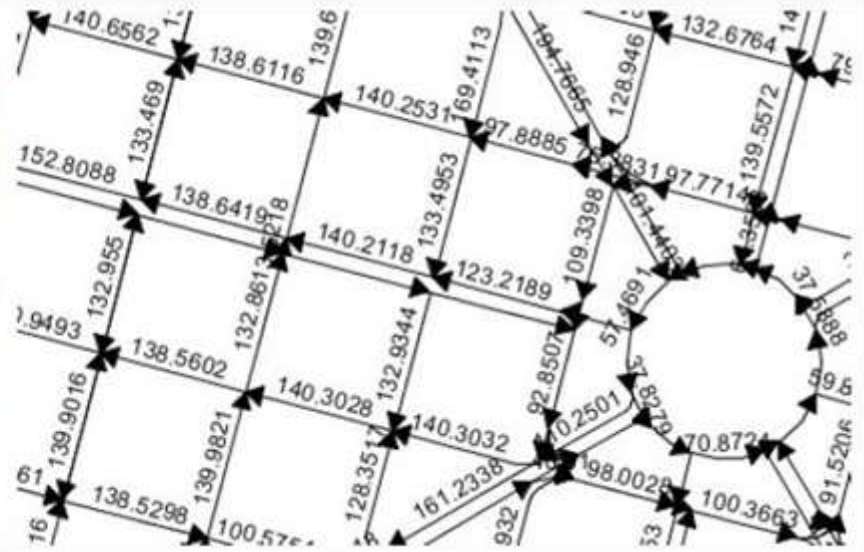


# Conceitos de Modelo de Rede



- Para o armazenamento das informações gráficas da rede são utilizadas coordenadas vetoriais;
- Utiliza a topologia a arco-nó
  - atributos de arcos incluem o sentido de fluxo;
  - atributos dos nós incluem seu custo de percorrimento.
- Deve armazenar as relações entre nós que a compõem;
- Nenhuma linha pode estar desconectada das demais para que a topologia da rede possa ficar totalmente definida.

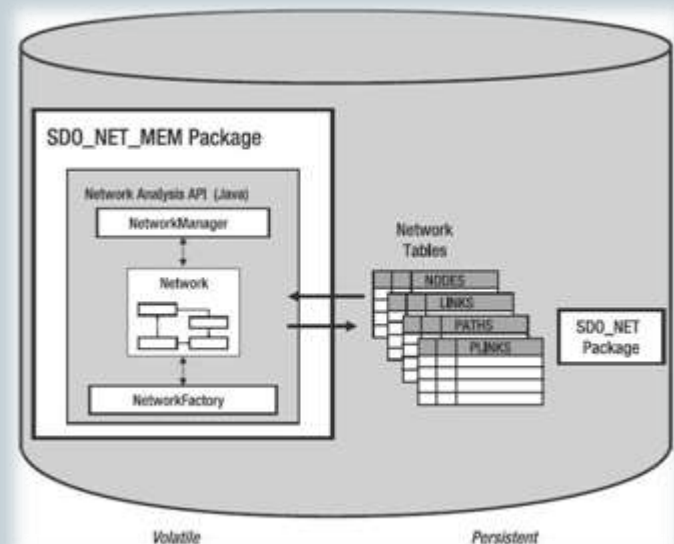
# Conceitos de Modelo de Rede



# Oracle Network Data Model



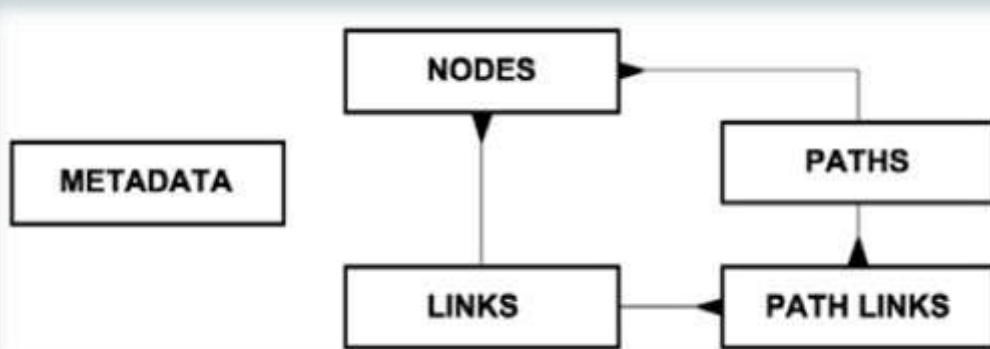
- Disponível na versão Oracle Database 10g (ou superior) e é composto por:
  - Um *Data Model* para armazenar rede em um conjunto de tabelas;
  - Funções SQL para definir e manipular a rede (pacote SDO\_NET);
  - Funções de rede em Java (API);
  - Funções de rede em PL/SQL (pacote SDO\_NET\_MEN)



# Estrutura de Dados



- A nomeação das tabelas que compõem a rede são definidas pela tabela de Metadados USER\_SDO\_NETWORK\_METADATA



# Estrutura de Dados



- Tabela *Node*

**Table .** *The Node Table*

Column	Data Type	Meaning
NODE_ID <sup>a</sup>	NUMBER	Unique identification for that node in the network. This is also the primary key of the table.
geometry_column	SDO_GEOMETRY	A point geometry object that contains the coordinates of the node. This is present only for spatial networks. Logical networks contain no geometries.
cost_column	NUMBER	A numeric value representing the cost for traversing that node. There could be multiple costs associated with a node. The actual cost column used for network analysis is defined in the network metadata. When no cost column is defined, then all nodes are assumed to have a cost of 0.
HIERARCHY_LEVEL	NUMBER	For hierarchical networks only. This is the level of the node.
PARENT_NODE_ID	NUMBER	For hierarchical networks only. This is the identifier of the parent node for this node.
ACTIVE	CHAR(1)	Defines whether the node is active (visible in the network)—'Y' or 'N'. An inactive node will not be used by the network analysis functions. When the column is not defined, then all nodes are considered to be active.
NODE_NAME	VARCHAR2(32)	Name of the node. Fill this with any descriptive name (not used by the network analysis functions).
NODE_TYPE	VARCHAR2(24)	Type of node. Fill this with any descriptive code or text.

<sup>a</sup> *This column is required. The remaining columns in the table are optional.*

# Estrutura de Dados



- Tabela *Link*

Table. *The Link Table*

Column	Data Type	Meaning
LINK_ID <sup>a</sup>	NUMBER	Unique identification for that link in the network. This is also the primary key of the table.
START_NODE_ID <sup>a</sup>	NUMBER	Unique identifier of the node from which the link originates.
END_NODE_ID <sup>a</sup>	NUMBER	Unique identifier of the node at which the link terminates.
geometry_column	SDO_GEOMETRY	A line geometry object that describes the shape of the link. This is present only for spatial networks. Logical networks contain no geometries.
cost_column	NUMBER	A numeric value representing the cost for traversing that link. There could be multiple costs associated with a link. The actual cost column used for network analysis is defined in the network metadata. When no cost column is defined, then all links are assumed to have a cost of 1.
BIDIRECTED	CHAR(1)	Defines whether the link is directed. A directed link (BIDIRECTED='N') can be traversed only from the start node to the end node. An undirected link (BIDIRECTED='Y') can be traversed either way. This column is applicable only if the network is defined as directed. If this column is absent and the network is defined as directed, then the link is assumed to be directed.
PARENT_LINK_ID	NUMBER	For hierarchical networks only. This is the identifier of the parent link for this node.
ACTIVE	CHAR(1)	Defines whether the link is active (visible in the network)—'Y' or 'N'. An invisible link will not be used by the network analysis functions. When the column is not defined, then all nodes are considered to be active.
LINK_LEVEL	NUMBER	Priority of the link.
LINK_NAME	VARCHAR2	Name of the link. Fill this with any descriptive name (not used by the network analysis functions).
LINK_TYPE	VARCHAR2	Type of link. Fill this with any descriptive code or text.

<sup>a</sup> These columns are required. All others are optional.

# Estrutura de Dados



- Tabela *Path*

**Table .** *The Path Table*

Column	Data Type	Meaning
PATH_ID <sup>a</sup>	NUMBER	Unique identification for that path in the network. This is also the primary key of the table.
START_NODE_ID <sup>a</sup>	NUMBER	Unique identifier of the node from which the path originates.
END_NODE_ID <sup>a</sup>	NUMBER	Unique identifier of the node at which the path terminates.
COST <sup>a</sup>	NUMBER	A numeric value representing the total cost for the path.
SIMPLE <sup>a</sup>	CHAR(1)	Contains Y if the path is simple path or N if it is complex. If the column does not exist, then all paths are considered simple. Note that all paths produced by the Java API are simple.
geometry_column	SDO_GEOMETRY	A line geometry object that describes the shape of the path, formed by linking together the geometries of all links in the path. This is present only when the network is spatial.
PATH_NAME	VARCHAR2	Name of the path. Fill this with any descriptive name.
PATH_TYPE	VARCHAR2	Type of path. Fill this with any descriptive code or text.

<sup>a</sup> *These columns are required. All others are optional.*



# Estrutura de Dados



- Tabela *Path Link*

**Table.** *The Path Link Table*

<b>Column</b>	<b>Data Type</b>	<b>Meaning</b>
PATH_ID	NUMBER	Path identification
LINK_ID	NUMBER	Link identification
SEQ_NO	NUMBER	Sequence of that link in the path

# Estrutura de Dados



- Tabela *Metadata*

Name	Data Type	Meaning
NETWORK	VARCHAR2(24)	Unique name of the network. Note that this is limited to 24 characters.
NETWORK_ID	NUMBER	Unique network number (optional).
NETWORK_CATEGORY	VARCHAR2(12)	The network category is SPATIAL if the network nodes and links are associated with spatial geometries and LOGICAL if the network nodes and links are not associated with spatial geometries.
GEOMETRY_TYPE	VARCHAR2(24)	Type of spatial geometry if the network category is SPATIAL. This is typically set to SDO_GEOMETRY, but it could also be set to LRS_GEOMETRY or TOPO_GEOMETRY (not covered in this book).
NETWORK_TYPE	VARCHAR2(24)	User-defined string to describe the type of network.
NO_OF_HIERARCHY_LEVELS	NUMBER	Number of levels in the network hierarchy. It contains 1 if there is no hierarchy.
NO_OF_PARTITIONS	NUMBER	Number of partitions in the network.
LINK_DIRECTION	VARCHAR2(12)	Specifies whether the links of the network are directed (DIRECTED or UNDIRECTED).
NODE_TABLE_NAME	VARCHAR2(32)	Name of the node table.
NODE_GEOM_COLUMN	VARCHAR2(32)	Name of the geometry column in the node table (if the network category is SPATIAL).
NODE_COST_COLUMN	VARCHAR2(1024)	Name of the cost column in the node table. If this is not specified, then network analysis does not use any node costing (in other words, all nodes have a cost of 0).

Name	Data Type	Meaning
LINK_TABLE_NAME	VARCHAR2(32)	Name of the link table.
LINK_GEOM_COLUMN	VARCHAR2(32)	Name of the geometry column in the link table (if the network category is SPATIAL).
LINK_COST_COLUMN	VARCHAR2(1024)	Name of the cost column in the link table. If this is not specified, then network analysis does not use any link costing (in other words, all links have a cost of 1).
PATH_TABLE_NAME	VARCHAR2(32)	Name of the path table. This is optional. If it is not specified, then the network does not use any path table.
PATH_LINK_TABLE_NAME	VARCHAR2(32)	Name of the path link table. This is optional. Specify it only if the network uses a path table.
PATH_GEOM_COLUMN	VARCHAR2(32)	Name of the geometry column in the path table.
LRS_TABLE_NAME	VARCHAR2(32)	Name of the table that contains the LRS geometries (only when GEOMETRY_TYPE is LRS_GEOMETRY).
LRS_GEOM_COLUMN	VARCHAR2(32)	Name of the geometry column in the LRS table.
PARTITION_TABLE_NAME	VARCHAR2(32)	Name of the table that contains the network partitions.

# Implementação de uma Rede



- Criação de rede de forma automática

## *Creating a Spatial Network Using Default Table Names*

```
SQL> BEGIN
  SDO_NET.CREATE_SDO_NETWORK (
    NETWORK => 'US_ROADS',
    NO_OF_HIERARCHY_LEVELS => 1,
    IS_DIRECTED => TRUE,
    NODE_WITH_COST => FALSE
  );
END;
/
```

## *Network Creation with Explicit Table and Column Names*

```
SQL> BEGIN
  SDO_NET.CREATE_SDO_NETWORK (
    NETWORK => 'US_ROADS',
    NO_OF_HIERARCHY_LEVELS => 1,
    IS_DIRECTED => TRUE,
    NODE_TABLE_NAME => 'US_INTERSECTIONS',
    NODE_GEOM_COLUMN => 'LOCATION',
    NODE_COST_COLUMN => NULL,
    LINK_TABLE_NAME => 'US_STREETS',
    LINK_GEOM_COLUMN => 'STREET_GEOM',
    LINK_COST_COLUMN => 'STREET_LENGTH',
    PATH_TABLE_NAME => 'US_PATHS',
    PATH_GEOM_COLUMN => 'PATH_GEOM',
    PATH_LINK_TABLE_NAME => 'US_PATH_LINKS'
  );
END;
/
```

# Implementação de uma Rede



- Criação de rede de forma Manual

## Manual Network Creation

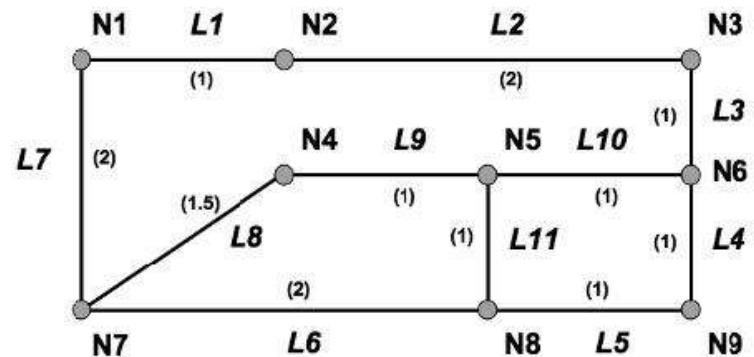
```
SQL> -- Create the node table
SQL> CREATE TABLE us_intersections (
  node_id      NUMBER,
  location     SDO_GEOMETRY,
  CONSTRAINT us_intersections_pk PRIMARY KEY (node_id)
);
SQL> -- Create the link table
CREATE TABLE us_streets (
  link_id      NUMBER,
  start_node_id NUMBER NOT NULL,
  end_node_id  NUMBER NOT NULL,
  active       CHAR(1),
  street_geom  SDO_GEOMETRY,
  street_length NUMBER,
  travel_time  NUMBER,
  bidirected   CHAR(1),
  CONSTRAINT us_streets_pk PRIMARY KEY (link_id)
);
SQL> -- Create path table
SQL> CREATE TABLE us_paths (
  path_id      NUMBER,
  start_node_id NUMBER NOT NULL,
  end_node_id  NUMBER NOT NULL,
  cost         NUMBER,
  simple       VARCHAR2(1),
  path_geom    SDO_GEOMETRY,
  CONSTRAINT us_paths_pk PRIMARY KEY (path_id)
);
SQL> -- Create path link table
SQL> CREATE TABLE us_path_links (
  path_id      number,
  link_id      number,
  seq_no       number,
  CONSTRAINT us_path_links_pk PRIMARY KEY (path_id, link_id)
);
```

# Implementação de uma Rede



- Exemplo 1

```
SQL> -- Populate the node table
SQL> INSERT INTO unet_nodes (node_id, node_name, geom)
VALUES (1, 'N1',
SDO_GEOMETRY (2001, NULL, SDO_POINT_TYPE (1,3,NULL), NULL, NULL));
...
SQL> COMMIT;
SQL> -- Populate the link table
SQL> INSERT INTO unet_links
(link_id, link_name, start_node_id, end_node_id, cost, geom)
VALUES ( 1, 'L1', 1, 2, 1,
SDO_GEOMETRY (2002, NULL, NULL,
SDO_ELEM_INFO_ARRAY (1,2,1),
SDO_ORDINATE_ARRAY (1,3, 2,3))
);
...
SQL> COMMIT;
```

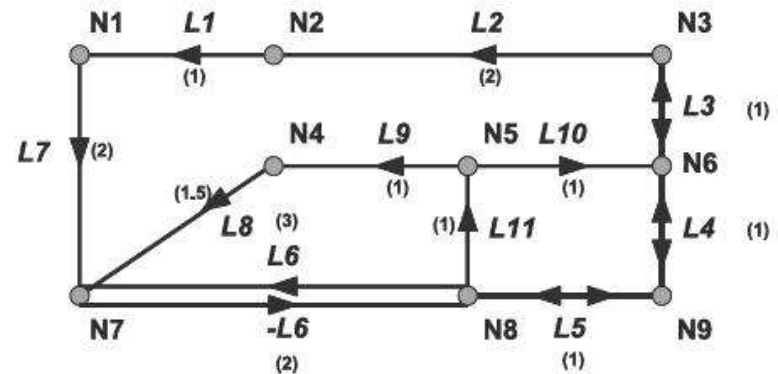


# Implementação de uma Rede



- Exemplo 2

```
SQL> -- Populate The Node Table
SQL> INSERT INTO dnet_nodes (node_id, node_name, geom)
      VALUES (1, 'N1',
              SDO_GEOMETRY (2001, NULL, SDO_POINT_TYPE (1,3,NULL), NULL, NULL));
...
SQL> COMMIT;
SQL> -- Populate The Link Table
SQL> INSERT INTO dnet_links
      (link_id, link_name, start_node_id, end_node_id, cost, geom, bidirected)
      VALUES ( 1, 'L1', 2, 1, 1,
              SDO_GEOMETRY (2002, NULL, NULL,
                            SDO_ELEM_INFO_ARRAY (1,2,1),
                            SDO_ORDINATE_ARRAY (2,3, 1,3)),
              'N'
      );
...
SQL> COMMIT;
```



# Principais Referências



- WANG, Jack C. **Oracle Spatial Network Data Model: An Oracle Technical White Paper**. Mai. 2005. Disponível em <<http://oracle.com>> Acesso em junho de 2005.
- SILVA, Gabriel de. **Modelagem e implementação de uma ferramenta inteligente e de código aberto para inserção automática de inferência Fuzzy em SIG convencionais**. Dissertação do Curso de Mestrado em Modelagem Matemática e Computacional. CEFET-MG. Belo Horizonte. 2006
- KOTHURI, Ravi; GODFRIND, Albert; BEINAT, Euro. **Pro Oracle Spatial for Oracle Database 11g**. Editora Apress. 2007

# Dúvidas??



## Modelo de Dados de Rede

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