Chapter 3

Spatial Databases and GIS

3.1 What are Spatial Databases and GIS?

3.2 Geographic versus Spatial Data Models

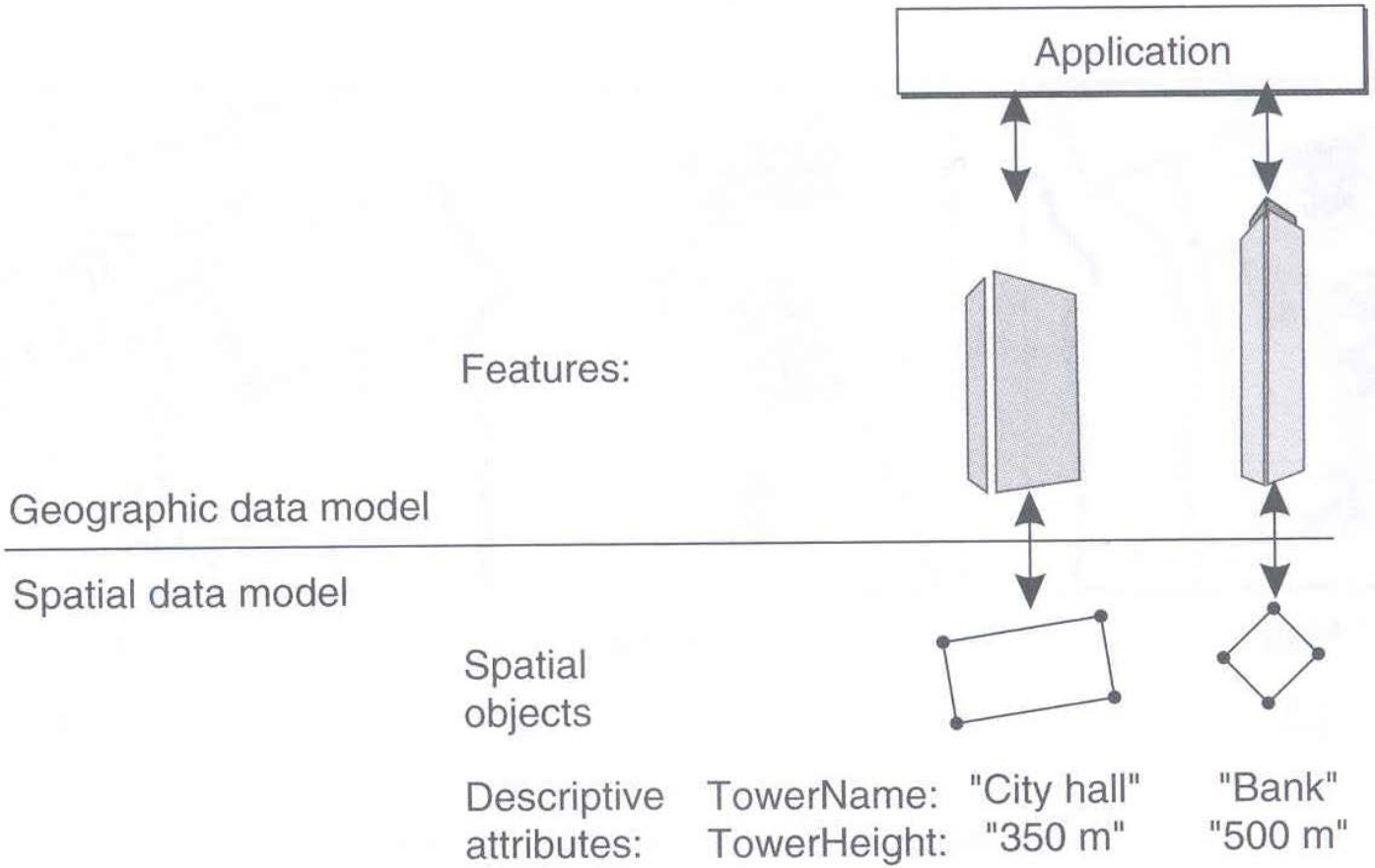


Figure 3.1 Layered GIS approach.

3.3 Representing Spatial Objects

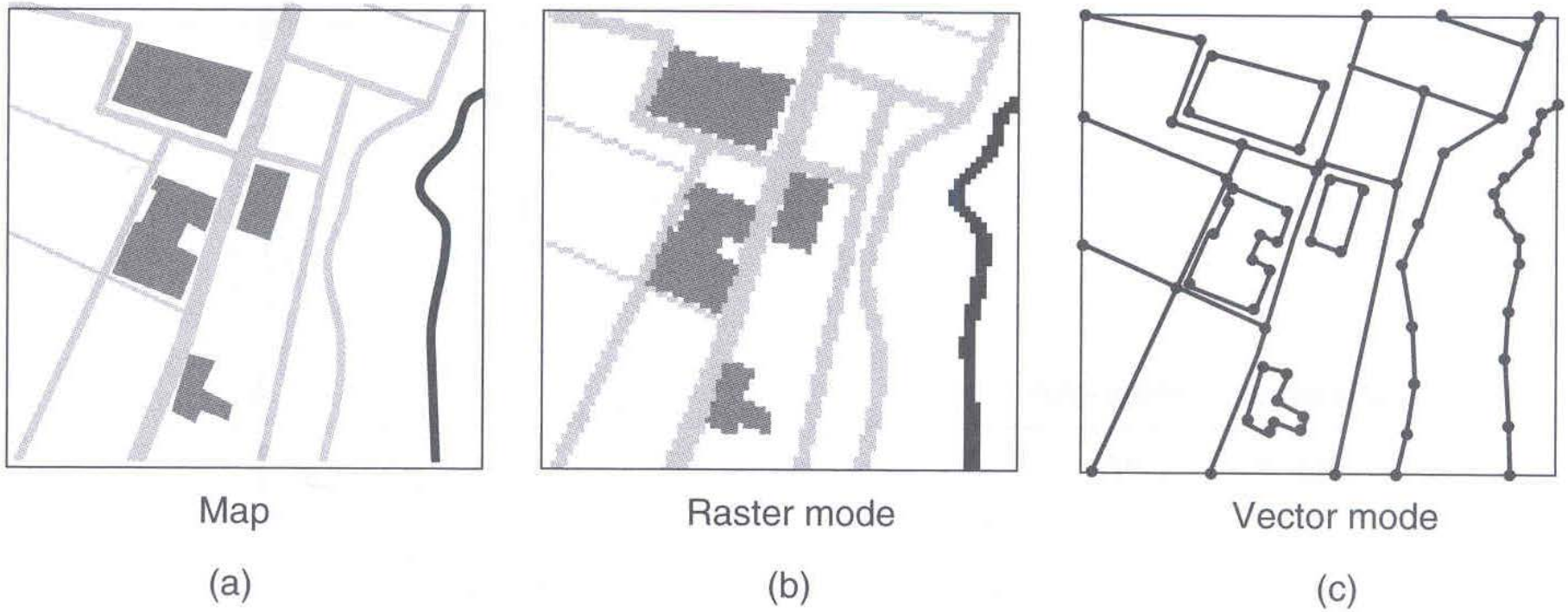


Figure 3.2 Raster and vector mode.

3.3.1 Raster Mode

3.3.2 Vector Mode

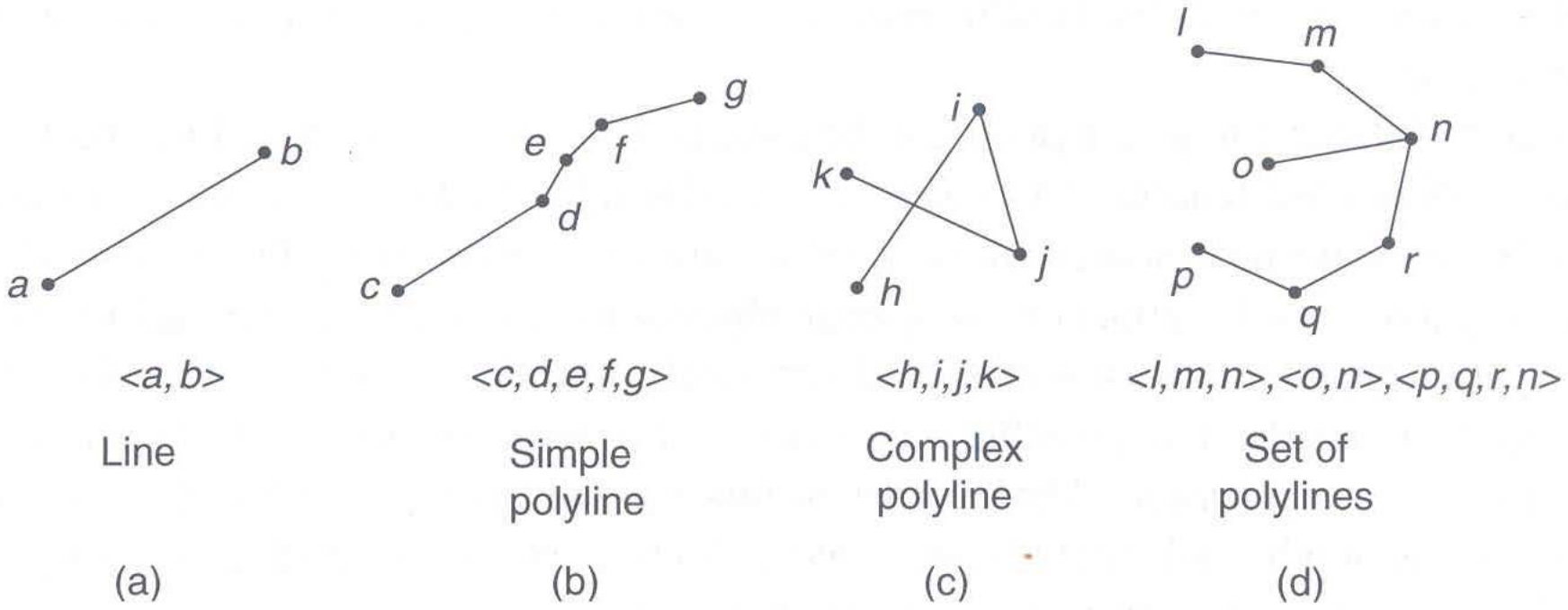


Figure 3.3 Linear spatial objects.

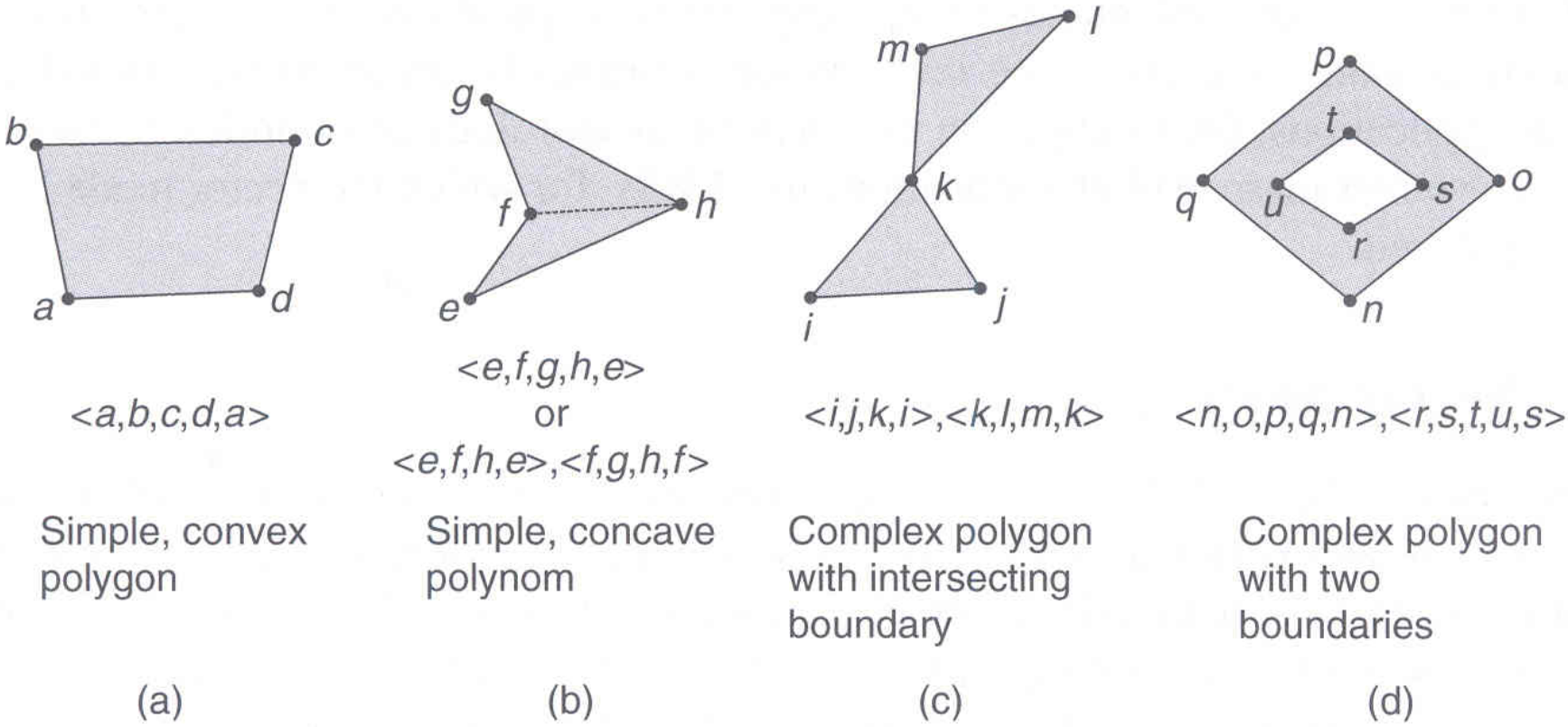
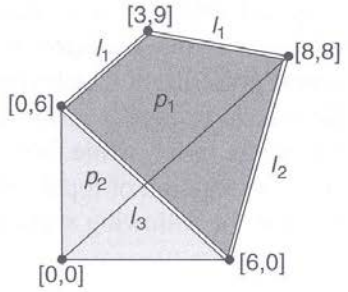


Figure 3.4 Surfacic spatial objects.

3.3.3 Representing Topological Relationships

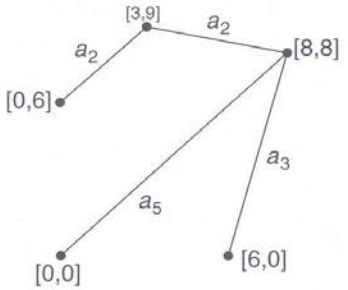


Spaghetti model

(a)

Lines:
l_1:<[0,6],[3,9],[8,8]>
l_2:<[6,0],[8,8]>
l_3:<[0,0],[8,8]>

Polygons:
p_1:<[0,6],[3,9],[8,8],[6,0],[0,6]>
p_2:<[0,0],[0,6],[6,0],[0,0]>



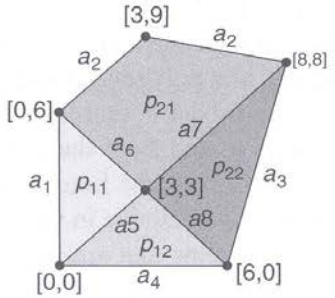
Network model

(b)

Nodes:
n_1:[[0,0],<a_5>]
n_2:[[0,6],<a_2>]
n_3:[[8,8],<a_2,a_3,a_5>]
n_4:[[6,0],<a_3>]
n_5:[[3,3],<a_5,a_6,a_7,a_8>]

Arcs:
a_2:[n_2,n_3,<3,9>]
a_3:[n_3,n_4,_]
a_5:[n_1,n_3,_]

Polygons:
p_1:<[0,6],[3,9],[8,8],[6,0],[0,6]>
p_2:<[0,0],[0,6],[6,0],[0,0]>



Topological model

(c)

Nodes:
n_1:[[0,0],<a_1,a_4,a_5>]
n_2:[[0,6],<a_1,a_2,a_6>]
n_3:[[8,8],<a_2,a_3,a_7>]
n_4:[[6,0],<a_3,a_4,a_8>]
n_5:[[3,3],<a_5,a_6,a_7,a_8>]

Arcs:
a_1:[n_1,n_2,_,p_{11},_]
a_2:[n_2,n_3,_,p_{21},<3,9>]
a_3:[n_3,n_4,_,p_{22},_]
a_4:[n_4,n_1,_,p_{12},_]
a_5:[n_1,n_5,p_{11},p_{12},_]
a_6:[n_2,n_5,p_{21},p_{11},_]
a_7:[n_3,n_5,p_{22},p_{21},_]
a_8:[n_4,n_5,p_{12},p_{22},_]

Polygons:
p_{11}:<a_1,a_6,a_5>
p_{12}:<a_4,a_5,a_8>
p_{21}:<a_2,a_7,a_6>
p_{22}:<a_3,a_8,a_7>

Figure 3.5 Explicit Modeling of Topological Relationships.

Table 3.1 Data representations of spatial objects (Rigaux et al. 2002)

	Spaghetti model	**Network model**	**Topological model**
point	[x:real,y:real]	[x:real,y:real]	[x:real,y:real]
node	–	[point,<arc>]	[point,<arc>]
polyline	<point>	–	–
arc	–	[start:node, end:node, <point>]	[start:node, end:node, polygon, polygon, <point>]
polygon	<point>	<point>	<arc>

3.3.4 Database Approaches for Spatial Objects

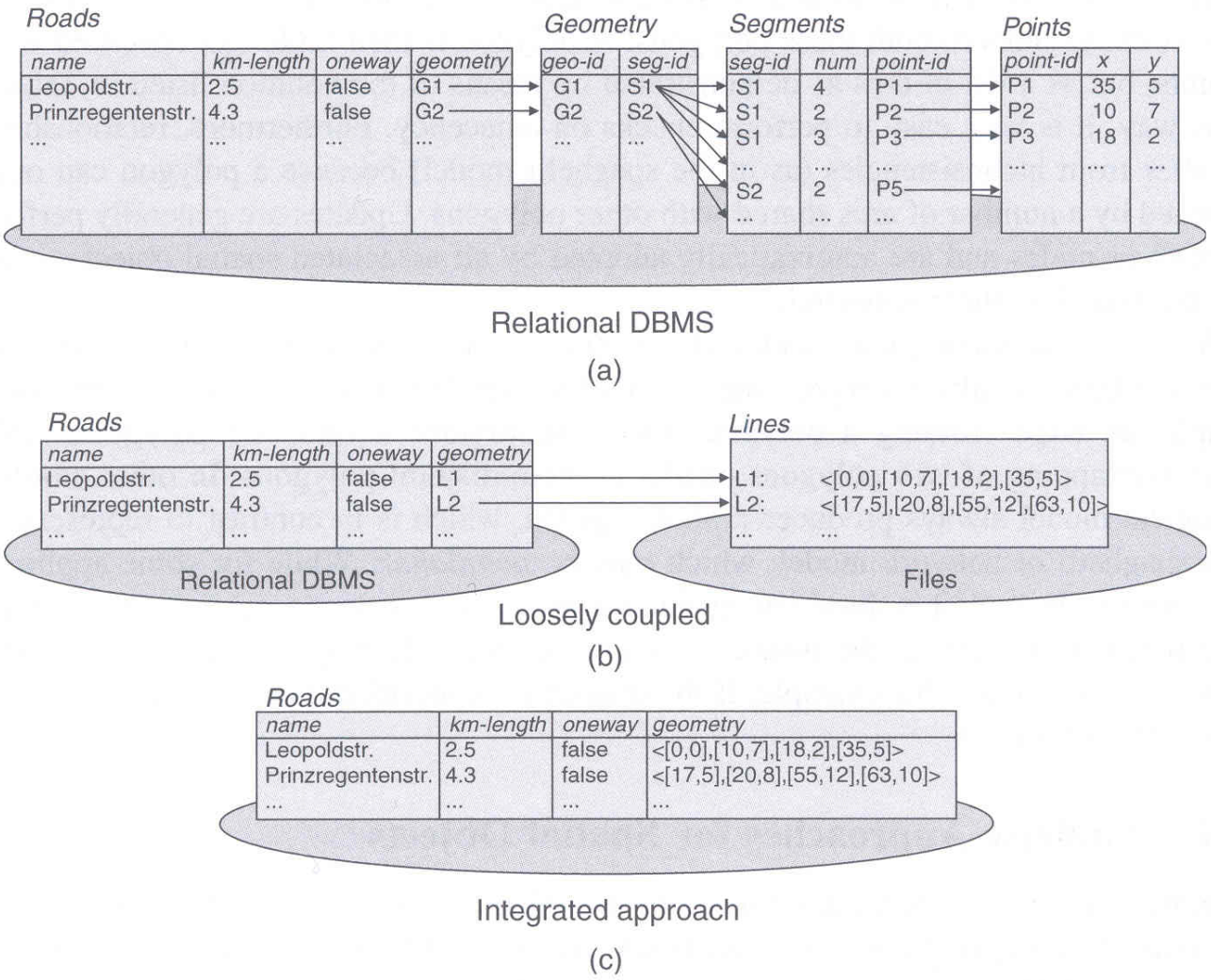


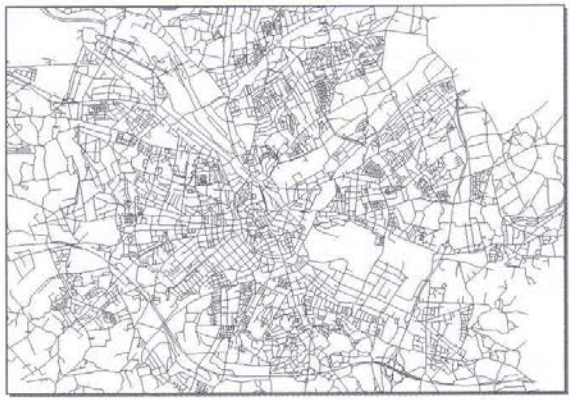
Figure 3.6 Database approaches for GIS.

Representation by relational DBMSs

Loosely coupled approach

Integrated approach

3.4 Features and Themes

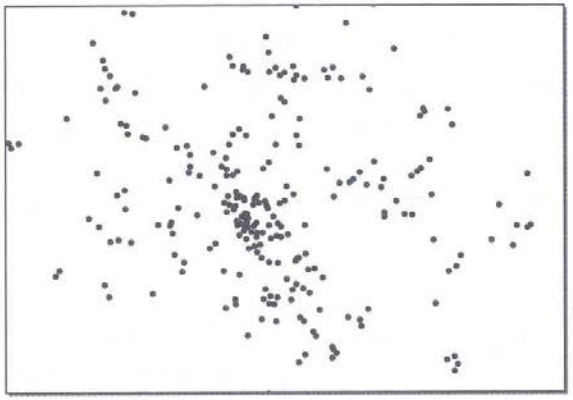


Layer 1: road network

(a)

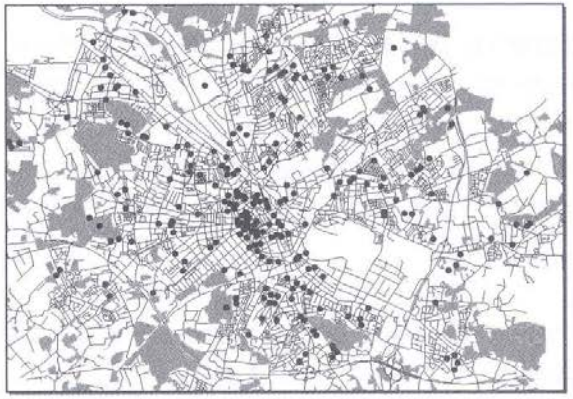
Layer 2: public park areas

(b)



Layer 3: points of interest

(c)



Combination of layers

(d)

Figure 3.7 Layers and combination of layers.

3.4.1 Conceptual Schemes

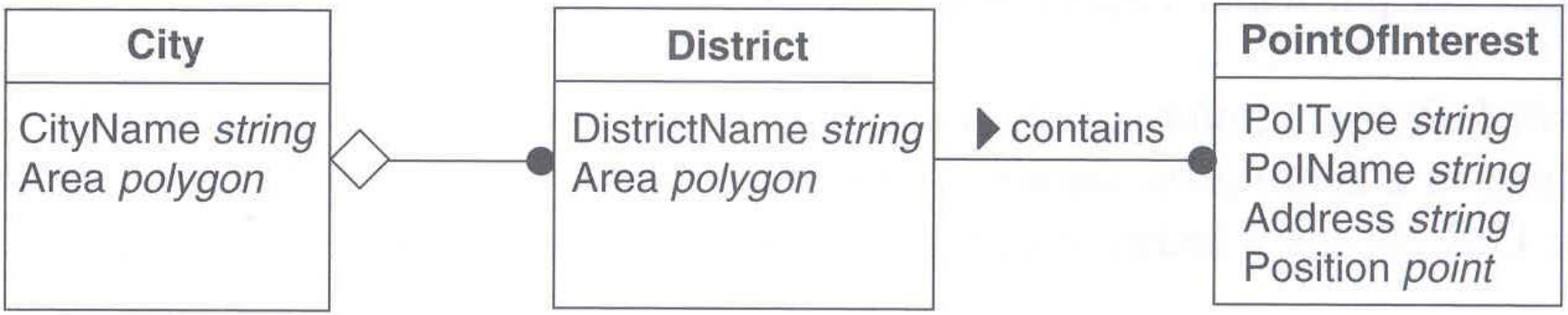


Figure 3.8 Conceptual schema example.

3.4.2 Operations

3.4.3 Topological Predicates

$$I_9(A,B) = \begin{bmatrix} A^0 \bigcap B^0 & A^0 \bigcap \delta B & A^0 \bigcap B^{-1} \\ \delta A \bigcap B^0 & \delta A \bigcap \delta B & \delta A \bigcap B^{-1} \\ A^{-1} \bigcap B^0 & A^{-1} \bigcap \delta B & A^{-1} \bigcap B^{-1} \end{bmatrix} \tag{3.1}$$

$$I_4(A,B) = \begin{bmatrix} A^0 \bigcap B^0 & A^0 \bigcap \delta B \\ \delta A \bigcap B^0 & \delta A \bigcap \delta B \end{bmatrix} \tag{3.2}$$

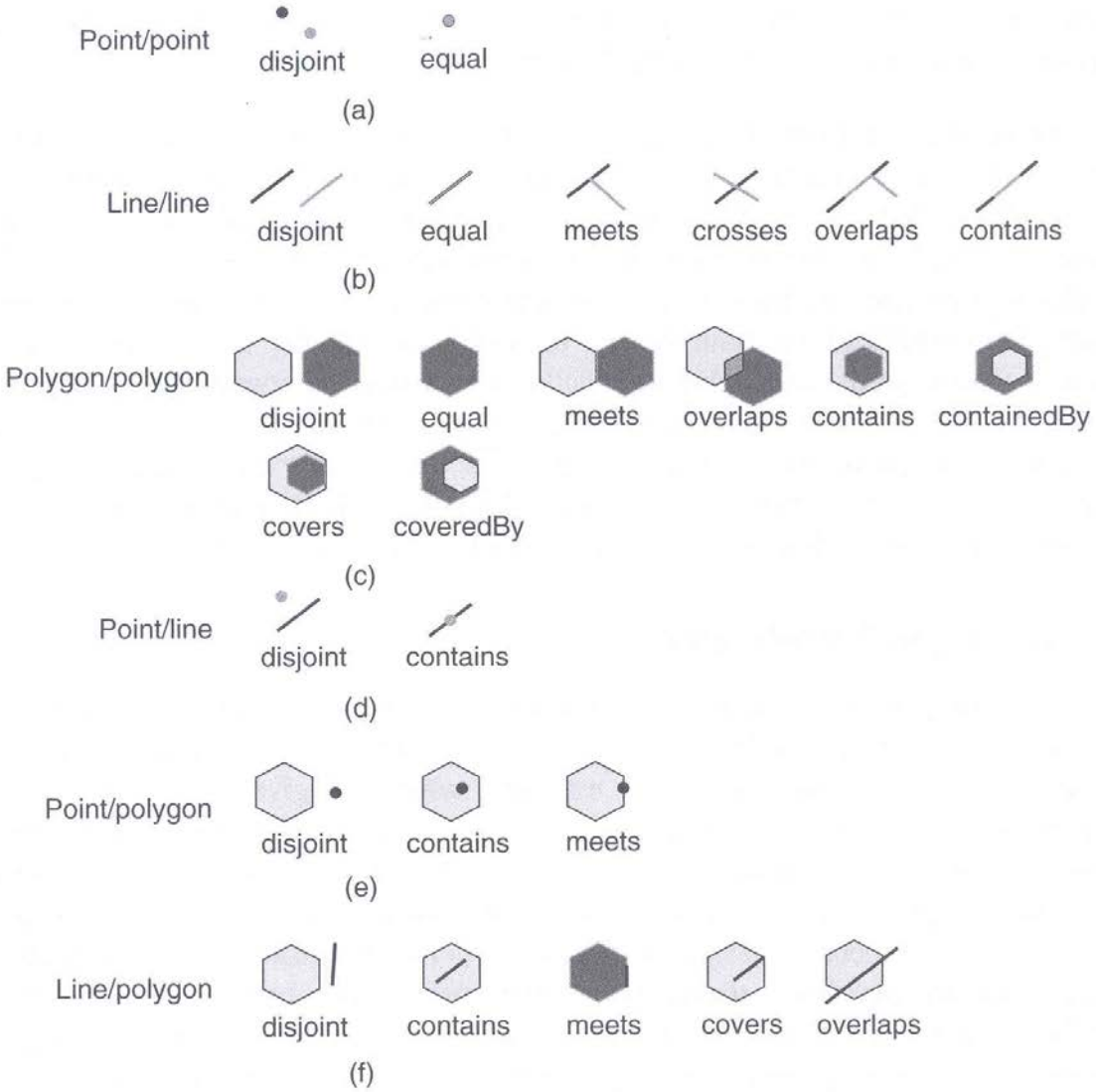


Figure 3.9 Topological predicates.

Table 3.2 Topological predicates (Egenhofer and Franzosa 1991)

	$\delta A \cap \delta B$	$A^0 \cap B^0$	$\delta A \cap B^0$	$A^0 \cap \delta B$
A disjoint B	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
A meets B	$\neg\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
–	$\emptyset$	$\neg\emptyset$	$\emptyset$	$\emptyset$
A equals B	$\neg\emptyset$	$\neg\emptyset$	$\emptyset$	$\emptyset$
–	$\emptyset$	$\emptyset$	$\neg\emptyset$	$\emptyset$
–	$\neg\emptyset$	$\emptyset$	$\neg\emptyset$	$\emptyset$
A containedBy B	$\emptyset$	$\neg\emptyset$	$\neg\emptyset$	$\emptyset$
A coveredBy B	$\neg\emptyset$	$\neg\emptyset$	$\neg\emptyset$	$\emptyset$
–	$\emptyset$	$\emptyset$	$\emptyset$	$\neg\emptyset$
–	$\neg\emptyset$	$\emptyset$	$\emptyset$	$\neg\emptyset$
A contains B	$\emptyset$	$\neg\emptyset$	$\emptyset$	$\neg\emptyset$
A covers B	$\neg\emptyset$	$\neg\emptyset$	$\emptyset$	$\neg\emptyset$
–	$\emptyset$	$\emptyset$	$\neg\emptyset$	$\neg\emptyset$
–	$\neg\emptyset$	$\emptyset$	$\neg\emptyset$	$\neg\emptyset$
–	$\emptyset$	$\neg\emptyset$	$\neg\emptyset$	$\neg\emptyset$
A overlaps B	$\neg\emptyset$	$\neg\emptyset$	$\neg\emptyset$	$\neg\emptyset$

3.4.4 Queries

3.5 Algorithms of Computational Geometry

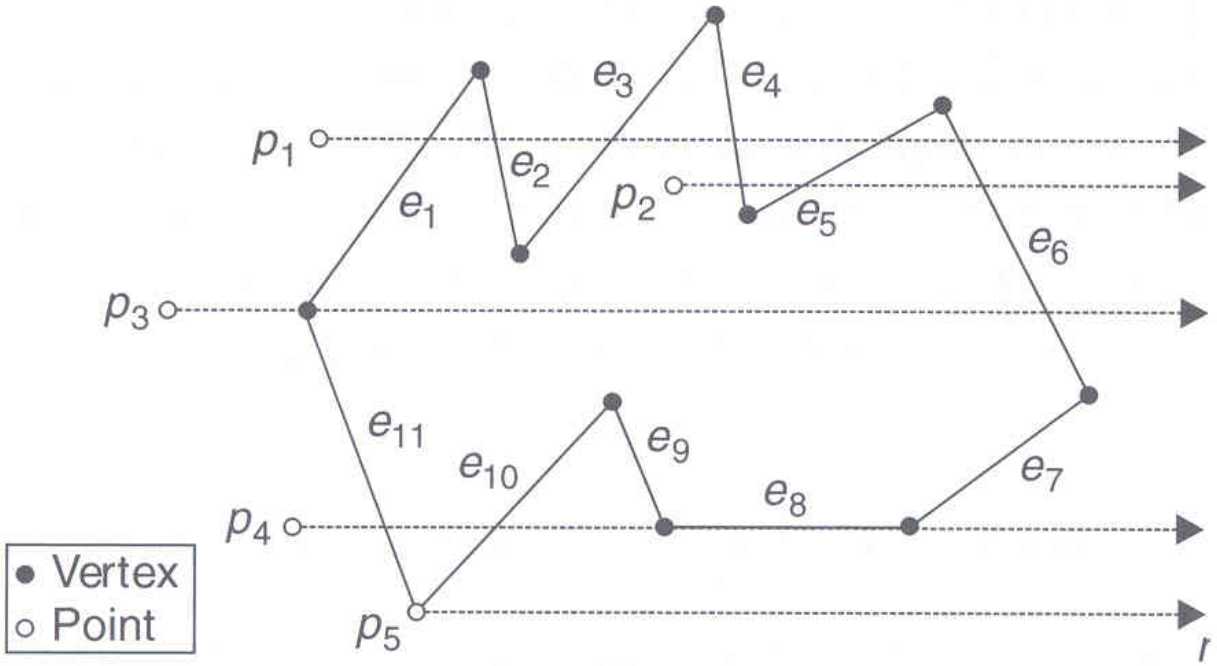


Figure 3.10 Point-in-polygon check.

3.6 Geography Markup Language

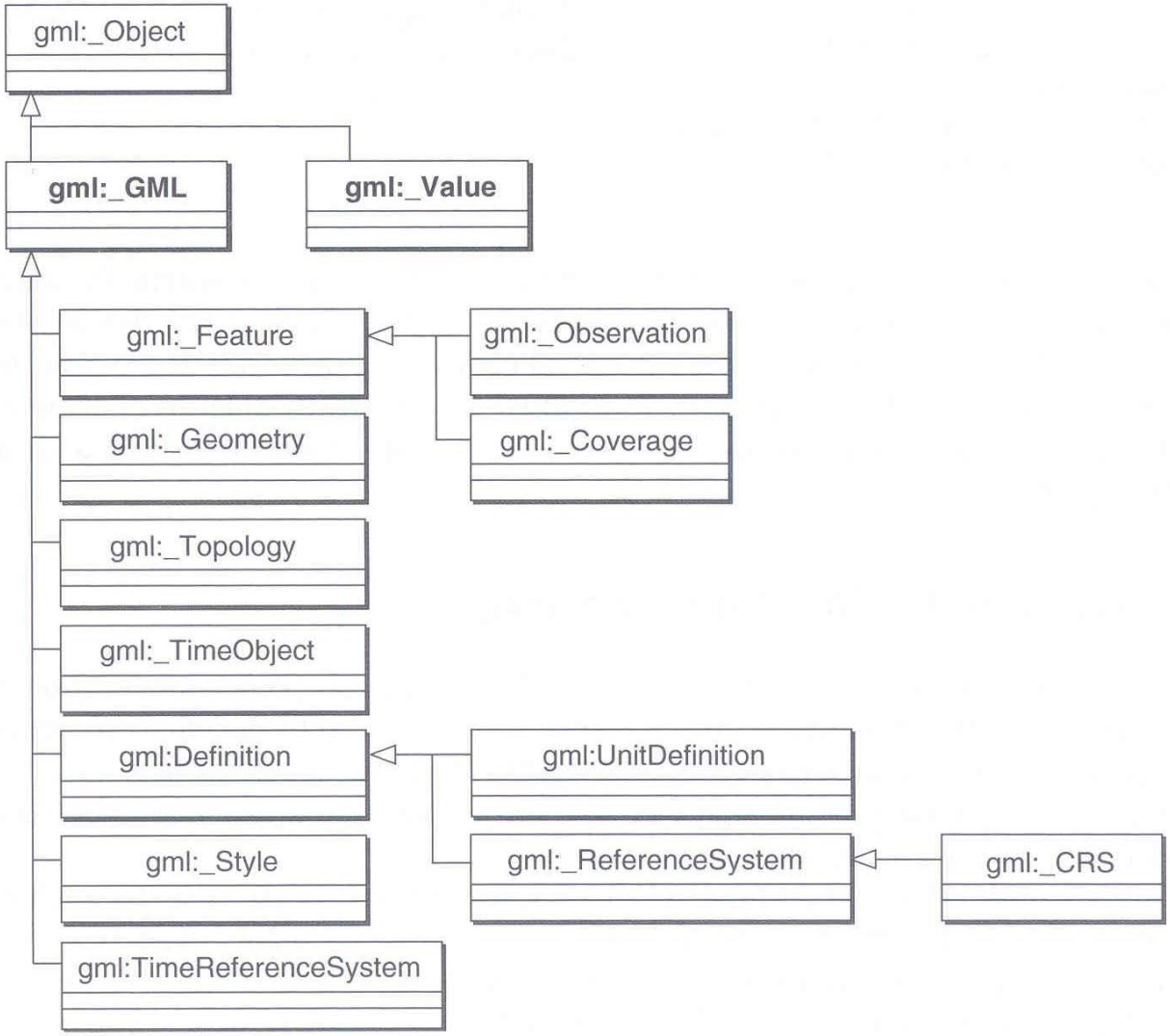


Figure 3.11 GML class hierarchy.

- **Point**
- **Line String**
- **Linear Ring**
- **Polygon**
- **MultiPoints, MultiLineStrings, MultiPolygons**
- **MultiGeometry**

3.7 Conclusion