Vector Data Representation
Reading: Chang’s Chapter 3

Geometric Objects

- The vector data model uses x, y-coordinates and simple geometric objects:
  - points, line and areas to represent spatial features.

A point (node, vertex or 0-cell) has 0 dimension and has only the property of dimension.

A line (edge, link, chain, 1-cell) has 1 dimension and has the property of length.

An area (polygon, face, zone, 2-cells) has 2 dimension and has the property of area and boundary.
Vector Data Representation

- The basic units of vector data model are points and their coordinates.
- A line feature is made of points.
  - See Figure 3.2
- An area feature is defined by lines.
  - See Figure 3.3

**Figure 3.2**
Line objects: two lines with beginning node, end node, and vertex.

AGS 722 (2-2003)
Topology

Explains the arrangement of geometric objects and the relationships between objects.

In vector data model topology is explained by digraph (directed graph) which include points and directed lines (arcs).

- Adjacency and incidence are two relationships that can be established between the point and line objects in digraphs. See Figure 3.4.
Vector Data Representation

- **Adjacency and Incidence**
  - If a line joins two points, the points are said to be adjacent and incident with the line.
  - Adjacency and incidence relationships can be expressed as matrices.
    - See Figure 3.4
  - In the adjacency matrix, the rows and column numbers are the node numbers, and the values in the cells are number of arcs joining the corresponding nodes.

![Adjacency and Incidence Diagram](image)

**Figure 3.4**
The adjacency matrix and incidence matrix for a simple digraph.

AGS 722 (2-2003)
Vector Data Representation

- The direction of the arc determines if 1 or 0 should be assigned.
  - Ex: 1 in (11,12) and 0 in (12,11)
- The row numbers of the incidence matrix correspond to the node numbers in Figure 3.4, the column number correspond to the arc numbers.
  - The number 1 in the matrix means an arc is incident from a node, -1 means an arc is incident to a node, and 0 means an arc is not incident from or to a node.
  - Ex: Arc 1 and 13 in Figure 3.4

AGS 722 (2-2003)

Vector Data Representation

- In ArcInfo, a coverage support 3 basic types of topology:
  - Connectivity: Arcs connect to each other at nodes.
  - Area definition: An area is defined by a series of connected arcs.
  - Contiguity: Arcs have directions and left and right polygons.
Topological Data Structures

- **Point features** are simple and coded with pairs of coordinates.
- Topology does not apply to points because points are separated from one another.
- See Figure 3.6

![Diagram showing point features with coordinates](image)

**Figure 3.6**
Points with x-, y-coordinates.
Topological Data Structures

- Line features have topology.
- In ArcInfo, a line segment is called an arc which is connected to nodes (two end points).
- The starting point is called from-node.

Topological Data Structures

- The ending point is called to-node.
- The arc-node list sorts out the arc-node relationship.
- The arc-coordinate list shows the x,y-coordinates that make up each arc.
- See Figure 3.7
Area data structure has polygon/arc list, and left/light list.

*The polygon/arc list* shows the relationship between polygons and arcs.

See Figure 3.8.

---

**Topological Data Structures**

- Area data structure has **polygon/arc list**, and **left/light list**.
- *The polygon/arc list* shows the relationship between polygons and arcs.
- See Figure 3.8.
The left/right list shows the relationship between arcs and their left right polygons.

The topology-based data structure facilitates the organization of data files and reduces data redundancy.

The share boundary between polygon is listed once not twice.

Figure 3.8
The data structure of the arc data model.
Non-Topological Vector Data

- The main advantage of non-topological (NTP) vector data is that they display more rapidly on the monitor, and can be used directly in different GIS software packages.
- The standard NTP format used in ArcView is *shapefile*.

Shapefile saves a point as a pair of x, y-coordinates, a line as a series of points, and a polygon as a series of lines.

- No files describe the spatial relationship among geometric objects.
- Two basic files in shapefile:
  - .shp file stores the feature geometry
  - .shx file maintains the index of feature geometry
Non-Topological Vector Data

- **Shapefiles** can be converted to **coverages** and vice versa.
- Conversion from shapefile to coverage require building topological relationships and removal of duplicate arcs.
- Conversion of coverages to shapefiles is simpler but need error-free coverage otherwise some features are missing in shapefiles (see **Figure 3.9a, 3.9b**).
Higher-level Objects

TIN (triangulated irregular network)

- A vector data for terrain mapping and analysis.
- A TIN approximates the surface with a set of non-overlapping triangle.
- Each triangle in the TIN is assumed to have a constant gradient.

Components of TIN
- Elevation points with x, y, z values
- Edges (lines) that connect these points to form triangles

Slope and aspect of each triangle can be calculated from x, y, z and edges.
Higher-level Objects

**Regions**

- Built from lines and areas
- Consists of region layers and regions (see Figure 3.11)
- A region layer is made of regions of the same attribute.
- Characteristics of region data model:
  - Region layers may overlap with another region layer
  - A region may have disconnected or disjoint components.
Higher-level Objects

Region data structure
- Region-polygon list
- Region-arc list
- See Figure 3.12

Figure 3.11
Properties of the regions data model: a—overlapped regions; b—a region with three components or rings; c—void area made of an area within the region and the external area.
Higher-level Objects

Dynamic Segmentation
- Combines a line coverage and a linear measurement such as milepost system to form a higher level object.
- ArcInfo uses 3 basic elements for the model:
  - Sections
  - Routes
  - Events
Higher-level Objects

Sections
- Arcs of a line coverage and positions along arcs.

Routes
- Collections of sections that represent linear phenomena such as roads, streams.

Events
- Attribute data associated with routes.
- See Figure 3.13

Figure 3.13
The dynamic segmentation data model.