Attribute Data Review

• Bits & Bytes
• Data types
  – Number (int, float, double, signed, unsigned…)
  – Text (string, character)
• Data structure (tables and fields)
  – Keys
  – Relating tables (Inner/outer join)
• GIS data models

Is Everything Best Represented as an Object? (Bian 2007)

• Environmental phenomena:
  – Objects (e.g., buildings)
  – Regions (e.g., campus)
  – Fields (e.g., urban residents)
• OO Paradigm
  – Encapsulation (identify, properties, behavior)
  – Composition (inherence, aggregation, association)
• Identification of spatial objects
  – Scale (point, line, polygon, region, individual, mass)
  – Boundary (physical, precise vs. perceived, vague)
  – Attributes (homogeneous, discrete vs. heterogeneous, continuous)
  – Process (temporal change – mobile vs. sedentary)
  – Mobility (spatial change – solid vs. fluid)
### Types of Environmental Phenomena (Bian 2007)

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object</td>
<td>Mobil individuals</td>
<td>Individual or groups of animals</td>
</tr>
<tr>
<td>Object</td>
<td>Sedentary individuals</td>
<td>Plants or bodies of water</td>
</tr>
<tr>
<td>Field</td>
<td>Masses of individuals</td>
<td>Vegetation</td>
</tr>
<tr>
<td>Region</td>
<td>Regions of individuals</td>
<td>Landscape patch</td>
</tr>
<tr>
<td>Field</td>
<td>Continuous solid mass</td>
<td>Land surface</td>
</tr>
<tr>
<td>Field</td>
<td>Continuous fluid mass</td>
<td>Water, air</td>
</tr>
<tr>
<td>Region</td>
<td>Sedentary regions in mass</td>
<td>Watershed</td>
</tr>
<tr>
<td>Region</td>
<td>Mobile regions in mass</td>
<td>Pollution plumes</td>
</tr>
</tbody>
</table>

### GIS Data Models for Areal Fields (Bian 2007)

<table>
<thead>
<tr>
<th>Field Models</th>
<th>GIS Model</th>
<th>Attribute Assoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polygons</td>
<td>Vector</td>
<td>Piecewise</td>
</tr>
<tr>
<td>Contours</td>
<td>Vector</td>
<td>Sampled</td>
</tr>
<tr>
<td>TINs</td>
<td>Vector</td>
<td>Piecewise</td>
</tr>
<tr>
<td>Cell-grids</td>
<td>Raster</td>
<td>Sampled</td>
</tr>
<tr>
<td>Point-grids</td>
<td>Raster</td>
<td>Sampled</td>
</tr>
<tr>
<td>Irregular points</td>
<td>Vector</td>
<td>Sampled</td>
</tr>
</tbody>
</table>
Next generation GIS data model?

GEOG 475/575

Vector Data Model

- Represent discrete geometric objects
  - Isolated objects and connected coverages
- Points, lines, & areas (nodes, chains, polygons)
  - Scale
- Topology (geometric rules)
  - Categorical coverage
  - Planar vs non-planar network

GEOG 475/575
Vector Data Model (cont.)

- Composite geometric objects
  - TIN, regions, dynamic segmentation (routes)

- Object-based vector data model

- Non-topological vector data
  - CAD .dxf
  - Arcview shape file
  - Data conversion issues

Topology

- Why topology
  - Enforce geometric rules for spatial representation and maintain data integrity (having implications in data interoperability)
  - Reduce data redundancy
  - Improve data access/update efficiency
Data Structures for Implementing Topology

- Coordinates \((x, y)\)
- Digraph: adjacency and incidence matrices
- Line data model: arc-node list, arc-coordinate list
- Area data model: left/right list, polygon/arc list
- TIN: points, edges, & triangles list, adjacency matrix
- Region: region-arc and region-polygon lists
- Dynamic segmentation: section, routes, events tables
- OO data model

Adjacency & incidence matrices

Nodes: 11, 12, 13, 14
Arcs: 1, 2, 3, 4, 5, 6
Incidence: -1: end node, 1: start node
Adjacency: 1: Yes, 0: No
ESRI’s Coverage Topology

- Connectivity: arcs - nodes
- Area definition: polygons – arcs
- Contiguity: arc directions, left/right polygon

Universal Polygon in a Polygon Coverage
Regions

Polygon Topology

Region Topology

Dynamic segmentation (To be covered in Week 8)

<table>
<thead>
<tr>
<th>Section table</th>
<th>Arc</th>
<th>F-MEAS</th>
<th>T-MEAS</th>
<th>F-POS</th>
<th>T-POS</th>
<th>BIKEPATH #</th>
<th>BIKEPATH-ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Link #</td>
<td>Arc #</td>
<td>Link #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>100</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>40</td>
<td>170</td>
<td>0</td>
<td>100</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>170</td>
<td>210</td>
<td>0</td>
<td>80</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Route table</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIKEPATH #</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point event table</th>
<th>BIKEPATH-ID</th>
<th>LOCATION</th>
<th>ATTRIBUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>40</td>
<td>Stop sign</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linear event table</th>
<th>BIKEPATH-ID</th>
<th>FROM</th>
<th>TO</th>
<th>ATTRIBUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>100</td>
<td>120</td>
<td></td>
<td>Sleep</td>
</tr>
</tbody>
</table>

GEOG 475/575
Triangulated Irregular Network (TIN)

- Point (x, y, z)
- Edge
- Triangles
- Topology
  - The triangle number
  - The numbers of each adjacent triangle
  - The three nodes defining the triangle
  - The x, y coordinates of each node
  - The surface z value of each node
  - The edge type of each triangle edge (hard or soft)

Generating Topology

- Ways of generating topology in vector data model
  - Automated methods
    - Delaunay triangulation, Arcinfo BUILD, Arcinfo REGIONQUERY
  - Manual methods
Object-Based Vector Data Model

- Georelational vector data model
- Object-oriented model
  - Class and instance
  - Properties and methods
  - Interface:
    - Inheritance, encapsulation, polymorphism

ArcGIS Geodatabase Structure

- Spatial features: point, polyline, polygon
- Feature class
- Feature dataset
- Validation rules
  - Attribute domain
  - Relationship
  - Connectivity
- User specified topology
ArcGIS Geodatabase Data Structure

Features / Feature Classes

• All point, line, and polygon features can:
  – Be multipart
  – Have x,y; x,y,z; or x,y,z,m coordinates
    • (m-coordinates store distance measurement values, a line with m-coordinates becomes a route)
  – Be stored as continuous layers instead of tiled

• Network
  – Junctions, edges
Geodatabase Topology

Details will be covered in Week 5.

ESRI’s GIS Data Structures

<table>
<thead>
<tr>
<th>Data Structure</th>
<th>Type</th>
<th>Topology</th>
<th>Portability</th>
<th>Spatial Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>File-based</td>
<td>Required</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Shapefile</td>
<td>File-based</td>
<td>None</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Personal Geodatabase</td>
<td>DBMS</td>
<td>Optional</td>
<td>High</td>
<td>High (if topology rules are defined)</td>
</tr>
<tr>
<td>File Geodatabase</td>
<td>File-based</td>
<td>Optional</td>
<td>High</td>
<td>High (if topology rules are defined)</td>
</tr>
</tbody>
</table>
Spatial Reference

• Prior to ArcGIS 9.2, spatial references were low precision. Each integer coordinate was allotted 31 bits rather than the 53 bits provided by high resolution spatial references created and maintained with 9.2 or above.

• With low precision, you have to specify a domain extent as well as a resolution (precision) value. A large domain extent is only possible with low resolution values.

• Therefore, when working with low-precision spatial references, you must carefully balance the trade-off between domain extent and the resolution or precision values.

About x,y Resolution and Domain

• A low-precision geodatabase stores coordinates as positive 4-byte integers that have a maximum value of 2,147,483,647.

• If you need to store meter precision, you have 2.14 billion meters to work with (approximately 53 times the circumference of the earth).

• If you need to store centimeters precision, in which case you would have 2.14 billion centimeters to work with (about one-half the circumference of the earth).

• Resolution values represent the minimum allowed separation between two coordinate values. Resolution values are used to convert decimal values to the integers stored in the geodatabase.
<table>
<thead>
<tr>
<th>Minimum separation between coordinates</th>
<th>Resolution</th>
<th>Coordinate system units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>0.01</td>
<td>Meters</td>
</tr>
<tr>
<td>1 mm</td>
<td>0.001</td>
<td>Meters</td>
</tr>
<tr>
<td>2 cm</td>
<td>0.02</td>
<td>Meters</td>
</tr>
<tr>
<td>1 inch</td>
<td>0.083333</td>
<td>Feet</td>
</tr>
</tbody>
</table>
Advantages of ESRI Geodatabase

- Functionality (ArcObjects)
  - Attribute domain
  - Connectivity rules/geometric networks
  - Relationship class
  - Topology rules
- Web-based, versioned operations (ArcSDE)
- Portability (Personal Geodatabase)
- Integration with RDBMS
- Customized data models