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 (inheritance, aggregation, association)

- Identification of spatial objects
  - Scale, boundary, attributes, process (temporal change), mobility (spatial change)

Types of Environmental Phenomena
(Bian 2007)

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

GIS Data Models for Areal Fields
(Bian 2007)

Field Models	GIS Model	Attribute Assoc
Polygons	Vector	Piecewise
Contours	Vector	Sampled
TINs	Vector	Piecewise
Cell-grids	Raster	Sampled
Point-grids	Raster	Sampled
Irregular points	Vector	Sampled

Conceptual vs implementation OO models (Bian 2007)

Table 1. A summary of the compatibility between the principles of object-orientation, the object-oriented implementation, including both proprietary and in-house, and conceptual models of environmental phenomena

| | | | Object-oriented implementation | | |
| | | | ArcObjects | | In-house |
Environment phenomena	Examples	Object-oriented representation	Vector	Raster	Raster
Mobile individuals	animals	yes	yes	no	yes
Sedentary individuals	plants	yes	yes	no	yes
Regions of individuals	plant patches	yes	yes	no	yes
Sedentary regions in mass	watersheds	yes	yes	no	yes
Mobile regions in mass	weather fronts	yes	yes	no	–
Masses of individuals	vegetation	n.a.	–	yes	yes
Continuous solid mass	land-surface	n.a.	–	yes	yes
Continuous fluid mass	air mass	n.a.	–	yes	yes

Note: For the object-oriented representation, "yes" and "no" designate whether they are appropriate to represent the eight categories of spatial objects, regions, and fields. For the object-oriented implementation, "yes" and "no" indicate whether it supports the categories of environmental phenomena. The dash indicates complex situations, depending on specific conceptualization and implementation models. Detailed discussions of these situations are presented in the article text.

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

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
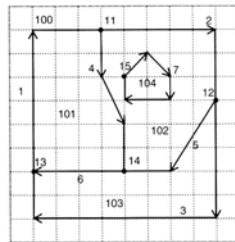Arcs: 1, 2, 3, 4, 5, 6
Incidence: -1: end node, 1: start node
Adjacency: 1: Yes, 0: No

Adjacency matrix — To / From

	11	12	13	14
11	0	1	0	1
12	0	0	1	0
13	1	0	0	0
14	0	1	1	0

Incidence matrix — Arcs / Nodes

	1	2	3	4	5	6
11	-1	1	0	1	0	0
12	0	-1	1	0	-1	0
13	1	0	-1	0	0	-1
14	0	0	0	-1	1	1

ESRI's Coverage Topology

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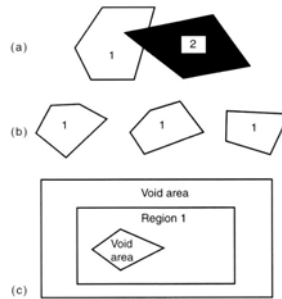
Left/right list

Arc#	L-poly	R-poly
1	100	101
2	100	102
3	100	103
4	102	101
5	103	102
6	103	101
7	102	104

Polygon/arc list

Polygon #	Arc#
101	1,4,6
102	4,2,5,0,7
103	6,5,3
104	7

Regions

Polygon Topology   Region Topolgy
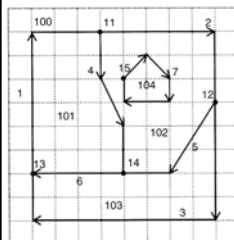
Left/right list

Arc#	L-poly	R-poly
1	100	101
2	100	102
3	100	103
4	102	101
5	103	102
6	103	101
7	102	104

Polygon/arc list

Polygon #	Arc#
101	1,4,6
102	4,2,5,0,7
103	6,5,3
104	7
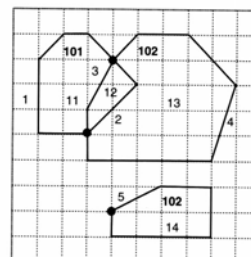
Region-polygon list

Region #	Polygon #
101	11
101	12
102	12
102	13
102	14

Region-arc list

Region #	Ring #	Arc #
101	1	1
101	1	2
102	1	3
102	1	4
102	2	5

Dynamic segmentation (To be covered in Week 8)
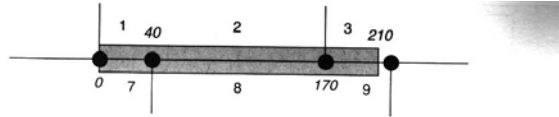
Section table

Route Link #	Arc Link #	F-MEAS	T-MEAS	F-POS	T-POS	BIKEPATH #	BIKEPATH-ID
1	7	0	40	0	100	1	1
1	8	40	170	0	100	2	2
1	9	170	210	0	80	3	3

Route table

BIKEPATH #	BIKEPATH-ID
1	109

Point event table

BIKEPATH-ID	LOCATION	ATTRIBUTE
109	40	Stop sign

Linear event table

BIKEPATH-ID	FROM	TO	ATTRIBUTE
109	100	120	Steep

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)
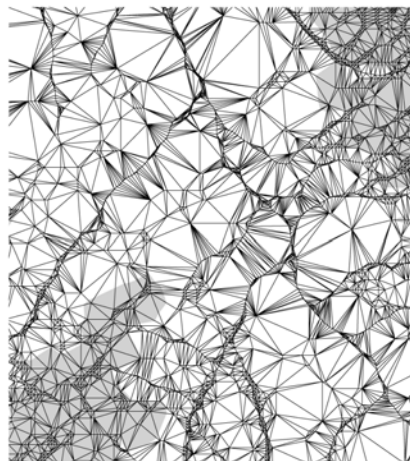
Generating Topology

- 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:
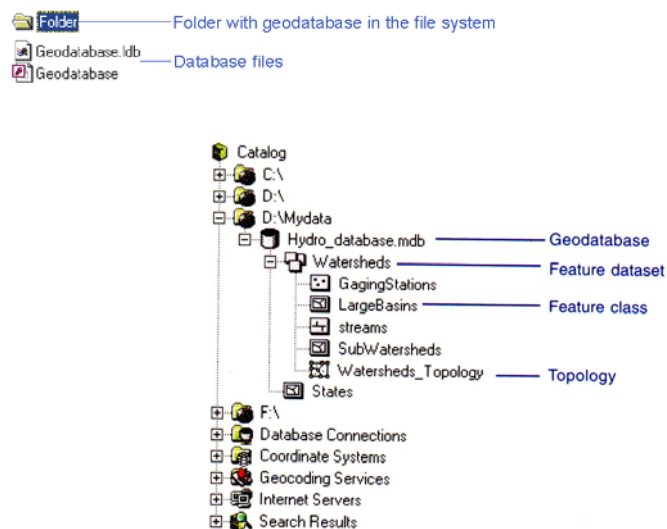   - Inheritance, encapsulation, polymorphism

ArcGIS Geodatabase Structure

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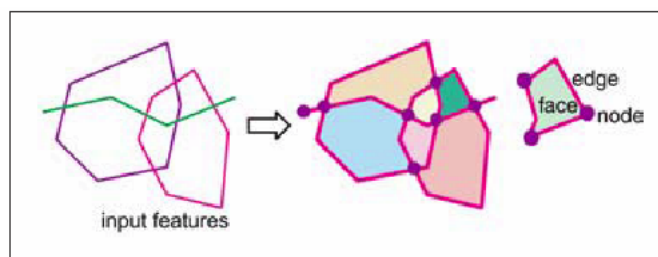
ArcGIS Geodatabase Data Structure

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
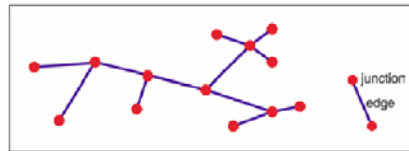
Geodatabase Topology

- Details will be covered in Week 5.

ESRI's GIS Data Structures

Data Structure	Type	Topology	Portability	Spatial Integrity
Coverage	File-based	Required	Low	High
Shapefile	File-based	None	High	None
Personal Geodatabase	DBMS	Optional	High	High (if topology rules are defined)
File Geodatabase	File-based	Optional	High	High (if topology rules are defined)

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.

GEOG 475/575

Minimum separation between coordinates	Resolution	Coordinate system units
1 cm	0.01	Meters
1 mm	0.001	Meters
2 cm	0.02	Meters
1 inch	0.083333	Feet

GEOG 475/575