# Geographic Information Systems 2018/19
## *Week 3, Topic 2*

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# *In this session...*

Topology

- Topological data structures - general overview
- Advantages/disadvantages vis a vis simple features

# Topology

Geometric characteristics of objects which do not change under transformation

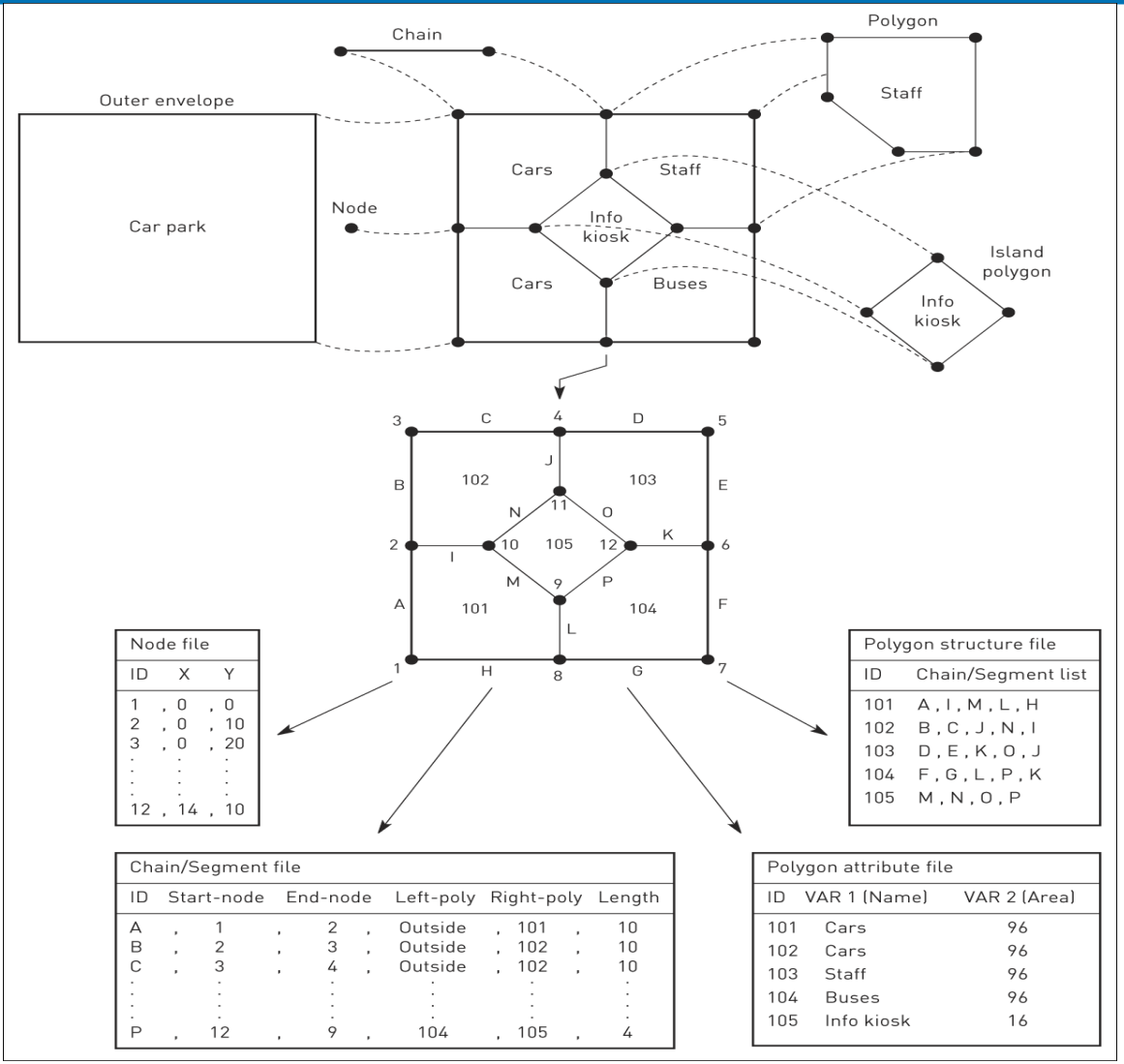
Three elements

- Adjacency
- Containment
- Connectivity

Useful in spatial analysis, routing etc. More complex to create than simple features but easier to query

Good example of where topology is more important than geographic  accuracy is a subway map such as *London Underground*

# Topological structuring of complex areas




Node file

| ID | X | Y |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 0 | 10 |
| 3 | 0 | 20 |
| . | . | . |
| . | . | . |
| . | . | . |
| 12 | 14 | 10 |

Polygon structure file

| ID | Chain/Segment list |
|---|---|
| 101 | A, I, M, L, H |
| 102 | B, C, J, N, I |
| 103 | D, E, K, O, J |
| 104 | F, G, L, P, K |
| 105 | M, N, O, P |

Chain/Segment file

| ID | Start-node | End-node | Left-poly | Right-poly | Length |
|---|---|---|---|---|---|
| A | 1 | 2 | Outside | 101 | 10 |
| B | 2 | 3 | Outside | 102 | 10 |
| C | 3 | 4 | Outside | 102 | 10 |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| P | 12 | 9 | 104 | 105 | 4 |

Polygon attribute file

| ID | VAR 1 (Name) | VAR 2 (Area) |
|---|---|---|
| 101 | Cars | 96 |
| 102 | Cars | 96 |
| 103 | Staff | 96 |
| 104 | Buses | 96 |
| 105 | Info kiosk | 16 |

# Importance of topology

Topology can be explained by directed graphs (digraphs)

Edge

- Directed line with start and end point

Node

- End point of an edge

Face

- Polygon bounded by edges

If an edge joins two nodes, the nodes are said to be *adjacent* and *incident* with the edge

# Importance of topology

Requires additional files to store spatial relationships

Ensures data quality and integrity

- Rules are baked in

Enhances GIS analysis

- e.g. Routing calculations, geocoding

Easier implementation of data query

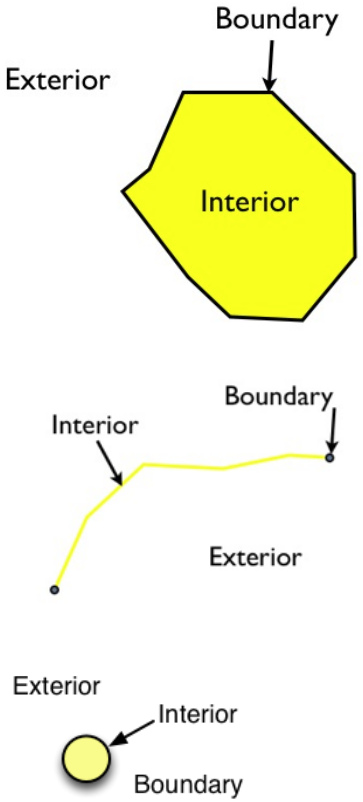
- e.g. containment and intersection

# Dimensionally Extended Nine-Intersection Model (DE-9IM)

The “Dimensionally Extended 9-Intersection Model” (DE9IM) provides a framework for modeling the interaction of two spatial objects.

Every spatial object is characterized by the following spatial attributes:

- An interior
- A boundary
- An exterior



# TopoJSON

As its name implies, **TopoJSON** is a *topological* geospatial data format. In contrast to a geometry, where each shape is encoded with separate (and often redundant) arrays of coordinates, a topology encodes sequences of coordinates in line fragments called arcs that can be shared. For example, the border between California and Nevada is an arc that is shared by both polygons.

The main benefit of a topology is that it improves shape simplification by avoiding artifacts that would be caused by simplifying shapes independently. It also enables applications like map coloring and selective meshing, and makes the format more compact by removing redundant coordinates.

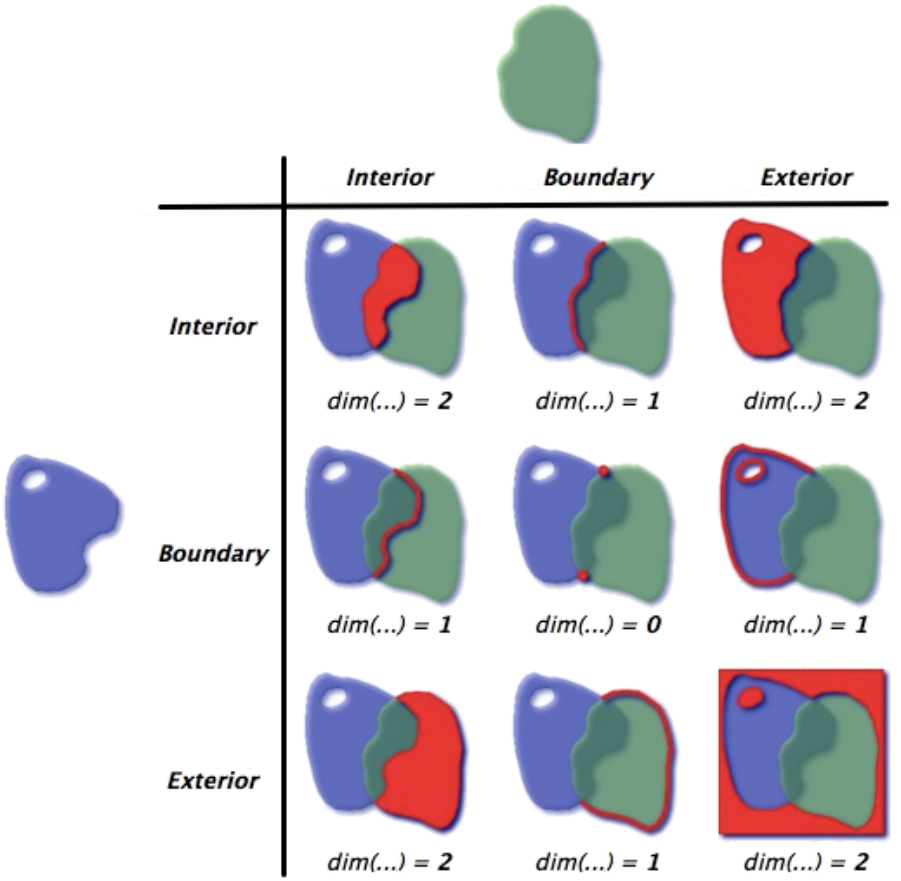
Yet because most geospatial data formats are non-topological, you must typically create TopoJSON by **inferring the topology from geometry**.


```
{
 "type": "Topology",
 "objects": {
  "example": {
   "type": "GeometryCollection",
   "geometries": [
    {
     "type": "Point",
     "properties": {
      "prop0": "value0"
     },
     "coordinates": [102, 0.5]
    },
    {
     "type": "LineString",
     "properties": {
      "prop0": "value0",
      "prop1": 0
     },
     "arcs": [0]
    },
    {
     "type": "Polygon",
     "properties": {
      "prop0": "value0",
      "prop1": {
       "this": "that"
      }
     },
     "arcs": [[-2]]
    }
   ]
  }
 },
 "arcs": [
  [[102, 0], [103, 1], [104, 0], [105, 1]],
  [[100, 0], [101, 0], [101, 1], [100, 1], [100, 0]]
 ]
}
```

# DE-9IM (cont'd)

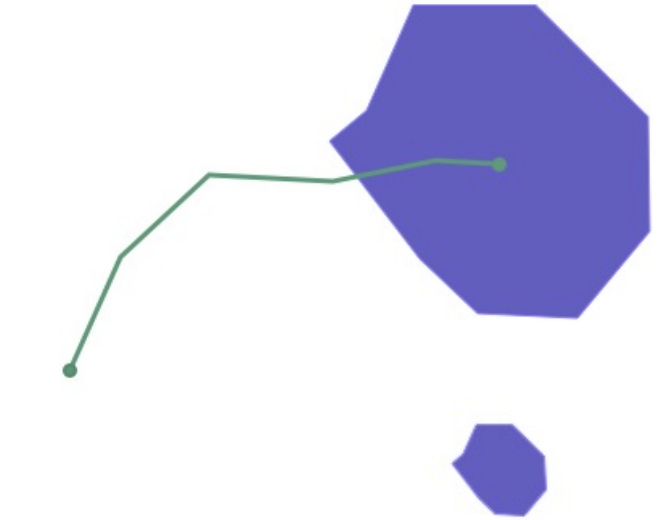
Using these definitions of interior, boundary, and exterior attributes, the relationships between any pair of spatial features can be characterized using the dimensionality of the nine possible intersections between the interiors, boundaries, and exteriors.

For the polygons in the example, the intersection of the interiors is a two-dimensional area, so that portion of the matrix is completed with a 2. If the boundaries intersect along a line, that portion of the matrix is completed with a 1. When the boundaries only intersect at points, which are zero-dimensional, that portion of the matrix is completed with a 0. When there is no intersection between components, the matrix is filled out with an F.



# DE9-IM example
## *Line intersects polygon*

Note that the boundaries of the two objects don't intersect at all (the end point of the line interacts with the interior of the polygon, not the boundary, and vice versa), so the B/B (boundary/boundary) cell is completed with an F.



| | ***I*** | ***B*** | ***E*** |
|---|---|---|---|
| ***I*** | I | 0 | I |
| ***B*** | 0 | F | 0 |
| ***E*** | 2 | I | 2 |

# *Coming next...*

Attribute data

Symbology

Classification