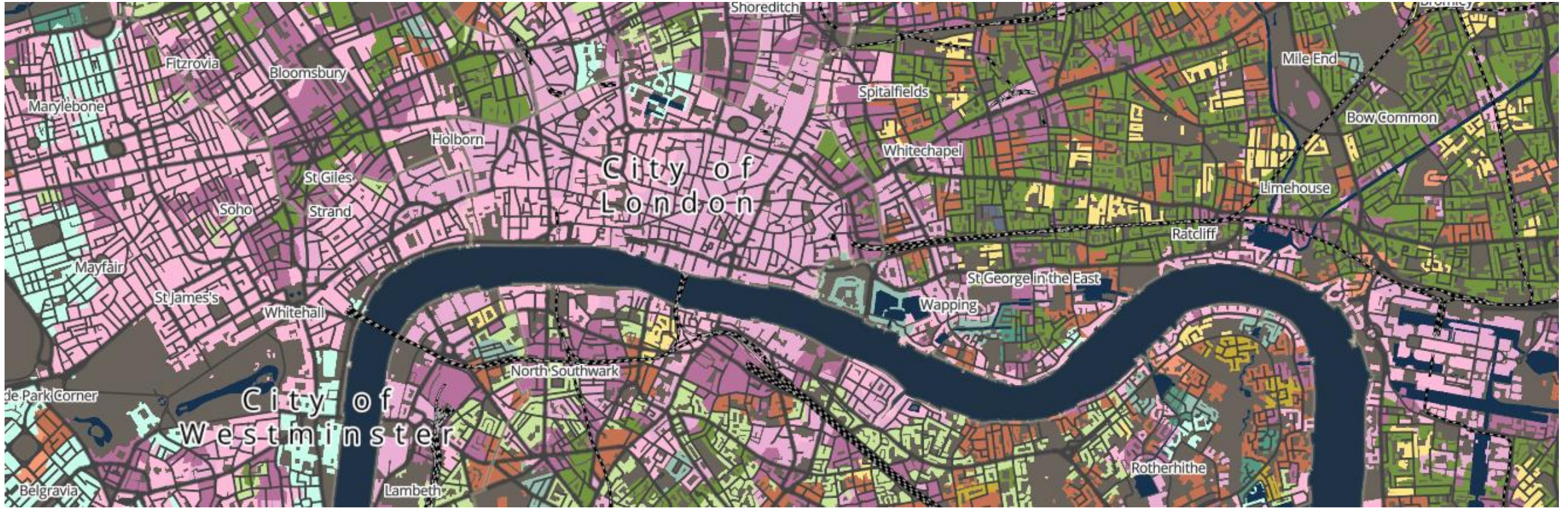


Geocomputation

Spatial Queries and Geometric Operations



Module outline

- W1 Reproducible Spatial Analysis
- W2 Spatial Queries and Geometric Operations
- W3 Point Pattern Analysis
- W4 Spatial Autocorrelation
- W5 Spatial Models
- W6 Raster Data Analysis
- W7 Geodemographic Classification
- W8 Accessibility Analysis
- W9 Beyond the Choropleth
- W10 Complex Visualisations

Core Spatial Analysis

Applied Spatial Analysis

Data Visualisation

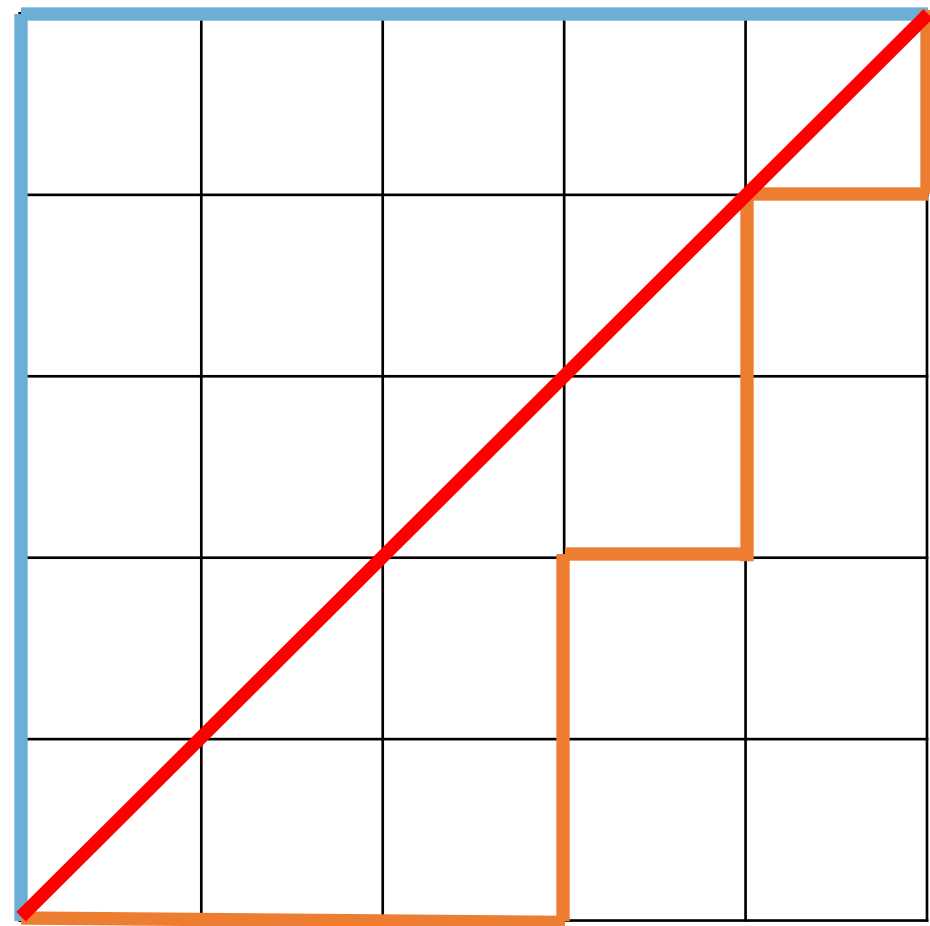
This week

- Spatial properties.
- Attribute joins.
- Spatial operations.

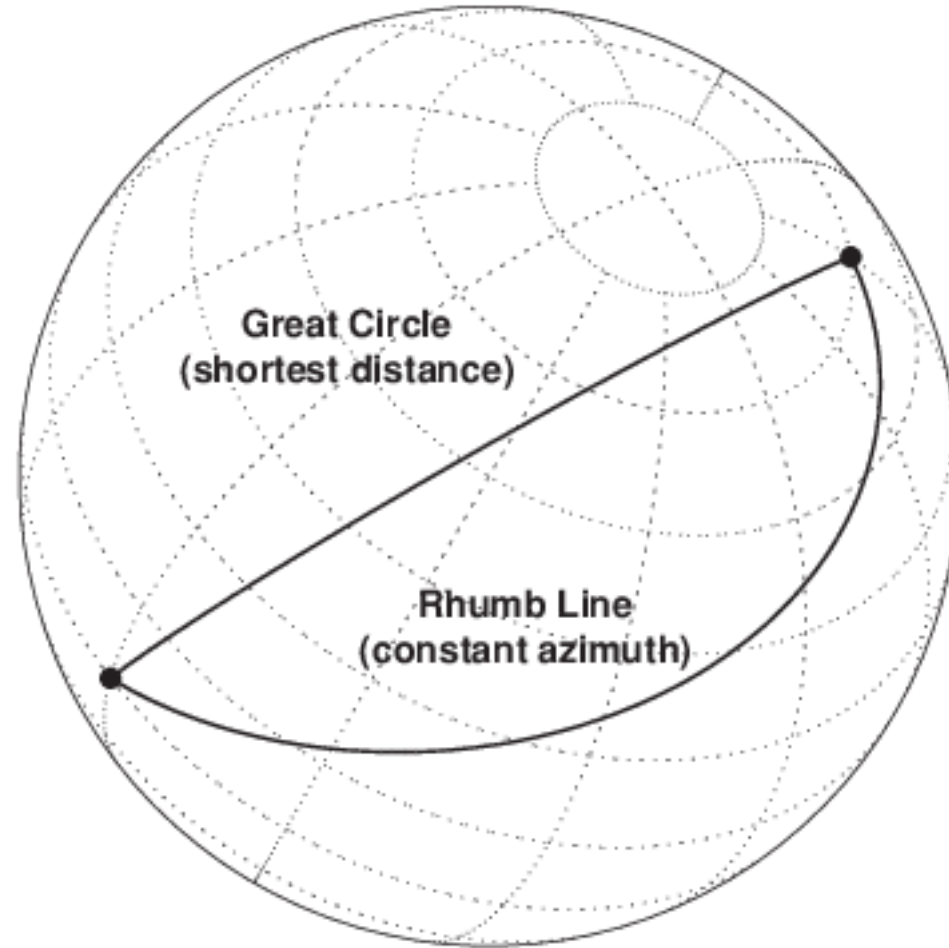
Spatial properties

- Spatial data often requires performing mathematical operations on spatial properties.
- Key properties include areas of and distances between spatial objects.
- There are diverse ways to conceptualise and work with these properties depending on the analytical context and available data.

Distance



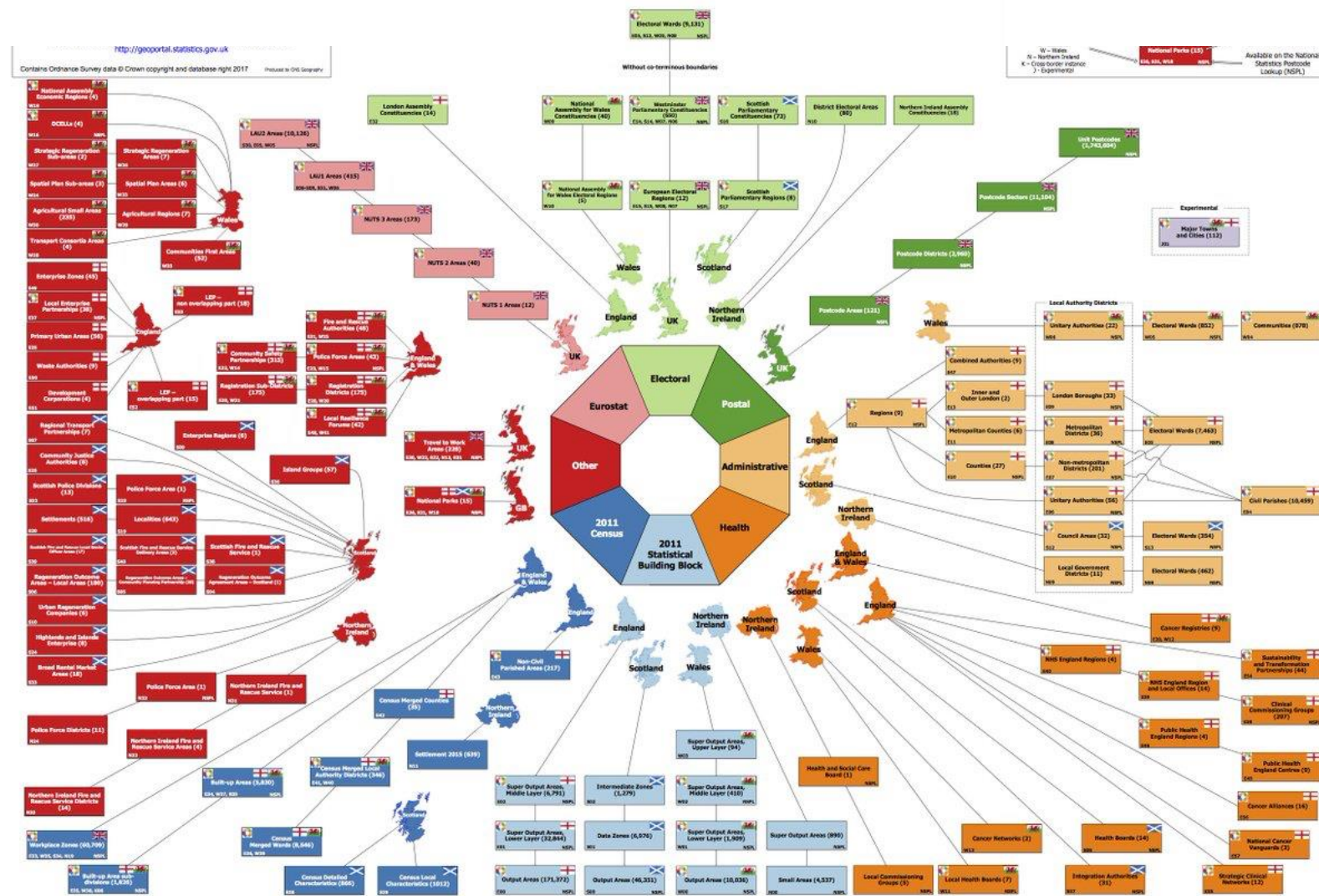
Distance



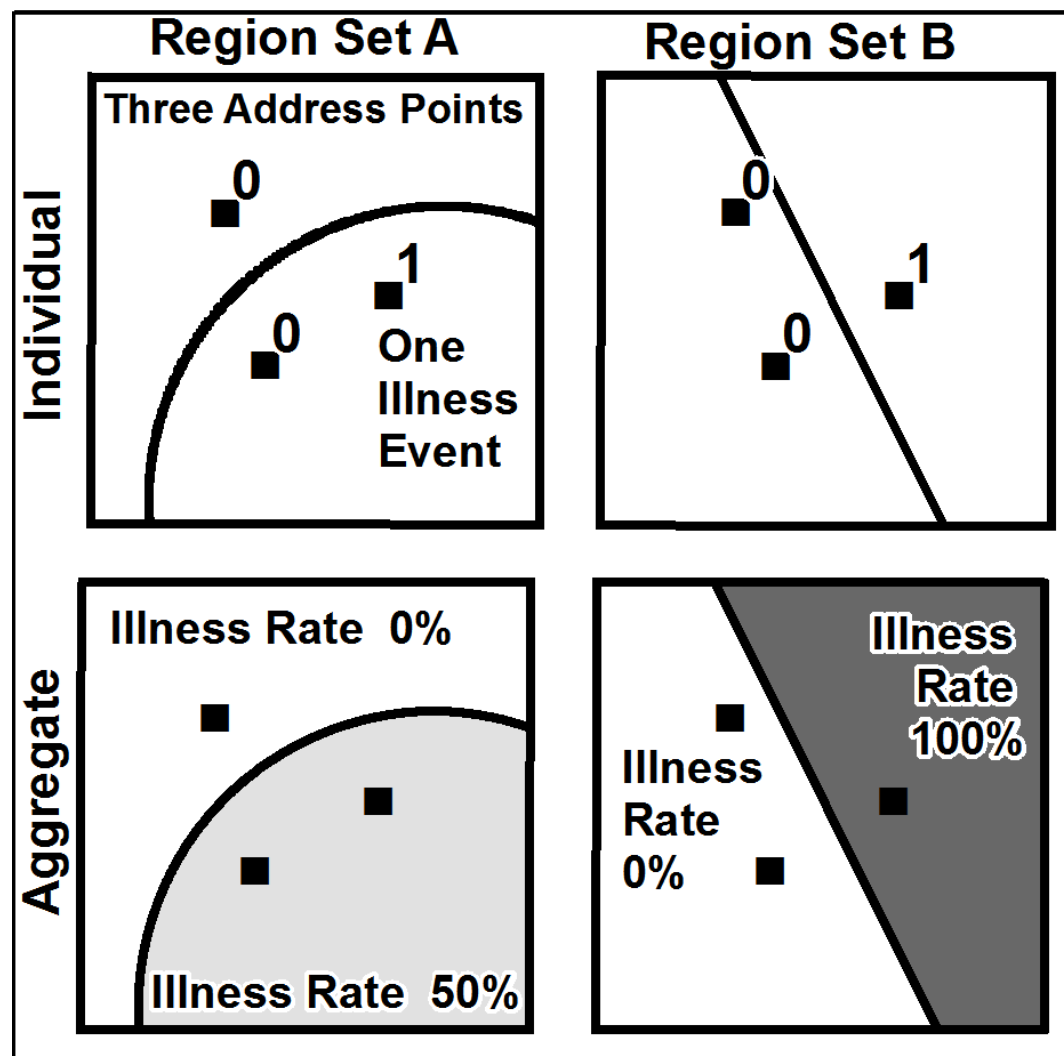
Area



Area



Area



Spatial features

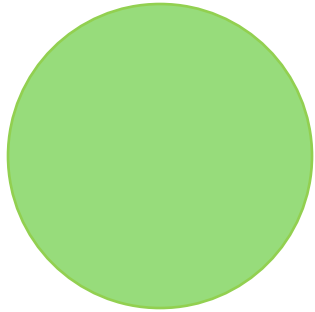
- Features: Objects created in a spatial dataset, representing geographic entities such as points, lines, or polygons.
- Attributes: Characteristics or properties of features, often stored as data in GIS, describing specific details about the feature.

Point vector

Characteristics of a point vector in a GIS data model:

- Single XY location (coordinate).
- Has no area.
- Has no length.
- Geometry consists of a single **node** or **vertex**.
- Used for: discrete features or events.

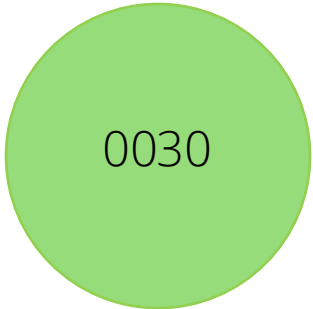
Point vector



Point vector



Point vector



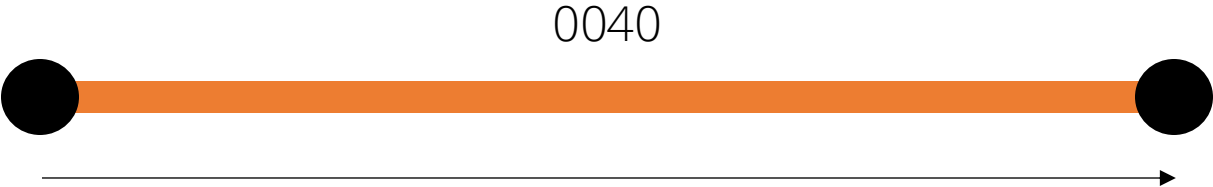
FeatureID	Type	Height
0030	Ent	500

Polyline vector

Characteristics of a polyline vector in a GIS data model:

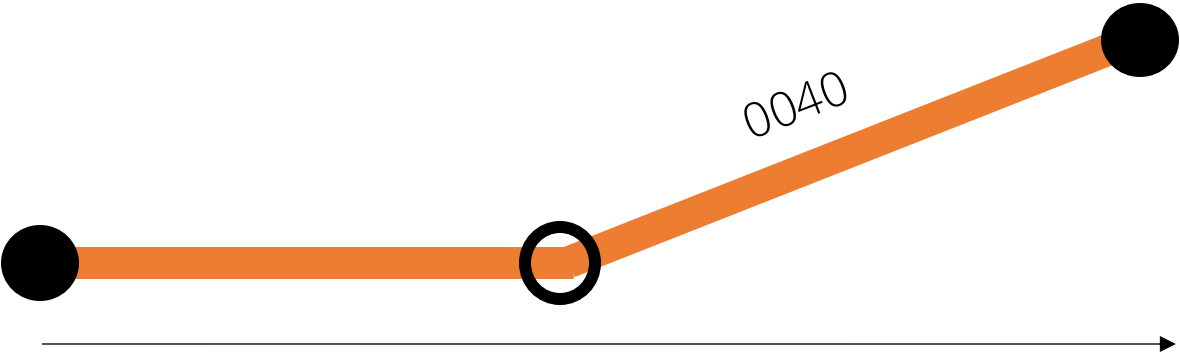
- Series of XY locations (coordinates) that form a line.
- Has no area.
- Has a length.
- Has a direction (importance when it comes to roads, rivers, etc.).
- Can be connected to other polyline vectors to form a network.
- Geometry consists of two **nodes** (start node and end node) and can have one or more **vertices**.
- Used for: features without an area but with a length.

Polyline vector



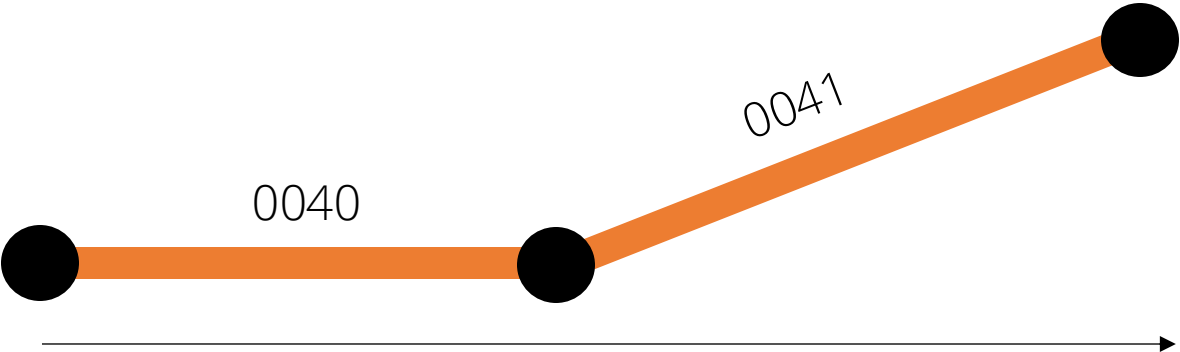
FeatureID	Type	Length
0040	Bicycle lane	1,500

Polyline vector



FeatureID	Type	Length
0040	Bicycle lane	1,650

Polyline vector



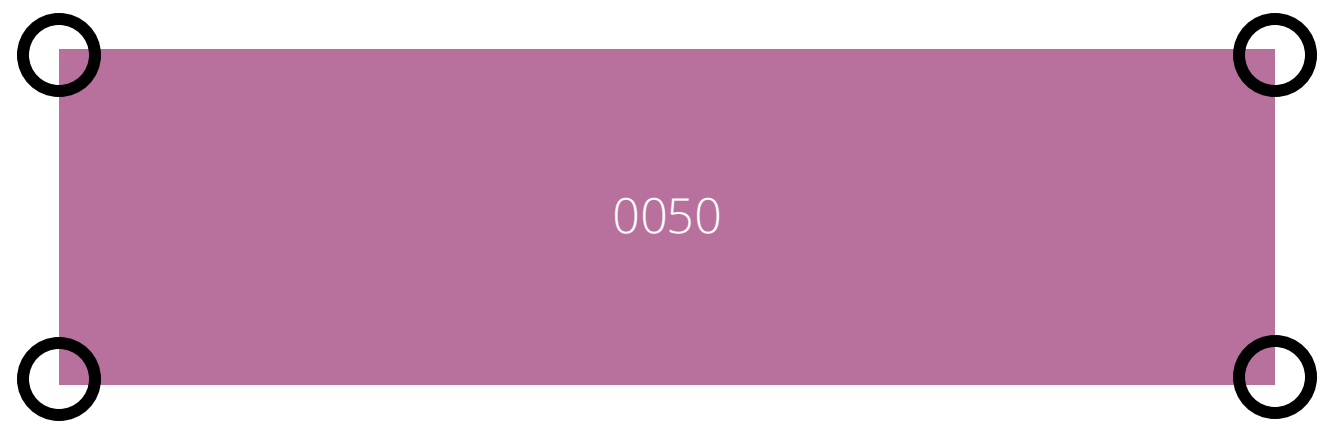
FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

Polygon vector

Characteristics of a polyline vector in a GIS data model:

- Series of XY locations (coordinates) to form an enclosed region.
- Has an area.
- Has no length.
- Geometry consists of at least three **nodes** or **vertices** whereby the first node or vertex connects with the last one.
- Used for: features with enclosed regions such as buildings and administrative areas.

Polygon vector



FeatureID	Type	Area
0050	University building	2000

Representation

Representing the North-West Wing Building



Attribute joins

GeolD	Population
GEO0030	540
GEO0031	320

Attribute joins

GEO0030

FeatureID	GeoID
0050	GEO0030

Attribute joins



		GeoID	Population
FeatureID	GeoID	GEO0030	540
0050	GEO0030	GEO0031	320

Attribute joins



FeatureID		GeoID		Population	
0050		GEO0030		540	
		GEO0031		320	

Attribute joins

GEO0030

FeatureID	GeoID	Population
0050	GEO0030	540

Spatial data formats

```
## Simple feature collection with 100 features and 6 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
## epsg (SRID):    4267
## proj4string:    +proj=longlat +datum=NAD27 +no_defs
## precision:      double (default; no precision model)
## First 3 features:
```

	BIR74	SID74	NWBIR74	BIR79	SID79	NWBIR79	geom
## 1	1091	1	10	1364	0	19	MULTIPOLYGON(((-81.47275543...
## 2	487	0	10	542	3	12	MULTIPOLYGON(((-81.23989105...
## 3	3188	5	208	3616	6	260	MULTIPOLYGON(((-80.45634460...

Simple feature

Simple feature geometry list-column (sfc)

Simple feature geometry (sfg)

Spatial data formats

- Several commonly used file formats that store spatial data exist.
- Different file formats for vector data and raster data.
- Common vector formats: shapefile, GeoJSON, GeoPackage
- Common raster formats: GeoTIFF, GeoPackage

Shapefiles

- Perhaps the most (in)famous file format.
- Widely used, despite being **outdated**, especially limitations of **.dbf** format.
- A shapefile is not a single file, but a collection of files of which at least three are needed for the data to be displayed in GIS software.

Shapefiles

- `.shp` contains the feature geometry. *Mandatory.*
- `.shx` index file which stores the position of the feature's ID in the `.shp` file. *Mandatory.*
- `.dbf` stores all attribute information associated with the records. *Mandatory.*
- `.prj` contains the coordinate system information and projection. *Optional but not really.*
- `.xml` general metadata. *Optional.*
- `.cpg` encoding information. *Optional.*
- `.sbn` optimisation file for spatial queries. *Optional.*

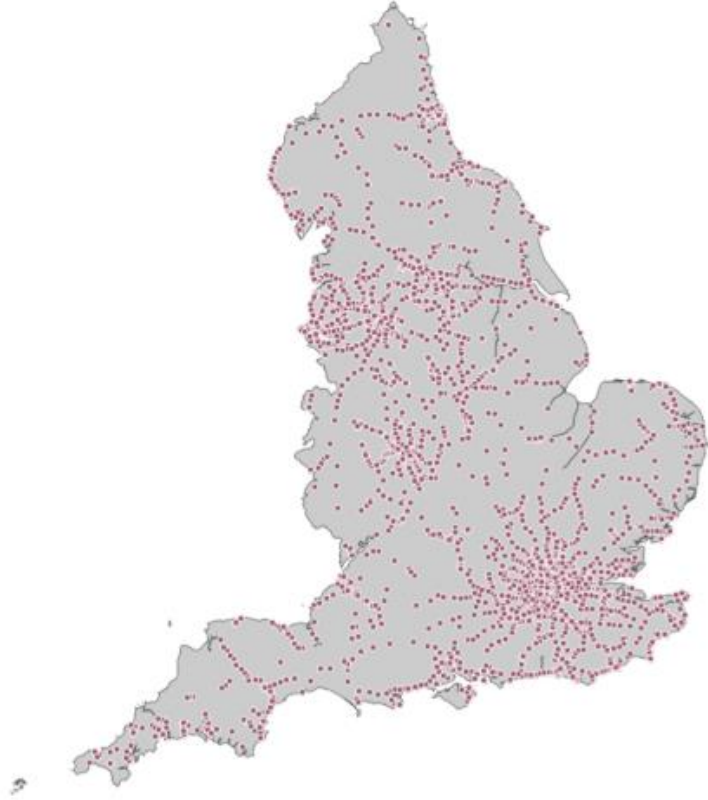
Shapefiles



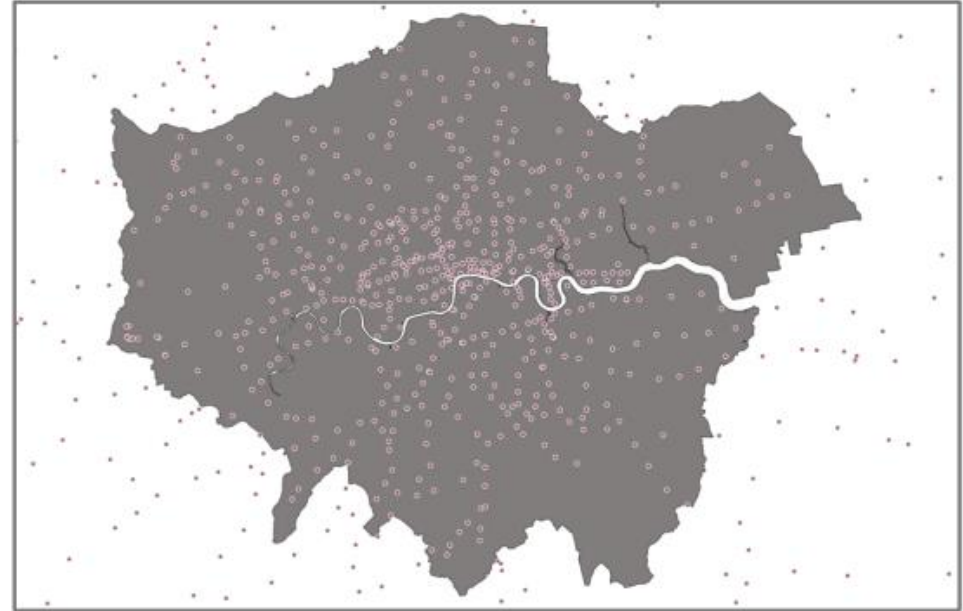
GeoPackage

- A GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial data.
- It stores spatial data layer as a single file, based upon an SQLite database.
- How to spot in the wild: `.gpkg`

Spatial operations



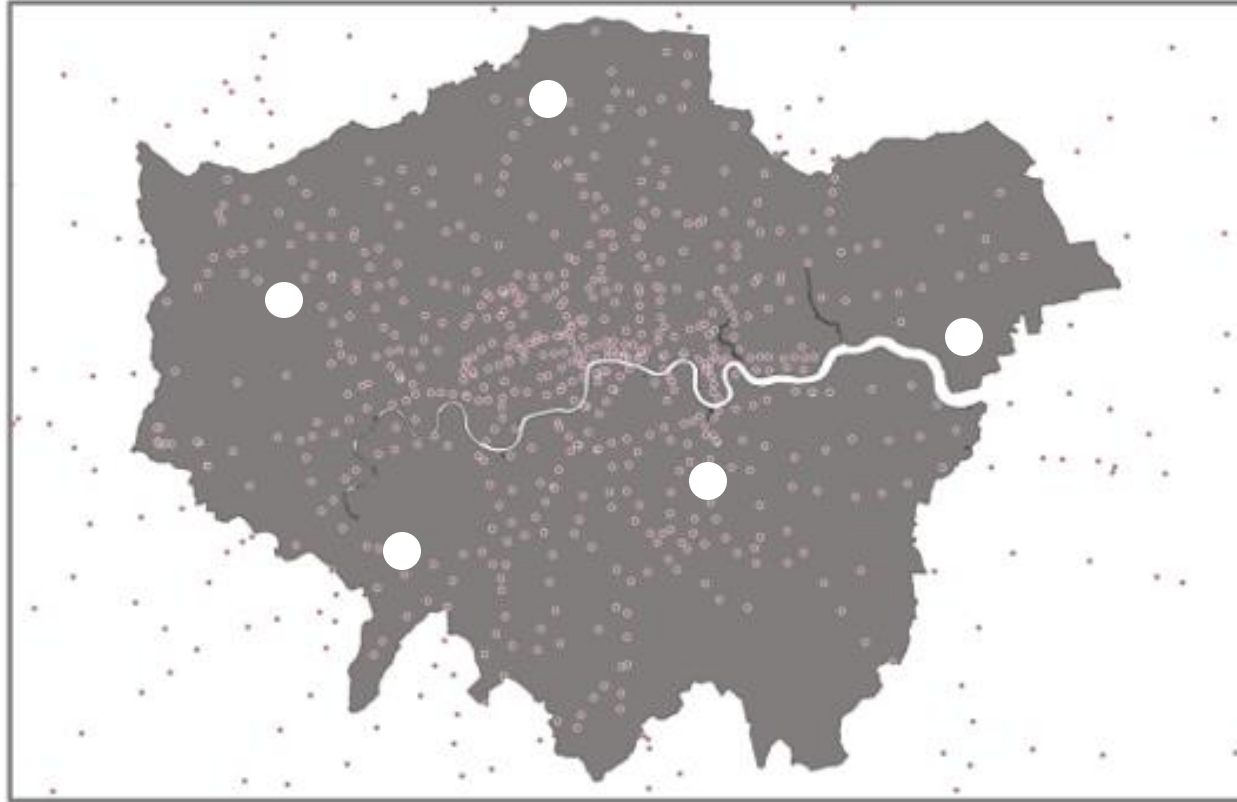
?



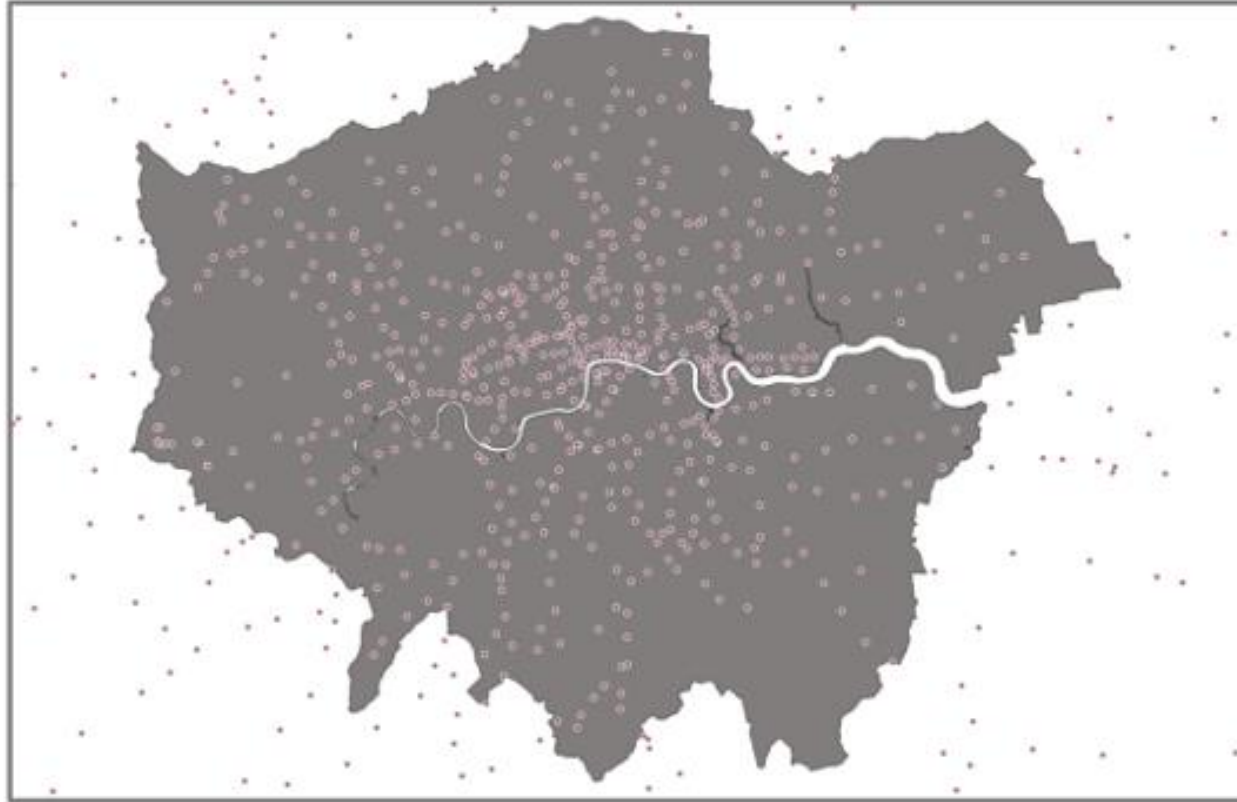
Spatial operations

- Spatial relationships describe how the exteriors, interiors, and boundaries of different geometries interact, often referred to as **topological relationships**.
- Spatial operations make use of these spatial relationships between spatial objects to combine, identify, extract information.
- Difference between spatial queries and geometric operations.

Attribute query

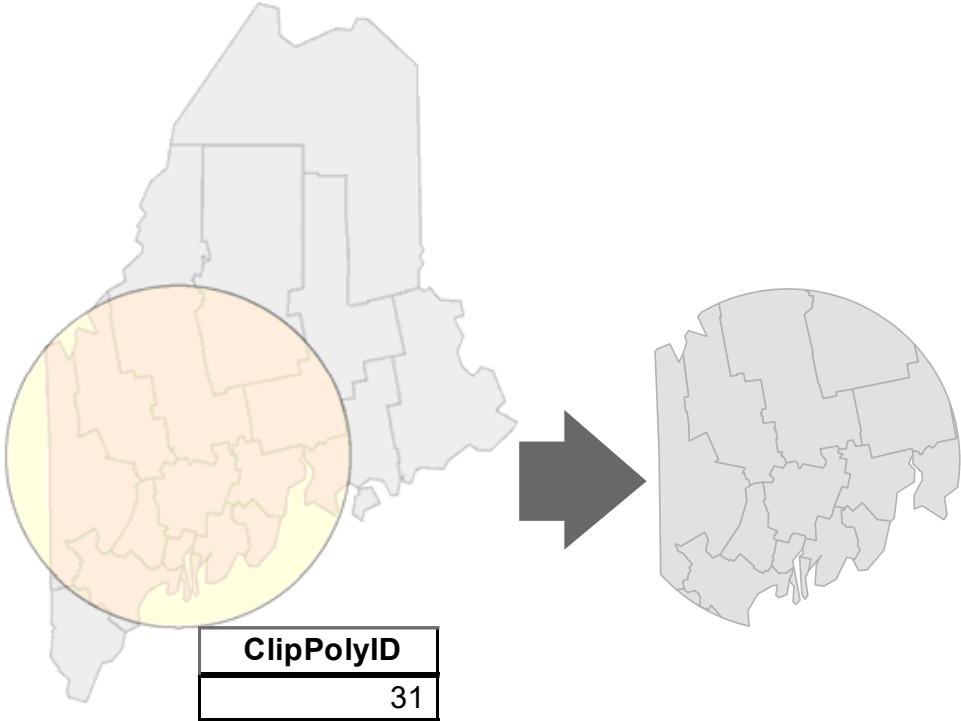


Spatial query



Geometric operations

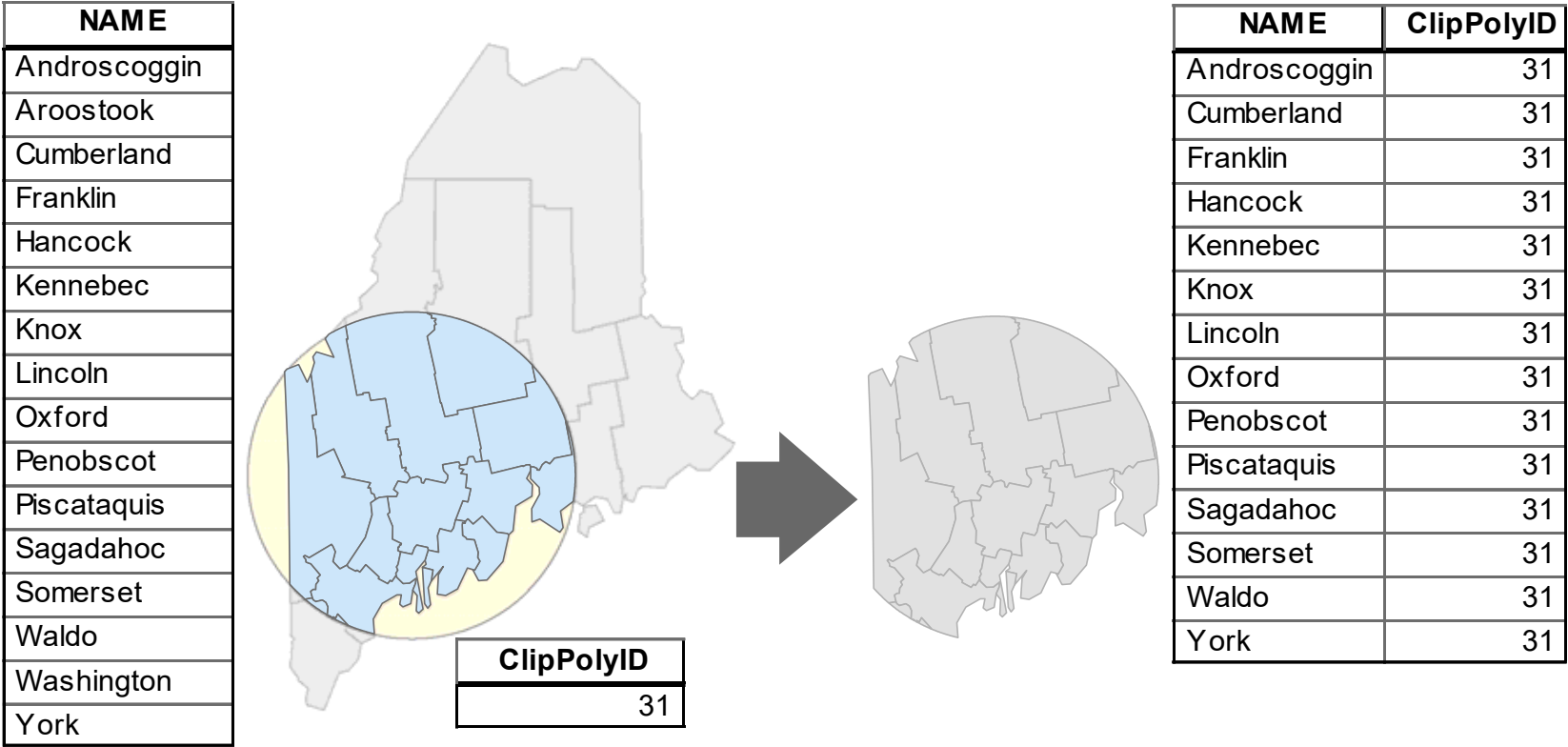
NAME
Androscoggin
Aroostook
Cumberland
Franklin
Hancock
Kennebec
Knox
Lincoln
Oxford
Penobscot
Piscataquis
Sagadahoc
Somerset
Waldo
Washington
York



NAME
Androscoggin
Cumberland
Franklin
Hancock
Kennebec
Knox
Lincoln
Oxford
Penobscot
Piscataquis
Sagadahoc
Somerset
Waldo
York

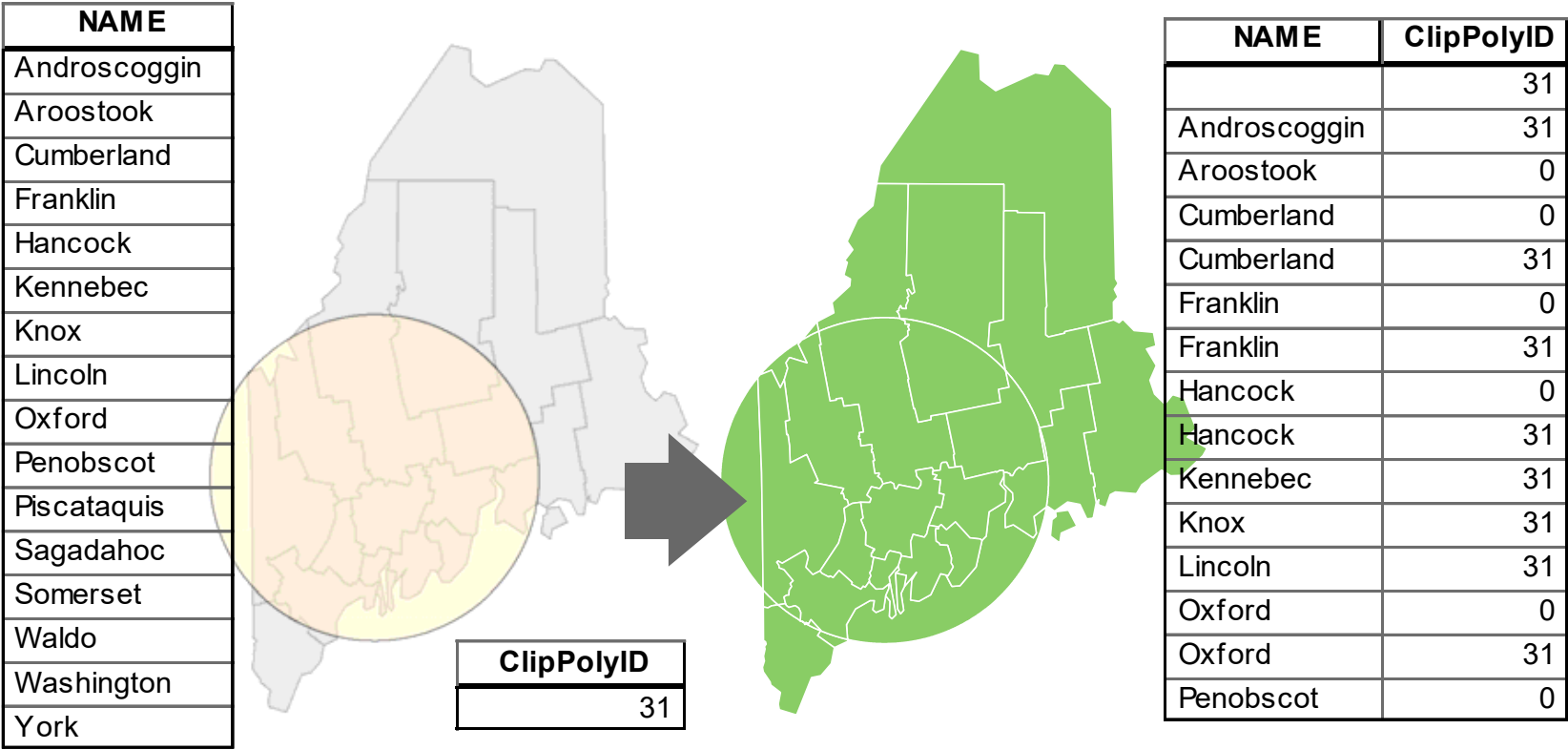
Gimond, M. 2021. Intro to GIS and Spatial Analysis. [online]
<https://mgimond.github.io/Spatial/introGIS.html>

Geometric operations



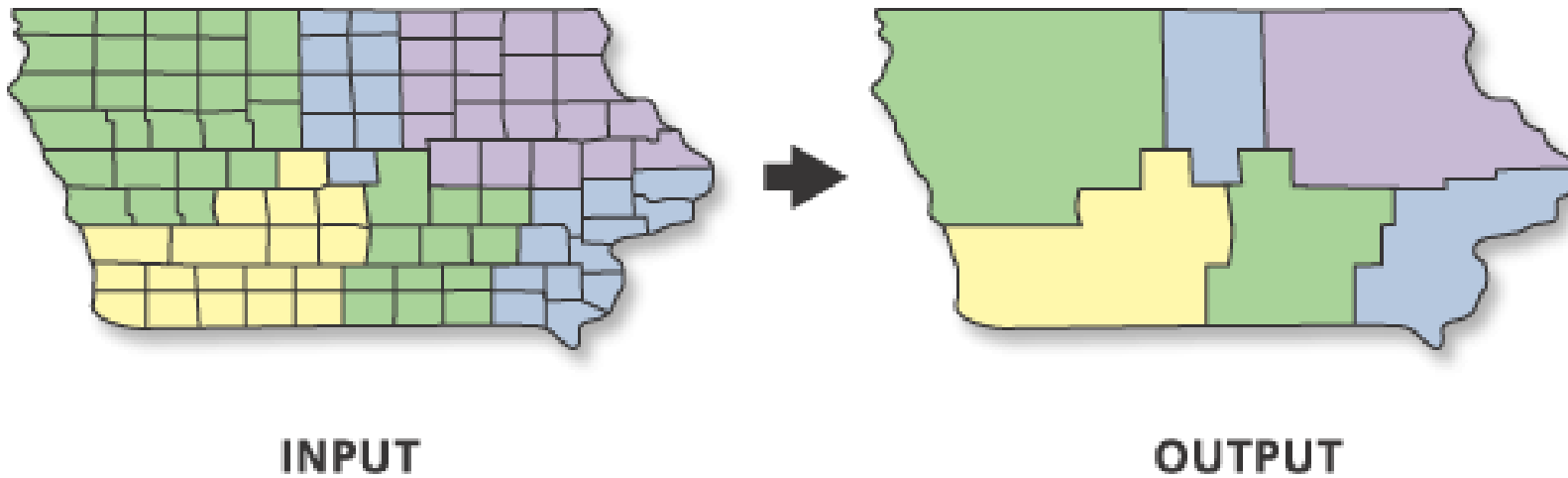
Gimond, M. 2021. Intro to GIS and Spatial Analysis. [online]
<https://mgimond.github.io/Spatial/introGIS.html>

Geometric operations



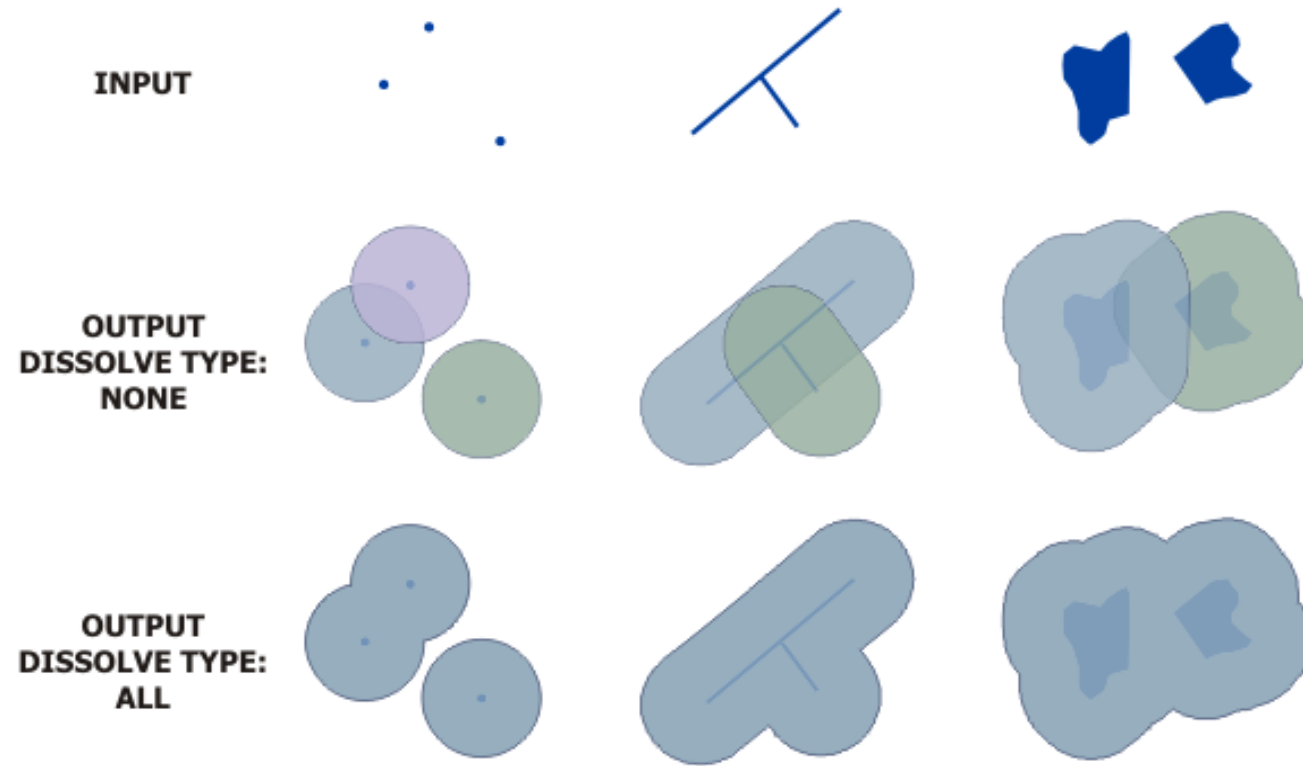
Gimdond, M. 2021. Intro to GIS and Spatial Analysis. [online]
<https://mgimond.github.io/Spatial/introGIS.html>

Geometric operations

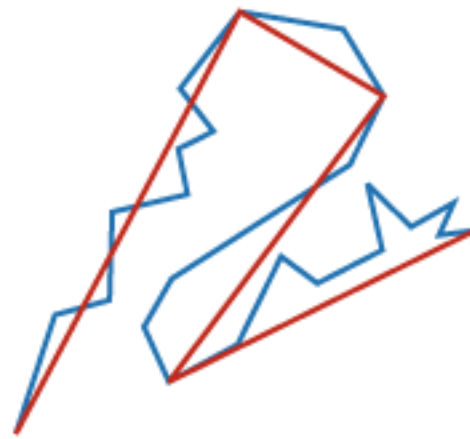


ESRI. 2025. Dissolve. [online]
<https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/dissolve.htm>

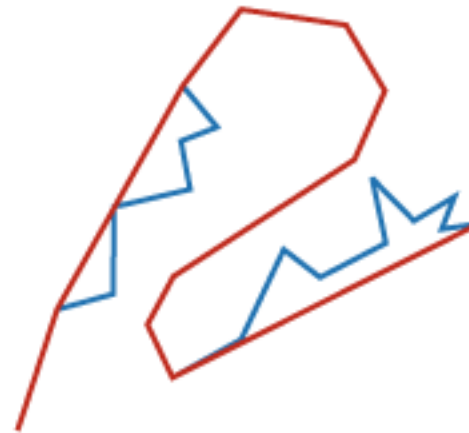
Geometric operations



Geometric operations



POINT REMOVE



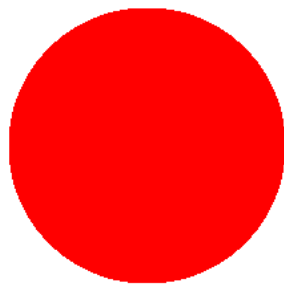
BEND SIMPLIFY

— ORIGINAL
— SIMPLIFIED

Geometric operations



RStudio



LIVE

Conclusion

- The core of spatial analysis comes down to conducting spatial queries and executing geometric operations.
- Spatial analysis relies therewith on the spatial properties of an object as well as on the spatial relationships both *within* and *between* spatial objects.

Questions

Justin van Dijk
j.t.vandijk@ucl.ac.uk

