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

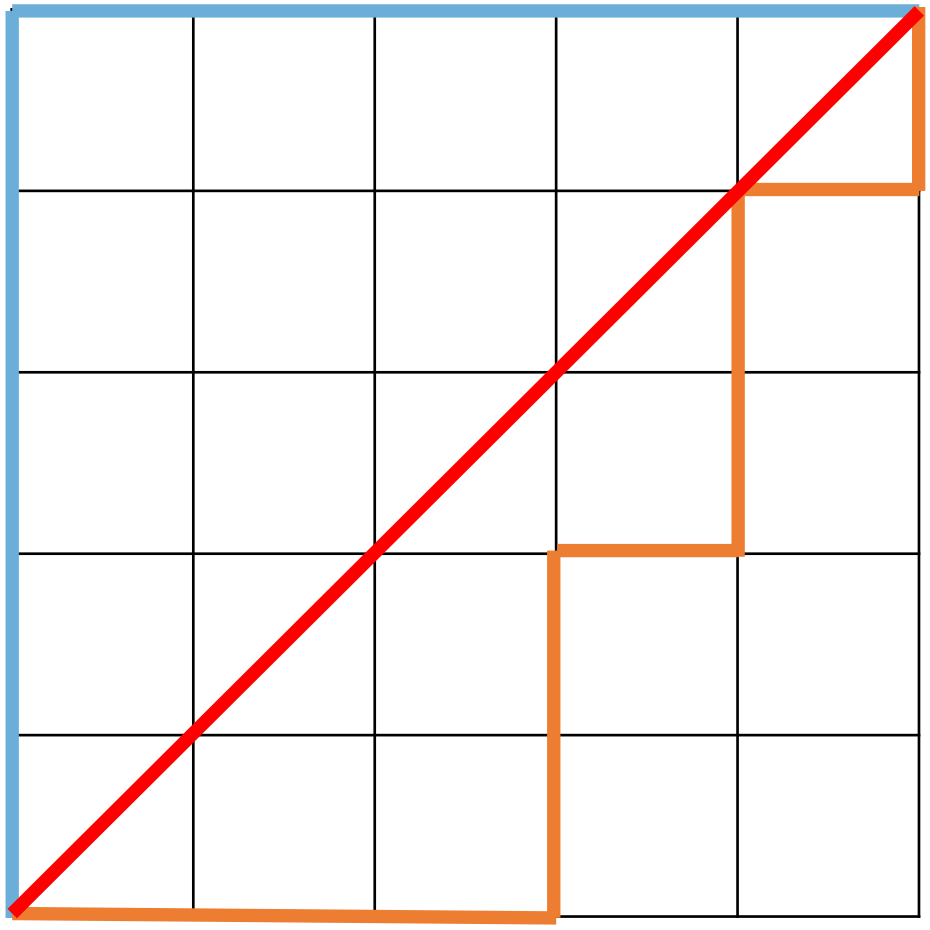
This week

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

Spatial properties

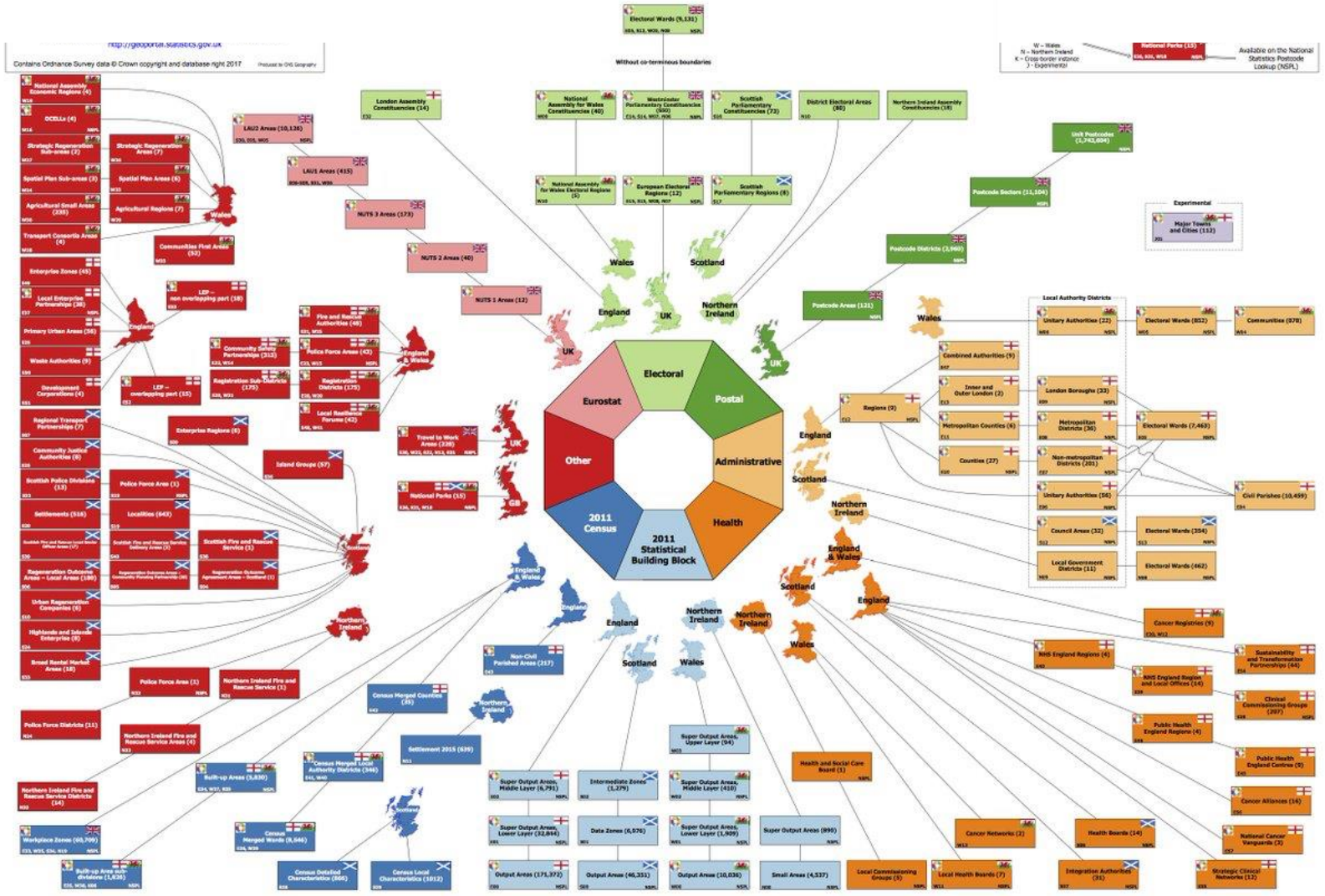
- Spatial involves performing mathematical operations on spatial properties.
- Key properties include areas of and distances between spatial objects.
- There are diverse ways to conceptualise and work with these properties depending on the analytical context and available data.

Distance

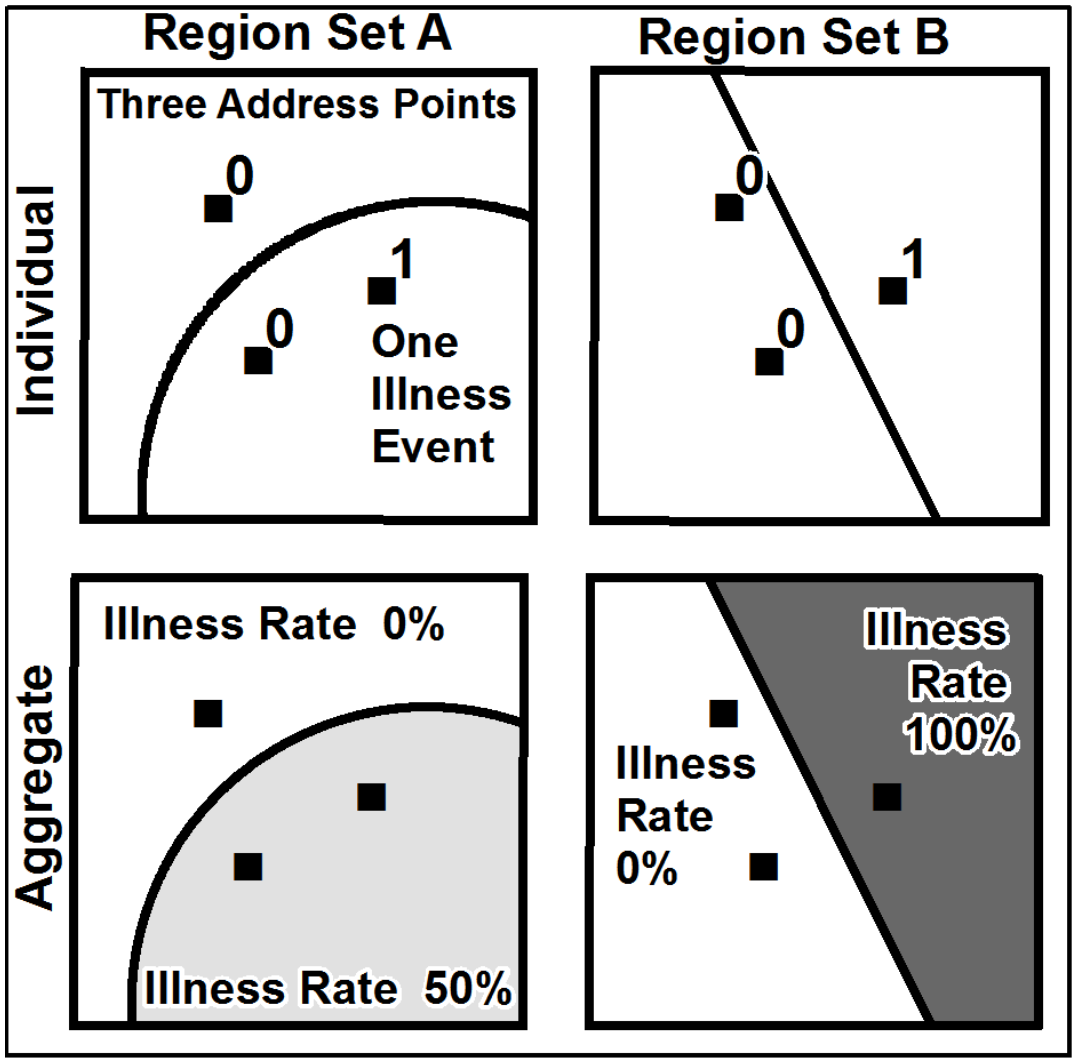


Area

Area


Electoral
Postal
Administrative
Health
2011 Statistical Building Block
2011 Census
Other
Eurostat
Without co-terminous boundaries
Available on the National Statistics Postcode Lookup (NSPL)
Contains Ordnance Survey data © Crown copyright and database right 2017
Produced by ONS Geography
Local Authority Districts
Experimental
England
Wales
Scotland
Northern Ireland
UK
GB
England & Wales

Area


Region Set A
Region Set B
Individual
Three Address Points
0
1
0
One
Illness
Event
0
1
0
Aggregate
Illness Rate 0%
Illness Rate 50%
Illness
Rate
100%
Illness
Rate
0%

Spatial features

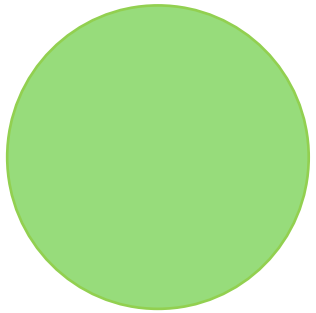
- Features: Objects created in a spatial dataset, representing geographic entities such as points, lines, or polygons.
- Attributes: Characteristics or properties of features, often stored as data in GIS, describing specific details about the feature.

Point vector

Characteristics of a point vector in a GIS data model:

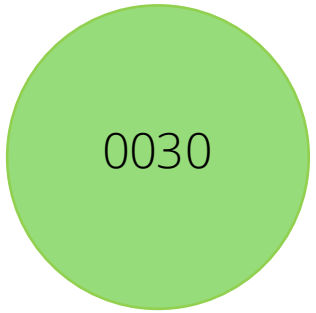
- Single XY location (coordinate).
- Has no area.
- Has no length.
- Geometry consists of a single node or vertex.
- Used for: discrete features or events.

Point vector



Point vector

Point vector



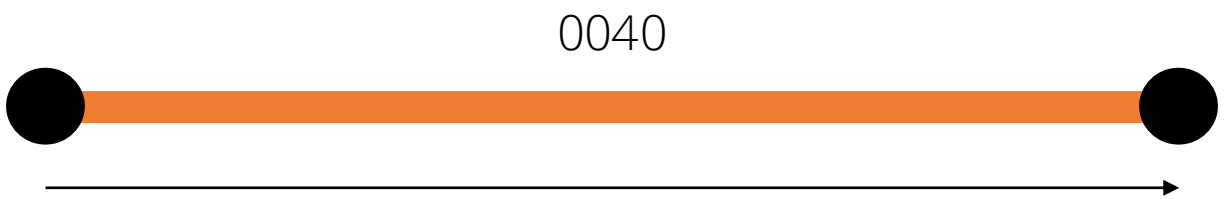
FeatureID	Type	Height
0030	Ent	500

Polyline vector

Characteristics of a polyline vector in a GIS data model:

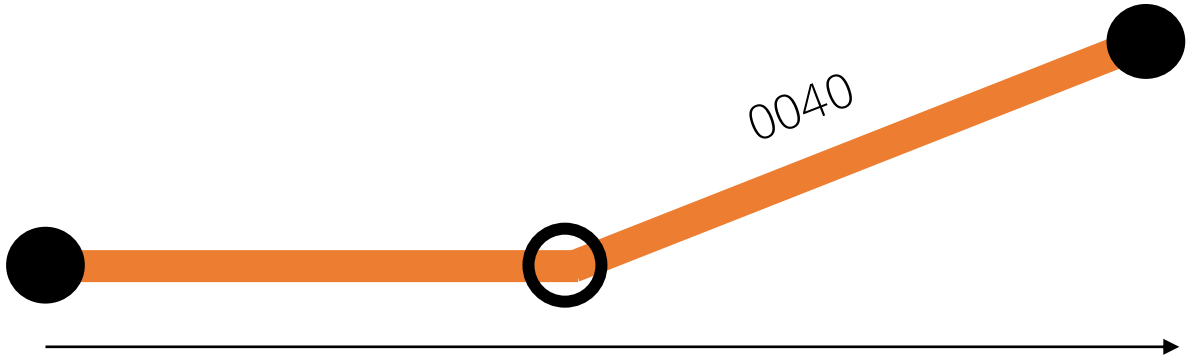
- Series of XY locations (coordinates) that form a line.
- Has no area.
- Has a length.
- Has a direction (importance when it comes to roads, rivers, etc.).
- Can be connected to other polyline vectors to form a network.
- Geometry consists of two nodes (start node and end node) and can have one or more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

Polyline vector



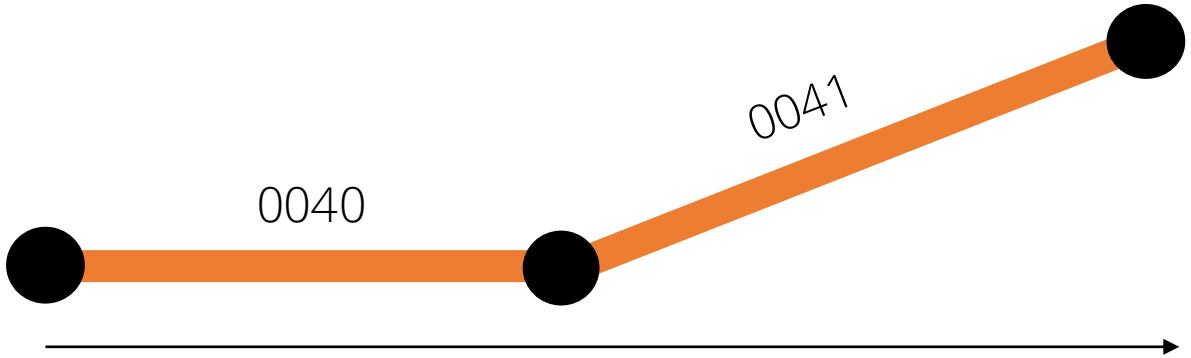
FeatureID	Type	Length
0040	Bicycle lane	1,500

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:

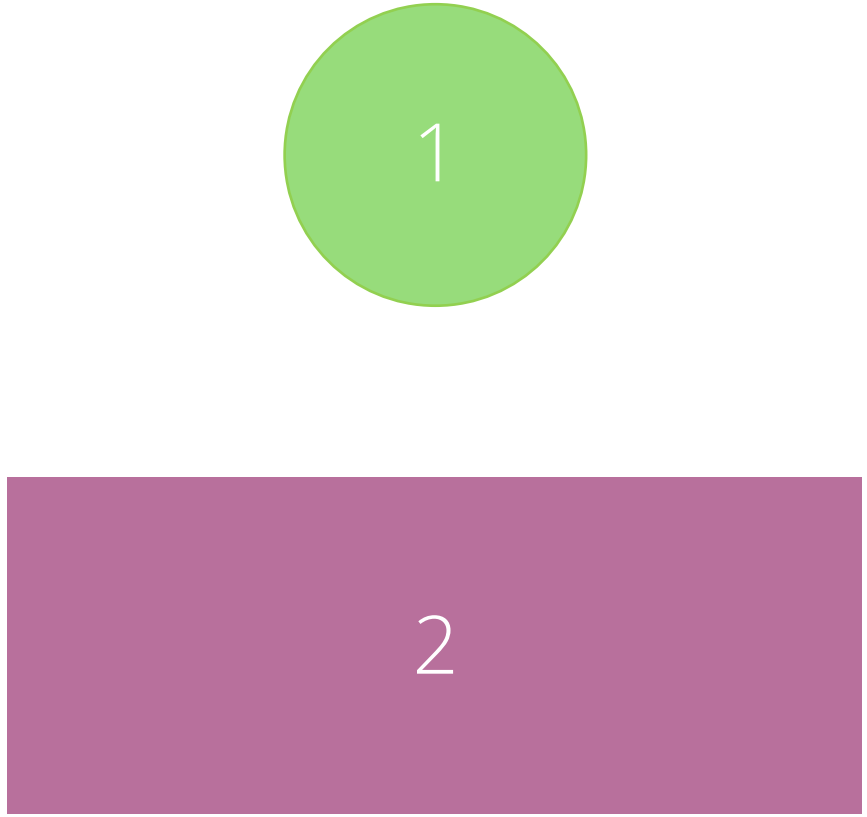
- Series of XY locations (coordinates) to form an enclosed region.
- Has an area.
- Has no length.
- Geometry consists of at least three nodes or vertices whereby the first node or vertex connects with the last one.
- Used for: features with enclosed regions such as buildings and administrative areas.

Polygon vector

FeatureID	Type	Area
0050	University building	2000

Representation

Representing the North-West Wing Building



Attribute joins

GeoID	Population
GEO0030	540
GEO0031	320

Attribute joins

FeatureID	GeoID
0050	GEO0030

Attribute joins

FeatureID	GeoID
0050	GEO0030

GeoID	Population
GEO0030	540
GEO0031	320

Attribute joins

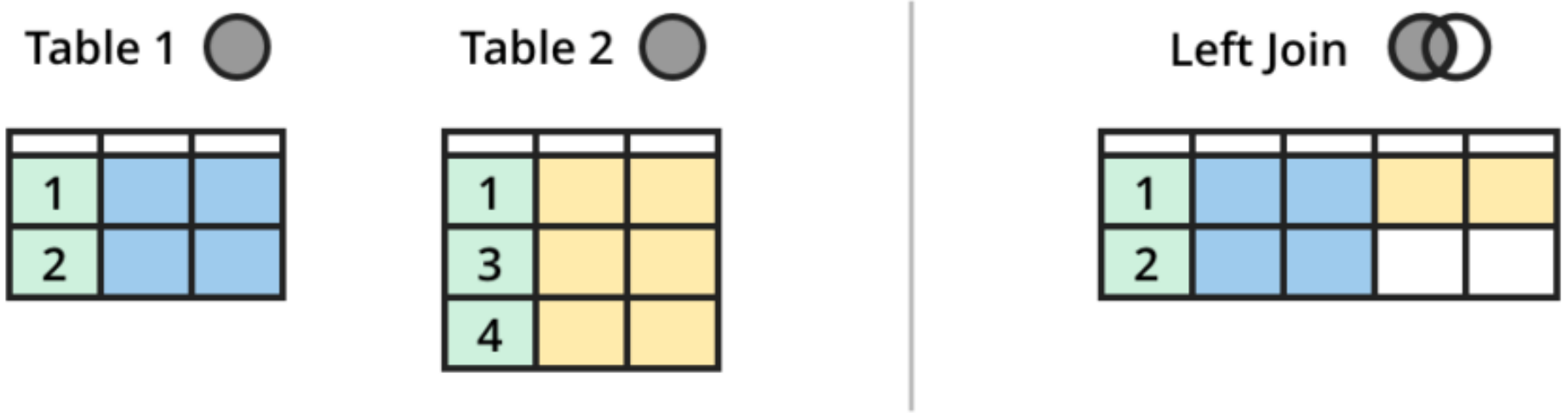
FeatureID	GeoID
0050	GEO0030

GeoID	Population
GEO0030	540
GEO0031	320

Attribute joins

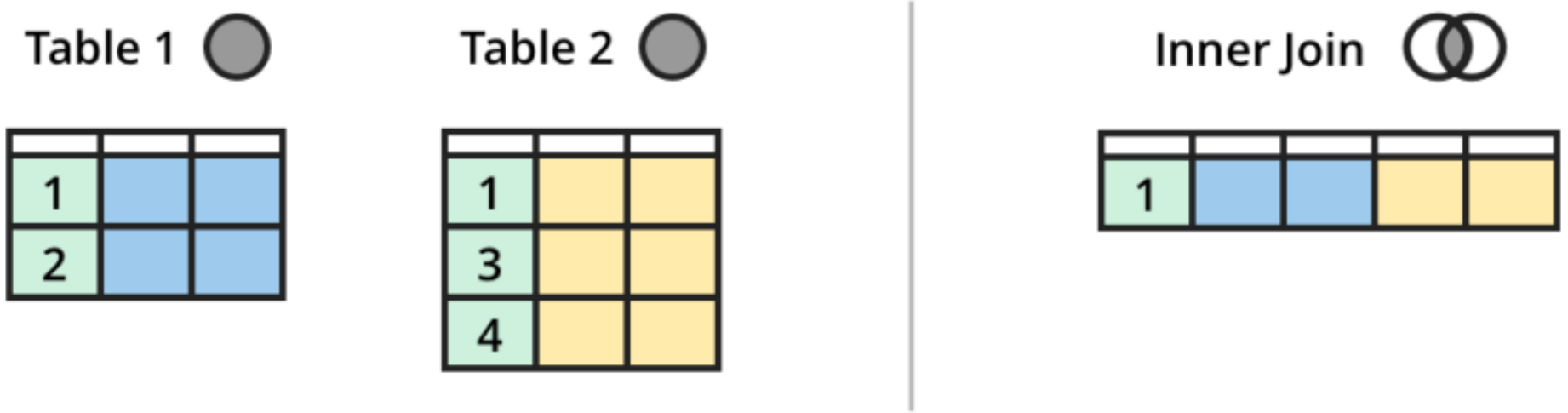
FeatureID	GeoID	Population
0050	GEO0030	540

Left joins



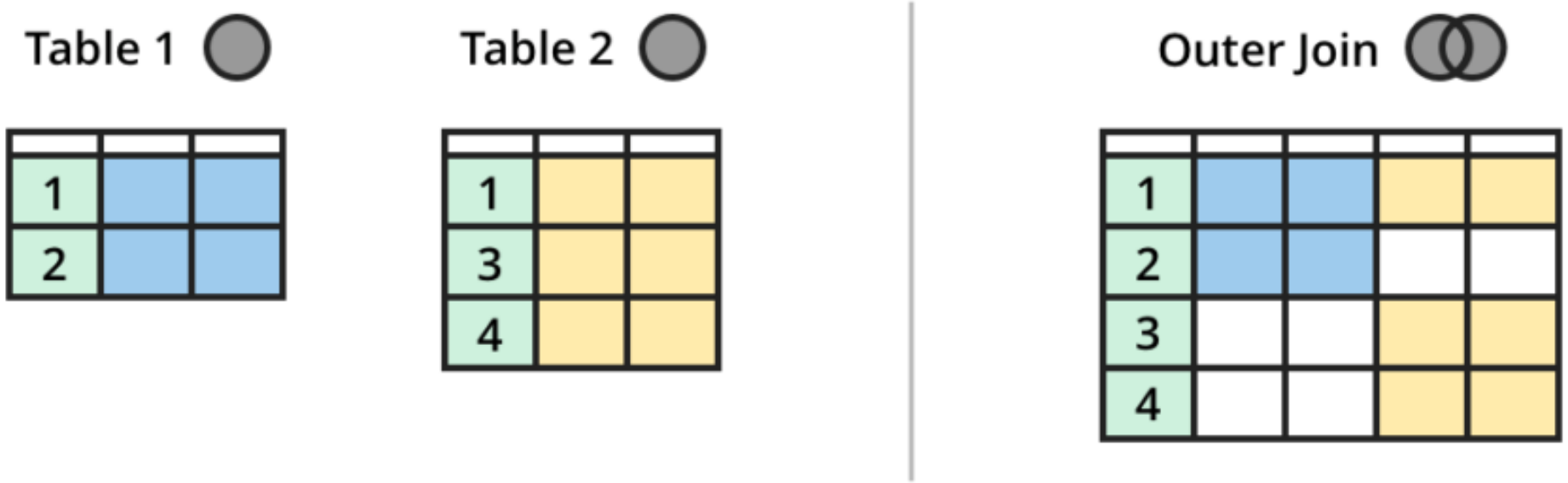
The Data School. 2019. *SQL Join Types Explained Visually*.

Inner joins



The Data School. 2019. *SQL Join Types Explained Visually*.

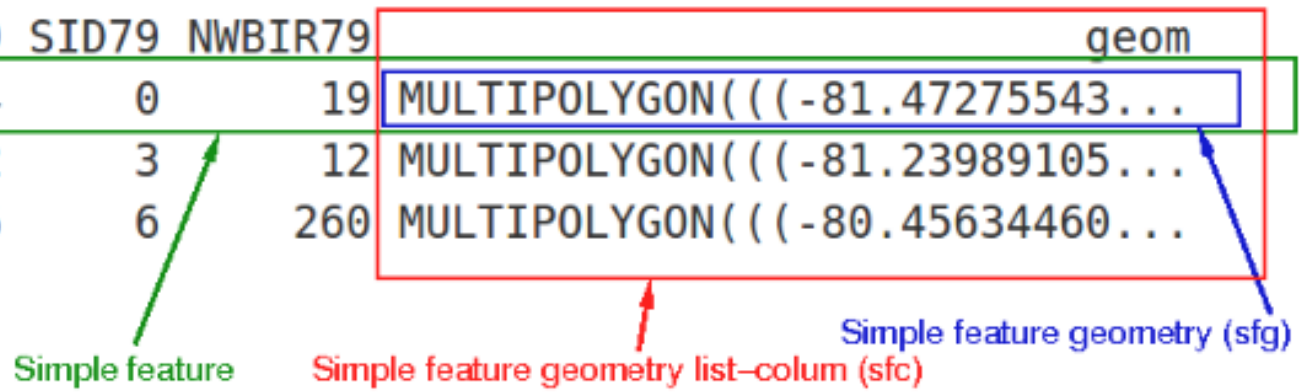
Outer joins



The Data School. 2019. *SQL Join Types Explained Visually*.

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...
```



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

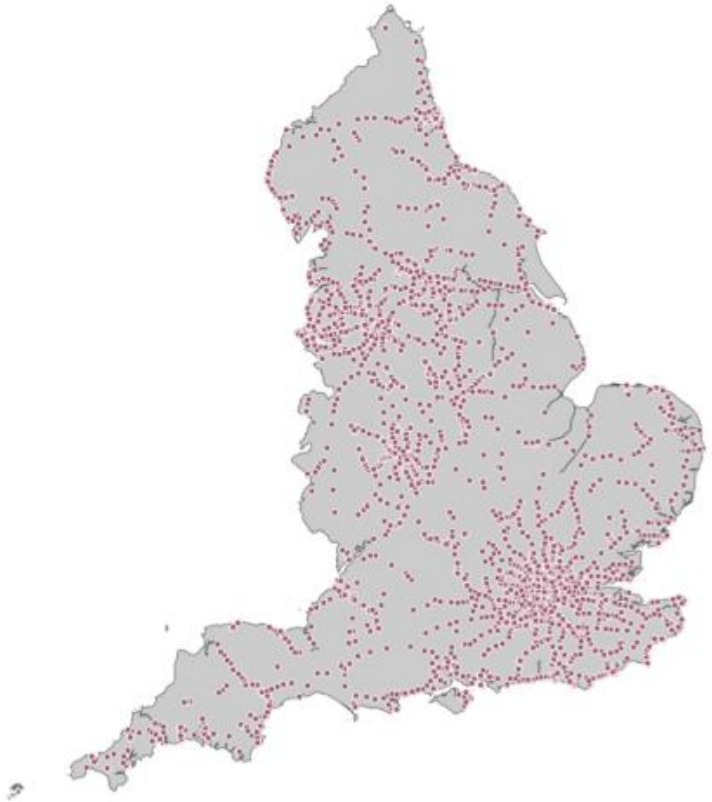
- `.shp` contains the feature geometry. *Mandatory.*
- `.shx` index file which stores the position of the feature's ID in the `.shp` file. *Mandatory.*
- `.dbf` stores alle attribute information associated with the records. *Mandatory.*
- `.prj` contains the coordinate system information and projection. *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



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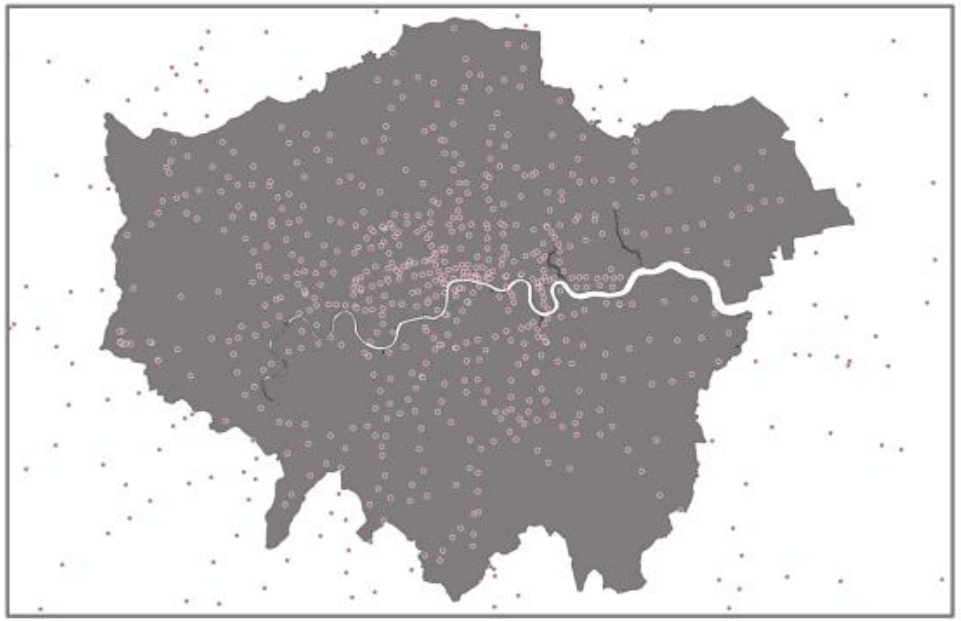
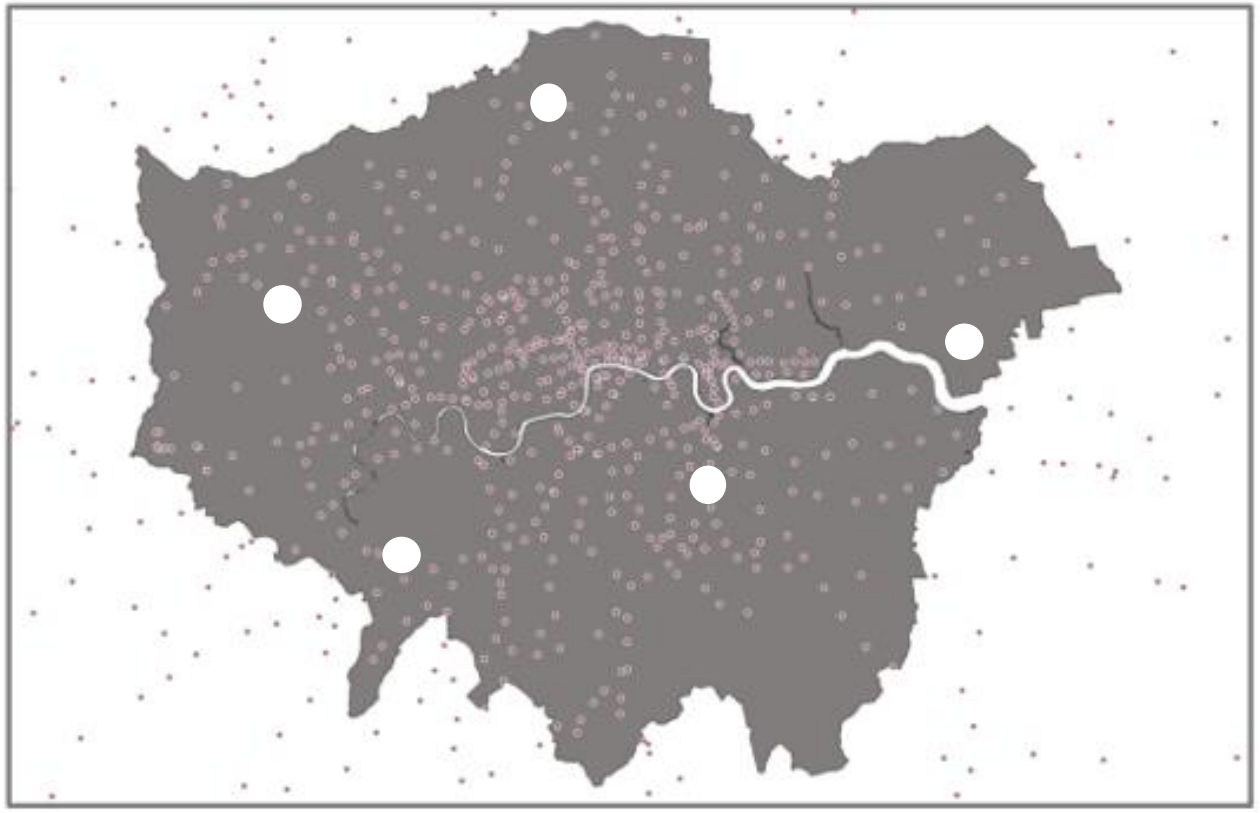


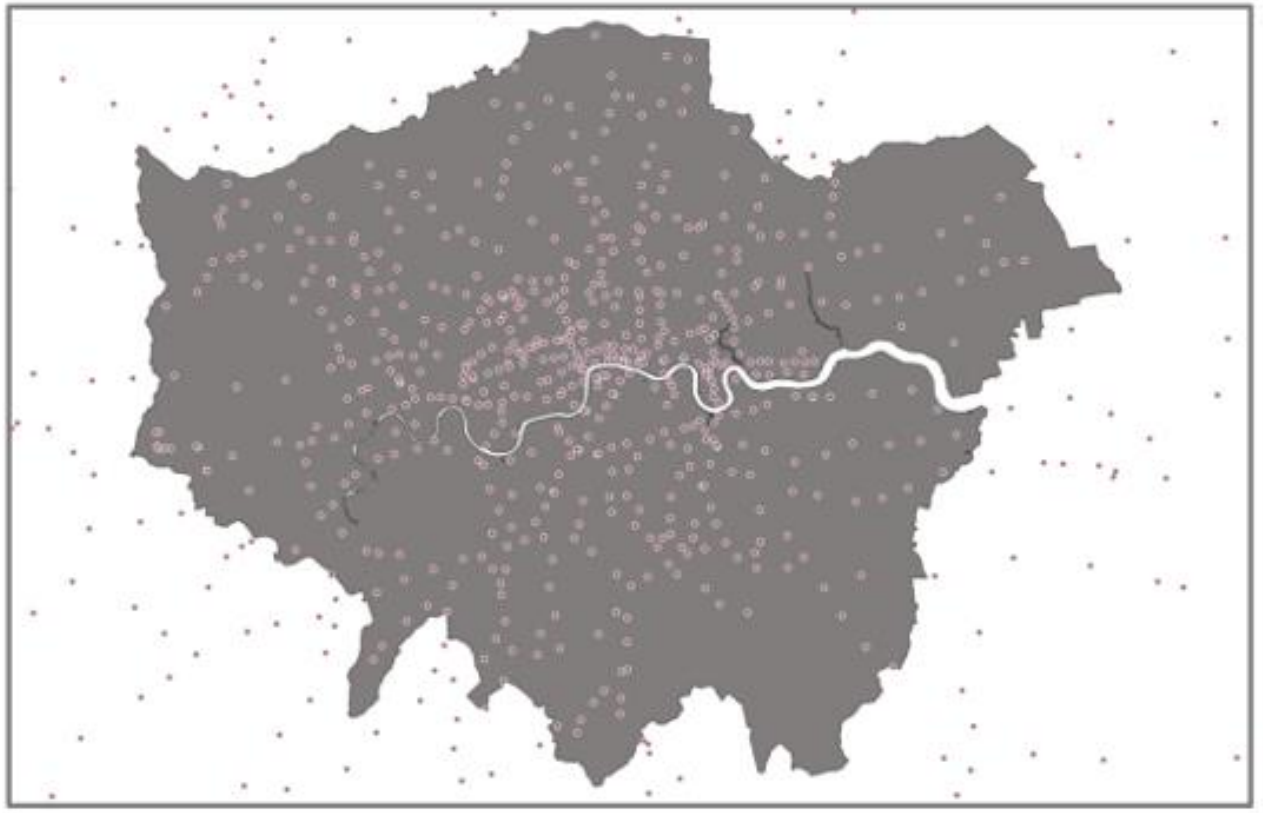
Spatial operations

- 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

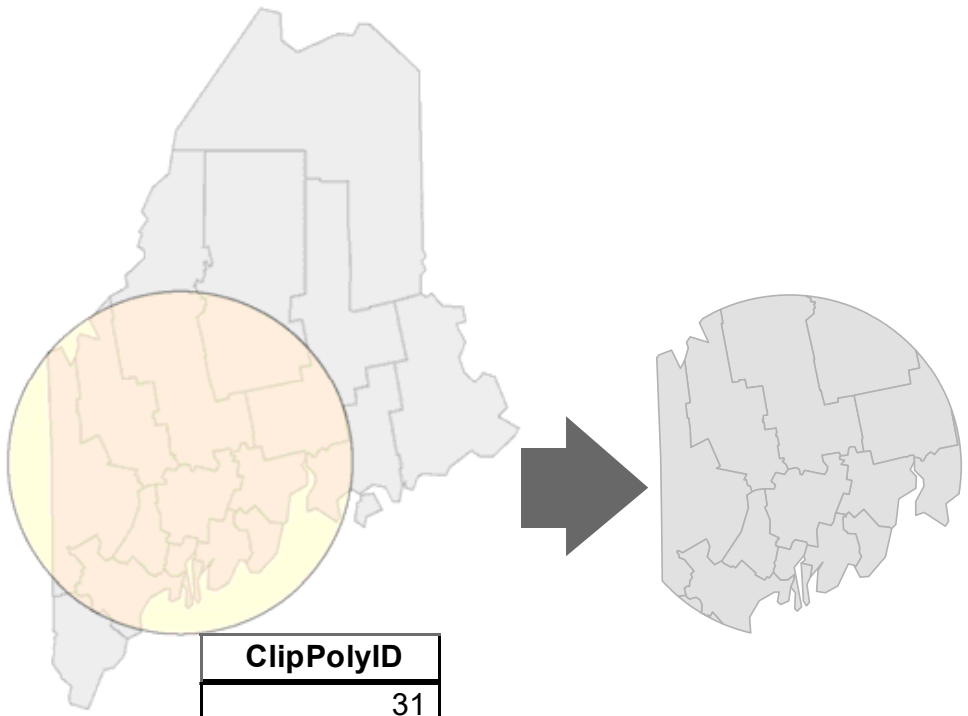


Spatial query



Geometric operations

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



ClipPolyID
31

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

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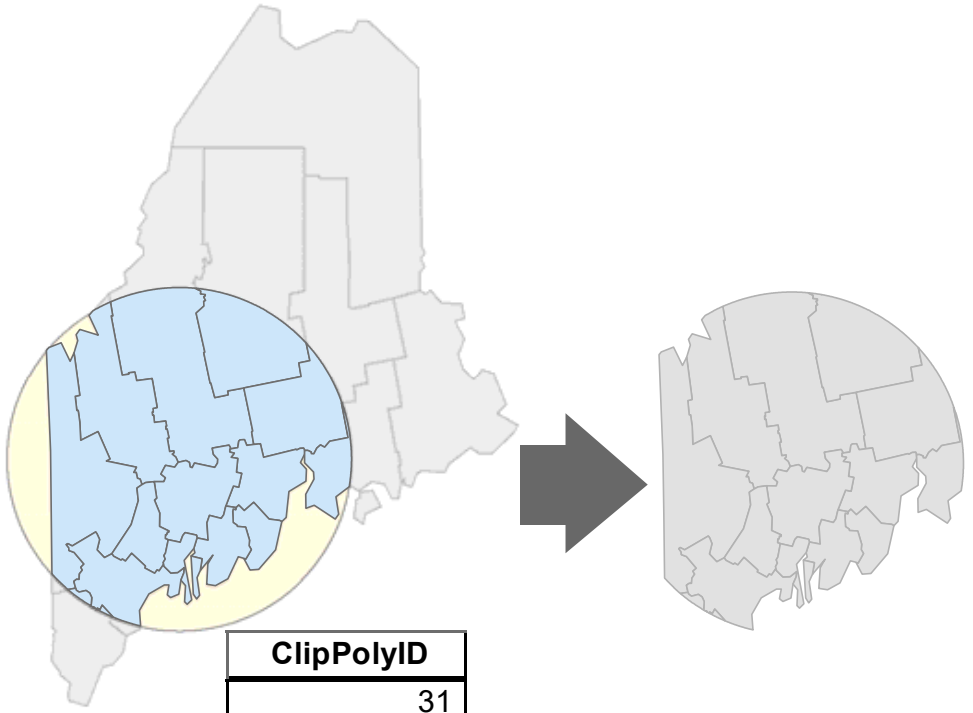

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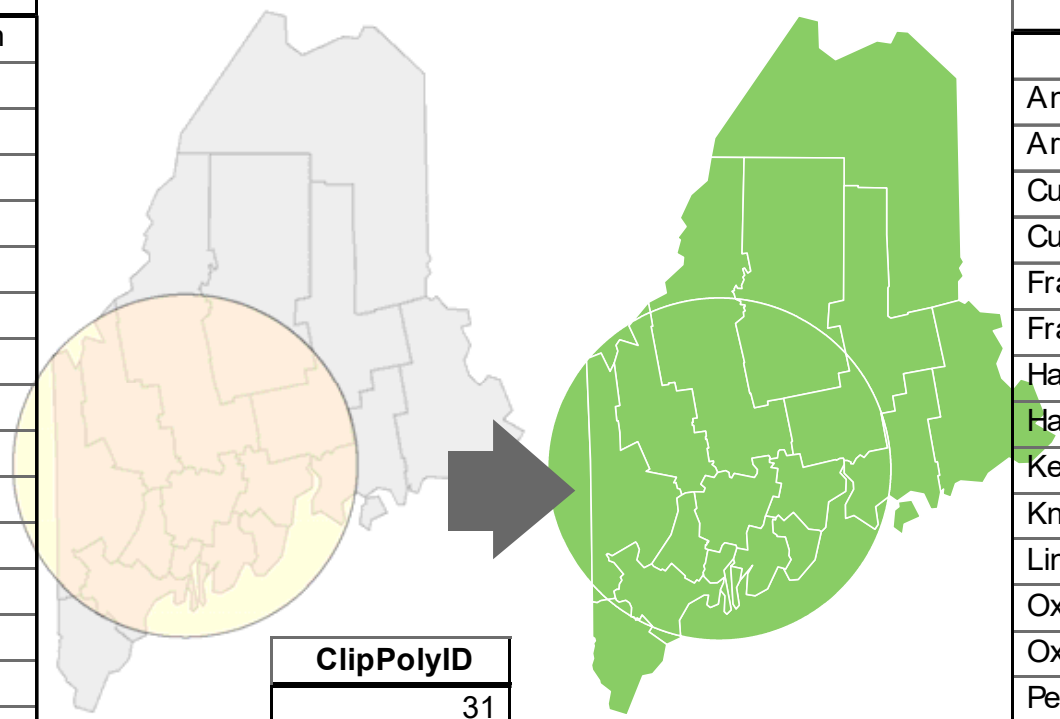

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Hancock	31
Kennebec	31
Knox	31
Lincoln	31
Oxford	0
Oxford	31
Penobscot	0

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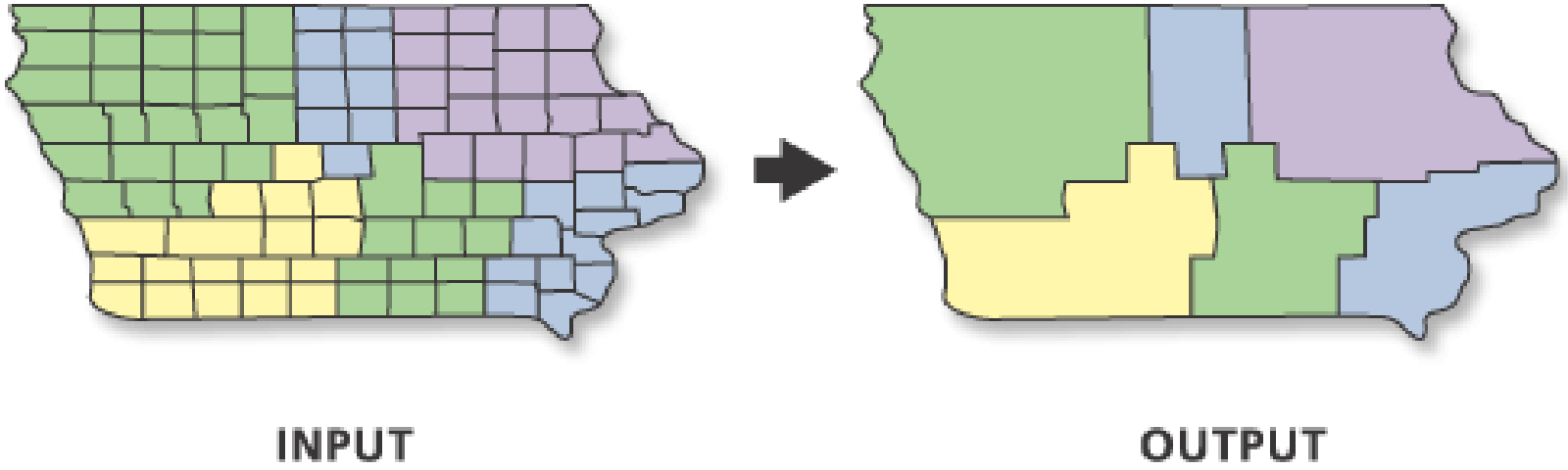
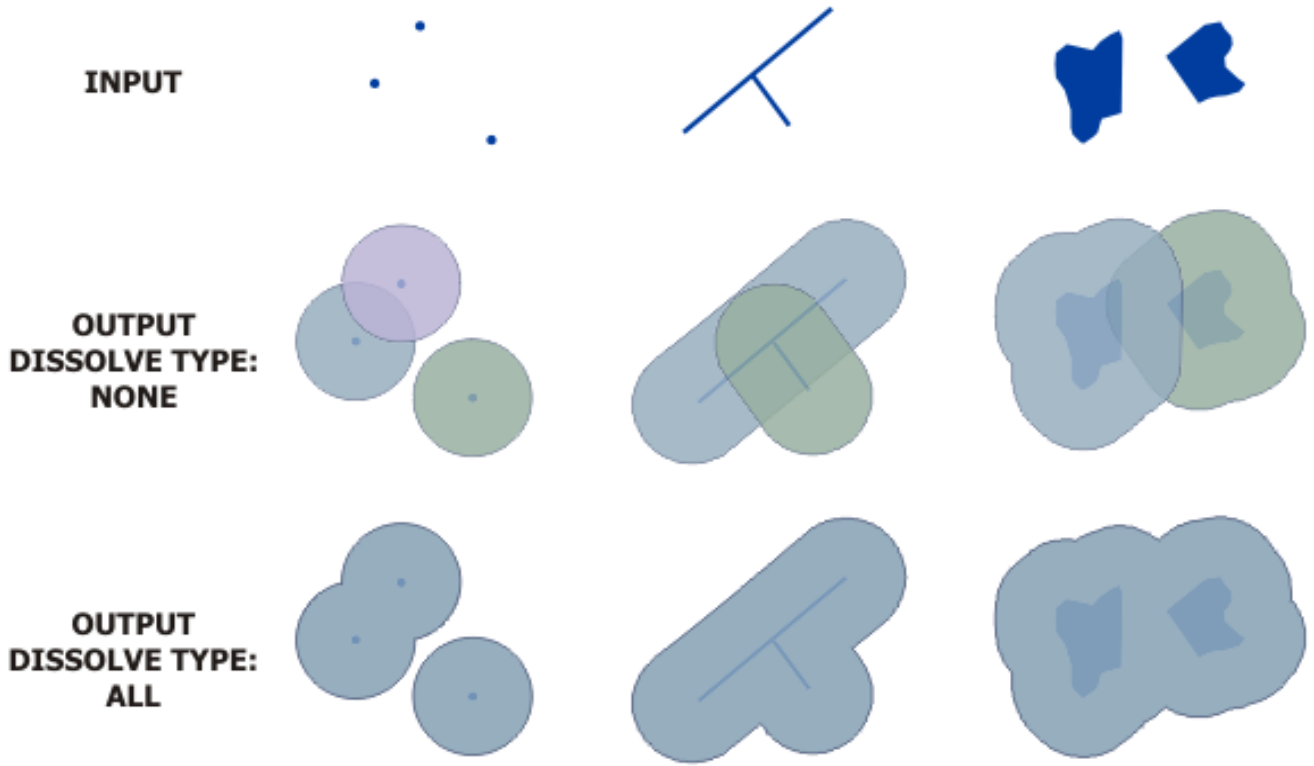
Geometric operations



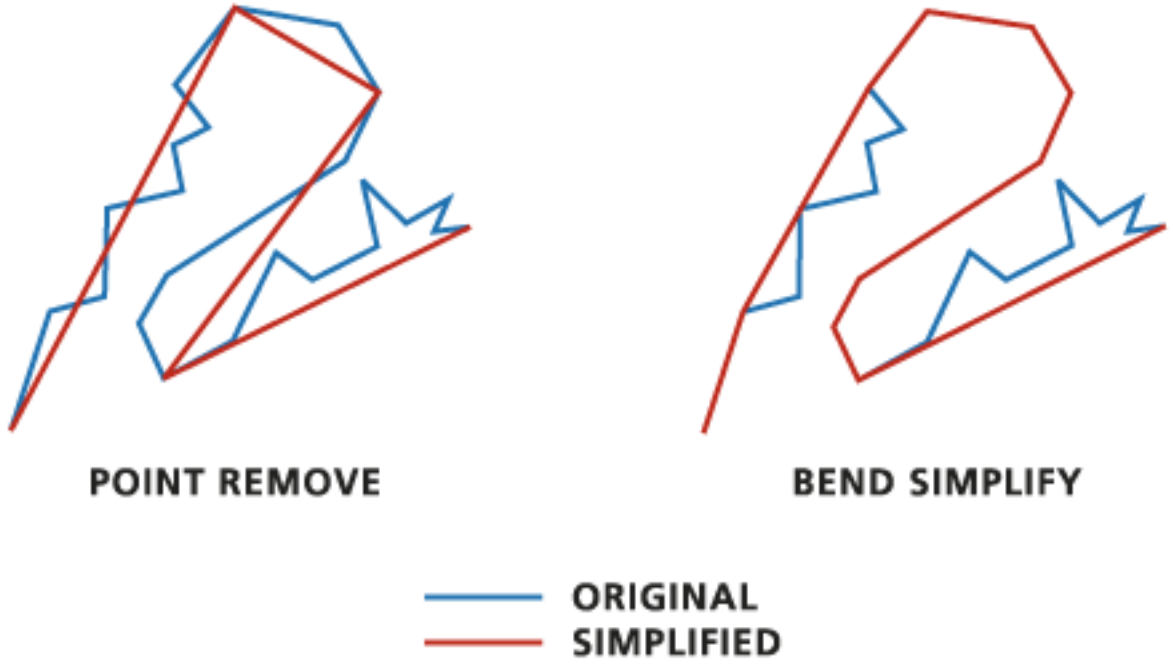
ESRI. 2025. Dissolve. [online]
https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/dissolve.htm

Geometric operations



ESRI. 2025. Buffer (Analysis). [online]
https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/buffer.htm

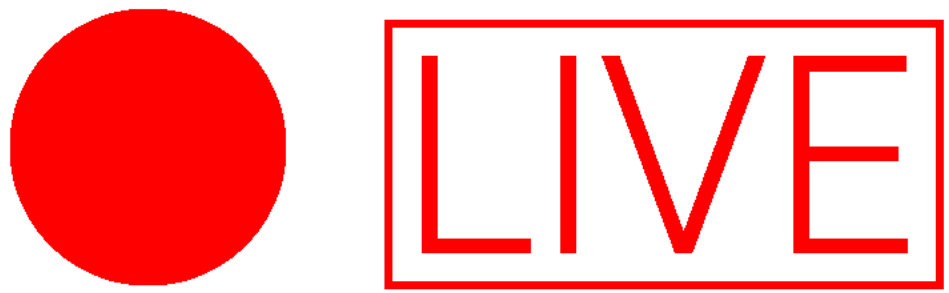
Geometric operations



ESRI. 2025. Simplify line. [online]
https://desktop.arcgis.com/en/arcmap/10.3/tools/cartography-toolbox/simplify-line.htm

Geometric operations

RStudio



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

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