

# ESRI Object Models; Data Capture

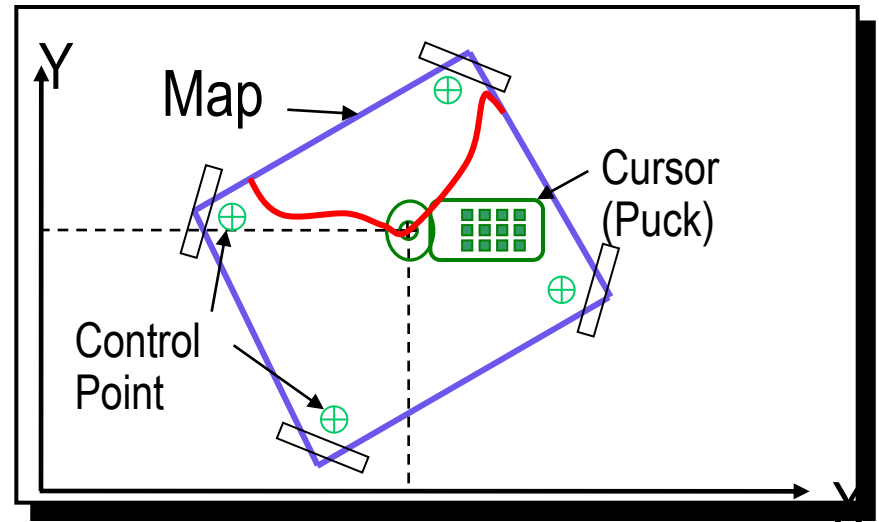
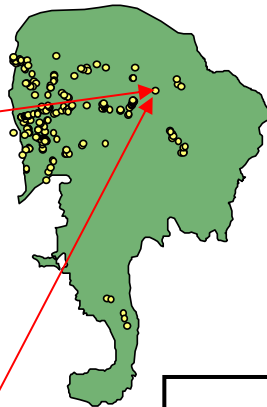
Attributes of Condrey\_samples\_NAD27

FID	Shape*	Id	Number	NAD27_East	NAD27North
0	Point	0	1230	490921	4636832
1	Point	0	123	491124	4637700
2	Point	0	124	491375	4638149
3	Point	0	125	491522	4638902
4	Point	0	126	491653	4638751
5	Point	0	127	492872	4639489
6	Point	0	128	492963	4639515

Feature Class (spatial table)

Number	Age_Ma	1_sigma	Rx_Type	Size_kg
123	142	1.5	B_schist	3.4
124	136	2.0	G_schist	1.3
125				

Object Class (nonspatial table)



# Conceptual Models

Characterized all features or phenomena as:

⌘ Discrete objects; e.g. wells, roads, rock bodies, etc.

☑ ***Object-based models*** ←

⌘ Continuous phenomena; e.g. gravity, topography, temperature, snowfall, soil pH, etc.

☑ ***Field-based models***

# Outline



- ⌘ ESRI Software Family
- ⌘ ESRI Object Data Models
  - ☒ History
  - ☒ Data Organization – Physical Models
    - ☒ Coverage
    - ☒ Shapefile
    - ☒ Geodatabase
- ⌘ Data Capture
  - ☒ Digitizing
    - ☒ “Heads Down”
    - ☒ “Heads Up”
  - ☒ Building Topology

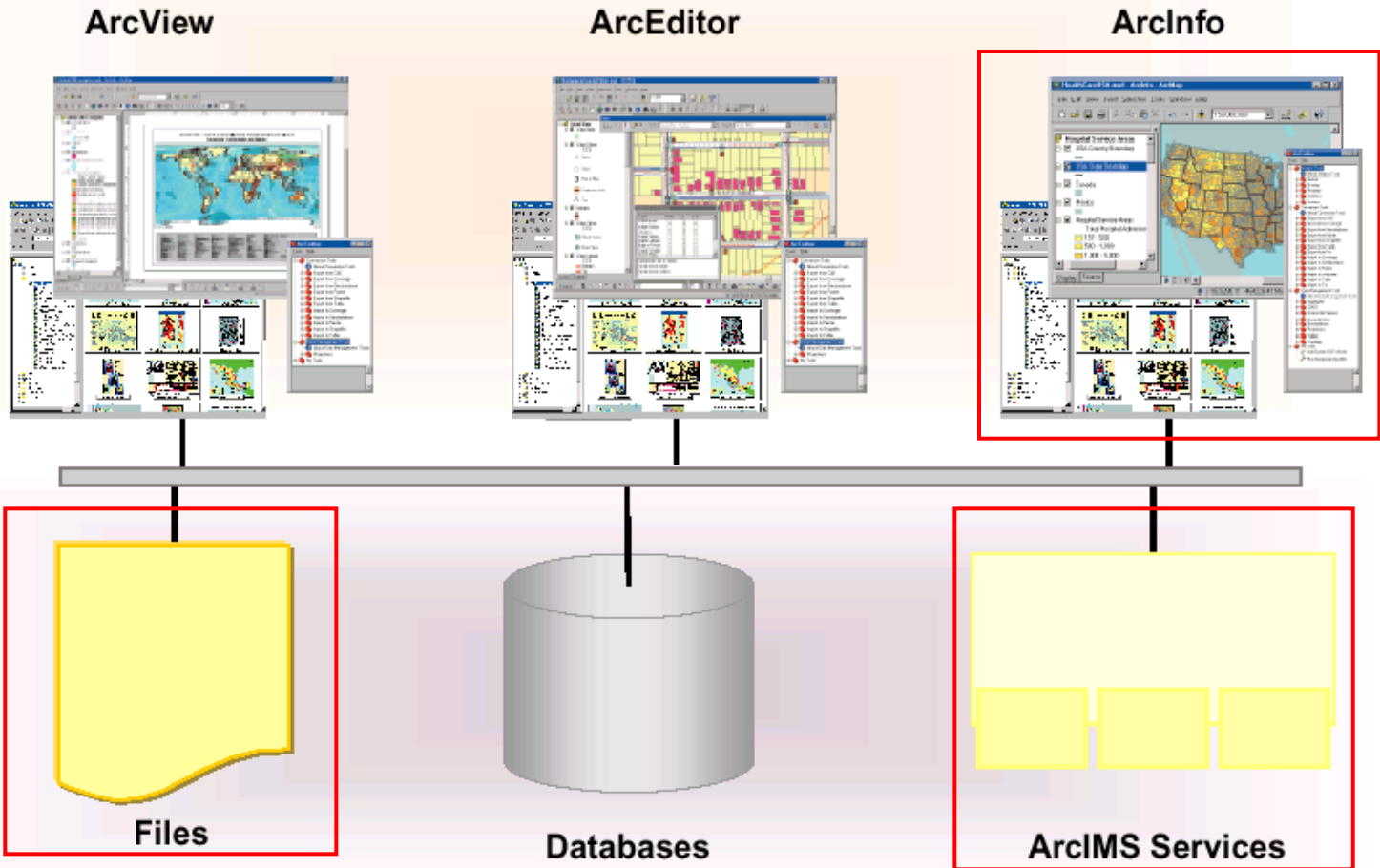
ESRI = Environmental Systems Research Institute, Inc.

# Some ESRI History...

ESRI	Arc/Info	ArcView	ArcGIS
Date	1980-1999	1993-1999	2000 - present
Versions	1-7	1-3.2	8.0 – 10.2
Data Model	Coverage	Shapefile	Geodatabase
O.S.	Unix, PC DOS	Windows	Windows
Scripting Language	Arc Macro Language (AML)	Avenue Scripting	Vis. Basic for Appl. (VBA), Python
Database Software	Proprietary; Arc Tables	DBase	M.S. Access; ArcSDE for Oracle, etc.

# ArcGIS Desktop Levels

**PRODUCTS**  
(Licensing Levels)



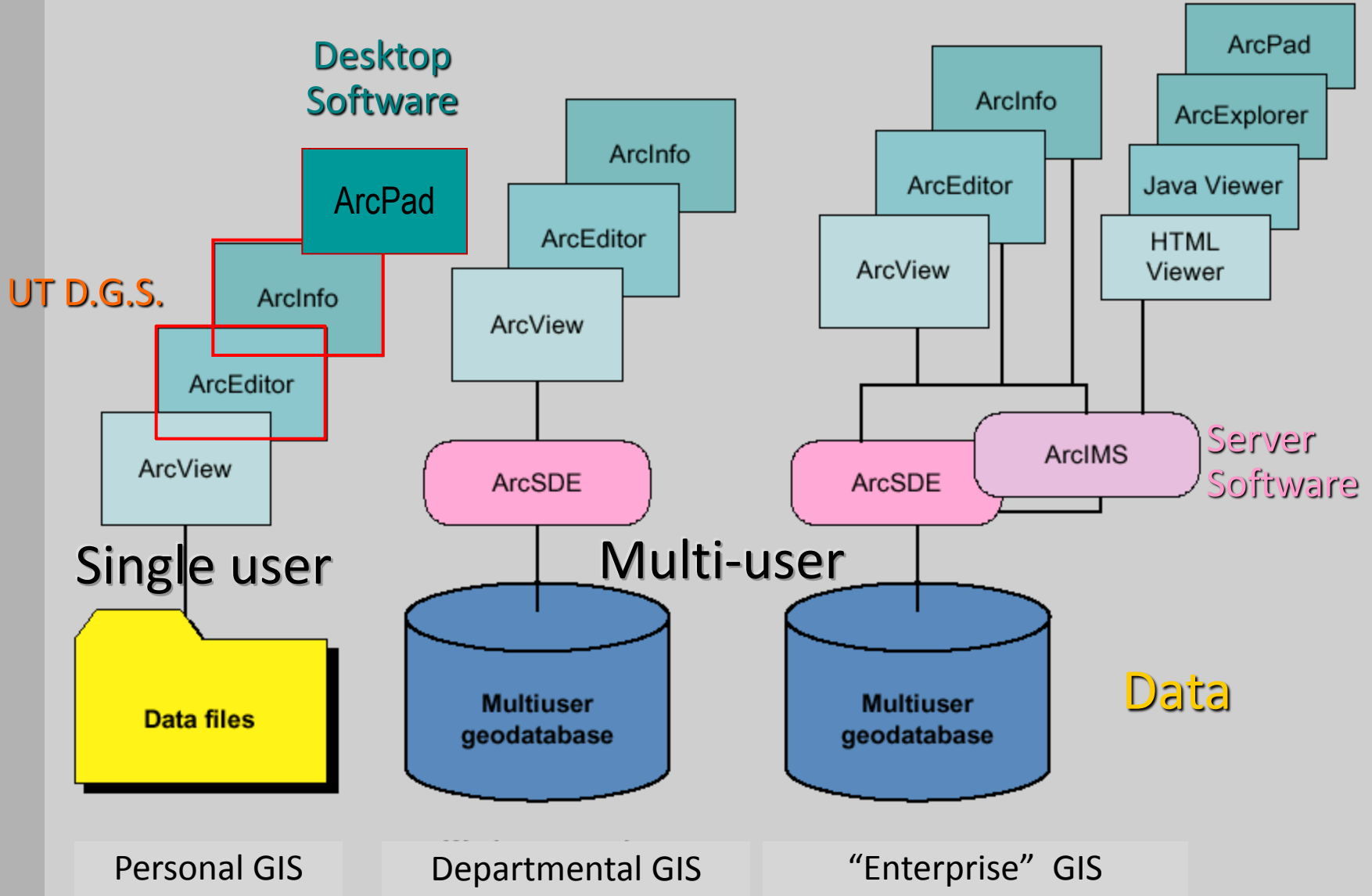
# ArcGIS Licensing Levels

- ⌘ **ArcView** – Make maps, do queries, some spatial analysis, some editing (shapefiles, personal geodatabases) – included with GTK ArcGIS Desktop
- ⌘ **ArcEditor** – plus edit multi-user geodatabases; more tools in toolbox
- ⌘ **ArcInfo** – full functionality; comes with ArcInfo Workstation (i.e. “legacy” ArcInfo v. 7). *UT D.G.S. licenses*

# ArcGIS Extensions

	ArcView, ArcEditor, and ArcInfo		ArcInfo only
<b>ArcGIS Spatial Analyst</b>	<ul style="list-style-type: none"> <li>Advanced raster modeling</li> <li>ARC GRID calculator with ARC GRID algebra</li> <li>VBA for raster analysis</li> </ul>	+	<ul style="list-style-type: none"> <li>ARC GRID program in ArcInfo Workstation</li> <li>ARC GRID commands in Arc program</li> </ul>
<b>ArcGIS 3D Analyst</b>	<ul style="list-style-type: none"> <li>ArcScene™—real-time interactive three-dimensional scenes</li> <li>Scene views in ArcCatalog</li> <li>Three-dimensional modeling tools</li> <li>ARC TIN tools</li> </ul>	+	<ul style="list-style-type: none"> <li>ARC TIN™ commands in Arc program</li> <li>Surfacescene command</li> </ul>
<b>Geostatistical Analyst</b>	<ul style="list-style-type: none"> <li>Advanced kriging and surface modeling</li> <li>Exploratory spatial data analysis tools</li> <li>Probability, threshold, and error mapping</li> </ul>		

# ESRI GIS - Scalable Product Lines





# ESRI Data Models

## ⌘ Topologic:

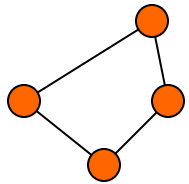
- ☑ ArcInfo - Coverage
- ☑ ArcInfo “.E00” – export format for coverage
- ☑ ArcGIS - Geodatabase

## ⌘ Non-Topologic:

- ☑ ArcView (legacy) - Shapefile

# Early ESRI Data Models

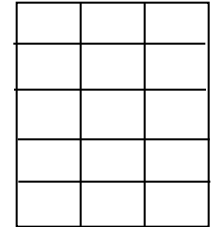
## Spatial Data



*Arc*

Geographic coordinates and attributes are stored in **separate** but linked files

## Aspatial Data



*Info*

## ⌘ Coverages

- ☑ Developed for workstation Arc/Info ~ 1980
- ☑ Complex structure, proprietary format
- ☑ Attributes in **Info** tables

## ⌘ Shapefiles

- ☑ Developed for ArcView ~ 1993
- ☑ Simpler structure in public domain
- ☑ Attributes in **dBase** (.dbf) tables

Slide courtesy of D. Maidment

# Data Organization

## ⌘ Coverage

- ☑ Data split between coverage and INFO *folders*
- ☑ Common boundaries between polygons stored once
- ☑ Topology explicitly stored
  - ☒ Planar graph maintained

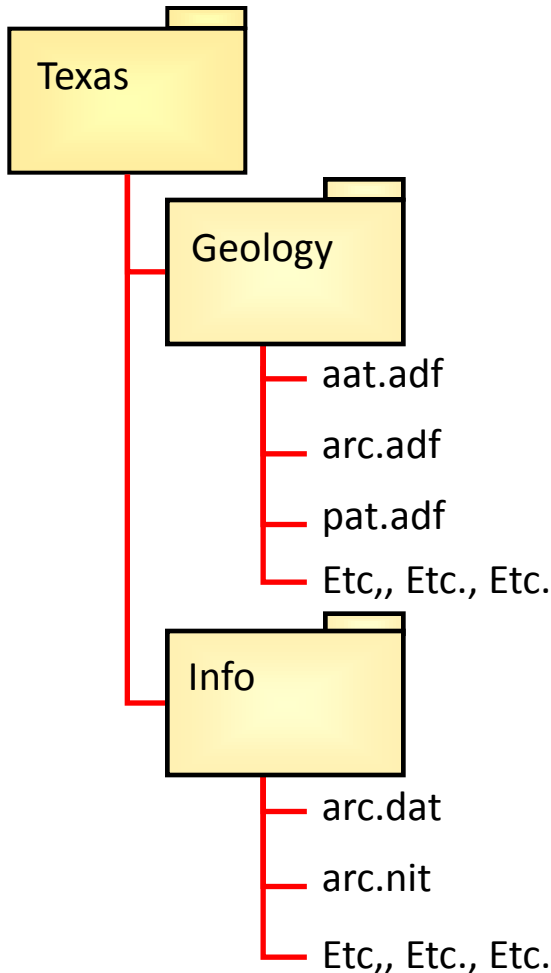
As in previous lecture

## ⌘ Shapefile

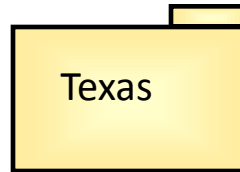
- ☑ Data divided among three or more *files* (.shp, .shx, .dbf, .sbx, .sbn, et al.)
- ☑ Common boundaries between polygons stored twice
- ☑ Topology created on-the-fly
  - ☒ Planar graph not required

# Folder/File Organization

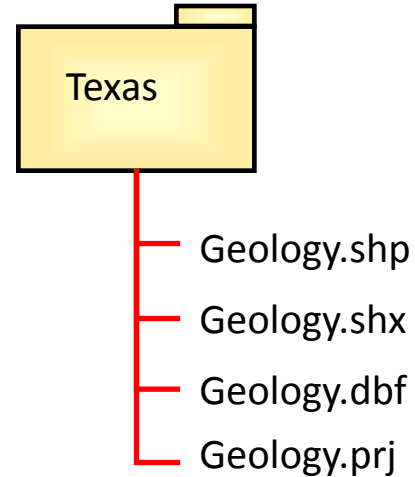
## Coverage



## .E00



## Shapefile

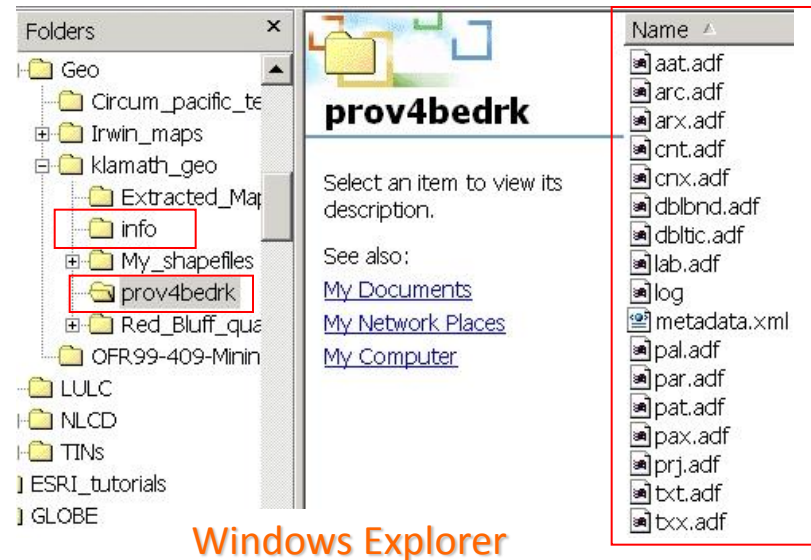
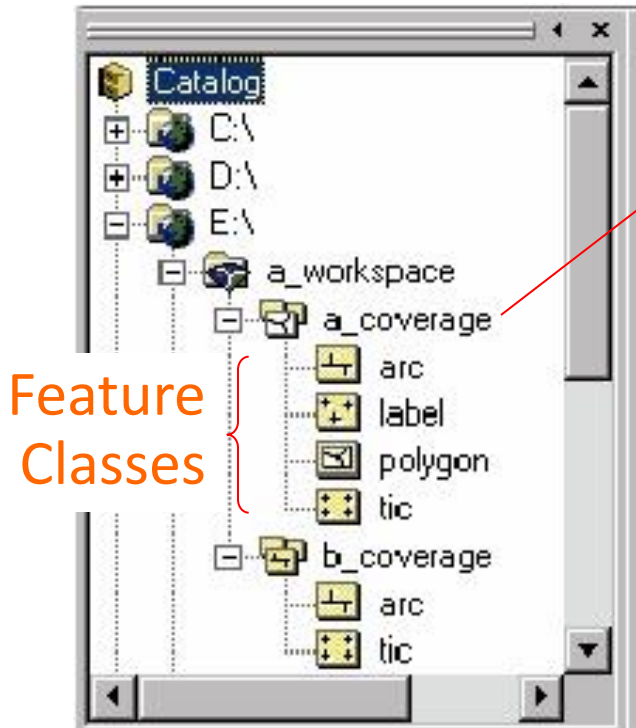
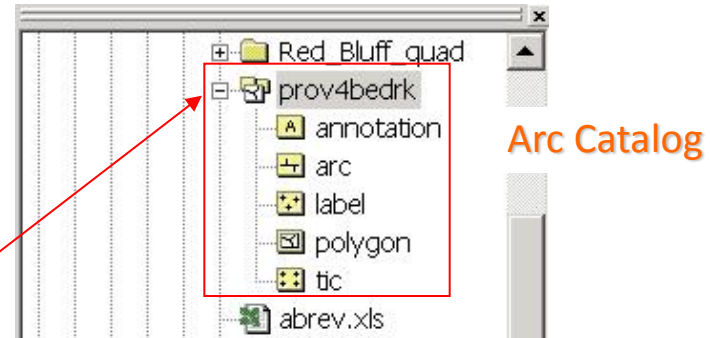


⌘ One feature shape (as points OR lines OR polygons) per file = “**SHAPEFILE**”

⌘ Many related features (as points AND lines AND polygons) per file = “**COVERAGE**”

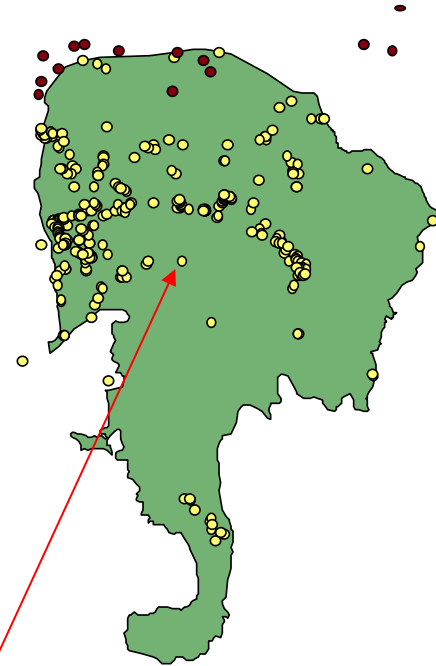
# Data Organization: Coverage in Windows Explorer and ArcCatalog

⌘ ArcCatalog:  
Workspace>Coverage>  
Feature Class



# Feature Class

- ⌘ A collection of geographic objects with the same geometry (point, line, polygon) that share the same attributes.
- ⌘ A shapefile contains one feature class
- ⌘ A coverage can contain many feature classes



Attributes of Condrey_samples_NAD27						
	FID	Shape*	Id	Number	NAD27 East	NAD27North
▶	0	Point	0	230	490921	4636832
	1	Point	0	123	491124	4637700
	2	Point	0	124	491375	4638149
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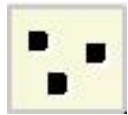
Sample location (points) Feature Class

# ArcInfo Coverage

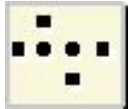
- ⌘ An integrated, homogeneous set of feature classes (pts., lines, polygons) stored together
  - ☑ Spatial (coordinate) data stored in binary files;
  - ☑ Attributes and topologic data stored in INFO tables
  - ☑ Stored within a “Workspace”

# ArcInfo Coverages can contain:

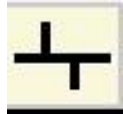
## ⌘ Primary feature classes:



Points, with attributes in PAT (point attribute table)



Nodes, with attributes in NAT



Arcs, with attributes in AAT



Polygons, with interior label points and attributes in PAT



# Coverages feature classes can contain:

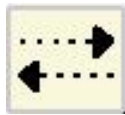
## ⌘ Secondary features:



Tics – registration points for digitized data



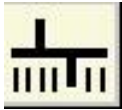
Annotations – text for map



Links – vectors used for adjusting local area to known locations (spatial adjustment)

# Coverages can also contain:

## ⌘ Composite features:



Routes – collections of Arcs with measurement system



Regions – collections of polygons; adjacent, noncontiguous or overlapping

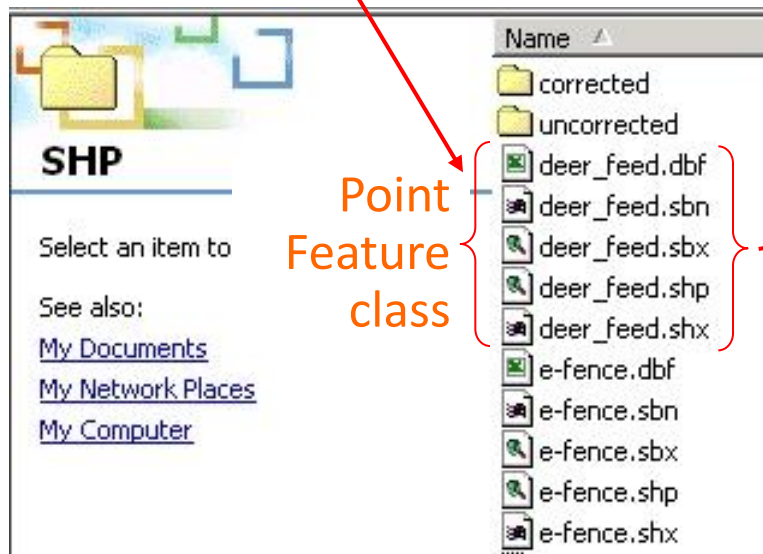
# Shapefile format



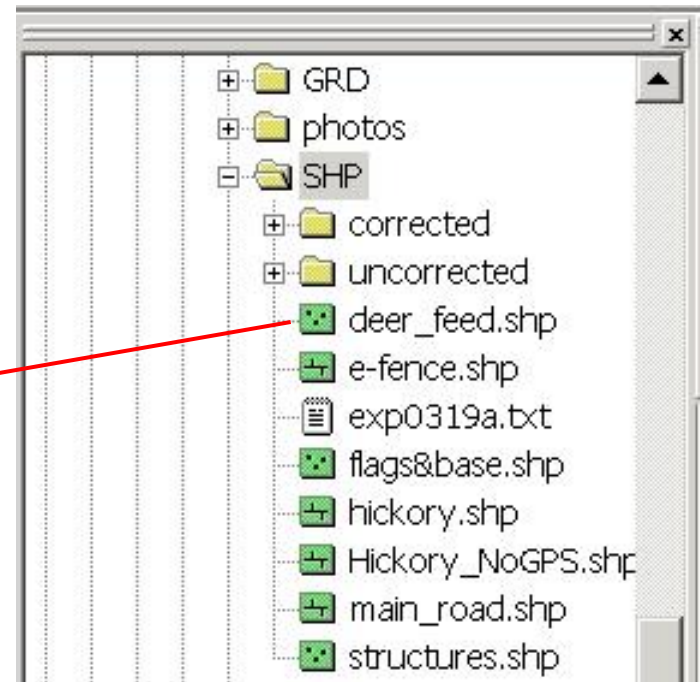
- ⌘ Simpler than coverage; doesn't store topology
- ⌘ Feature classes stored independently i.e. points, lines and polys. stored in physically separated files (e.g. no shared INFO table)
- ⌘ For each type, spatial data stored in a .shp file, attribute data in a .dbf table.
- ⌘ “Null” or “No Data” numerical values not supported in attribute tables

# Shapefiles in ArcCatalog/Explorer

- ⌘ Folder / Shapefile
- ⌘ Three or more files per feature class



Window Explorer



ArcCatalog

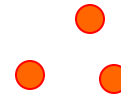
# Shapefile feature class types:

⌘ Point, Multipoint

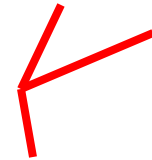
point



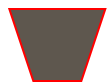
multipoint



⌘ Polyline (line with several paths)



⌘ Polygon



Ring – closed, nonintersecting path – simple poly.



Disjointed Rings – multiple polygons define feature



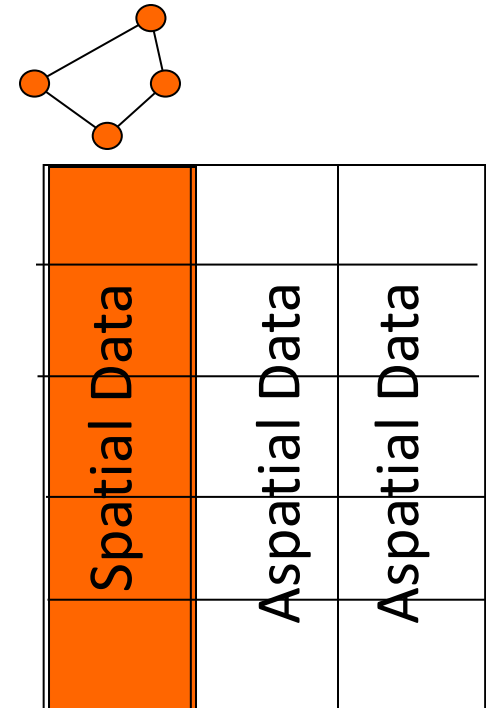
Nested Rings – “Island” or “Atoll” polygons

# Shapefile Topology

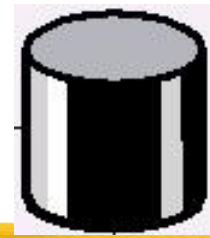
- ⌘ Shapefiles don't store information about adjacency
- ⌘ Topology is generated on the fly – vertices stored in systematic fashion to deal with containment and adjacency
- ⌘ *Planar enforcement can be broken by editing – not required in structure of shapefile*
- ⌘ But...tools available to maintain planar enforcement when digitizing in heads-up mode

# Geodatabase model

- ⌘ Stores geographic coordinates as one of many attribute in a relational database table; no separation between aspatial and spatial data, as in earlier models
- ⌘ Uses **MS Access** for “Personal Geodatabase” (single user)
- ⌘ Uses Oracle, DB2 or other **commercial relational databases** for “Enterprise GIS” (many simultaneous users).



Slide courtesy of D. Maidment



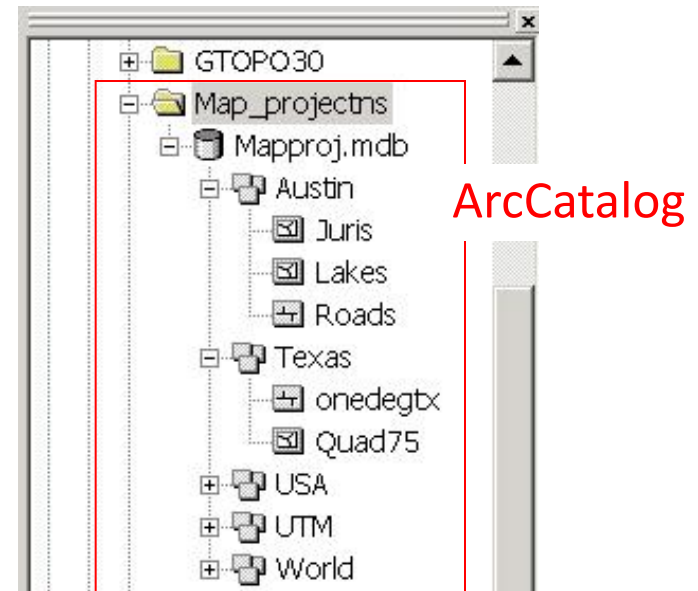
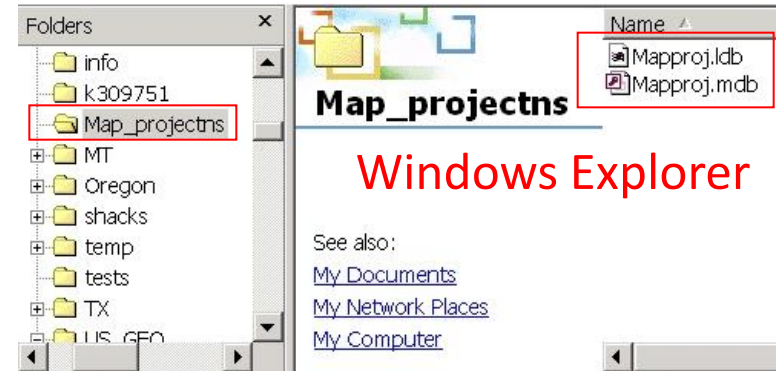
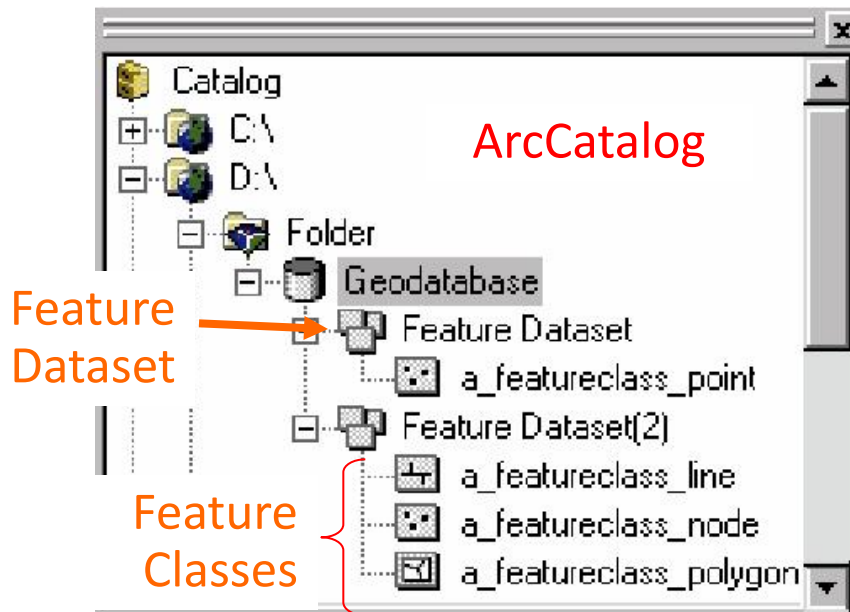
# Geodatabase Model

- ⌘ Data structure capable of storing objects with behaviors and relationships, not merely graphical shapes with topology and attributes
- ⌘ All spatial and attribute data for a feature are stored in a row of a single table
- ⌘ A Geodatabase is a top-level container for feature classes, coverages, shapefiles, rasters, et al. (more later) – ALL DATA CAN BE IN ONE CONTAINER AND ARE THUS PORTABLE



# Geodatabases in ArcCatalog/Windows Explorer

## Geodatabase/Feature Dataset/Feature Class



# Feature classes in Geodatabase include:

⌘ Points, Multipoints (groups of points)

⌘ Lines

⌘ Polygons

Plus ....

☒ Network Junctions (special Nodes)

☒ Network Edges

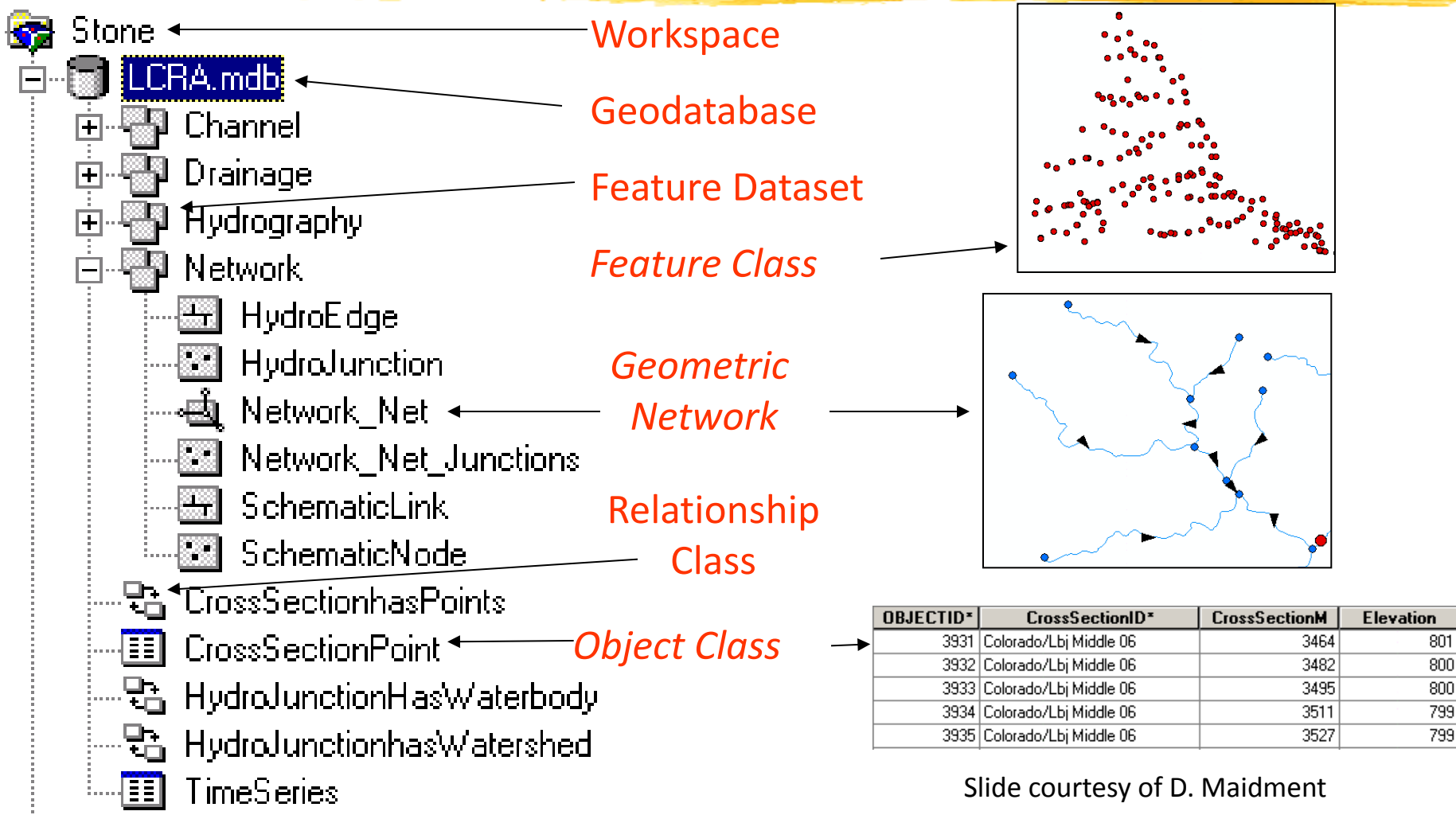
For geometric networks

Plus other classes

☒ Relationship classes

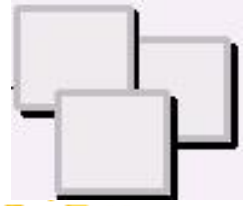
☒ Object Classes – tabular data without geography

# ArcGIS Geodatabase



Slide courtesy of D. Maidment

# Geodatabase Feature Datasets



- ⌘ Set of Feature Classes, some with topologies, *that share the same spatial reference*
- ⌘ All feature classes with topologies must be stored within a Feature Dataset
- ⌘ Analogous to coverage

# Object Class

- ⌘ A collection of *nonspatial* objects that share the same attributes and are stored in a table (i.e. a simple table)

Number	Age_Ma	1_sigma	Rx_Type	Size_kg
123	142	1.5	B_schist	3.4
124	136	2.0	G_schist	1.3
125				

Object Class (nonspatial table)

# Relationship

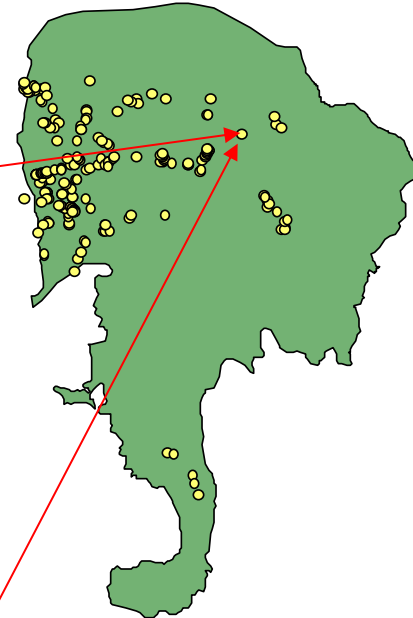


- ⌘ A **relationship** is an association or link between two objects in a database.
- ⌘ A relationship can exist between spatial objects (features in feature classes), non-spatial objects (objects in object classes), or *between spatial and non-spatial objects*.

# Relationship class

E.g. relationship between spatial and non-spatial objects

FID	Shape*	Id	Number	NAD27 East	NAD27North
0	Point	0	230	490921	4636832
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Feature Class (spatial table)

Number	Age_Ma	1_sigma	Rx_Type	Size_kg
123	142	1.5	B_schist	3.4
124	136	2.0	G_schist	1.3
125				

Object Class (nonspatial table)

# Paper Map Files Of Coordinates



⌘ How are they organized?

☑ Data Models, Topology

⌘ How are they stored?

☑ Data Organization

⌘ How are coordinates captured?

☑ Data Entry, Encoding





# Digitizing is:

⌘ Conversion of spatial data to digital form

☒ Lines, points or polygons are traced to record coordinates of their locations

⌘ Term conventionally used to denote the process of creating VECTOR data

☒ Scanning produces raster data (“bit maps”)

☒ But software exists to convert raster to vector so can digitize (“vectorize”) scanned images

# Digitizing is accomplished via:

## ⌘ Digitizing table or tablet

- ☑ “heads-down” digitizing

- ☑ Large table once available in Rm. 6.202

## ⌘ A mouse, on screen

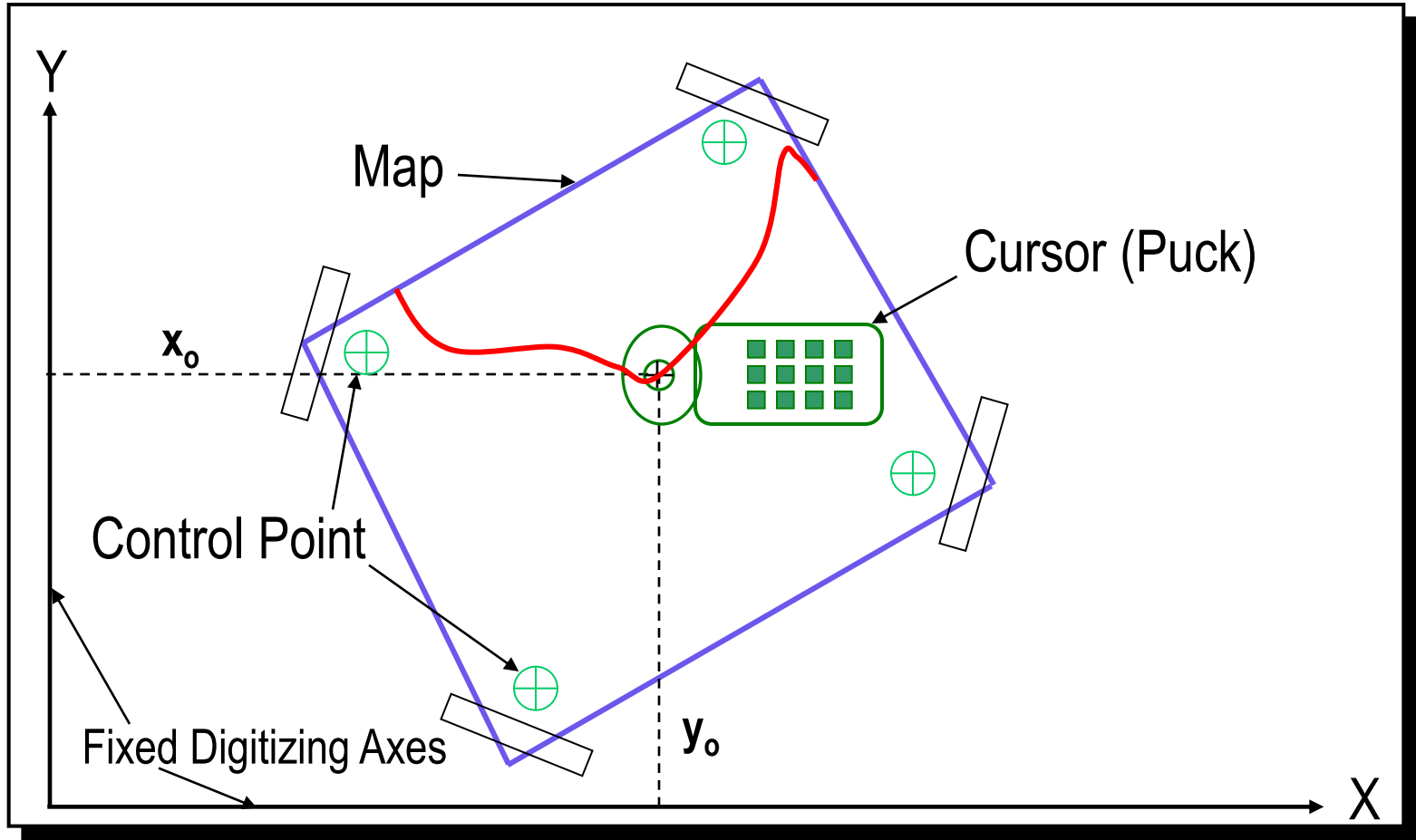
- ☑ “heads-up” digitizing

- ☑ Aerial photos, other raster or vector sources as base to digitize from

## ⌘ Software that converts raster to vector

- ☑ Vectorization – batch or interactive modes, e.g. ArcScan extension

# Digitizing table



# Digitizing with a tablet involves:



- ⌘ Digitize 3 reference points – define position of map w.r.t. digitizing table
- ⌘ Establishing 4 or more control points - distinctive features at known locations that can be used to register the map to ground coordinates (e.g. UTM, lat./lon.)
- ⌘ Separating features as point, line or polygon and tracing them to separate files (themes)

# Digitizing strategies governed by:

- ⌘ Will data be used for queries and analysis or just visual display?
  - ☑ i.e. Topology important or not?
  - ☑ “True” G.I.S. functionality or not?
- ⌘ What are accuracy requirements and how much generalization is permitted?

# Spaghetti vs. Topologic models

⌘ Spaghetti: Points, lines, polygons and their attributes stored in tables

⌘ Topological:

☑ Same, but with corresponding tables of information about what's adjacent or what's within what

# “Building Topology”

- ⌘ Clean: Edit to ensure planar enforcement
  - ☑ Remove sliver polygons & gaps between polygons
  - ☑ Correct overshoots, undershoots, leaky polygons
- ⌘ Build: Add topological attributes to spaghetti
  - ☑ Manual
  - ☑ Automatic
- ⌘ Digitizing with topology performed in ArcInfo or with tools in ArcToolbox, ArcMap and ArcCatalog
- ⌘ Changes to polygons or lines affect topological attributes – Strict rules for editing coverages in ArcMap

# Heads-up digitizing



- ⌘ Decide whether new file will have planar enforcement
- ⌘ Create new point, line or polygon feature class(es) in ArcCatalog
- ⌘ Edit feature class(es) to add features and attributes
- ⌘ Stop editing
- ⌘ Save edits as part of new feature class