

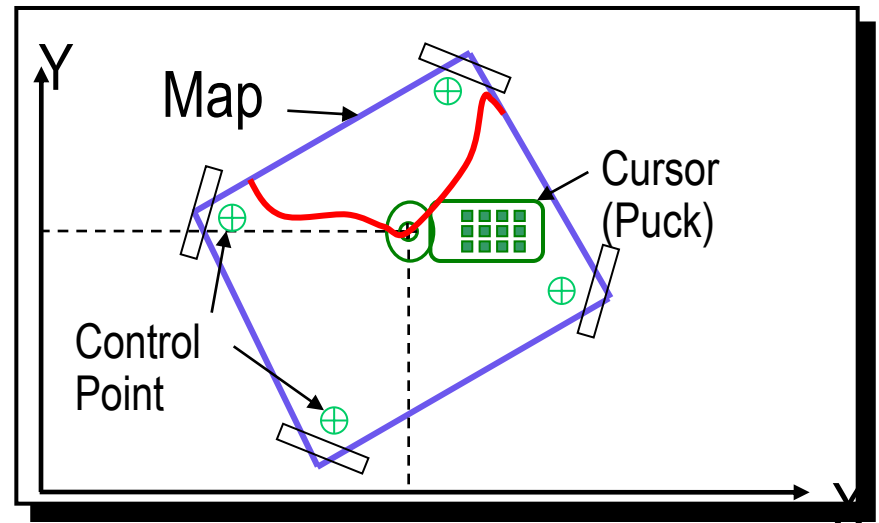
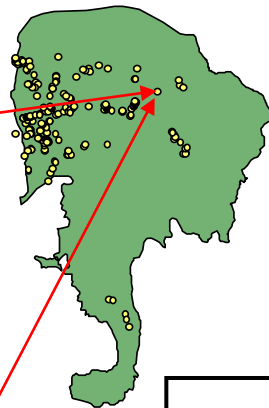
# ESRI Object Models; Data Capture

FID	Shape*	Id	Number	NAD27_East	NAD27North
0	Point	01230		490921	4636832
1	Point	01123		491124	4637700
2	Point	01124		491375	4638149
3	Point	01125		491522	4638902
4	Point	01126		491653	4638751
5	Point	01127		492872	4639489
6	Point	01128		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

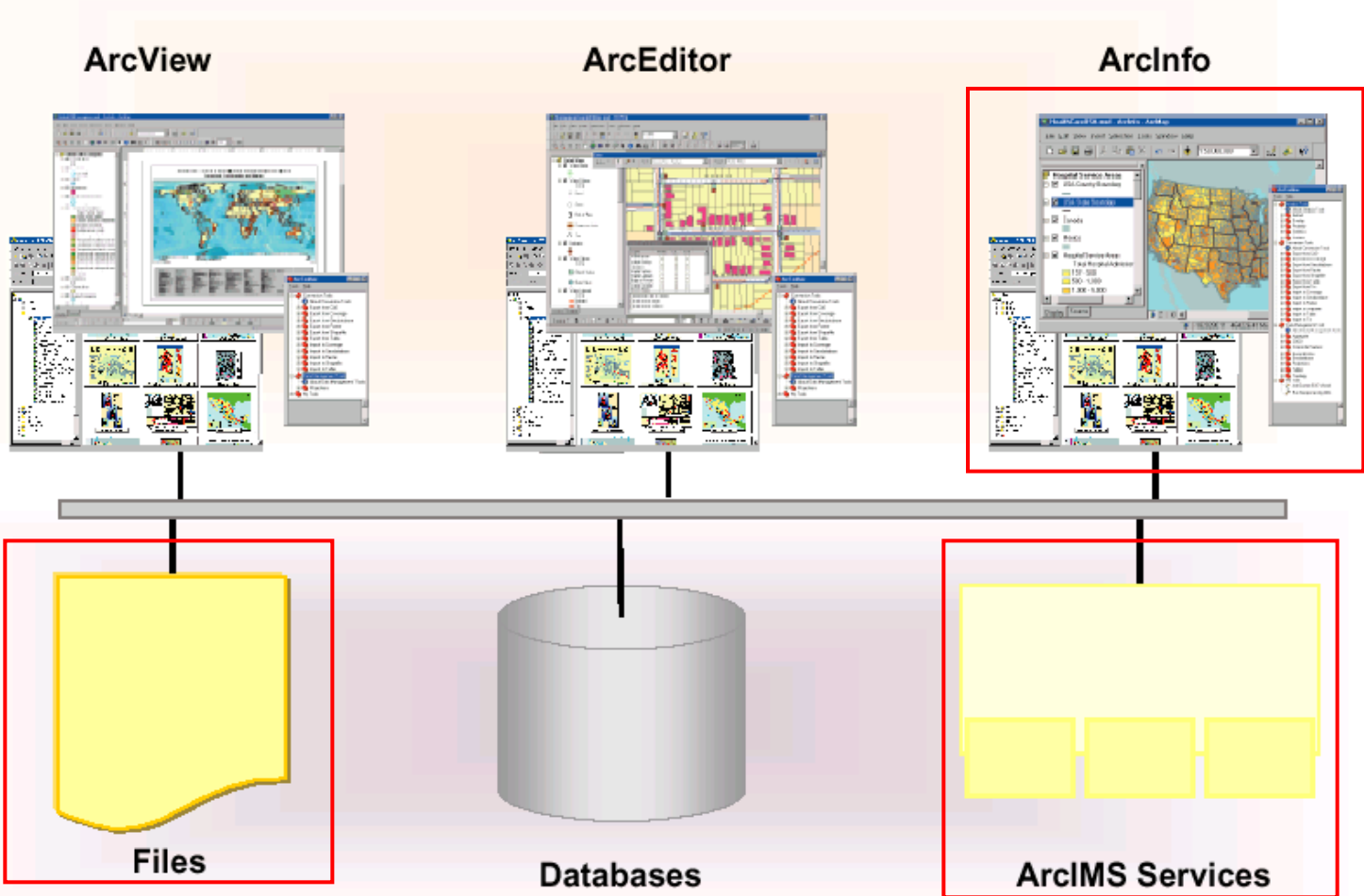
- ⌘ ESRI Software Family
- ⌘ ESRI Object Data Models
  - ☒ History
  - ☒ Data Organization - Physical Models
    - ☒ Coverage
    - ☒ Shapefile
    - ☒ Geodatabase
- ⌘ Data Capture
  - ☒ Digitizing
    - ☒ "Heads Down"
    - ☒ "Heads Up"
  - ☒ Building Topology

# Some History...

ESRI	Arc/Info	ArcView	ArcGIS
Date	1980-1999	1993-1999	2000 - 2010
Versions	1-7	1-3.2	8.0 - 9.2
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)
Database Software	Proprietary; Arc Tables	DBase	M.S. Access; ArcSDE for Oracle, etc.

# ArcGIS Desktop Levels

PRODUCTS  
(Licensing Levels)



# ArcGIS Licensing Levels

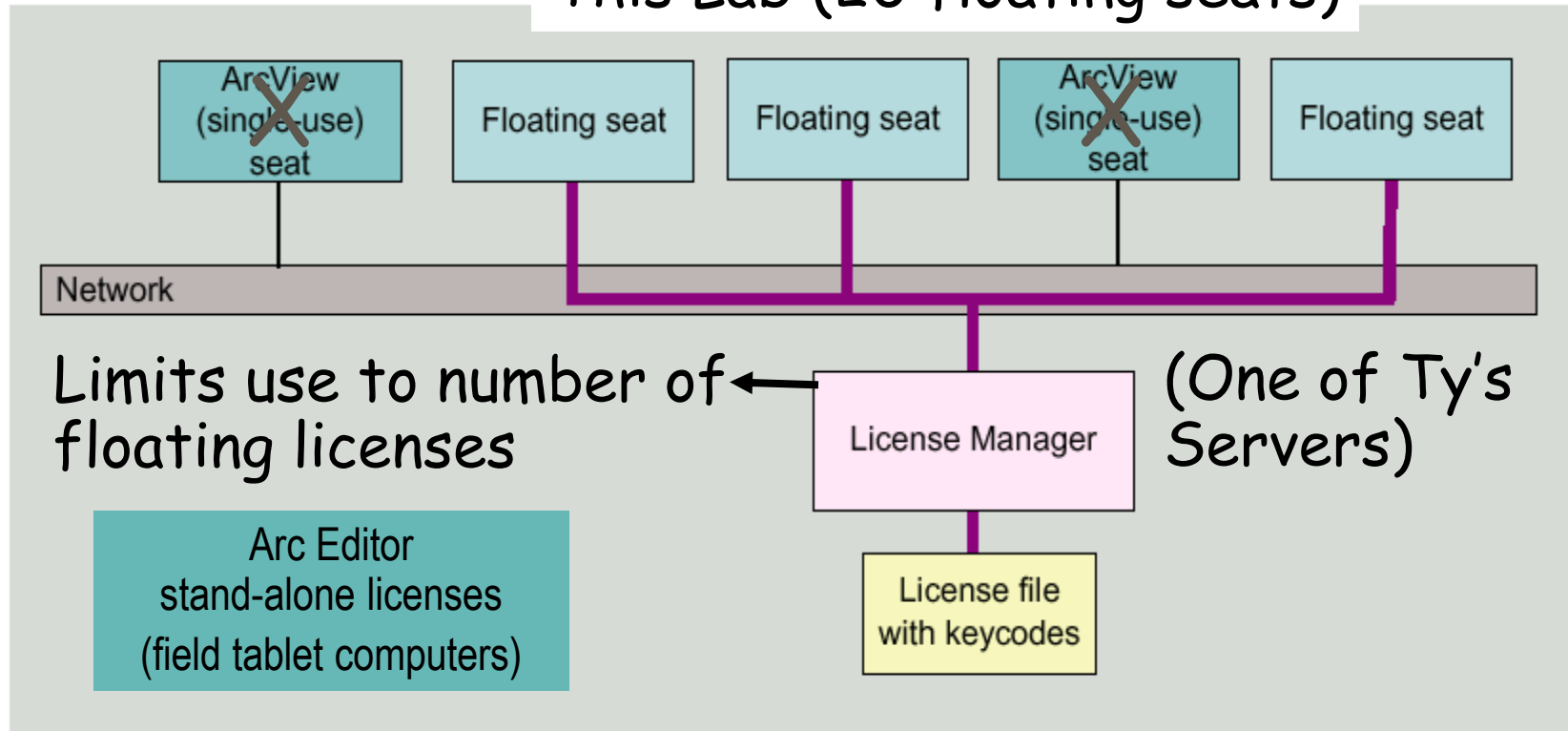
- ⌘ **ArcView** - Make maps, do queries, some spatial analysis, some editing (shapefiles, personal geodatabases) - included with GTK ArcGIS Desktop
- ⌘ **ArcEditor** - plus edit multi-user geodatabases; more tools in toolbox
- ⌘ **ArcInfo** - full functionality; comes with ArcInfo Workstation (i.e. "legacy" 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>		

# Licensing and "Floating Seats"

This Lab (20 floating seats)



# ESRI GIS - Scalable Product Lines

Desktop Software

ArcPad

ArcInfo

ArcEditor

ArcView

ArcSDE

Multiuser geodatabase

Departmental GIS

Personal GIS

ArcEditor

ArcView

ArcSDE

Multiuser geodatabase

Departmental GIS

ArcInfo

ArcEditor

ArcView

ArcSDE

Multiuser geodatabase

"Enterprise" GIS

ArcInfo

ArcEditor

ArcView

ArcSDE

Multiuser geodatabase

"Enterprise" GIS

ArcPad

ArcExplorer

Java Viewer

HTML Viewer

ArcIMS

Data

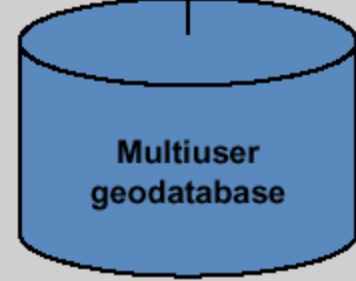
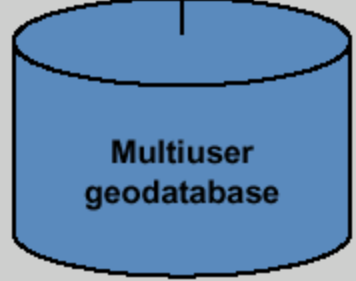
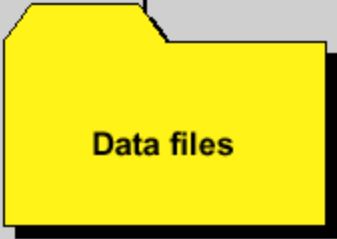
"Enterprise" GIS

UT D.G.S.

Single user

Multi-user

Server Software



Personal GIS

Departmental GIS

"Enterprise" GIS

# ESRI Data Models

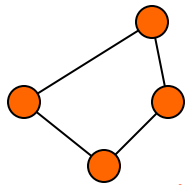
## ⌘ Topologic:

- ☑ ArcInfo - Coverage
- ☑ ArcInfo ".E00" - export format for coverage
- ☑ ArcGIS - Geodatabase

## ⌘ Non-Topologic:

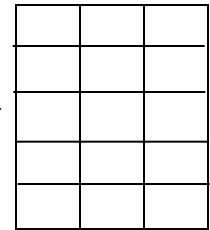
- ☑ ArcView - Shapefile

# Early ESRI Data Models



*Arc*

Geographic coordinates and attributes are stored in separate but linked files



*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

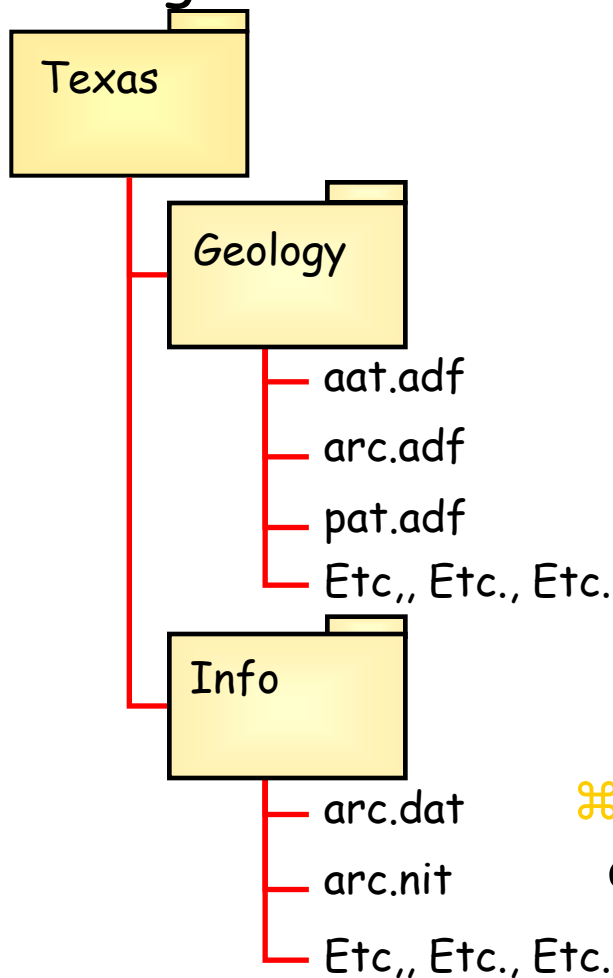
- ☑ Data split between coverage and INFO *folders*
- ☑ Common boundaries between polygons stored once
- ☑ Topology explicitly stored
  - ☒ Planar graph maintained

## ⌘ Shapefile

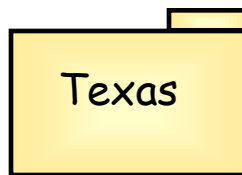
- ☑ Data divided among three or more *files* (.shp, .shx, .dbf, .sbx, .sbn, et al.)
- ☑ Common boundaries between polygons stored twice
- ☑ Topology created on-the-fly
  - ☒ Planar graph not required

# Folder/File Organization

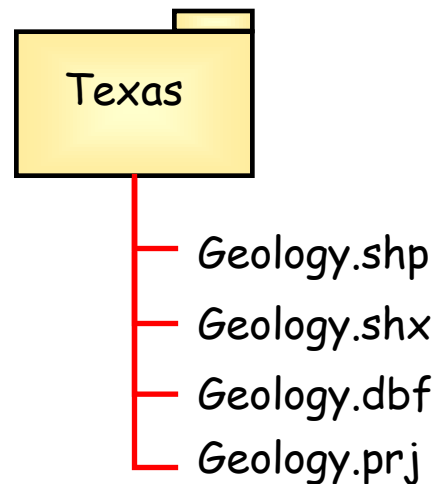
## Coverage



## .E00



## Shapefile

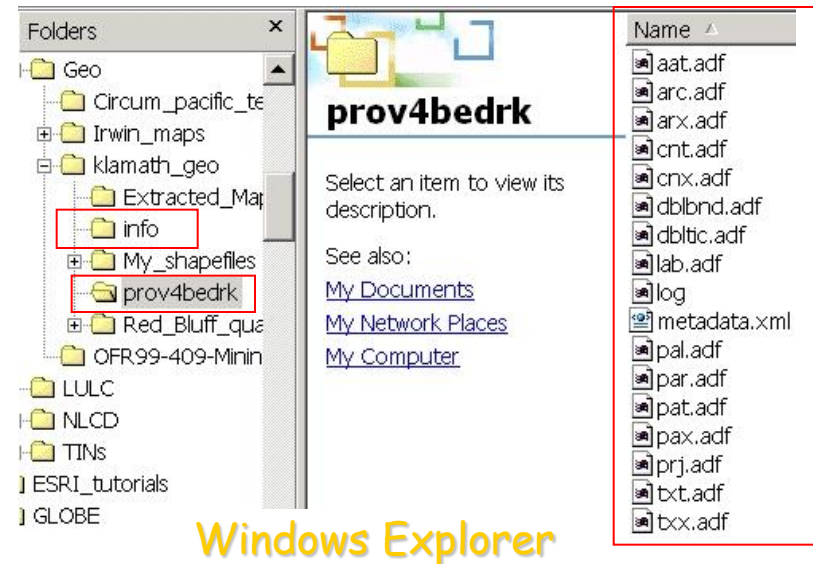
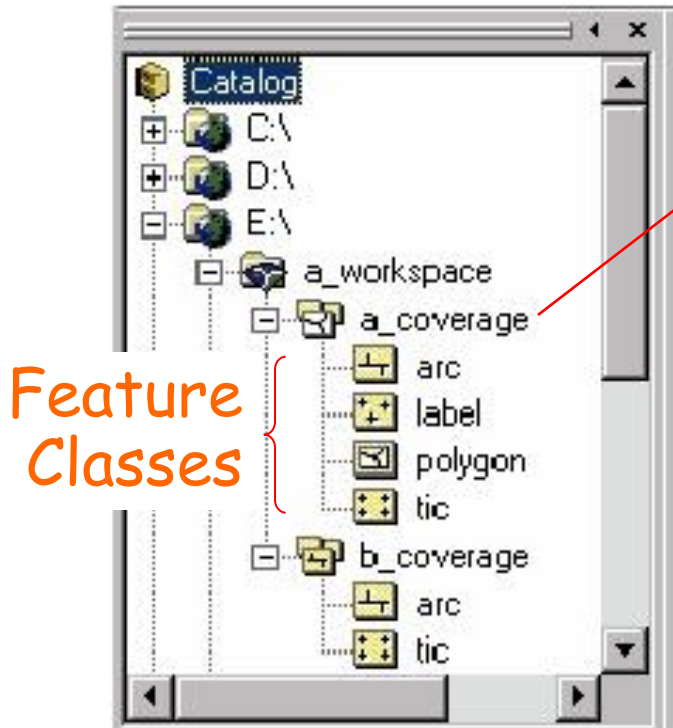
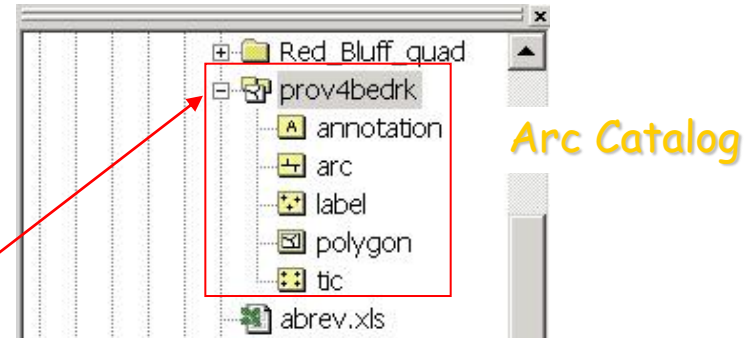


⌘ One shape (points or lines or polygons) per file = "SHAPEFILE"

⌘ Many related shapes (points and lines and polygons) per file = "COVERAGE"

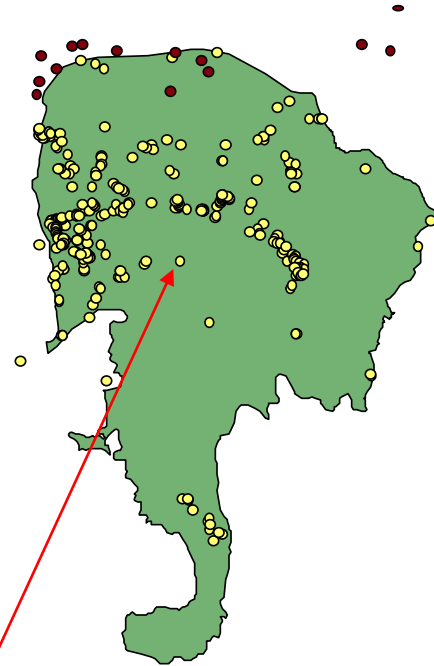
# Data Organization: Coverage in Windows Explorer and ArcCatalog

⌘ 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
	3	Point	0	125	491522	4638902
	4	Point	0	126	491653	4638751
	5	Point	0	127	492872	4639489
	6	Point	0	128	492963	4639515

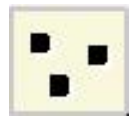
Sample location (points) Feature Class

# ArcInfo Coverage

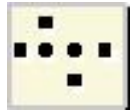
- ⌘ An integrated, homogeneous set of feature classes (pts., lines, polygons) stored together
  - ☑ Spatial (coordinate) data stored in binary files;
  - ☑ Attributes and topologic data stored in INFO tables
  - ☑ Stored within a "Workspace"

# ArcInfo Coverages can contain:

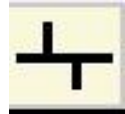
## ⌘ Primary feature classes:



Points, with attributes in PAT (point attribute table)



Nodes, with attributes in NAT



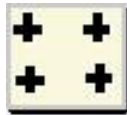
Arcs, with attributes in AAT



Polygons, with interior label points and attributes in PAT

# Coverages feature classes can contain:

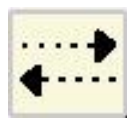
## ⌘ Secondary features:



Tics - registration points for digitized data



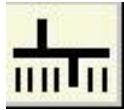
Annotations - text for map



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



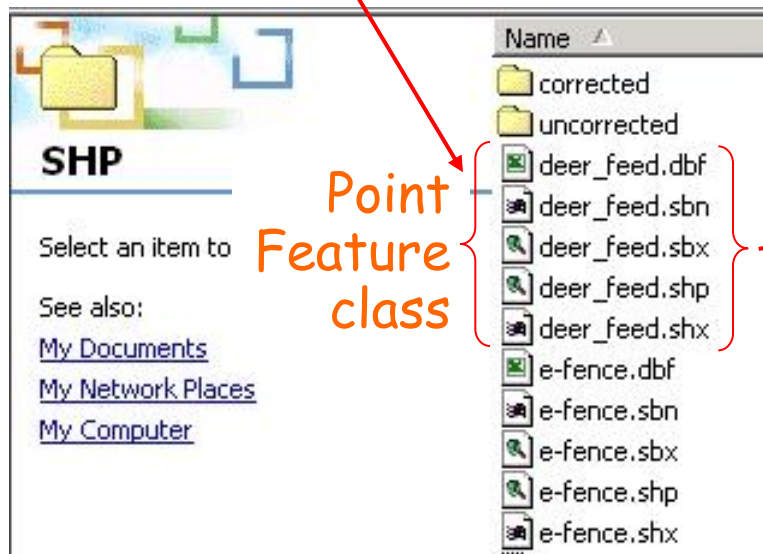
Regions - collections of polygons; adjacent, noncontiguous or overlapping

# Shapefile format

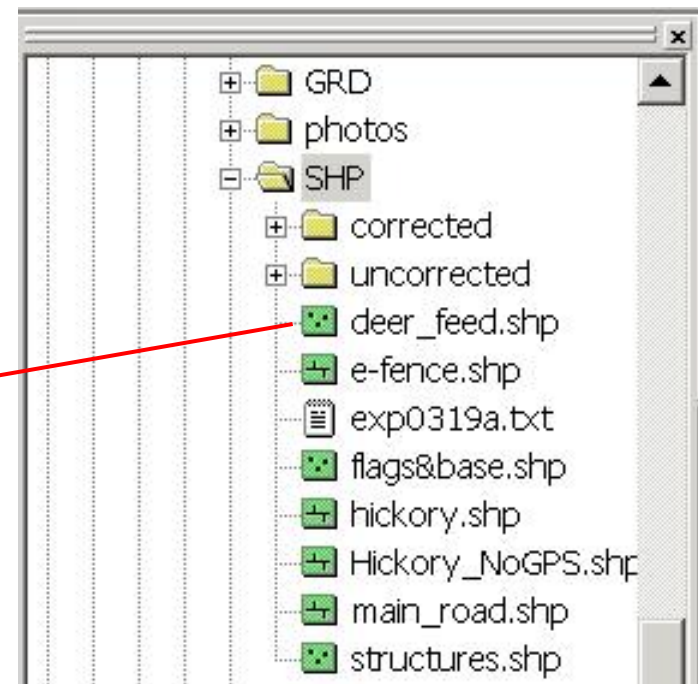
- ⌘ Simpler than coverage; doesn't store topology
- ⌘ Feature classes stored independently i.e. points, lines and polys. stored in physically separated files (e.g. no shared INFO table)
- ⌘ For each type, spatial data stored in a .shp file, attribute data in a .dbf table.

# Shapefiles in ArcCatalog/Explorer

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



Window Explorer



ArcCatalog

# Shapefile feature class types:

⌘ Point, Multipoint

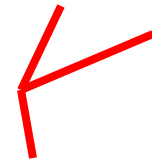
point



multipoint



⌘ Polyline (line with several paths)



⌘ Polygon



Ring - closed, nonintersecting path - simple poly.



Disjointed Rings - multiple polygons define feature



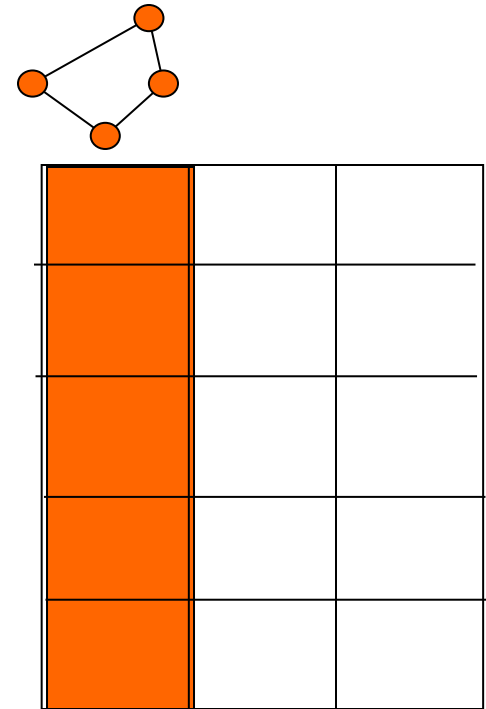
Nested Rings - "Island" or "Atoll" polygons

# Shapefile Topology

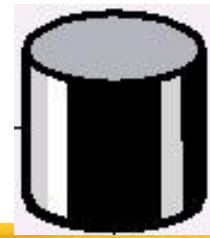
- ⌘ Shapefiles don't store information about adjacency
- ⌘ Topology is generated on the fly - vertices stored in systematic fashion to deal with containment and adjacency
- ⌘ *Planar enforcement can be broken by editing - not required in structure of shapefile*
- ⌘ But...tools available to maintain planar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

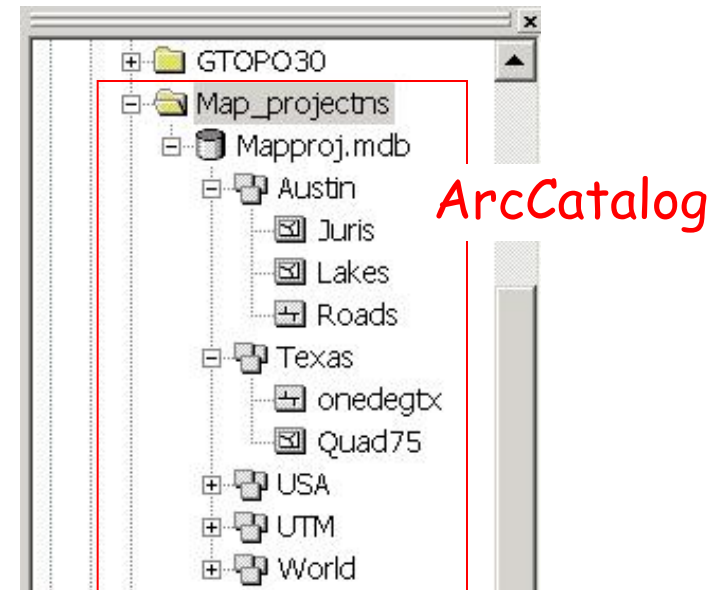
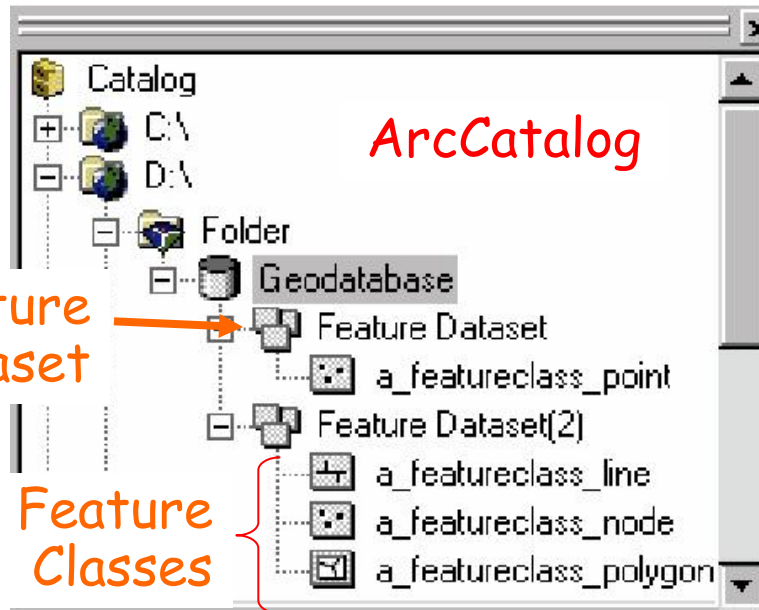
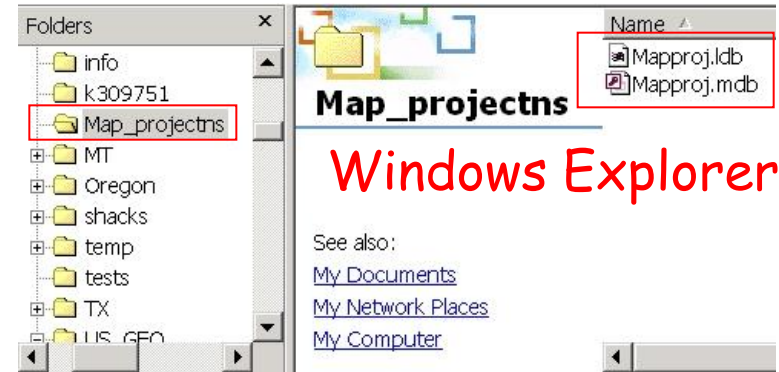


# Geodatabase Model

- ⌘ 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 IS 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

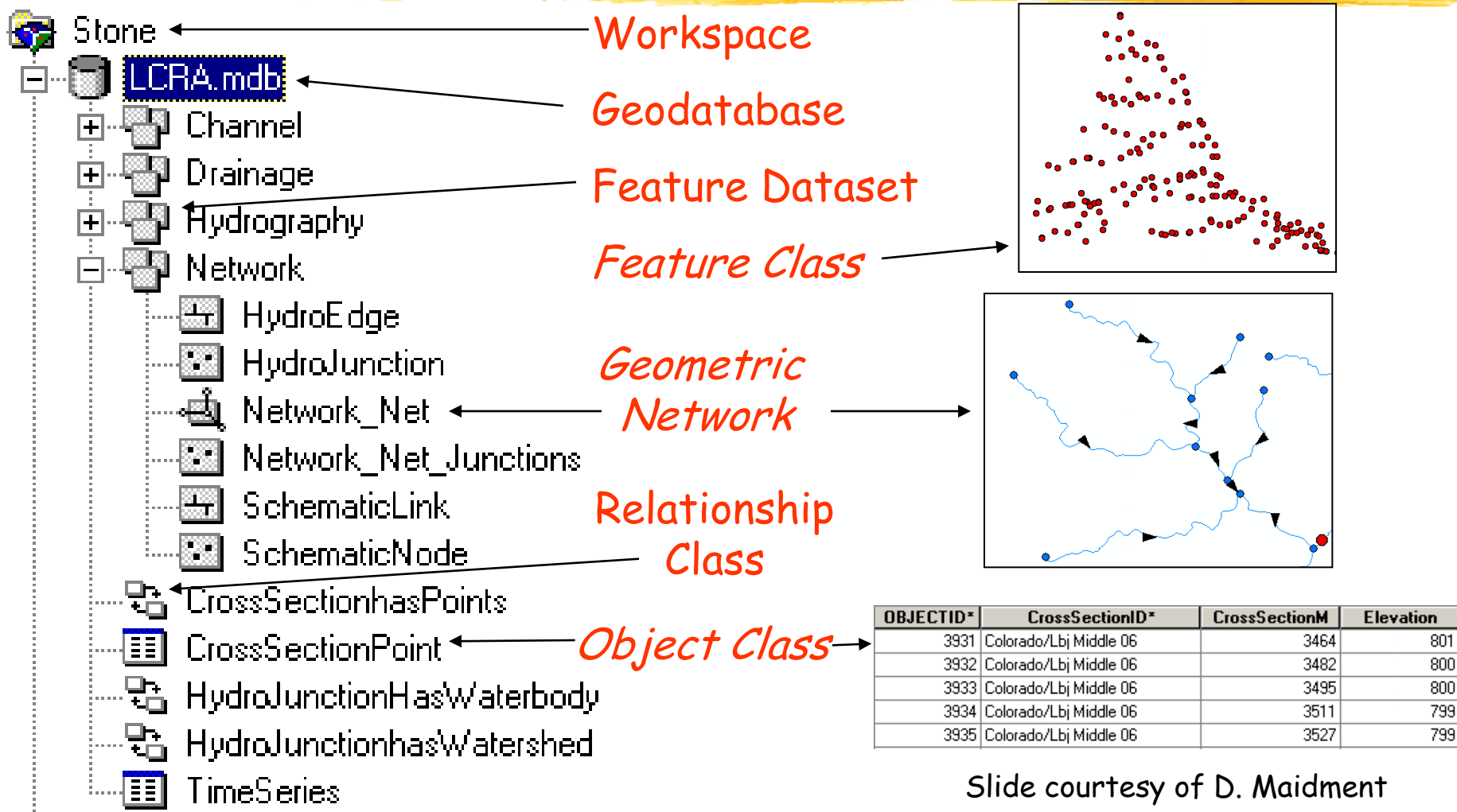
For geometric networks

Plus other classes

- ☒ Relationship classes

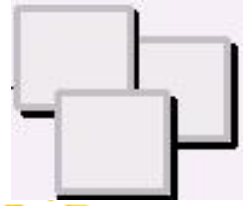
- ☒ Object Classes - tabular data without geography

# 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)

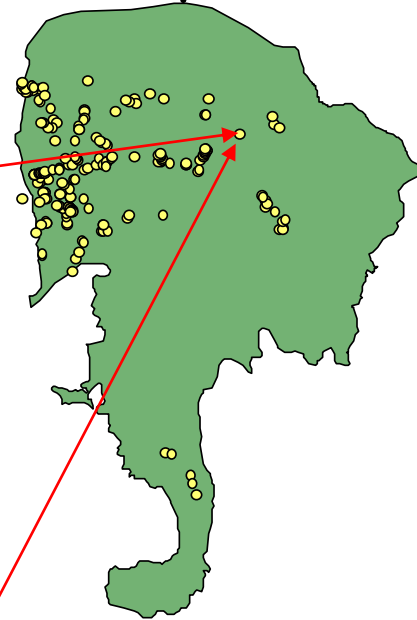
# Relationship

- ⌘ 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
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)

# 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

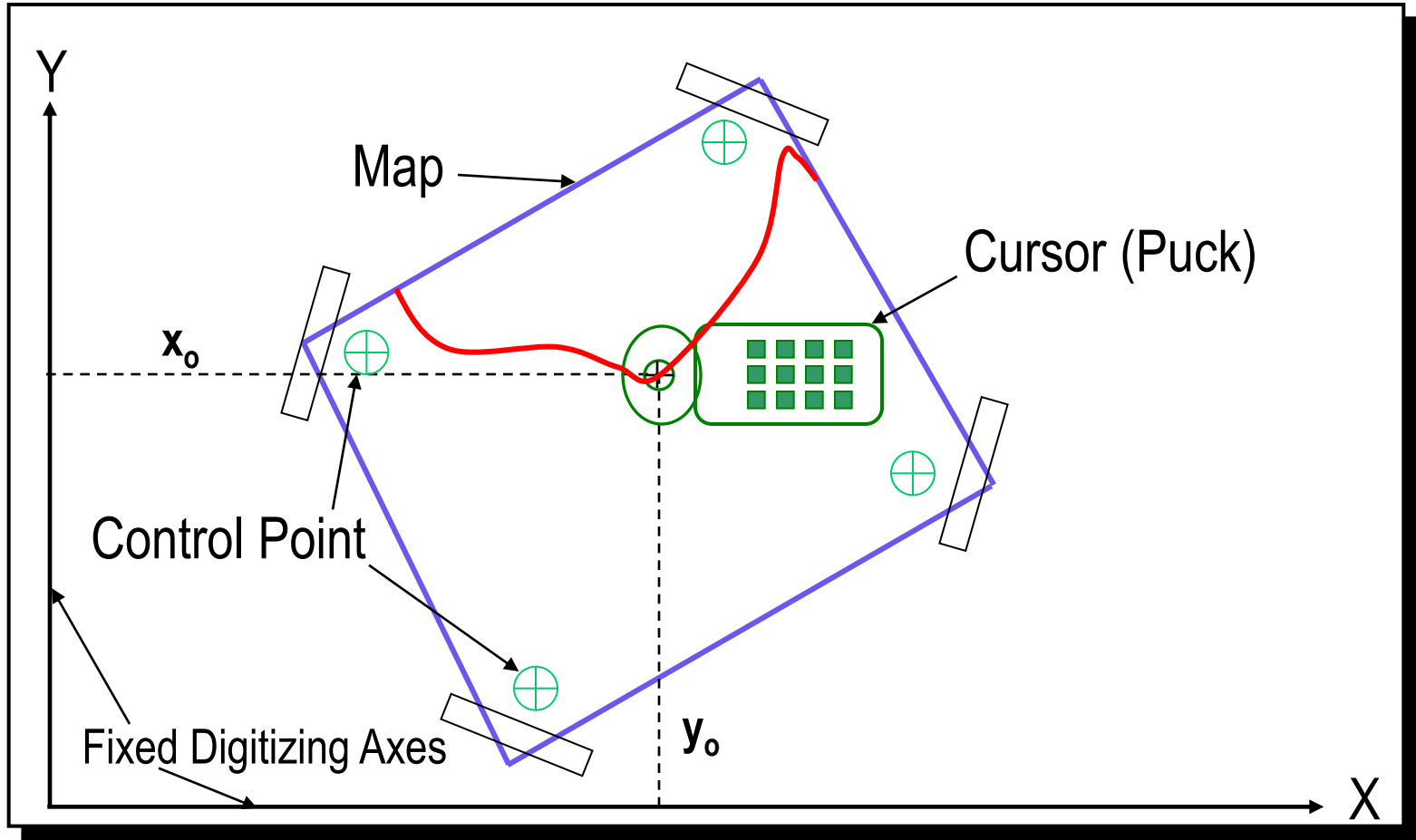
- ☑ "heads-up" digitizing

- ☑ 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