Database design & development in support of Disaster Risk Management

Workshop 2: Technical Issues Towards Effective Applications of Geospatial Technologies and Data in DRM

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Presented by Dr. Jacob Opadeyi, Disaster Risk Management Consultant



Geospatial Database Design Concepts

<u>Databases</u>

- The "I" in GIS
- GIS are often split into two components
 - Coordinate information (describes object geometry or spatial information)
 - Attribute information (describes other non-spatial properties associate with it)
 - Often referred as tabular data as they are presented in tabular form

Databases - cont.



Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485
King	53033	1507	2164	696
Mason	53045	38	904	42
Gray Harbor	53027	64	1917	33
Pierce	53053	586	1651	355
Thurston	53067	161	698	231
Pacific	53049	19	945	20
Lewis	53041	59	2479	24

Attribute Information Presentation

- In GIS, attribute information are typically entered, analyzed, and presented using a database management system (DBMS)
- DBMS is a specialized computer program for data organization and manipulation

DBMS Functions

- DBMS incorporates a special set of software tools to manage the GIS non-spatial tabular data
 - Efficient data storage
 - Data retrieval
 - Data indexing
 - Data reporting
- DBMS often provides data independence
 - Valuable while working with large data sets
- Multiple user views
- Centralized control and maintenance of important data

Database software...

• Light Duty



• Medium Duty





Heavy Duty



SQL Server

Database Components

Attribute or Item

- Attribute/item
- Entity
- Instance
- Record
 - Row/n-tuple

	(1		
	Name	FIPS	Pop90	Area	PopDn
	Whatcom	53073	128	2170	59
6	Skogit	53057	80	1765	15
Record	Clallam	53009	56	1779	32
	Shonomish	03001	400	2102	666
	Island	53029	60	231	261
	Jefferson	53031	20	1773	11
	Kitsap	53035	190	391	485

Database Design Procedure



- Identifies and evaluates alternatives
- Builds framework for database
- Represents a generalized 'user' view of data
- Software and hardware independent
- Identifies how entities will be represented in database
 - e.g. point, lines, areas; cells
- Identifies how relationships will be represented

Stages in Conceptual Design

- Identify database issues
- Evaluate data sources
 - examine format
 - categorize : standards, coding
 - eliminate redundancy
 - prioritize
- Select data model
- Conceptualize table design
- Develop implementation plan
- Prepare documentation
- Present, review and approve

Geospatial Data

Geological Maps



Geomorphologic Map



Geochemical Maps



Geophysical Maps

High resolution magnetic map, Scale 1:100000



Geophysical Maps

Total count radiometric map, 1:100000.



Attribute Data

What is Attribute Data ?

- Spatial databases containing geographic features
- Attribute data is descriptive information about features
- It is stored as data items in tables
- Features may be classified
- Attribute data facilitates interpretation and analysis of the data set

RDBMS

- Almost all of the tabular data used in a GIS are stored in relational database tables
- RDBMS models are more flexible than the other similar database models
- Table structure is simple to understand and does not restrict any kind of query
- Relational database supports eight primary operations important for GIS
 - Restrict, project, union, intersection, difference, product,, join, and divide (Bolstad, 2005)

Attribute data defines the different characteristics of an object such as:

- Name
- Date
- Time
- Magnitude
- Value
- Nature
- Condition
- Number
- Ownership

Domains

- A set of values an attribute may have
- Includes type, length and size of data

Column	olumn Domain		Column	Domain	
	Data Type	Size		Data Type	Size
Customer_Id	Integer	20	Customer_Id	Integer	20
Name	Character	30	Account_Number	Integer	15
Street	Character	30	Account_Type	Character	2
City	Character	25	Date_Opened	Date	
State	Character	2	Palanca	Pool	10.0
Zip	Character	5	Dalance	Redi	12,2

Business Rules

Business rules specify constraints on the data that can appear in tables and the operations that can be performed on data in tables. For example:

- An account balance can never be negative.
- A Customer can not be deleted if they have an existing (open) account.
- Facilities must have at least one building.
- Building height must be > 0 and < 22.
- Age must be < 120
- How do we enforce business rules ?
 - Setting Properties in the database
 - Applications

RDBMS

- Outside of a GIS, tabular data are commonly held and manipulated in relational databases:
 - dBASE, rBase, ACCESS, Oracle, SQLServer, INFORMIX, DB2, Rational Rose
- Object-oriented Relational Database Management Systems...

Primary and Foreign Keys

- Primary key is the unique identifier for each record
 - It may consist of one or more attributes (columns)
- Each table should have a primary key to facilitate *indexing*
- A Foreign key is an attribute (item) which is included in a table and is a primary key in another table
 - The process is referred to as the *posting* of the key into the table
 - they facilitate the relating (linking) of tables
 - Basis upon which referential integrity is enforced
- Preferred Key Characteristics
 - short length
 - numeric
 - non-volatile

Database Tables

Forests

Forest Name	Forest-ID	Location	Size
Nantahala	1	N. Carolina	184,447
Cherokee	2	N. Carolina	92,271

Trails

Trail Name	Forest-ID
Bryson's Knob	1
Slickrock Falls	2
North Fork	1
Cade's Cove	1
Cade's Cove	2
Appalachian	1
Appalachian	2

Recreational features

Feature	Description	Activity1	Activity2
Wfall	Waterfall	Photography	Swimming
Ogrth	Old-Growth Forest	Photography	Hiking
Vista	Scenic Overlook	Photography	Viewing
Wlife	Wildlife Viewing	Photography	Birding
Cmp	Camping	Camping	1 7 2)

Characteristics

Trail Name	Feature	Difficulty
Bryson's Knob	Vista	E,M
Bryson's Knob	Ogrth	E,M
Slickrock Falls	Ogrth	M
Slickrock Falls	Wfall	M
North Fork		M
Cade's Cove	Ogrth	E
Cade's Cove	Wlife	E
Appalachian	Wfall	M,D
Appalachian	Ogrth	M,D
Appalachian	Vista	M,D
Appalachian	Wlife	M,D
Appalachian	Cmp	M,D

Relationships



RDBMS Supporting Functions in GIS

a) restrict

age	size	color	type	ID
old	big	blue	a	1
young	big	green	c	2
mid	small	red	a	3
older	big	black	d	4
oldest	tiny	mauve	×	5
young	huge	dun	9	6
mid	small	ecru	с	7

restrict	
	140

project

	ID	type	color	size	age
	1	a	blue	big	old
÷.	4	d	black	big	older
	6	9	dun	huge	young
	2	C	green	big	young

a) union

ID	type	color	size	age
1	a	blue	big	old
6	9	dun	huge	young
	10 - 34C - 3			1. P. S.
ID	type	color	size	000
ID 2	type c	color	size bia	age vouna

	ID	type	color	size	age
-	1	a	blue	big	old
	4	d	black	big	older
	6	9	dun	huge	young
	2	c	green	big	young

b) project

ID	type	color	size	age	
1	a	blue	big	old	
2	C	green	big	young	
3	a	red	small	mid	
4	d	black	big	older	-
5	×	mauve	tiny	oldest	
6	9	dun	huge	young	
7	c	ecru	small	mid	

	ID	color	size
	1	blue	big
	2	green	big
+	3	red	small
	4	black	big
	5	mauve	tiny
	6	dun	huge
	7	ecru	smal

b) intersect

ID	color	size
1	blue	big
2	green	big
3	red	small
4	black	big
5	mauve	tiny
6	dun	huge
7	ecru	small

ID	color	size	
1	blue	big	intersect
5	mauve	tiny	
9	ivory	big	

union

	ID	color	size
	1	blue	big
ŝ	5	mauve	tiny

c) product

Dir. No. 1 N 2 S



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2	5	
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2	5	Г
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d) divide





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Yes	ID		
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	2		
No	3		
No	4		
	5		
	6		

type

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C)	air	Ter	en	ce

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	green	big	ID
	red	small	1
	black	big	5
	mauve	tiny	9
	dun	huge	
3	ecru	small	

colo	r size	Ê
blue	big	difference
mau	ve tiny	
ivor	y big	

join

ID	color	size
2	green	big
3	red	small
4	black	big
6	dun	huge
7	ecru	small

d) join

ID	type.	type	color	size	age
1	a	a	blue	big	old
2	b	h	dun	tiny	old
3	b		- and -		
4	۵				

	ID	type	color	size	age
	1	a	blue	big	old
-	2	Ь	dun	tiny	old
	3	Ь	dun	tiny	old
	4	a	blue	big	old

IWRM EAR



Pest Monitoring EAR



Attribute Tables: Database in ArcGIS



Some Facts about Attribute Table

- columns : fields/attributes
- rows : records
- Automatic Fields:
 - FID and Shape fields automatically created
 - During Digitizing:
 - Length of lines
 - Area & Perimeter of Polygons
- You can add new fields and values to an existing attribute table
- Attribute tables are saved in workspace as *.dbf file
- You can export your new updates in attribute file in many formats

Linking Tables

Shape*	AREA	PERIMETER	IDGAGE_ ID	GAGE_ID	STAID				STANAME		SI	HUC	CLA
Point		0 0	1	4710	12395000	Prie	t R nr Priest F	liver			ID	17010215	
Point		0 0	2	4714	12411000	NF	oeur d Alene	R n Prichard			Þ	17010301	
'oint		0 0	3	4715	12411935	Pric	ard Cr. at Pric	hard, ID			ID	17010301	
Point		0 0	4	4716	12413000	NF	oeur d Alene	R @ Enaville			ID	17010301	
Point		0 0	5	4726	12413500	Coe	<mark>u</mark> r d Alene R @	🛿 Cataldo			ID	17010303	
Point		0 0	6	4725	12413470	SF	<mark>oeur dAlene f</mark>	R n Pinehurst			ID	17010302	
Point		0 0	7	4723	12413300	SF	oeurdAlene R	Smelterville			ID	17010302	/
Point		0 0	8	4722	12413250	SF	<mark>oeur dAlene f</mark>	R at Kellogg			ID	17010302	
Point		0 0	9	4724	12413445	Pine	<mark>:</mark> Creek near Pi	nehurst, ID			ID	17010302	
Point		0 0	10	4727	12413860	Coe	<mark>u</mark> r d Alene R n	r Harrison			ID	17010303	
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Point		0 0	12	4719	12413130	Nin	nile Creek at ۱ <mark>،</mark>	Vallace, ID			ID	17010302	
Point		0 0	13	4718	12413125	Car	von Creek at V	Vallace <mark>, ID</mark>			b	17010302	
Point		0 0	14	4717	12413040	SF	oeur dAlene f	R nr Mu <mark>llan</mark>			ID	17010302	
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Relate Table

- Relate function lets you associate data (as we discussed) with the layer
- The data is not appended into the layer as in the case of join
- But, the data layer of the associated table can be accessed when you work with the other table
- Establishing a relate is useful when there is 1-to-many and many-to-many association between layer and the related data

Table Record Relationships Cardinality

🍭 Store Data		_0	×
Store Address	Store Phone	Store Number	
401 S. Center St.	(909) 555-2853	204	
818 W. Brookside	(909) 555-7931	335	
950 W. State St.	(909) 555-5853	387	-
4			F

🍭 Yearly Sales	Data	_ []	×
Store Number	Sales 1995	Sales 1996	
204	8462.00	9526.00	
335	582.00	1037.00	
387	5849.00	5634.00	•
◀			

🍭 Delivery Data			<u> </u>
Delivery Data	Track ID	Quantity	Store Number
1/28/95	542	34	204 🔺
2/14/95	635	74	335
2/23/95	563	14	204 •
3/16/95	156	47	387
4/3/95	925	87	559
4/30/95	234	24	335
5/13/95	623	68	204 🔎
5/28/95	274	36	204 🔽
9/15/95	625	57	387 💌
			•

			🍕 Emj	ployee Dat	a	_
			Share	e Number 👘	Employee Number	Shilt
				204	2001	
🂐 Store Data		<u>- 0 ×</u>		335	2010	
Store Address	Store Phone	Store Number		204	2116	
				387	2299	
401 S. Center St.	(909) 555-2853	204 🔜		387	2327	
318 W. Brookside	(909) 555-7931	335		559	2438	
950 W. State St.	(909) 555-5853	387		204	2518	
109 C Touso	(909) 555,5220	559 🔻		204	2521	
	: 13031 333-3320 :	333		559	2522	
<u> </u>				204	2567	
						▶

One-to-One Relationships



One-to-Many Relationships

Most common type of relationship

Related between primary and foreign keys



Many-to-Many Relationships

- ✓ Not directly supported between tables
- Use a junction table to relate
- One order, many products
- One product, many orders



Geodatabases in ArcGIS

- A structured set of data
- managed and stored as one unit
- generally associated with a software to update and query the data
- geodatabase = an object-oriented data model introduced by ESRI



The Geodatabase Offers A Comprehensive Approach to Modeling and Managing Spatial Data

- Hosted inside of a relational database management system
- Storage for features classes, feature datasets, non-spatial tables,...
- Relationships (spatial, non-spatial) > advantage over shapefiles

File geodatabase

- stores datasets in a folder of files
- each dataset a file up to 1 TB in size
- can be used across platforms
- can be compressed and encrypted for read-only, secure use
- ESRI's recommended choice

Personal geodatabase

- stores datasets in a Microsoft Access .mdb file
- storage sizes between 250 and 500 MB
- limited to 2GB
- only supported on Windows

ArcSDE geodatabase

- stores datasets in a number of optional DBMSs:
 - IBM DB2, IBM Informix, Microsoft SQL Server, Oracle, or PostgreSQL
- unlimited size and users



- Features and Feature classes collections of features (spatial objects) with the same type of geometry and the same attributes
 - Holds geometry attributes
 - rows features, table feature class

TATA	▦	Attributes of	f Parcels				
		OBJECTID *	SHAPE*	PARCEL_ID*	ZONE_CODE*	SHAPE_Length	SHAPE_Area
		4513	Polygon	67970	W	544.053559	9259.209935
		4514	Polygon	67971	W	158.545394	774.602847
		4515	Polygon	67973	R60M	400.003008	7499.965473
		4516	Polygon	67974	B1	236.126101	2905.890606
		4517	Polygon	67982	B1	550.458538	17499.011493
	-	A REAL PROPERTY AND A REAL					

- Feature datasets collections of feature classes that share the same spatial reference
 - Topological rules must be inside Feature datasets



- Subtypes
 - Categorize objects or features into groups
 - Share same attributes
 - Defined at the class level
 - Select a field to base the subtype on
 - Short or long integer field
 - Can have different default values and domains
 - Can define behavior rules



▦	Attributes of	Parcel			-DX
	OBJECTID *	SHAPE*	APN	ZoneCode	
	213	Polygon	70605	201	
	218	Polygon	70611	201	
	228	Polygon	70621	201	
	231	Polygon	70668	201	
	363	Polygon	70860	202	
	429	Polygon	70745	202	
	430	Polygon	70746	202	
	435	Polygon	70751	203	
	1278	Polygon	70473	203	
L,	1279	Polygon	70474	202	



- Relationship classes define relationships between objects (one-to-one, one-to-many, many-to-many)
- Related objects communicate (cascade delete)

R	Parcel	
OID	Zone	Area
28	Commercial	10000
794	Residential	5000
858	Residential	6050



Д	Buildings	i.
OID	Parcel_ID	Building Type
1	28	Office Building
2	794	Townhouse
3	794	Townhouse
4	858	Condo

- Object behavior
 - Control default value and acceptable values for any attributes (Domains)
 - Subdivide objects into similar groups (Subtypes)
 - Control the spatial relationships (Topology)

- Annotation
 - Placing text and graphic on a map
 - Linked to features or not
 - Can store text as well as other graphics

- Topology
 - Constraints on the shared geometry
 - Define data integrity
 - Control on editing tools
 - Validation of features
 - Ensures quality of your data



- Create topology in a feature dataset
 - Participating feature classes
 - Cluster tolerance
 - Ranks and rules
- Define rules
 - Rules evaluated during validation
- Errors
 - Managed as a part of the topology
 - Exceptions
 - Examine and fix errors in ArcMap

- Editing with topology
 - Editing creates dirty area
 - Can be symbolized
- Errors found during validation
 - Have properties
 - What rule is concerned
 - Which features are involved
- Options
 - Ignore error
 - Mark as exception
 - Fix



- Other elements included
 - Terrains
 - Point datasets for modeling 3D surfaces
 - Requires 3D Analyst extension
 - Representations
 - Properties of feature classes storing symbologies
 - Rules and overrides
 - Parcel fabrics
 - Designed for parcel data management



- Directly loadable data types
 - dBase (.dbf)
 - Text with comma (.csv) or tab-separated values (.txt)
 - Microsoft Access (.mdb)
 - Microsoft Excel (.xls)

What made all of these possible?

Access to

- Technology (currency)
- Data (currency, resolution, accuracy)
- Policy (relevance, monitoring)
- Human resources (skills and benefits)
- Funding (driven by applications and results)
- Political support (motivation for success)

Thank you!

• -----END------

