Geographic Databases

(Metric Data Models from Sections 6.1- 6.4
and Queries from Section 6.6)

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Geographic Data Abstraction

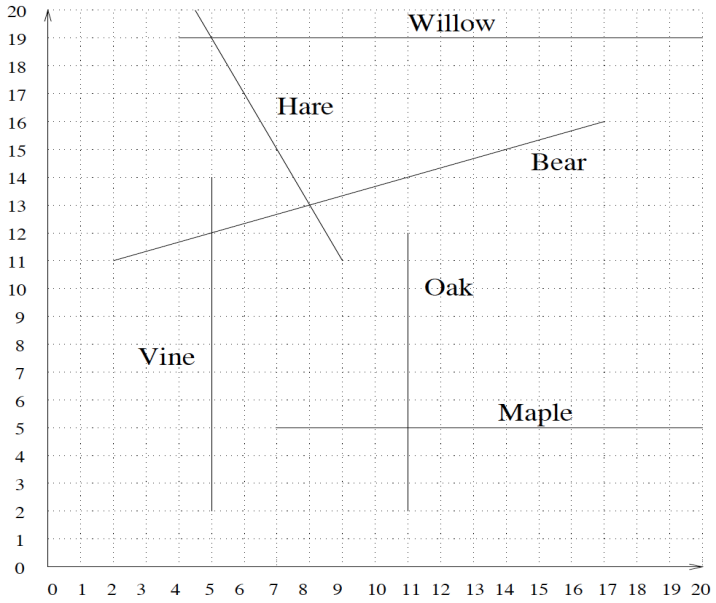
View Level: Drawing of some kind of map.

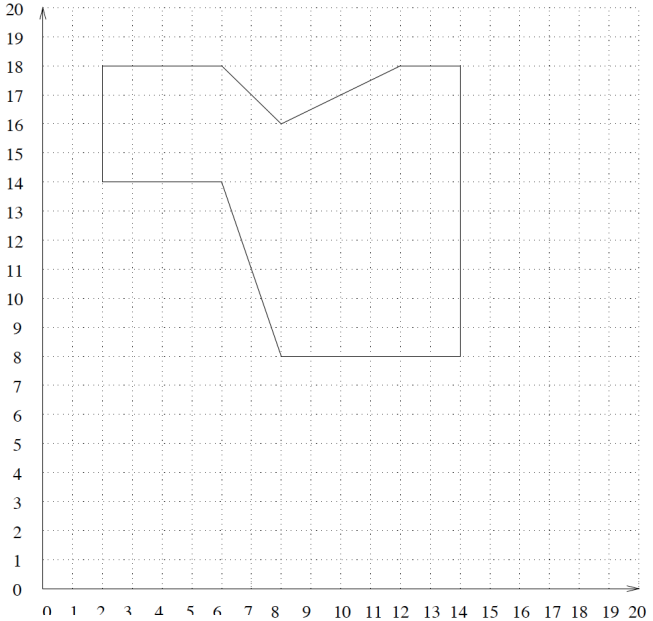
Logical Level: Infinite relational database scheme.

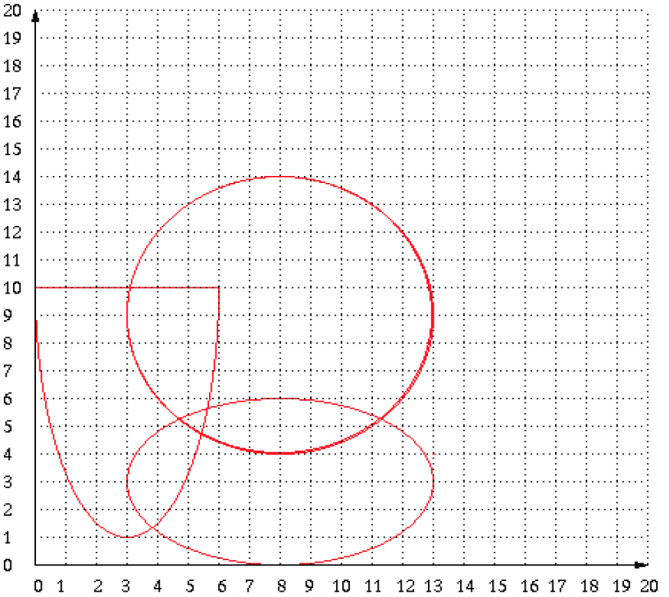
Constraint Level: Some finite representation.

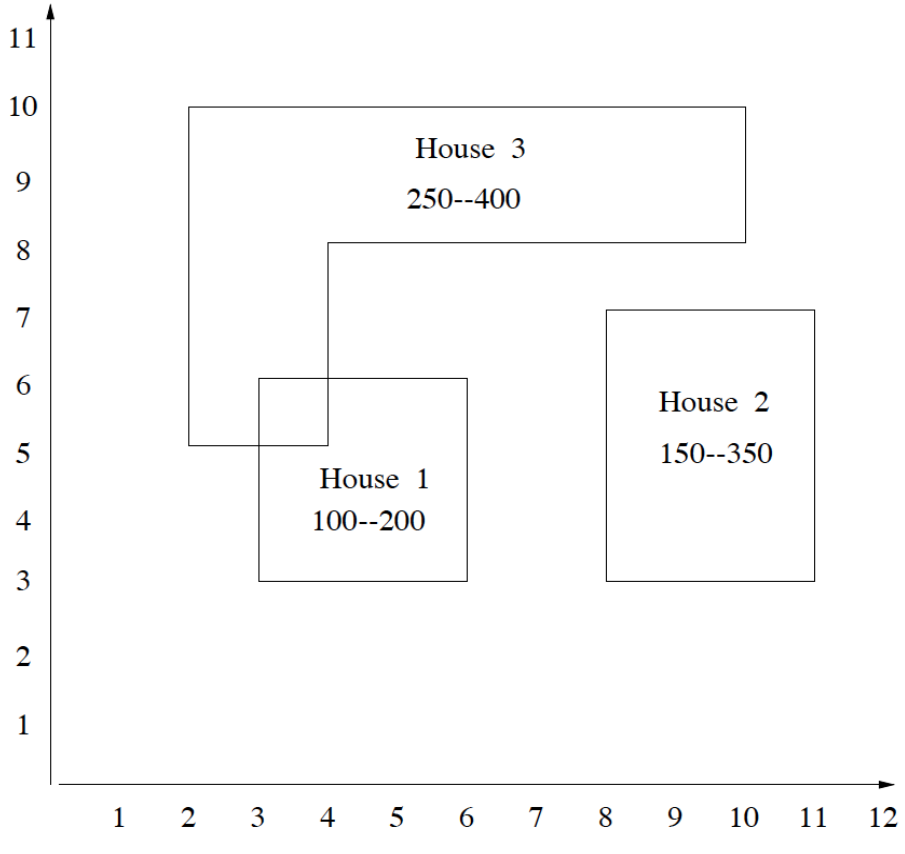
Physical Level: The way data is actually stored in a computer.

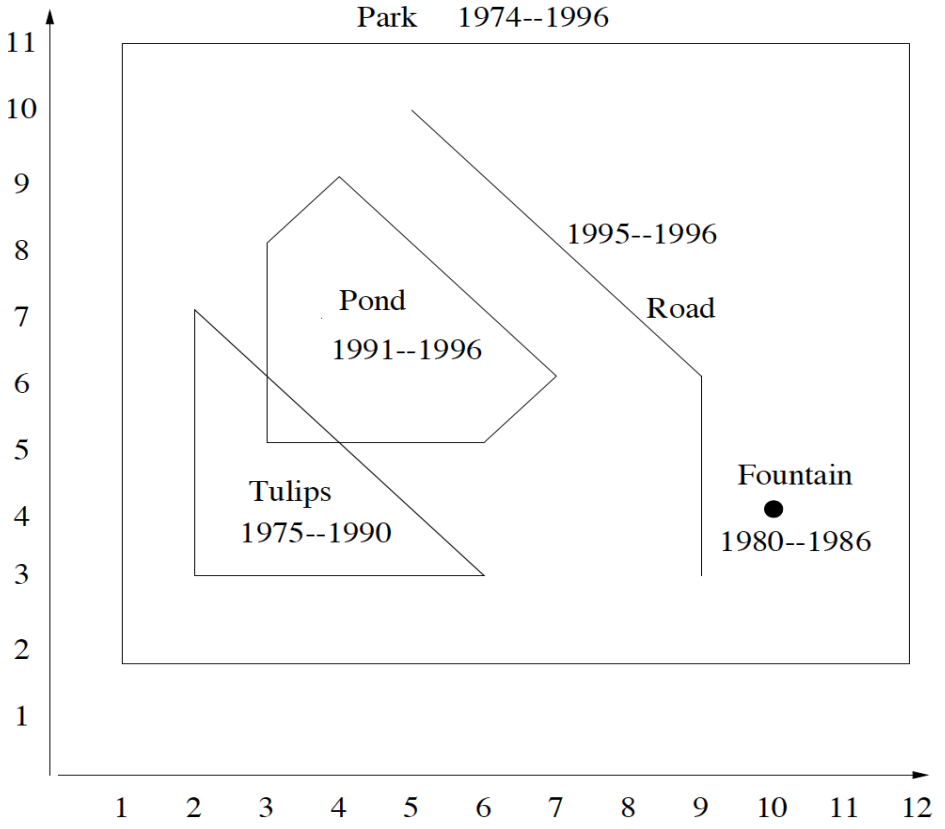
View Level: streets, town, radio broadcast areas, archaeological site, park.











Logical Level: radio broadcast areas

Broadcast

Radio	X	Y
1	8	9
⋮	⋮	⋮
2	8	3
⋮	⋮	⋮
3	3	1
⋮	⋮	⋮

Constraint Level

There are many proposals to finitely represent geographic data.

Option 1: Rectangles Data Model

House

Id	X	Y	T
1	[3, 6]	[3, 6]	[100, 200]
2	[8, 11]	[3, 7]	[150, 350]
3	[2, 4]	[5, 10]	[250, 400]
3	[2, 10]	[8, 10]	[250, 400]

Option 2: Vector Data Model

Street

Id	Type	List
Bear	polyline	[(2, 11), (17, 16)]
Hare	polyline	[(4.5, 20), (9, 11)]
Maple	polyline	[(7, 5), (20, 5)]
Oak	polyline	[(11, 2), (11, 12)]
Vine	polyline	[(5, 2), (5, 14)]
Willow	polyline	[(4, 19), (20, 19)]

Town

Id	Type	List
Lincoln	polygon	[(2, 18), (6, 18), (8, 16), (12, 18), (14, 18), (14, 8), (8, 8), (6, 14), (2, 14)]

Constraint Level

Option 3: Worboys' Data Model

Park

Id	Ax	Ay	Bx	By	Cx	Cy	From	To
Fountain	10	4	10	4	10	4	1980	1986
Road	5	10	9	6	9	6	1995	1996
Road	9	6	9	3	9	3	1995	1996
Tulip	2	3	2	7	6	3	1975	1990
Park	1	2	1	11	12	11	1974	1996
Park	12	11	12	2	1	2	1974	1996
Pond	3	5	3	8	4	9	1991	1996
Pond	4	9	7	6	3	5	1991	1996
Pond	3	5	7	6	6	5	1991	1996

Option 4: Constraint Data Model

Broadcast

Radio	X	Y	
1	x	y	$(x-8)^2+(y-9)^2 \leq 25$
2	x	y	$\frac{(x-8)^2}{5^2}+\frac{(y-3)^2}{3^2} \leq 1$
3	x	y	$(y-1) \geq (x-3)^2, y \leq 10$

Constraint Level

Comparing the expressive power of various constraint level geographic data model proposals:

Vector Data Model < Worboys' Data Model < Constraint Data Model

Rectangles Data Model < Worboys' Data Model

Question: Why?

Querying Geographic Databases

Point-based queries using the logical level and *standard SQL queries.*

Example: Find the areas where at least three park objects intersect.

```
SELECT   P1.X, P1.Y
FROM     Park AS P1, Park AS P2, Park AS P3
WHERE    P1.X = P2.X  AND  P2.X = P3.X  AND
         P1.Y = P2.Y  AND  P2.Y = P3.Y
         AND P1.Id <> P2.Id AND P1.Id <> P3.Id AND P2.Id <> P3.Id;
```

Querying Geographic Databases

Constraint level queries using SQL extended with *geographic operators.*

Example: Find the areas where at least three park objects intersect.

First we need to define *intersect* on triangles as follows.

$intersect\_\Delta 2^{\Delta}(triangle,\ 2^{triangle}) \rightarrow 2^{triangle}$: This operator returns the intersection of a triangle ADT of the Worboys' data model with a set of triangle ADTs of the Worboys' data model.

With this patch of the query language and the evaluation system, it is now convenient to express the above query as:

```
SELECT   intersect_Δ2^Δ(P1,intersect_ΔΔ(P2,P3))
FROM     Park AS P1, Park AS P2, Park AS P3
WHERE    P1.Id <> P2.Id AND P1.Id <> P3.Id AND P2.Id <> P3.Id;
```

where $\overline{Pi} = Pi.Ax, Pi.Ay, Pi.Bx, Pi.By, Pi.Cx, Pi.Cy$ for $1 \leq i \leq 3$.