

Bases de Dados Espaciais

Joana Simões

February 17, 2013

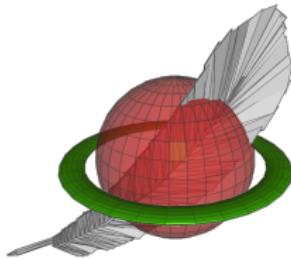


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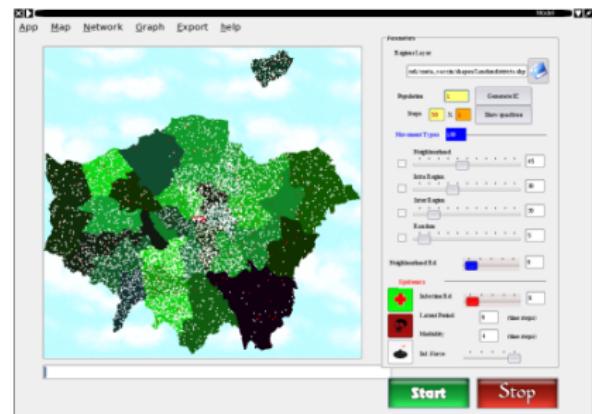
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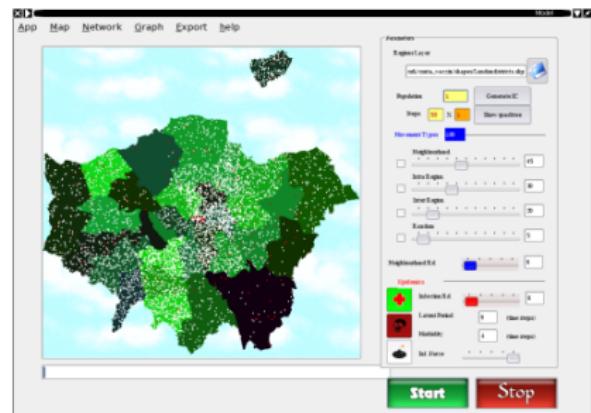
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- PhD CASA, UCL: "An Agent-based Approach to Epidemics through GIS"



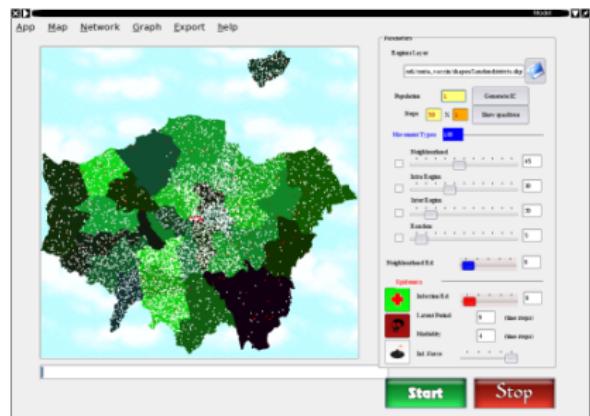
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- + 2 anos na FAO-UN, como consultora de diversos aspectos relacionados com Software (programacao, Bases de Dados e SIG)



Conceitos Gerais de Base de Dados
Base de Dados Espaciais
Um Exemplo
NoSQL
+
Licenca

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- Pretexto para reunir pessoas com interesse nesta area (“social networking”)

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O que este Talk nao e...

O que este Talk nao e...

- Nao e uma introducao ao SQL

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- Nao e um tutorial de SpatiaLite

O que sao Bases de Dados...?



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O que sao Bases de Dados...? (+)



O que sao Bases de Dados...? (+)

- As BD tratam de organizar a informacao;



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- As BD tratam de organizar a informacao;
- Exemplos de BD: arquivo de uma biblioteca, folha de calculo ou ficheiro de texto;



O que sao Bases de Dados...? (+)



O que sao Bases de Dados...? (+)

Os computadores/Internet geram um volume de dados muito grande e necessitamos de ferramentas adequadas para tirar partido deles.



BD Relacionais

O modelo relacional foi formulado por Edgar F. Codd (1969/1970?).

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- As tabelas tipicamente apresentam **chaves** - uma ou mais colunas que identificam unicamente essa linha dentro da tabela.

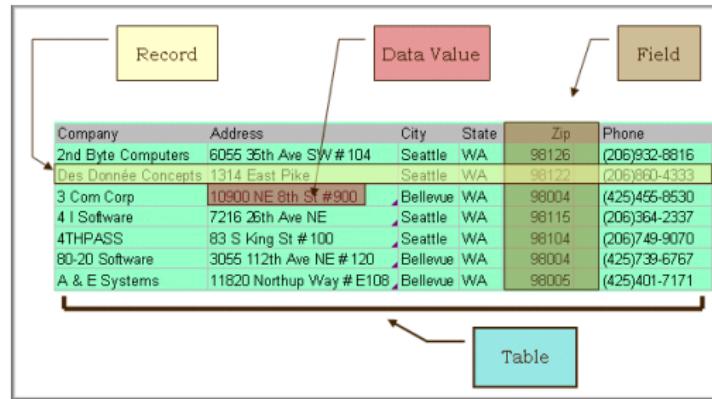
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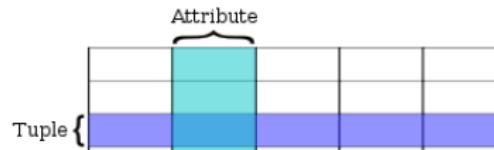
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- Para tornar o acesso a tabela mais rápido, é definido um **índice**. Um índice possibilita buscas rápidas na tabela,

BD Relacionais (+)

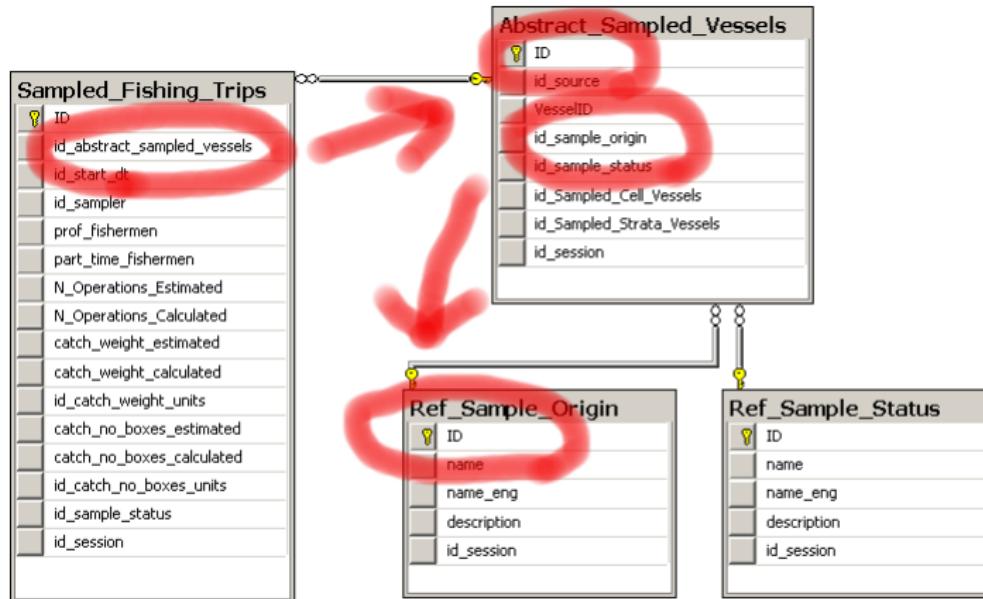


Relacao: conjunto de registos com os mesmos atributos (i.e.: mesmo dominio).



BD Relacionais (+)

Relacoes entre tabelas:



BD Relacionais (+)

O objectivo do modelo relacional é possibilitar um método declarativo para especificar dados e *queries*.

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- ① Os utilizadores declaram que informação contém a BD e que informação querem extraír dela.

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O objectivo do modelo relacional é possibilitar um método declarativo para especificar dados e *queries*.

- ① Os utilizadores declaram que informação contém a BD e que informação querem extraír dela.
- ② O software encarrega-se de descrever as estruturas de dados para armazenamento e os procedimentos de recuperação dos dados para responder às *queries*.

SQL

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- Embora nao subscreva a 100% o modelo proposto por Todd (1970) tornou-se a linguagem de BD mais utilizada.

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- Linguagem estruturada de pesquisa (**Structured Query Language**).
- Embora nao subscreva a 100% o modelo proposto por Todd (1970) tornou-se a linguagem de BD mais utilizada.
- Originalmente baseada na algebra relacional, foi extendendo o seu ambito (e.g.: insercao de dados, pesquisa, actualizacao, remocao, etc)

SQL (+)

```
SELECT * FROM STUDENTS WHERE YR 2012;  
SELECT (1+1);  
ALTER TABLE MyTable ADD myField4 NUMBER(3);  
DROP DATABASE MYDB;
```

SQL (+)

```

SELECT Ref_Vessels.Name
FROM      dbo.FR_ALS2Vessel INNER JOIN
dbo.Ref_Vessels ON dbo.FR_ALS2Vessel.vesselID = dbo.Ref_Vessels.VesselID
WHERE     (dbo.FR_ALS2Vessel.id_sub_frame =
(SELECT   ID
FROM      dbo.FR_Sub_Frame
WHERE    (Type =
(SELECT   ID
FROM      dbo.Ref_Frame
WHERE    (Name = 'root'))) AND (id_frame = 8)))
AND (dbo.FR_ALS2Vessel.id_abstract_landingsite =
(SELECT   id_abstract_LandingSite
FROM      dbo.Sampled_Cell
WHERE    (ID = 53)))
AND (dbo.FR_ALS2Vessel.vesselID NOT IN
(SELECT   VesselID
FROM      dbo.Changes_Temp_Vessel
WHERE    (id_cell = 53) AND (To_LS =
(SELECT   ID
FROM      dbo.Ref_Abstract_LandingSite
WHERE    (Name = 'outside')))))
UNION
SELECT Ref_Vessels.Name
FROM      dbo.FR_ALS2Vessel INNER JOIN
dbo.Ref_Vessels ON dbo.FR_ALS2Vessel.vesselID = dbo.Ref_Vessels.VesselID
WHERE     (dbo.Ref_Vessels.VesselID IN
(SELECT   VesselID
FROM      dbo.Changes_Temp_Vessel
WHERE    (id_cell = 53) AND (To_LS =
(SELECT   ID
FROM      dbo.Ref_Abstract_LandingSite
WHERE    (Name = 'inside')))))

```

SGBD

Um **Sistema de Gestao De Base de Dados** e o software que controla o armazenamento, recuperacao, remocao, seguranca e integridade dos dados dentro da BD.

Algumas vantagens dos SGBDR:

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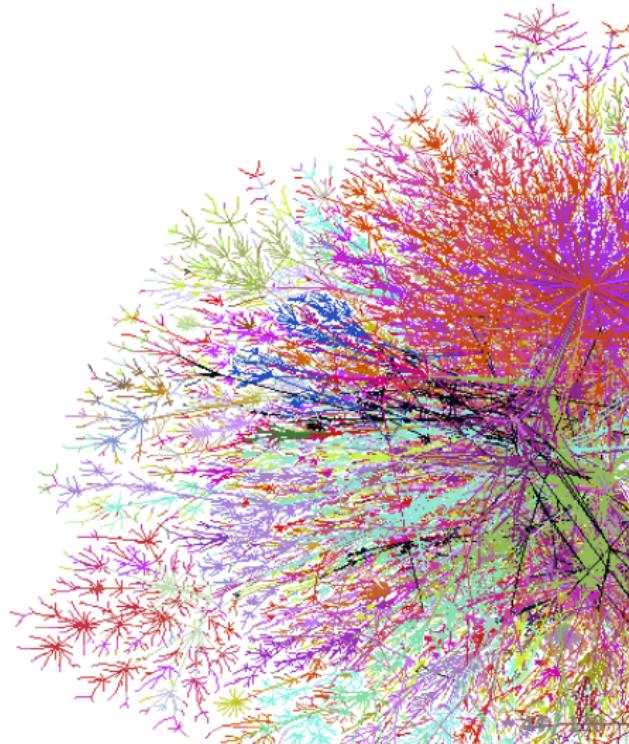
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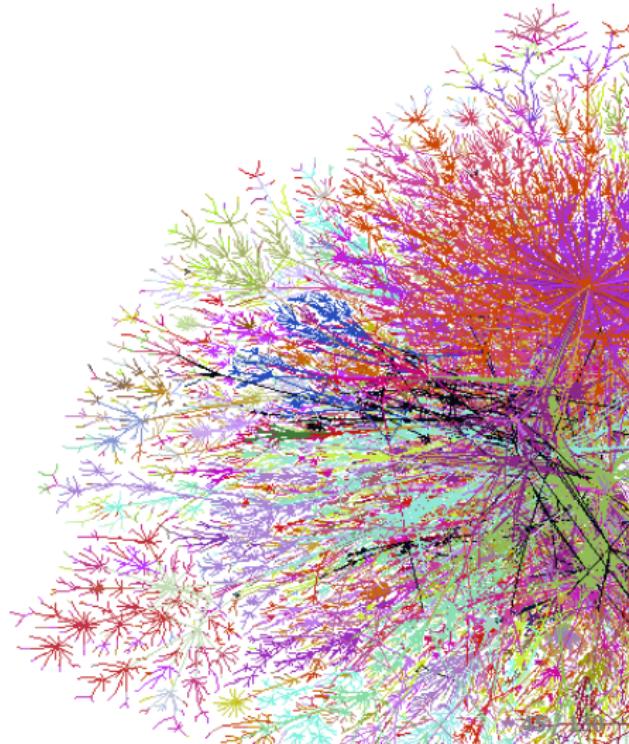
O que sao as BD Espaciais

- Se as BD sao um conjunto integrado de informacao sobre um determinado tema, as BD espaciais contem dados **espaciais**, sobre um determinado tema e numa determinada **dimensao espacial**.



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- BD espaciais != BD Geograficas



BD e SIG

Historicamente os SIG sempre incluiram BD (modelos de dados).

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- A primeira geracao de SIG tinha representacoes de dados em sistemas simples de ficheiros (e.g.: Shapefile).

ObjectID	FIPS_CTRY	GMI_CTRY	ISO_2DIGIT	ISO_3DIGIT	CNTRY_NAME	LONG_NAME	Sovereign	POP_CTRY	CURR_TYPE	CURR_CODE	LAI
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1	MG	MNG	MN	MNG	Mongolia	Mongolia	Mongolia	228222	Tugrik	MNT	Y
2	US	USA	US	USA	United States	United States	United States	258833000	US Dollar	USD	N
3	KN	PRK	KP	PRK	North Korea	Korea, Democr...	North Korea	22034990	Won	KPW	N
4	JA	JPN	JP	JPN	Japan	Japan	Japan	125746300	Yen	JPY	N
5	CH	CHN	CN	CHN	China	China	China	1281396894	Renminbi Yuan	CNY	N
6	ID	IDN	ID	IDN	Indonesia	Indonesia	Indonesia	18847200	Rupiah	IDR	N
7	BR	BRA	BR	BRA	Brazil	Brazil	Brazil	151525400	Cruzeno Real	BRL	N
8	PE	PER	PE	PER	Peru	Peru	Peru	24496400	Nuevo Sol	PEN	N
9	TL	TKL	TK	TKL	Tokelau	Tokelau	New Zealand	1600	NZ Dollar	NZD	N
10	BL	BOL	BO	BOL	Bolivia	Bolivia	Bolivia	7648315	Boliviano	BOB	Y
11	WS	WSM	WS	WSM	Samoas	Samoas	Samoas	159000	Tala	WST	N
12	WF	WLF	WF	WLF	Wallis & Futuna	Wallis & Futuna	France	14000	Euro	EUR	N
13	AQ	ASM	AS	ASM	American Samoa	American Samoa	United States	53000	US Dollar	USD	N
14	SH	SHN	SH	SHN	St. Helena	St. Helena	United Kingdom	6782	Pound	SHP	N
15	PF	PYF	PF	PYF	French Polynesia	French Polynesia	France	217000	Euro	EUR	N
16	NE	NIU	NU	NIU	Niue	Niue	New Zealand	2000	NZ Dollar	NZD	N
17	PA	PY	PY	PY	Paraguay	Paraguay	Paraguay	4773464	Guarani	PYG	Y
18	TN	TON	TO	TON	Tonga	Tonga	Tonga	98000	Pa'anga	TOP	N
19	CW	COK	CK	COK	Cook Is.	Cook Islands	New Zealand	17000	NZ Dollar	NZD	N
20	AR	ARG	AR	ARG	Argentina	Argentina	Argentina	33796870	Peso	ARP	N
21	PC	PCN	PN	PCN	Pitcairn Is.	Pitcairn Island	United Kingdom	56	NZ Dollar	NZD	N
22	UY	URY	UY	URY	Uruguay	Uruguay	Uruguay	3084461	Peso	UYU	N
23	NZ	NZL	NZ	NZL	New Zealand	New Zealand	New Zealand	3528197	NZ Dollar	NZD	N
24	FK	FLK	FK	FLK	Falkland Is.	Falkland Islands	United Kingdom	2136	Pound	FKP	N
25	SK	SGS	GS	SGS	South Georgia ...	South Georgia...	United Kingdom	-99999	NULL	NCIC	N
26	CI	CHL	CL	CHL	Chile	Chile	Chile	13772710	Peso	CLP	N
27	AV	ATA	AQ	ATA	Antarctica	Antarctica	Antarctica	-99999	NULL	NCIC	N
28	GA	CAN	CA	CAN	Canada	Canada	Canada	28402320	Dollar	CAD	N

BD e SIG (+)

- Com a generalizacao dos SGBDR, algumas casas de SIG (e.g.: ESRI, Mapinfo) começaram a desenvolver produtos de *middleware*, que usavam os SGBDR como repositórios de dados (segunda geração).

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- A terceira geração de SIG nasce da motivação de aproveitar a 100% as capacidades dos SGBDR e de criar uma certa independência de APIs proprietárias. Isto foi alcançado *movendo* a gestão primária dos dados para a BD e *expandido* a sintaxe do SQL.

SGBD com Extensao Espacial

Uma BD espacial é uma BD que *compreende* informação espacial, em adição a outros tipos de informação (número, texto, binário, etc). Podemos considerá-la como uma *extensão* de uma BD *tradicional*, adicionando a capacidade de armazenamento de *features* geométricas (e.g.: pontos, linhas, polígonos) e uma série de operações que podemos processar sobre estas *features* (e.g.: *buffering*, interseção). De facto muitas BD espaciais são distribuídas como extensões de BD relacionais existentes.

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- PostGIS *extende* o PostgreSQL;
- MySQL Spatial *extende* o MySQL;
- SQL Spatial *extende* o SQL Server;
- Oracle Spatial *extende* o Oracle;
- Spatialite *extende* o SQLite;
- ...

Pesquisas Espaciais

Indices Espaciais sao indices que optimizam as pesquisas espaciais (e.g.: Quadtree). O **Open Geospatial Consortium** (OGC) suporta os seguintes tipos de pesquisas espaciais:

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- **Funcoes de Observacao**: pesquisas que retornam

Porque usar SGBD com extensoes Espaciais?

Apresentam todas as vantagens de um SGBD *tradicional*:

Porque usar SGBD com extensoes Espaciais?

Apresentam todas as vantagens de um SGBD *tradicional*:

- Eficiencia de armazenamento;
- Funcionalidade de pesquisa;
- acesso concorrente;
- modelo de segurança;
- ...

Porque usar SGBD com extensoes Espaciais? (+)

Hoje em dia a maior parte dos software de SIG interagem directamente com as BD espaciais.

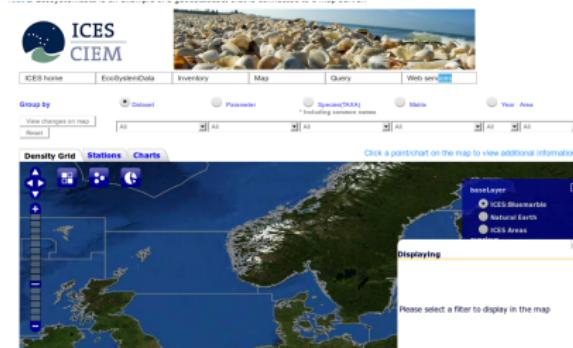


Figure: O website interactivo do ICES usa uma BD espacial.

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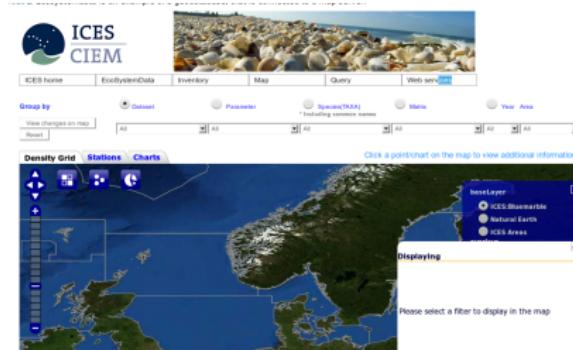
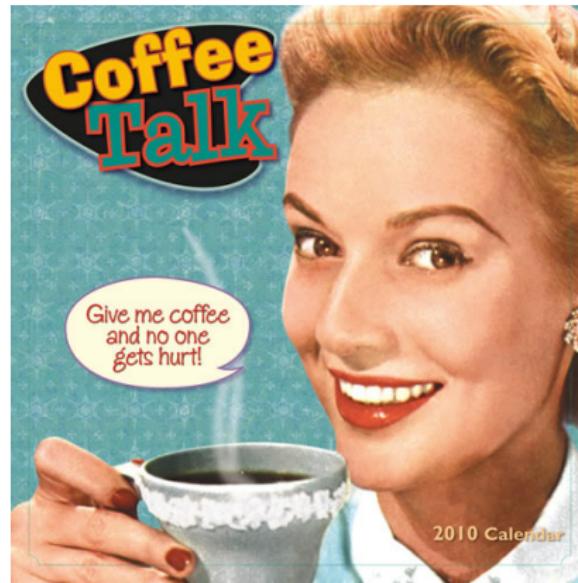


Figure: O website interactivo do ICES usa uma BD espacial.

- Nao ha nenhum motivo para nao utilizar os SGBD com extensoes espaciais como sistema de armazenamento e gestao

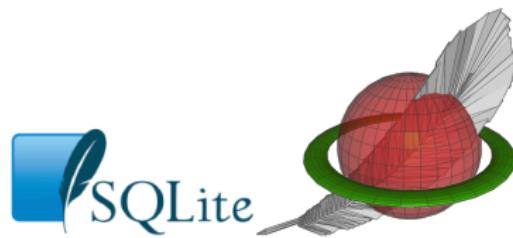
BREAK?



SQLite e SpatiaLite

SpatiaLite é a extensão espacial do **SQLite**.

O SQLite é o *engine* de BD mais utilizado no mundo. O código está no domínio público.



SQLite e SpatiaLite

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- sem configuração;
- transacional;



Libspatialite

O Spatialite é uma biblioteca *livre e de código aberto*, simples, e leve.

Algumas vantagens:

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- Implementação standard de SQL (quase completa SQL-92).
- Modelo de três licenças (uma para cada gosto!).

FOSS

A definição de Software livre foi publicada pela *Free Software Foundation* (FSF) em 1985, como sendo software que respeita quatro liberdades fundamentais:



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- **ReadOSM:** biblioteca para extrair dados do formato OpenStreet Map;

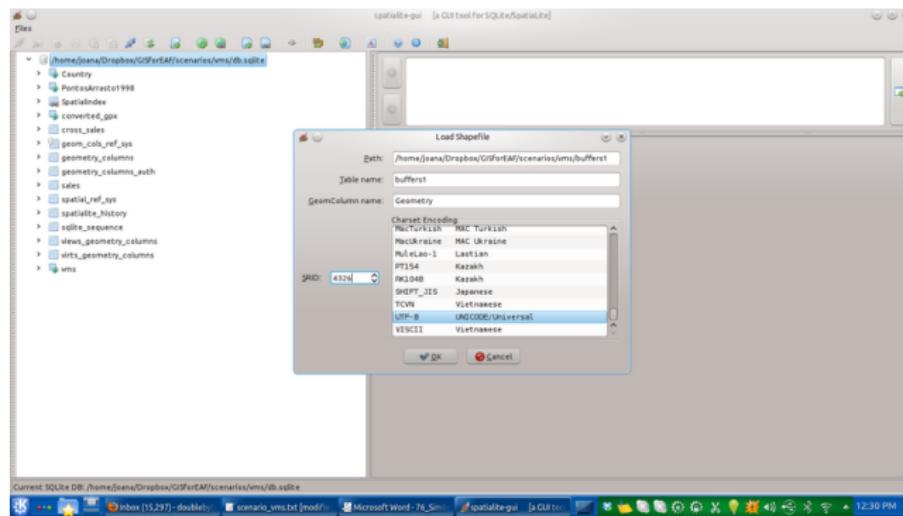
Spatial Is Not Special

O SpatiaLite é um dos projectos Gaia-SINS

- **ReadOSM:** biblioteca para extrair dados do formato OpenStreet Map;
- **Spatialite-tools:** coleccao de ferramentas de linha de comando (CLI) que suportam o SpatiaLite (e.g.:cliente, import/export)

Spatial Is Not Special (+)

- **Spatialite-gui:** interface grafico para utilizar o Spatialite;



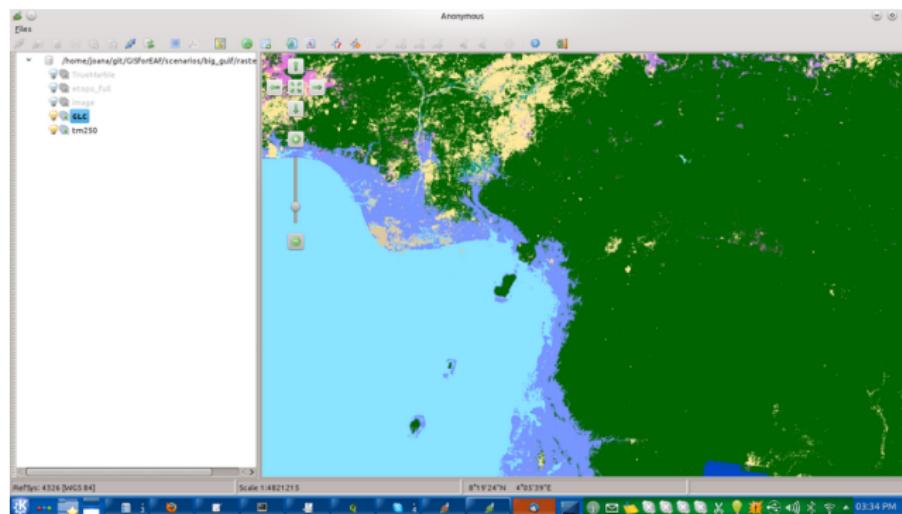
Spatial Is Not Special (+)

- **Librasterlite:** biblioteca que extende o suporte do SpatiaLite a dados Raster;



Spatial Is Not Special (+)

- **Spatialite-gis:** SIG minimal, construido sobre o SpatiaLite e o RasterLite;



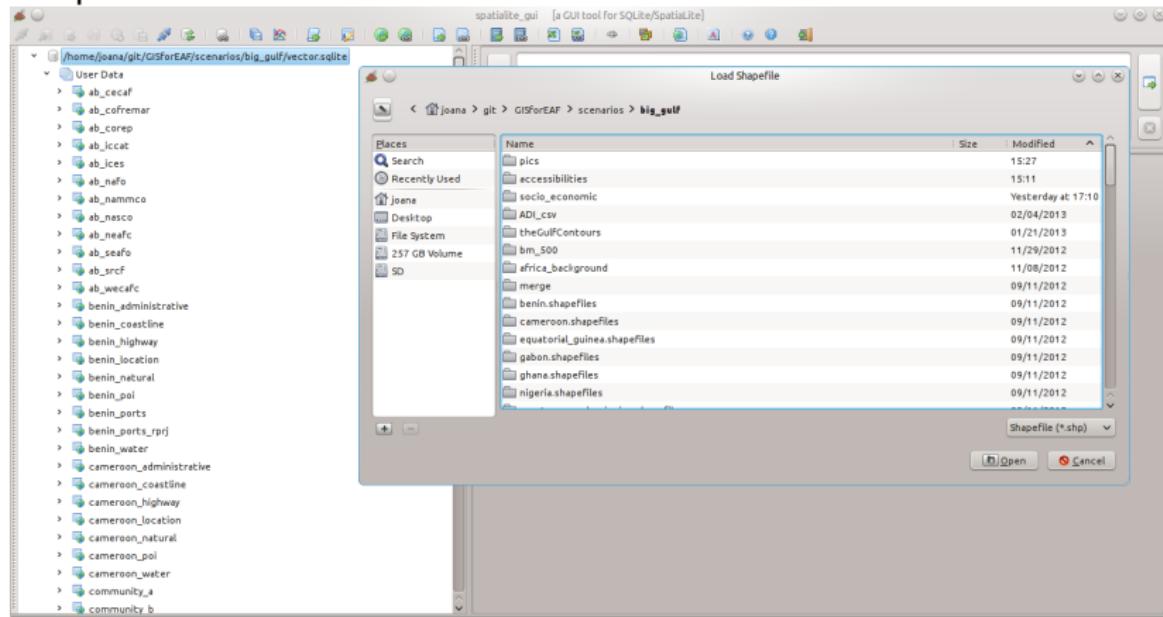
Solucionando um problema Geografico

Use Case: Temos uma serie de portos de pesca, na area do Benin, e uma serie de mercados, onde potencialmente se podem vender as capturas. O nosso objectivo é calcular uma matriz de distancias, para saber que mercados distam mais proximos de cada porto. Os portos e os mercados estão armazenados em Shapefiles (WGS84).



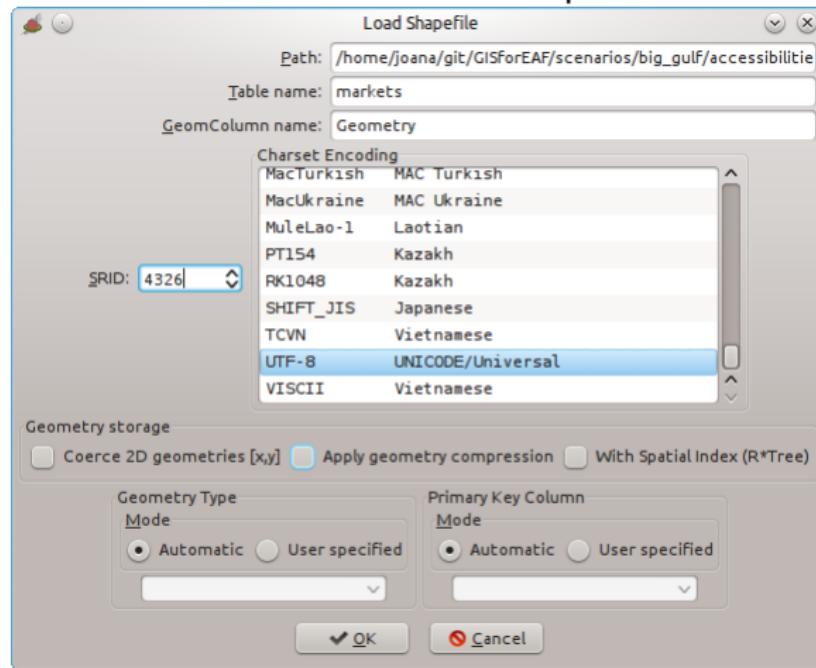
Importar as Shapefiles

O Spatialite_gui tem um interface amigavel para importar Shapefiles.



Importar as Shapefiles (+)

A definicao do SRID e muito importante.



Analise do Problema

Podiamos calcular as distancias em graus, mas e mais relevante faze-lo num sistema com unidades lineares (e.g.: *metros*).

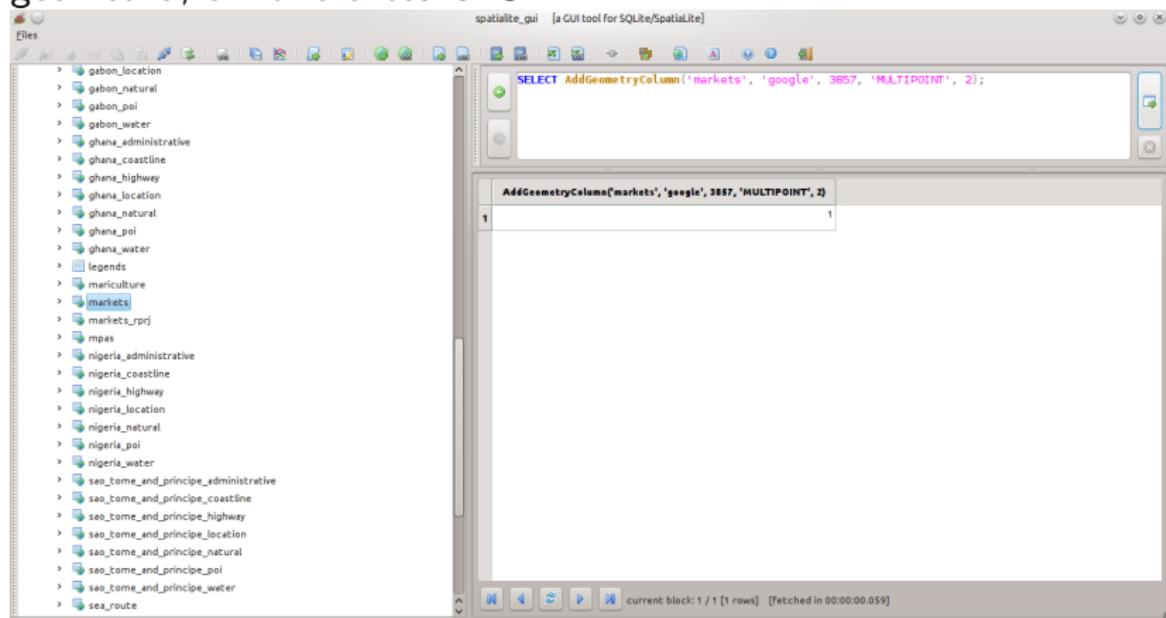
Analise do Problema

Podiamos calcular as distancias em graus, mas e mais relevante faze-lo num sistema com unidades lineares (e.g.: *metros*).

Como faze-lo sem reprojectar o layer?

Adicionar uma Coluna Geometrica

Nao ha nada que nos impeca de ter duas colunas contendo geometria, em diferentes CRS!



The screenshot shows the spatialite_gui application window. On the left, there is a tree view of tables from a SQLite database:

- gabon_location
- gabon_natural
- gabon_pol
- gabon_water
- ghana_administrative
- ghana_coastline
- ghana_highway
- ghana_location
- ghana_natural
- ghana_pol
- ghana_water
- legends
- mariculture
- markets
- markets_rprj
- mpas
- nigeria_administrative
- nigeria_coastline
- nigeria_highway
- nigeria_location
- nigeria_natural
- nigeria_pol
- nigeria_water
- seo_tome_and_principe_administrative
- seo_tome_and_principe_coastline
- seo_tome_and_principe_highway
- seo_tome_and_principe_location
- seo_tome_and_principe_natural
- seo_tome_and_principe_pol
- seo_tome_and_principe_water
- sea_route

In the center, there is a SQL query window with the following code:

```
SELECT AddGeometryColumn('markets', 'google', 3857, 'MULTIPOINT', 2);
```

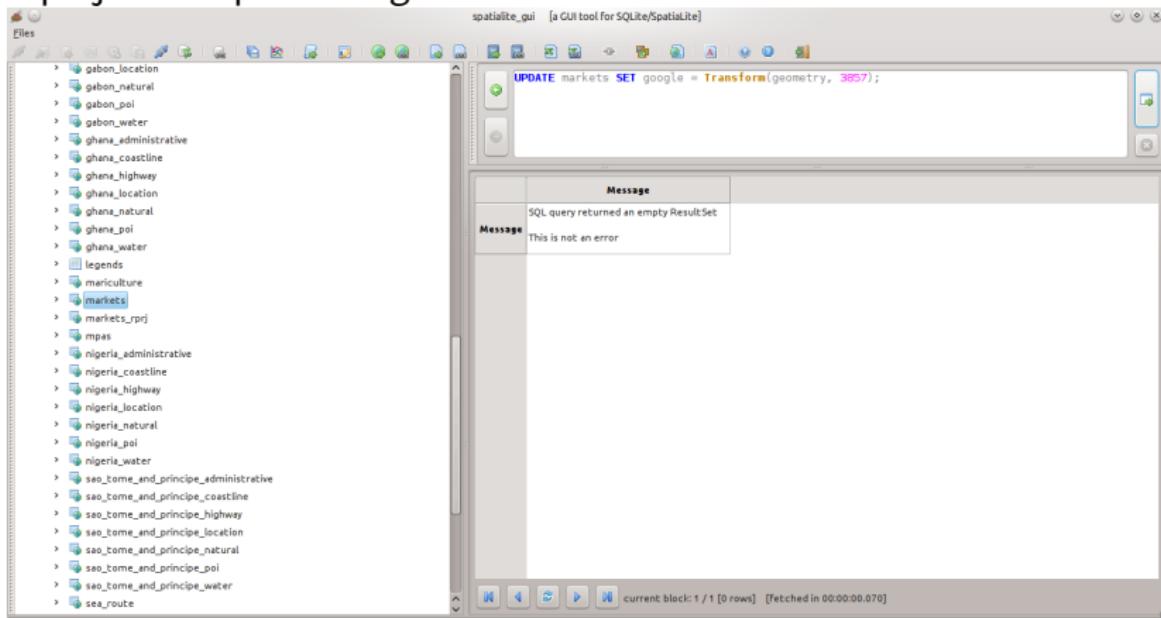
Below the query window, a results table shows the output of the command:

AddGeometryColumn('markets', 'google', 3857, 'MULTIPOINT', 2)
1

At the bottom of the window, status information is displayed: "current block: 1 / 1 [1 rows] [fetched in 00:00:00.059]".

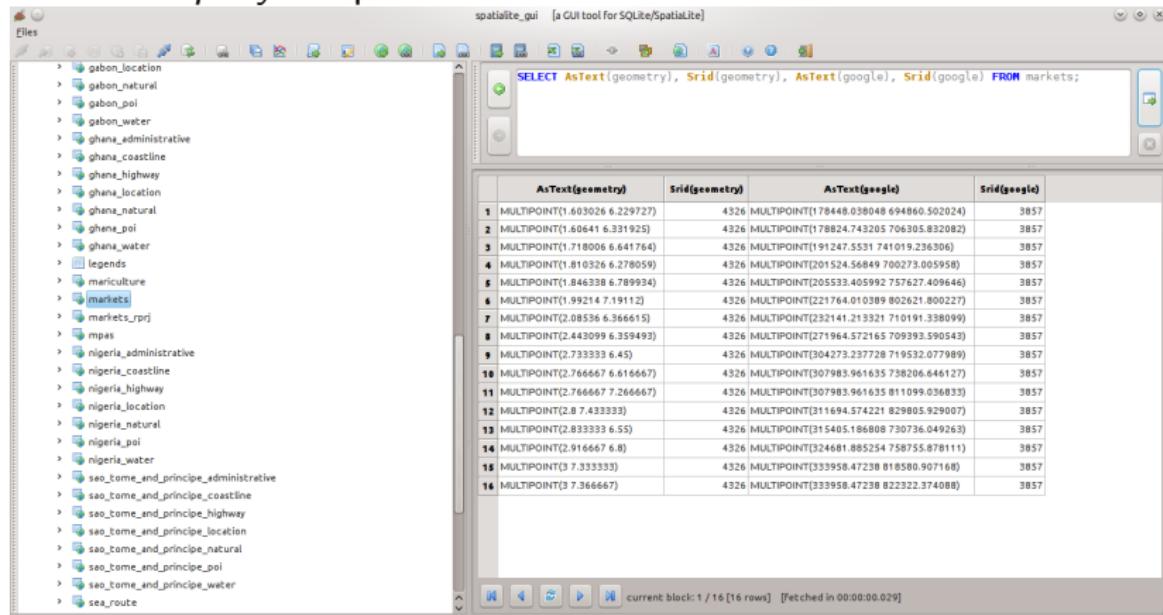
Clonar a Geometria

Ao mesmo tempo que *clonamos* a geometria, podemos reprojecta-la para *Google Mercator*.



Confirmar o Resultado

Podemos confirmar o SRID e a definicao da geometria em texto, com uma *query* simples.



The screenshot shows the spatialite_gui application interface. On the left is a tree view of database tables: gabon_location, gabon_natural, gabon_pol, gabon_water, ghana_administrative, ghana_coastline, ghana_highway, ghana_location, ghana_natural, ghana_pol, ghana_water, legends, mariculture, markets, markets_prj, mpas, nigeria_administrative, nigeria_coastline, nigeria_highway, nigeria_location, nigeria_natural, nigeria_pol, nigeria_water, seo_tome_and_principe_administrative, seo_tome_and_principe_coastline, seo_tome_and_principe_highway, seo_tome_and_principe_location, seo_tome_and_principe_natural, seo_tome_and_principe_pol, seo_tome_and_principe_water, and sea_route. The main window contains a SQL query editor with the following text:

```
SELECT AsText(geometry), Srid(geometry), AsText(google), Srid(google) FROM markets;
```

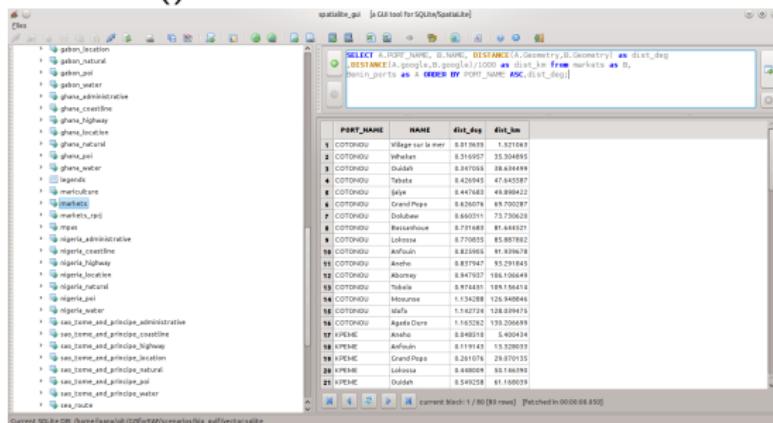
Below the query editor is a results table with four columns: AsText(geometry), Srid(geometry), AsText(google), and Srid(google). The table displays 16 rows of data, each corresponding to a market location. The data is as follows:

	AsText(geometry)	Srid(geometry)	AsText(google)	Srid(google)
1	MULTIPOINT(1.603026 6.229927)	4326	MULTIPOINT(178448.038048 694860.502024)	3857
2	MULTIPOINT(1.60441 6.331925)	4326	MULTIPOINT(178824.743205 706305.832082)	3857
3	MULTIPOINT(1.718006 6.641764)	4326	MULTIPOINT(191247.5531 741019.236306)	3857
4	MULTIPOINT(1.810326 6.278059)	4326	MULTIPOINT(201524.56849 700273.005958)	3857
5	MULTIPOINT(1.846338 6.789934)	4326	MULTIPOINT(205333.405992 757627.409646)	3857
6	MULTIPOINT(1.99214 7.19112)	4326	MULTIPOINT(221764.010389 802621.800227)	3857
7	MULTIPOINT(2.08536 6.366615)	4326	MULTIPOINT(232141.213321 710191.338099)	3857
8	MULTIPOINT(2.443099 6.359493)	4326	MULTIPOINT(271964.572165 709393.590543)	3857
9	MULTIPOINT(2.733333 6.45)	4326	MULTIPOINT(304273.237728 719532.077989)	3857
10	MULTIPOINT(2.766667 6.616667)	4326	MULTIPOINT(307983.961635 738206.646127)	3857
11	MULTIPOINT(2.766667 7.266667)	4326	MULTIPOINT(307983.961631 81109.036833)	3857
12	MULTIPOINT(2.8 7.433333)	4326	MULTIPOINT(311694.57421 829805.929007)	3857
13	MULTIPOINT(2.833333 6.55)	4326	MULTIPOINT(315405.186808 730736.049263)	3857
14	MULTIPOINT(2.916667 7.8)	4326	MULTIPOINT(324681.885254 758755.878111)	3857
15	MULTIPOINT(3 7.333333)	4326	MULTIPOINT(333958.47238 810580.907168)	3857
16	MULTIPOINT(3 7.366667)	4326	MULTIPOINT(333958.47238 822322.374088)	3857

At the bottom of the results table, it says "current block: 1 / 16 [16 rows] [fetched in 0:00:00.029]".

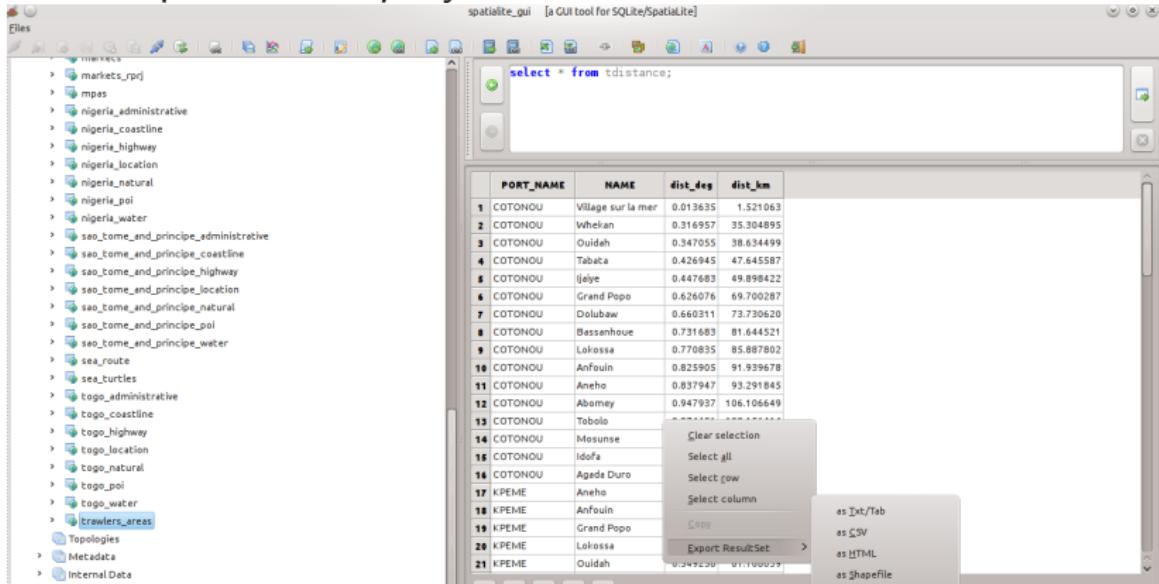
Criando a Matriz de Distâncias

Depois de criar a coluna com a geometria reprojectada nos dois layers, podemos proceder ao calculo das distancias lineares. A matriz de distancias e criada com uma *query* que usa a funcao Distance().



Guardar os resultados

Para tornar os resultados permanentes, podemos exportá-los para um ficheiro de texto (.csv); ou ainda criar uma *View* ou uma tabela a partir desta *query*.

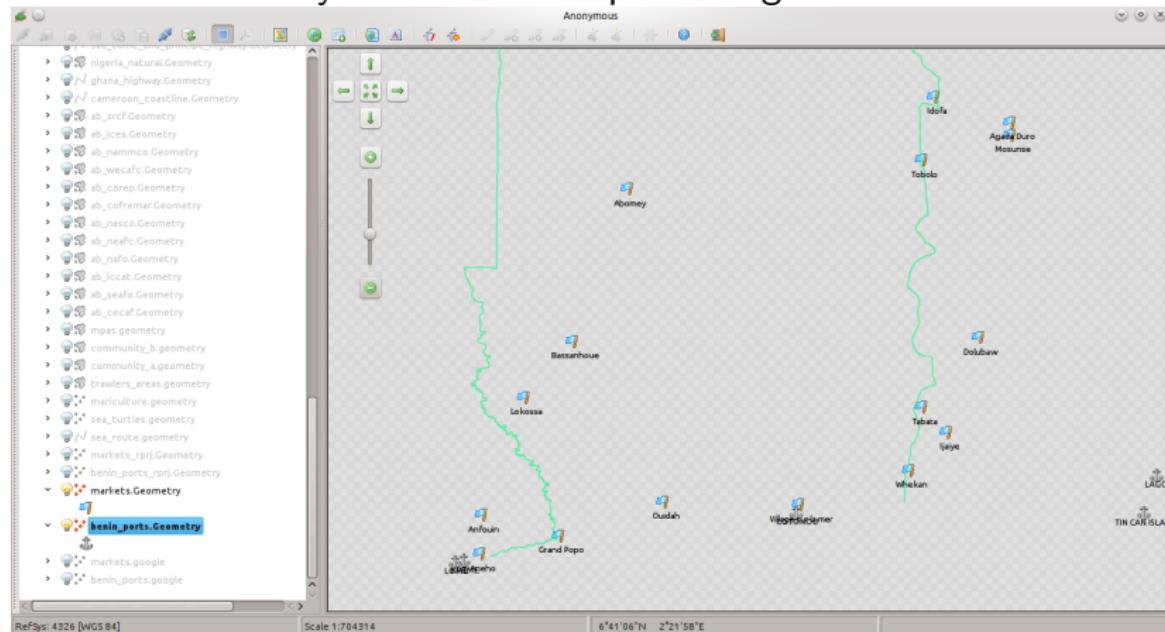


The screenshot shows the spatialite_gui application interface. On the left, there is a tree view of the database schema, listing various tables and spatial objects such as 'markets_rpd', 'mpas', 'nigeria_administrative', etc. In the center, a query window displays the SQL command: 'select * from tdistance;'. To the right, the results of this query are shown in a table with columns: PORT_NAME, NAME, dist_deg, and dist_km. The results list several locations in Cotonou, Togo, and Kpeme, along with their distances. A context menu is open over the last row of the table, with options like 'Clear selection', 'Select all', 'Select row', 'Select column', 'Copy', and 'Export ResultSet'.

	PORT_NAME	NAME	dist_deg	dist_km
1	COTONOU	Village sur la mer	0.013635	1.521063
2	COTONOU	Vrehien	0.316957	35.304893
3	COTONOU	Ouidah	0.347055	38.634499
4	COTONOU	Tabata	0.426945	47.645587
5	COTONOU	Ijeye	0.447683	49.989422
6	COTONOU	Grand Popo	0.626076	69.700287
7	COTONOU	Dolubaw	0.660311	73.730620
8	COTONOU	Bassanhoue	0.731683	81.644521
9	COTONOU	Lokossa	0.770855	85.887802
10	COTONOU	Anfoulin	0.825905	91.939678
11	COTONOU	Aneho	0.837947	93.291845
12	COTONOU	Abomey	0.947937	106.106649
13	COTONOU	Tobolo		
14	COTONOU	Mosunse		
15	COTONOU	Idofa		
16	COTONOU	Agada Duro		
17	KPEME	Aneho		
18	KPEME	Anfoulin		
19	KPEME	Grand Popo		
20	KPEME	Lokossa		
21	KPEME	Ouidah		

Layers no Spatialite_gis

Visualizando os layers criados no Spatialite_gis.



NoSQL



NoSQL



O modelo relacional é um *top-down approach*, que se baseia em ideias fortes sobre os dados (*schema*). A realidade muitas vezes é outra...

NoSQL (+)

No modelo NoSQL a **habilidade de armazenar e recuperar grandes quantidades de dados e mais importante do que as relacoes entre os elementos.** Algumas vantagens:

NoSQL (+)

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- Adaptam-se bem ao modelo orientado para o objecto (e.g.: trees).
- São desenhados como sistemas distribuídos, e por isso crescem muito bem.
- Suportam a replicação de dados, para assegurar a disponibilidade e a recuperação em caso de desastre.



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