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Making Postgres Central in Your Data Center

Bruce Momjian

This talk explores why Postgres is uniquely capable of functioning as a central database in enterprises. *Title concept from Josh Berkus*

 http://momjian.us/presentations

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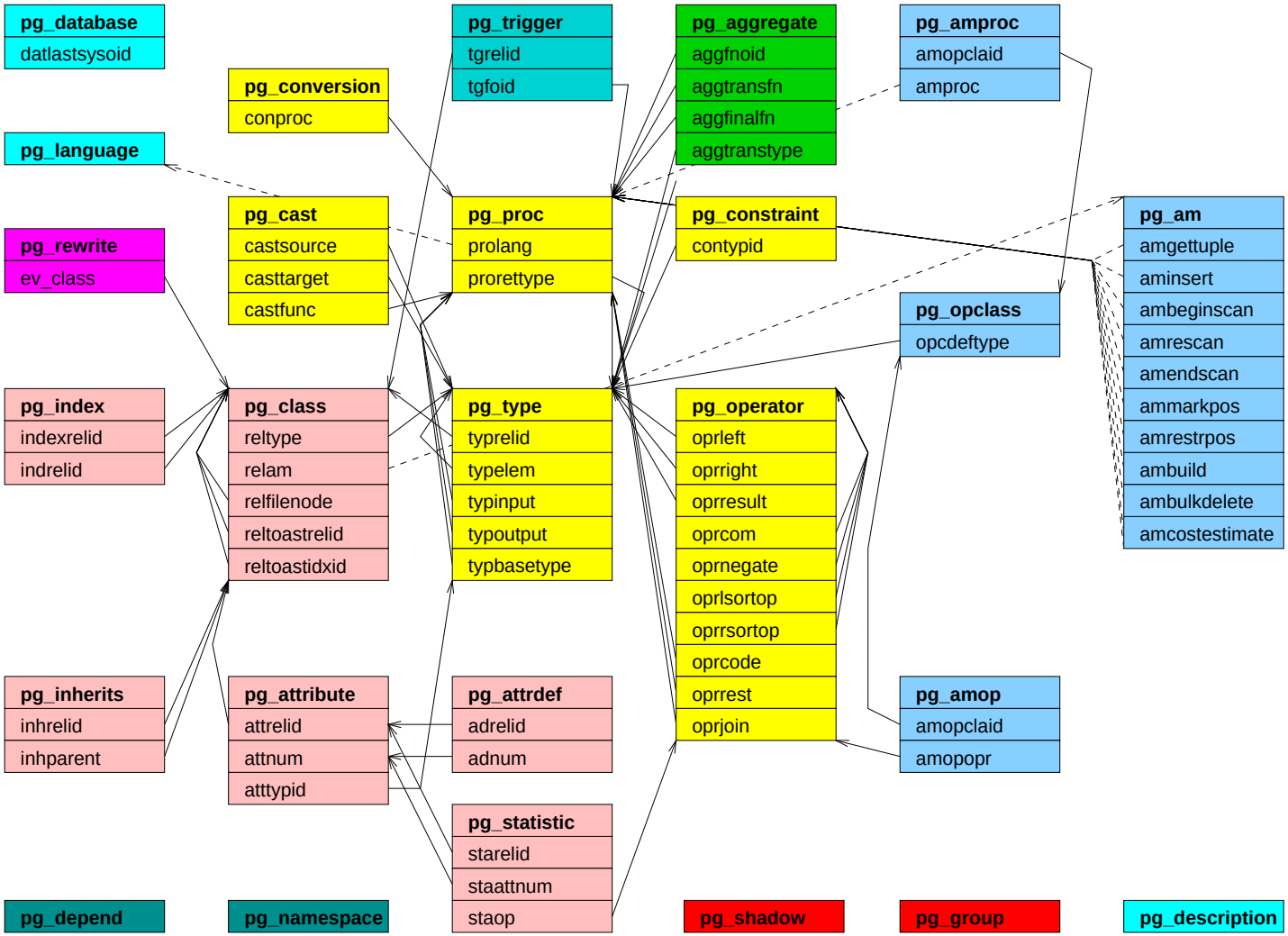
Outline

1. Object-relational (extensibility)
2. NoSQL
3. Data analytics
4. Foreign data wrappers (database federation)
5. Central role

1. Object-Relational (Extensibility)

Object-relational databases like Postgres support support classes and inheritance, but most importantly, they define database functionality as objects that can be easily manipulated.
http://en.wikipedia.org/wiki/Object-relational_database

How Is this Accomplished?



http://www.postgresql.org/docs/current/static/catalogs.html

Example: ISBN Data Type

```
CREATE EXTENSION isn;

\dT
                          List of data types
 Schema |  Name   |                      Description
--------+---------+-----------------------------------------------
 public | ean13   | International European Article Number (EAN13)
 public | isbn    | International Standard Book Number (ISBN)
 public | isbn13  | International Standard Book Number 13 (ISBN13)
 public | ismn    | International Standard Music Number (ISMN)
 public | ismn13  | International Standard Music Number 13 (ISMN13)
 public | issn    | International Standard Serial Number (ISSN)
 public | issn13  | International Standard Serial Number 13 (ISSN13)
 public | upc     | Universal Product Code (UPC)
```

http://www.postgresql.org/docs/current/static/isn.html

ISBN Behaves Just Like Built-In Types

```
\dTS
…
 pg_catalog | integer  | -2 billion to 2 billion integer, 4-byte storage
…
 public     | isbn     | International Standard Book Number (ISBN)
```

The System Catalog Entry for INTEGER

```
SELECT * FROM pg_type WHERE typname = 'int4';
-[ RECORD 1 ]--+---------
typname        | int4
typnamespace   | 11
typowner       | 10
typlen         | 4
typbyval       | t
typtype        | b
typcategory    | N
typispreferred | f
typisdefined   | t
typdelim       | ,
typrelid       | 0
typelem        | 0
typarray       | 1007
typinput       | int4in
typoutput      | int4out
typreceive     | int4recv
typsend        | int4send
typmodin       | -
typmodout      | -
typanalyze     | -
typalign       | i
typstorage     | p
typnotnull     | f
```

The System Catalog Entry for ISBN

```
SELECT * FROM pg_type WHERE typname = 'isbn';
-[ RECORD 1 ]--+--------------
typname        | isbn
typnamespace   | 2200
typowner       | 10
typlen         | 8
typbyval       | t
typtype        | b
typcategory    | U
typispreferred | f
typisdefined   | t
typdelim       | ,
typrelid       | 0
typelem        | 0
typarray       | 16405
typinput       | isbn_in
typoutput      | public.isn_out
typreceive     | -
typsend        | -
typmodin       | -
typmodout      | -
typanalyze     | -
typalign       | d
typstorage     | p
typnotnull     | f
```

Not Just Data Types, Languages

```
CREATE EXTENSION plpythonu;
```

```
\dL
                                List of languages
   Name     |  Owner   | Trusted |                Description
------------+----------+---------+-------------------------------------------
 plpgsql    | postgres | t       | PL/pgSQL procedural language
 plpythonu | postgres | f       | PL/PythonU untrusted procedural language
```

http://www.postgresql.org/docs/current/static/plpython.html

Available Languages

- PL/Java
- PL/Perl
- PL/pgSQL (like PL/SQL)
- PL/PHP
- PL/Python
- PL/R (like SPSS)
- PL/Ruby
- PL/Scheme
- PL/sh
- PL/Tcl
- SPI (C)

http://www.postgresql.org/docs/current/static/external-pl.html

Specialized Indexing Methods

- BRIN
- BTREE
- Hash
- GIN (generalized inverted index)
- GiST (generalized search tree)
- SP-GiST (space-partitioned GiST)

http://www.postgresql.org/docs/current/static/indexam.html

Index Types Are Defined in the System Catalogs Too

```
SELECT amname FROM pg_am ORDER BY 1;
 amname
--------
 brin
 btree
 hash
 gin
 gist
 spgist
```

http://www.postgresql.org/docs/current/static/catalog-pg-am.html

Operators Have Similar Flexibility

Operators are function calls with left and right arguments of specified types:

```
\doS
   Schema   | Name | Left arg type | Right arg type | Result type | Description
…
 pg_catalog | +    | integer       | integer        | integer     | add

\dfS
   Schema   | Name   | Result data type | Argument data types |  Type
…
 pg_catalog | int4pl | integer          | integer, integer    | normal
```

Other Extensibility

- Casts are defined in pg_cast, int4(float8)
- Aggregates are defined in pg_aggregate, sum(int4)

Externally Developed Plug-Ins

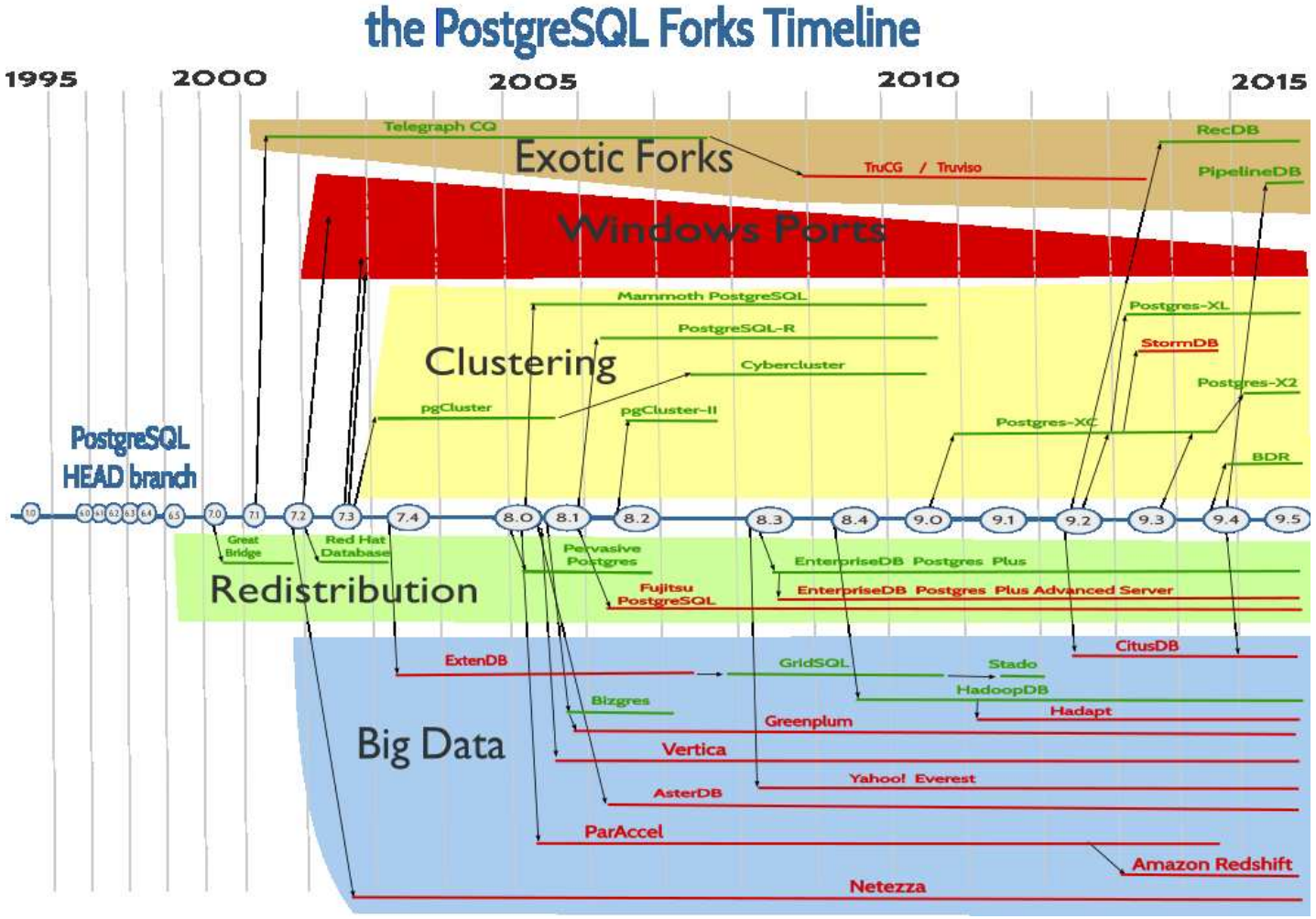
- PostGIS (Geographical Information System)
- PL/v8 (server-side JavaScript)
- experimentation, e.g. full text search was originally externally developed

Offshoots of Postgres

- AsterDB
- Greenplum
- Informix
- Netezza
- ParAccel
- Postgres XC
- Redshift (Amazon)
- Truviso
- Vertica
- Yahoo! Everest

https://wiki.postgresql.org/wiki/PostgreSQL_derived_databases
http://de.slideshare.net/pgconf/elephant-roads-a-tour-of-postgres-forks

Offshoots of Postgres

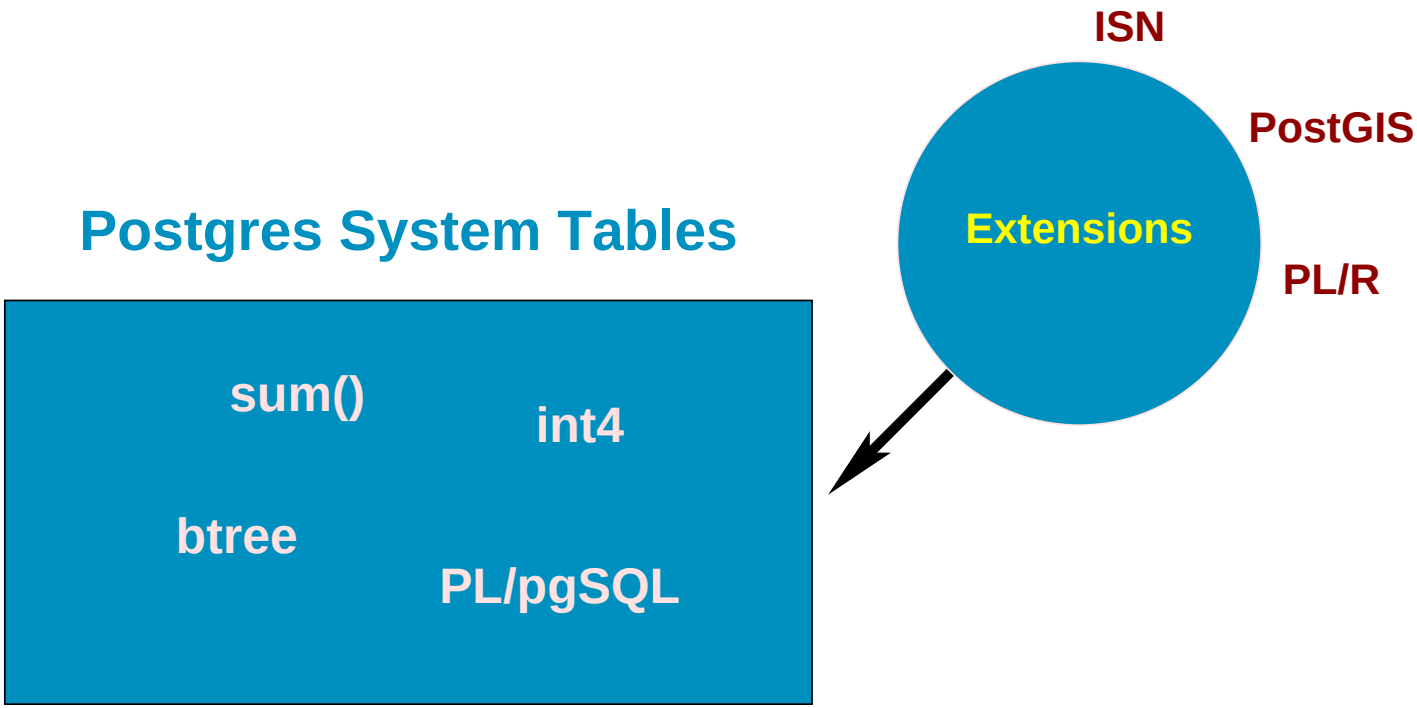


https://raw.github.com/daamien/artwork/master/inkscape/PostgreSQL_timeline/timeline_postgresql.png

Plug-In Is Not a Bad Word

Many databases treat extensions as special cases, with serious limitations. Postgres built-ins use the same API as extensions, so ll extensions operate just like built-in functionality.

Extensions and Built-In Facilities Behave the Same




SQL

NoSQL Types

There is no single NoSQL technology. They all take different approaches and have different features and drawbacks:

- Key-value stores, e.g. Redis
- Document databases, e.g. MongoDB (JSON)
- Columnar stores: Cassandra
- Graph databases: Neo4j

Why NoSQL Exists

Generally, NoSQL is optimized for:

- Fast simple queries
- Auto-sharding
- Flexible schemas

NoSQL Sacrifices

- A powerful query language
- A sophisticated query optimizer
- Data normalization
- Joins
- Referential integrity
- Durability

Are These Drawbacks Worth the Cost?

- **Difficult Reporting** Data must be brought to the client for analysis, e.g. no aggregates or data analysis functions. Schema-less data requires complex client-side knowledge for processing
- **Complex Application Design** Without powerful query language and query optimizer, the client software is responsible for efficiently accessing data and for data consistency
- **Durability** Administrators are responsible for data retention

When Should NoSQL Be Used?

- Massive write scaling is required, more than a single server can provide
- Only simple data access pattern is required
- Additional resource allocation for development is acceptable
- Strong data retention or transactional guarantees are not required
- Unstructured duplicate data that greatly benefits from column compression

When Should Relational Storage Be Used?

- Easy administration
- Variable workloads and reporting
- Simplified application development
- Strong data retention

The Best of Both Worlds: Postgres

Postgres has many NoSQL features without the drawbacks:

- Schema-less data types, with sophisticated indexing support
- Transactional schema changes with rapid additional and removal of columns
- Durability by default, but controllable per-table or per-transaction

Schema-Less Data: JSON

```
CREATE TABLE customer (id SERIAL, data JSON);

INSERT INTO customer VALUES (DEFAULT, '{"name" : "Bill", "age" : 21}');

SELECT data->'name' FROM customer WHERE data->>'age' = '21';
 ?column?
----------
 "Bill"
```

Easy Relational Schema Changes

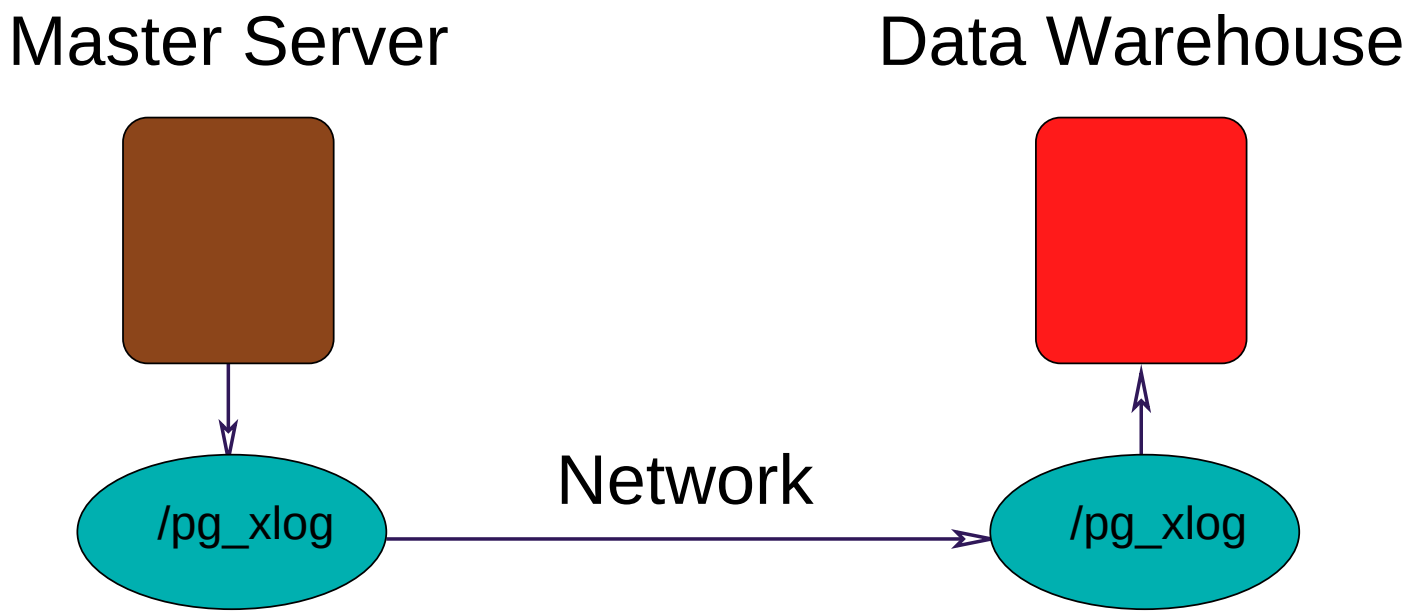
```
ALTER TABLE customer ADD COLUMN status CHAR(1);
BEGIN WORK;
ALTER TABLE customer ADD COLUMN debt_limit NUMERIC(10,2);
ALTER TABLE customer ADD COLUMN creation_date TIMESTAMP WITH TIME ZONE;
ALTER TABLE customer RENAME TO cust;
COMMIT;
```

3. Data Analytics

- Aggregates
- Optimizer
- Server-side languages, e.g. PL/R
- Window functions
- Bitmap heap scans
- Tablespaces
- Data partitioning
- Materialized views
- Common table expressions (CTE)
- BRIN indexes
- GROUPING SETS, ROLLUP, CUBE
- Parallelism
- Sharding (in progress)

http://www.slideshare.net/PGExperts/really-big-elephants-postgresql-dw-15833438
http://wiki.postgresql.org/images/3/38/PGDay2009-EN-Datawarehousing_with_PostgreSQL.pdf

Read-Only Slaves for Analytics



4. Foreign Data Wrappers (Database Federation)

Foreign data wrappers (SQL MED) allow queries to read and write data to foreign data sources. Foreign database support includes:

- CouchDB
- Informix
- MongoDB
- MySQL
- Neo4j
- Oracle
- Postgres
- Redis

The transfer of joins, aggregates, and sorts to foreign servers is not yet implemented.

http://www.postgresql.org/docs/current/static/ddl-foreign-data.html
http://wiki.postgresql.org/wiki/Foreign_data_wrappers

Foreign Data Wrappers to Interfaces

- JDBC
- LDAP
- ODBC

Foreign Data Wrappers to Non-Traditional Data Sources

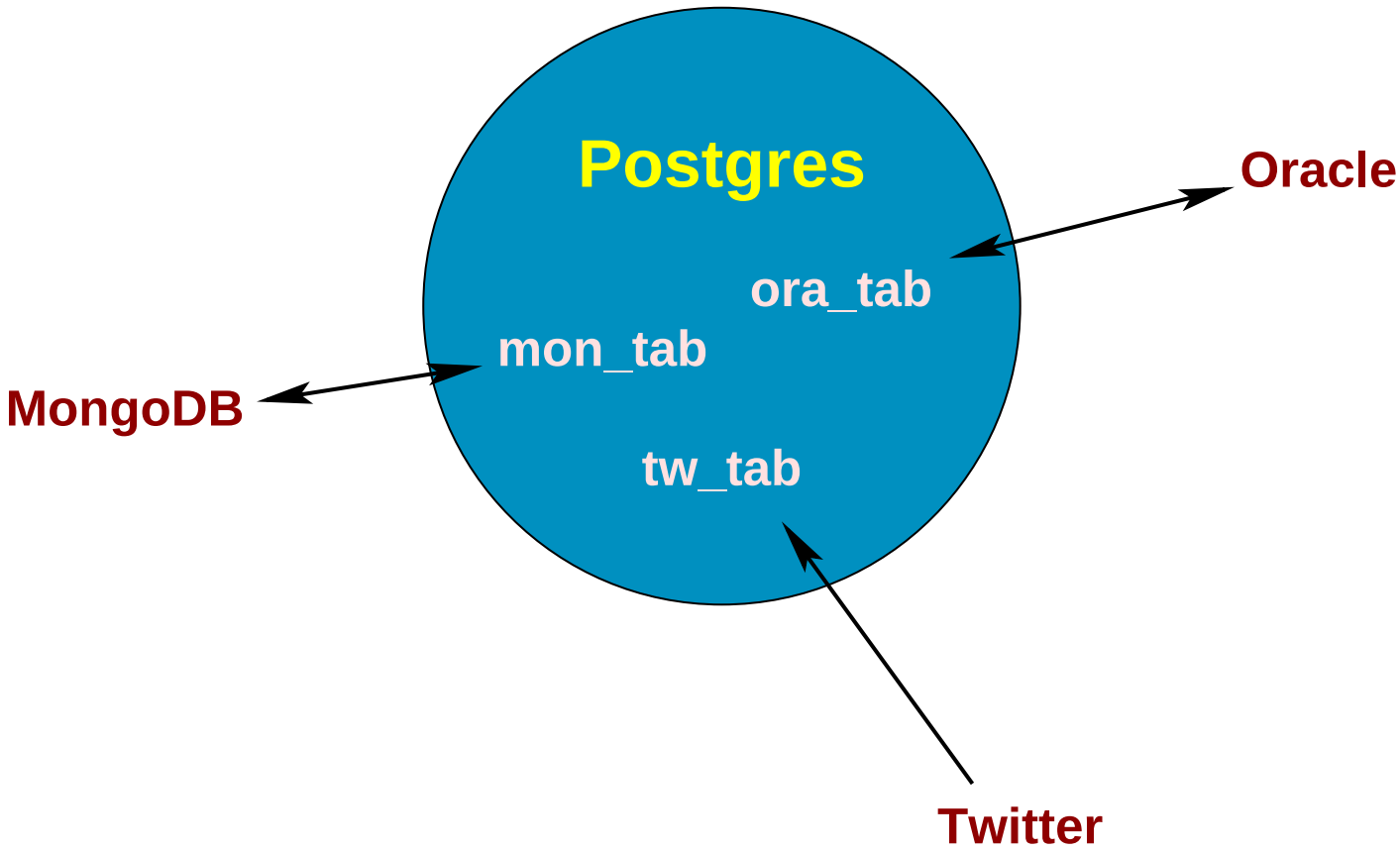
- Files
- HTTP
- AWS S3
- Twitter

Foreign Data Wrapper Example

```
CREATE SERVER postgres_fdw_test

FOREIGN DATA WRAPPER postgres_fdw

OPTIONS (host 'localhost', dbname 'fdw_test');


CREATE USER MAPPING FOR PUBLIC

SERVER postgres_fdw_test

OPTIONS (password '');


CREATE FOREIGN TABLE other_world (greeting TEXT)

SERVER postgres_fdw_test

OPTIONS (table_name 'world');


\det
List of foreign tables
Schema | Table | Server
--------+-------------+------------------
public | other_world | postgres_fdw_test
(1 row)
```

Foreign Postgres server name in red; foreign table name in blue

Read and Read/Write Data Sources



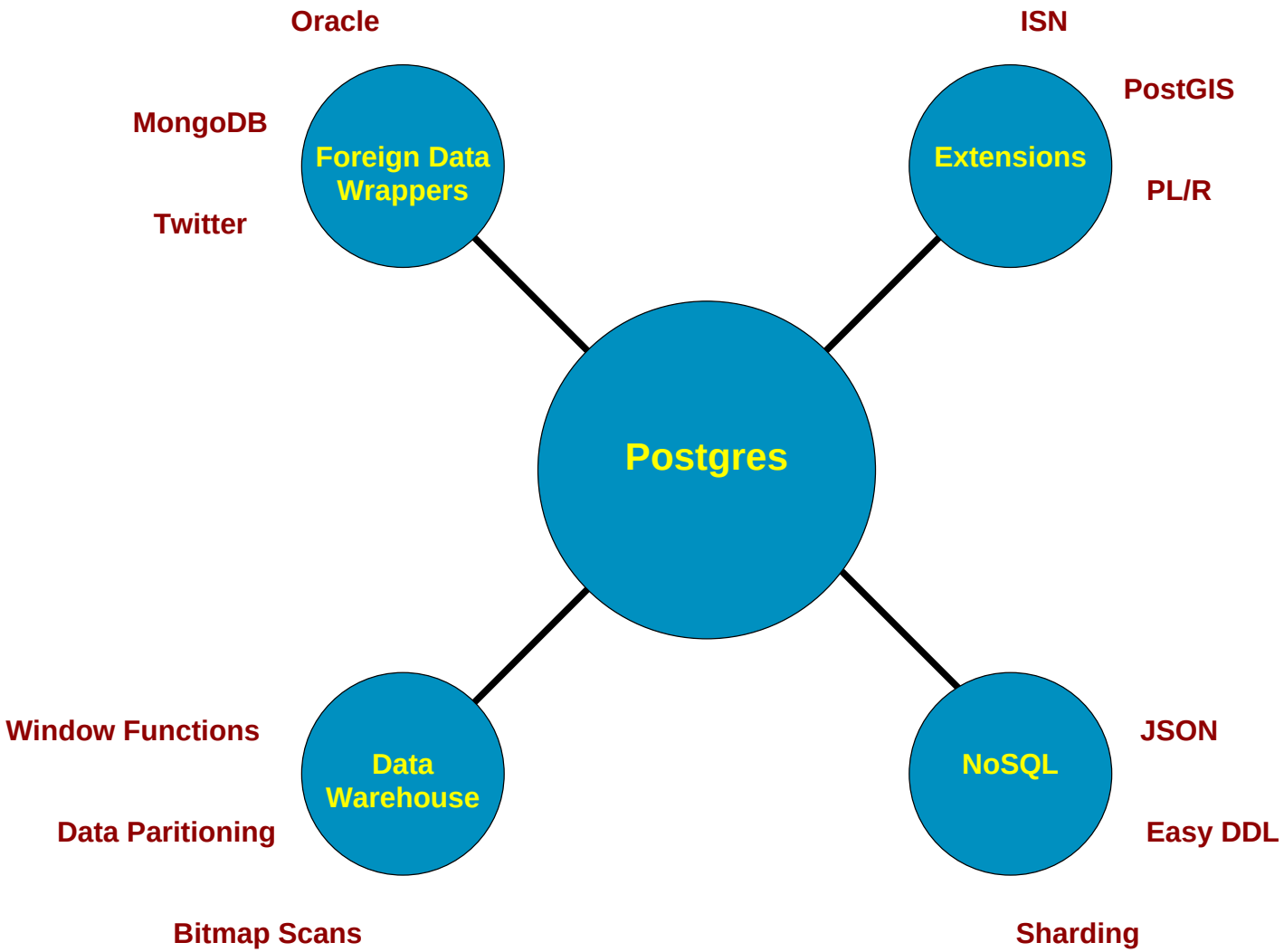
5. Postgres Centrality

Postgres can rightly take a central place in the data center with its:

- Object-relation flexibility and extensibility
- NoSQL-like workloads
- Powerful data analytics capabilities
- Access to foreign data sources

No other database has all of these key components.

Postgres's Central Role



Conclusion

http://momjian.us/presentations

https://www.flickr.com/photos/kenny_barker/