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PostgreSQL Overview

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❖ PostgreSQL

PostgreSQL is a full-featured open-source (O)RDBMS.

- provides a relational engine with:
  - efficient implementation of relational operations
  - transaction processing (concurrent access)
  - backup/recovery (from application/system failure)
  - novel query optimisation (based on genetic algorithm)
  - replication, JSON, extensible indexing, etc. etc.
- already supports several non-standard data types
- allows users to define their own data types
- supports most of the SQL3 standard

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❖ PostgreSQL Online

Web site: www.postgresql.org

Key developers: Tom Lane, Andres Freund, Bruce Momjian, ...

Full list of developers: postgresql.org/contributors/

Source code: ~cs9315/21T1/postgresql/src.tar.bz2

Documentation: postgresql.org/docs/12/index.html

❖ User View of PostgreSQL

Users interact via SQL in a client process, e.g.

```
$ psql webcms
psql (12.5)
Type "help" for help.
webcms2=# select * from calendar;
 id | course |   evdate   |      event
----+--------+------------+--------------------------
  1 |      4 | 2001-08-09 | Project Proposals due
 10 |      3 | 2001-08-01 | Tute/Lab Enrolments Close
 12 |      3 | 2001-09-07 | Assignment #1 Due (10pm)
 ...
```

or

```
$dbconn = pg_connect("dbname=webcms");
$result = pg_query($dbconn,"select * from calendar");
while ($tuple = pg_fetch_array($result))
   { ... $tuple["event"] ... }
```

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❖ PostgreSQL Functionality

PostgreSQL systems deal with various kinds of entities:

- users ... who can access the system
- groups ... groups of users, for role-based privileges
- databases ... collections of schemas/tables/views/...
- namespaces ... to uniquely identify objects (schema.table.attr)
- tables ... collection of tuples (standard relational notion)
- views ... "virtual" tables (can be made updatable)
- functions ... operations on values from/in tables
- triggers ... operations invoked in response to events
- operators ... functions with infix syntax
- aggregates ... operations over whole table columns
- types ... user-defined data types (with own operations)
- rules ... for query rewriting (used e.g. to implement views)
- access methods ... efficient access to tuples in tables

❖ PostgreSQL Functionality (cont)

PostgreSQL's dialect of SQL is mostly standard (but with extensions).

- attributes containing arrays of atomic values

```
create table R ( id integer, values integer[] );
insert into R values ( 123, '{5,4,3,2,1}' );
```

- table-valued functions

```
create function f(integer) returns setof TupleType;
```

- multiple langauges available for functions
  - PLpgSQL, Python, Perl, Java, R, Tcl, ...
  - function bodies are strings in whatever language

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❖ PostgreSQL Functionality (cont)

Other variations in PostgreSQL's **`CREATE TABLE`**

- **`TEMPORARY`** tables
- **`PARTITION`**'d tables
- **`GENERATED`** attribute values (derived attributes)
- **`FOREIGN TABLE`** (data stored outside PostgreSQL)
- table type inheritance

```
create table R ( a integer, b text);
create table S ( x float, y float);
create table T inherits ( R, S );
```

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❖ PostgreSQL Functionality (cont)

PostgreSQL stored procedures differ from SQL standard:

- only provides functions, not procedures
  (but functions can return **`void`**, effectively a procedure)
- allows function overloading
  (same function name, different argument types)
- defined at different "lexical level" to SQL
- provides own PL/SQL-like language for functions

```
create function ( Args ) returns ResultType
as $$
... body of function definition ...
$$ language FunctionBodyLanguage;
```

- where each ***`Arg`*** has a *Name* and *Type*

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❖ PostgreSQL Functionality (cont)

Example:

```
create or replace function
    barsIn(suburb text) returns setof Bars
as $$
declare
    r record;
begin
    for r in
        select * from Bars where location = suburb
    loop
       return next r;
    end loop;
end;
$$ language plpgsql;
used as e.g.
select * from barsIn('Randwick');
```

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❖ PostgreSQL Functionality (cont)

Uses multi-version concurrency control (MVCC)

- multiple "versions" of the database exist together
- a transaction sees the version that was valid at its start-time
- readers don't block writers; writers don't block readers
- this significantly reduces the need for locking

Disadvantages of this approach:

- extra storage for old versions of tuples (until **`vacuum`**'d)
- need to check "visibility" of every tuple fetched

PostgreSQL also provides locking to enforce critical concurrency.

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❖ PostgreSQL Functionality (cont)

PostgreSQL has a well-defined and open extensibility model:

- stored procedures are held in database as strings
  - allows a variety of languages to be used
  - language interpreters can be integrated into engine
- can add new data types, operators, aggregates, indexes
  - typically requires code written in C, following defined API
  - for new data types, need to write input/output functions, ...
  - for new indexes, need to implement file structures

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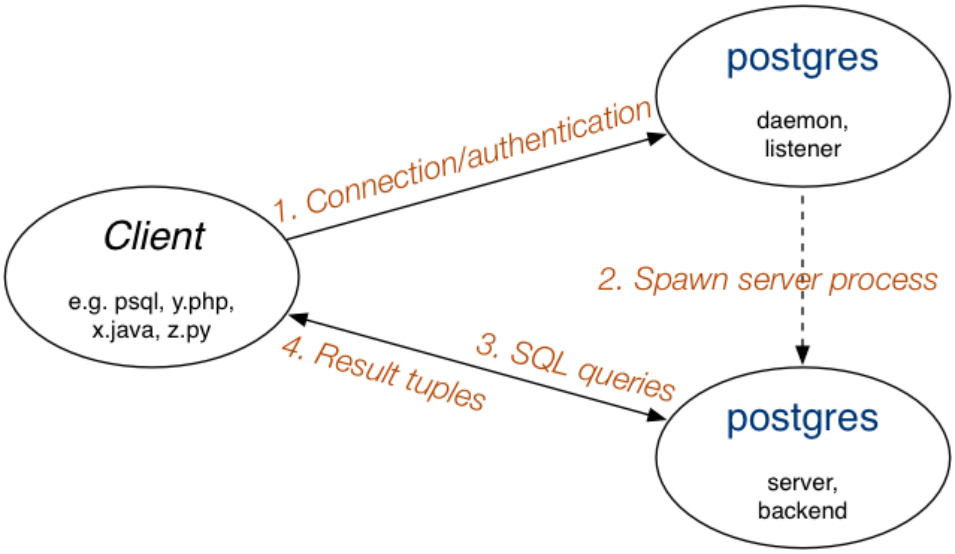
❖ PostgreSQL Architecture

Client/server process architecture:



The listener process is sometimes called **`postmaster`**

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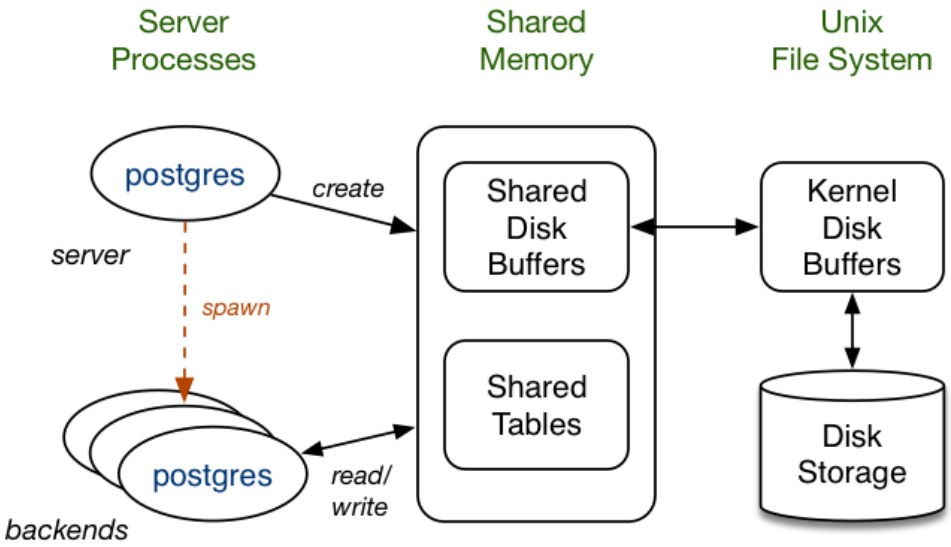
❖ PostgreSQL Architecture (cont)

Memory/storage architecture:



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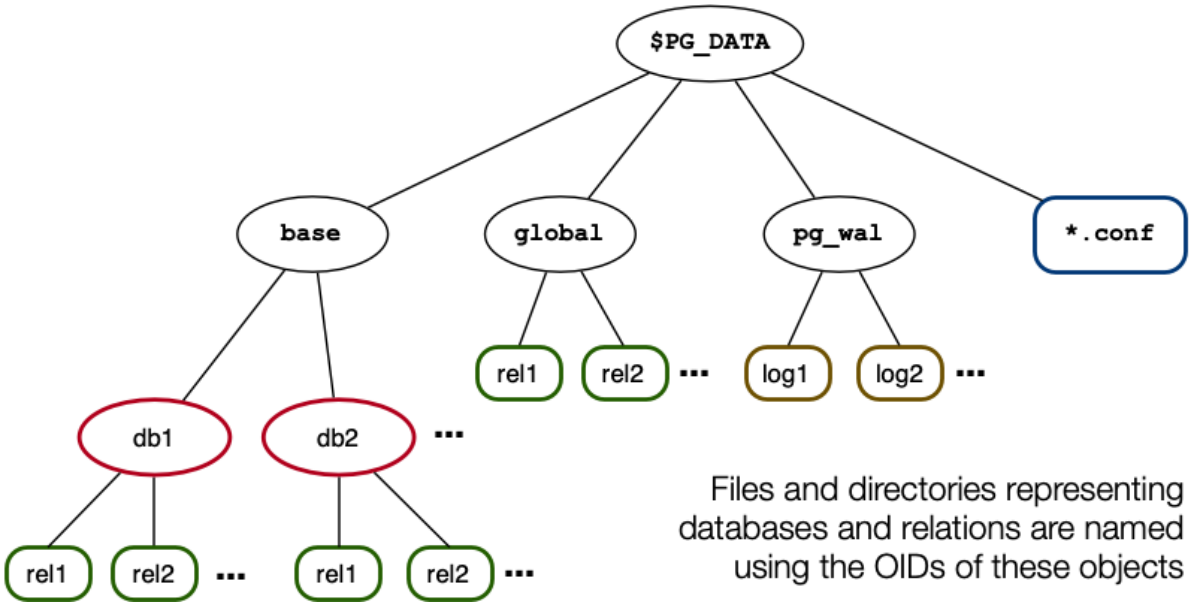
❖ PostgreSQL Architecture (cont)

File-system architecture:



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