2ndQuadrant

Professional PostgreSQL

Data warehousing with PostgreSQL

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Audience

- Case of one PostgreSQL node data warehouse
  - This talk does not directly address multi-node distribution of data
- Limitations on disk usage and concurrent access
  - No rule of thumb
  - Depends on a careful analysis of data flows and requirements
- Small/medium size businesses

Summary

- Data warehousing introductory concepts
- PostgreSQL strengths for data warehousing
- Data loading on PostgreSQL
- Analysis and reporting of a PostgreSQL DW
- Extending PostgreSQL for data warehousing
- PostgreSQL current weaknesses

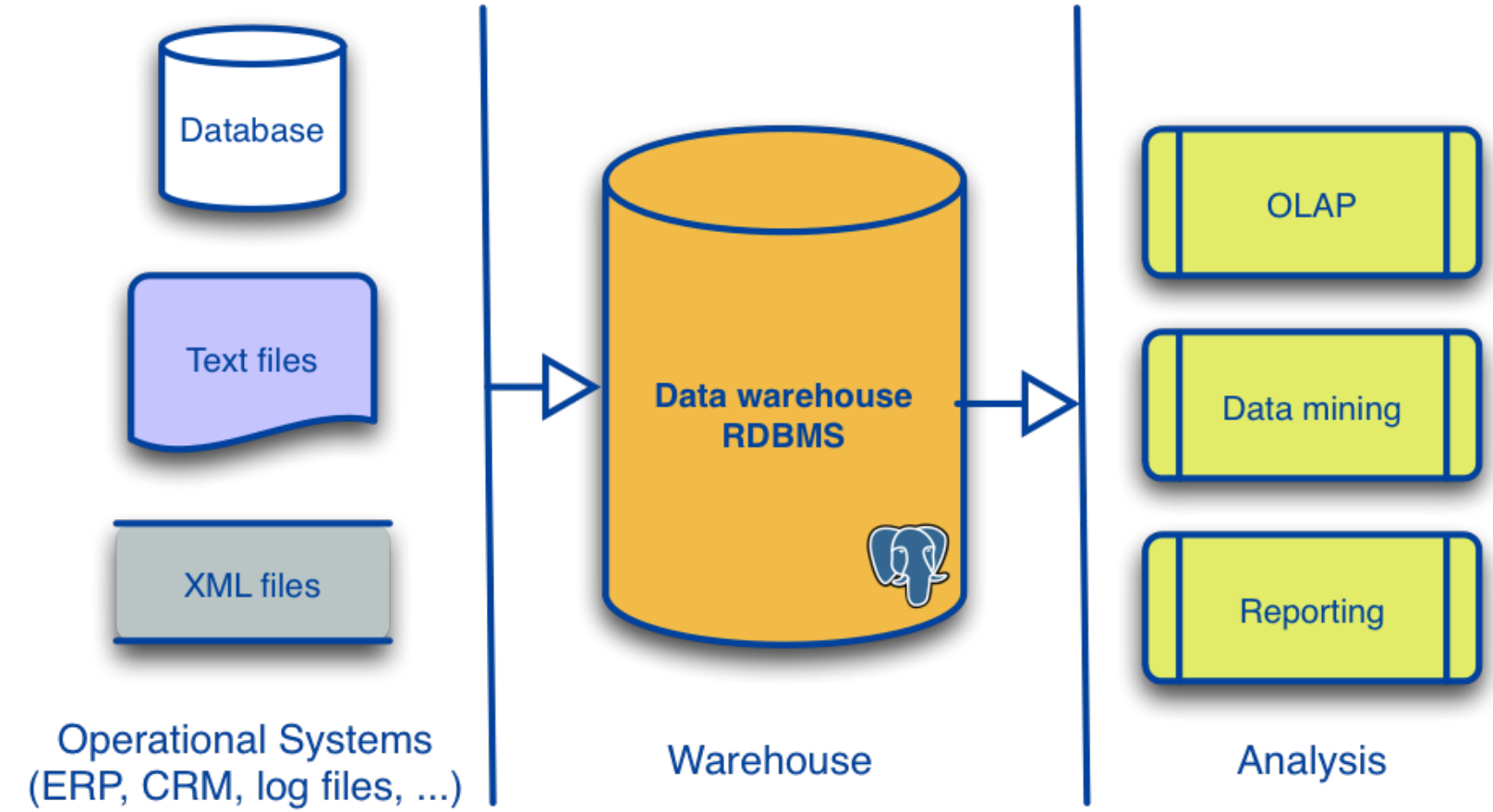
Part one: Data warehousing basics

- Business intelligence
- Data warehouse
- Dimensional model
- Star schema
- General concepts

Business intelligence & Data warehouse

- **Business intelligence:** *"skills, technologies, applications and practices used to help a business acquire a better understanding of its commercial context"*
- **Data warehouse:** *"A **data warehouse** houses a standardized, consistent, clean and integrated form of data sourced from various operational systems in use in the organization, structured in a way to specifically address the reporting and analytic requirements"*
  - ***Data warehousing** is a broader concept*

A simple scenario

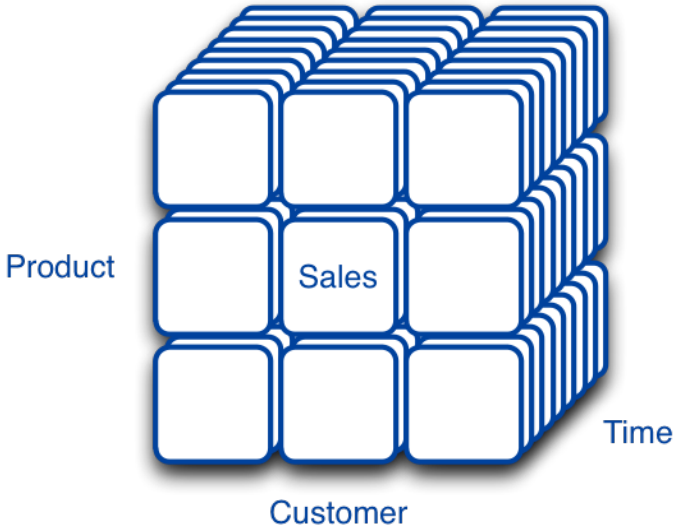


PostgreSQL = RDBMS for DW?

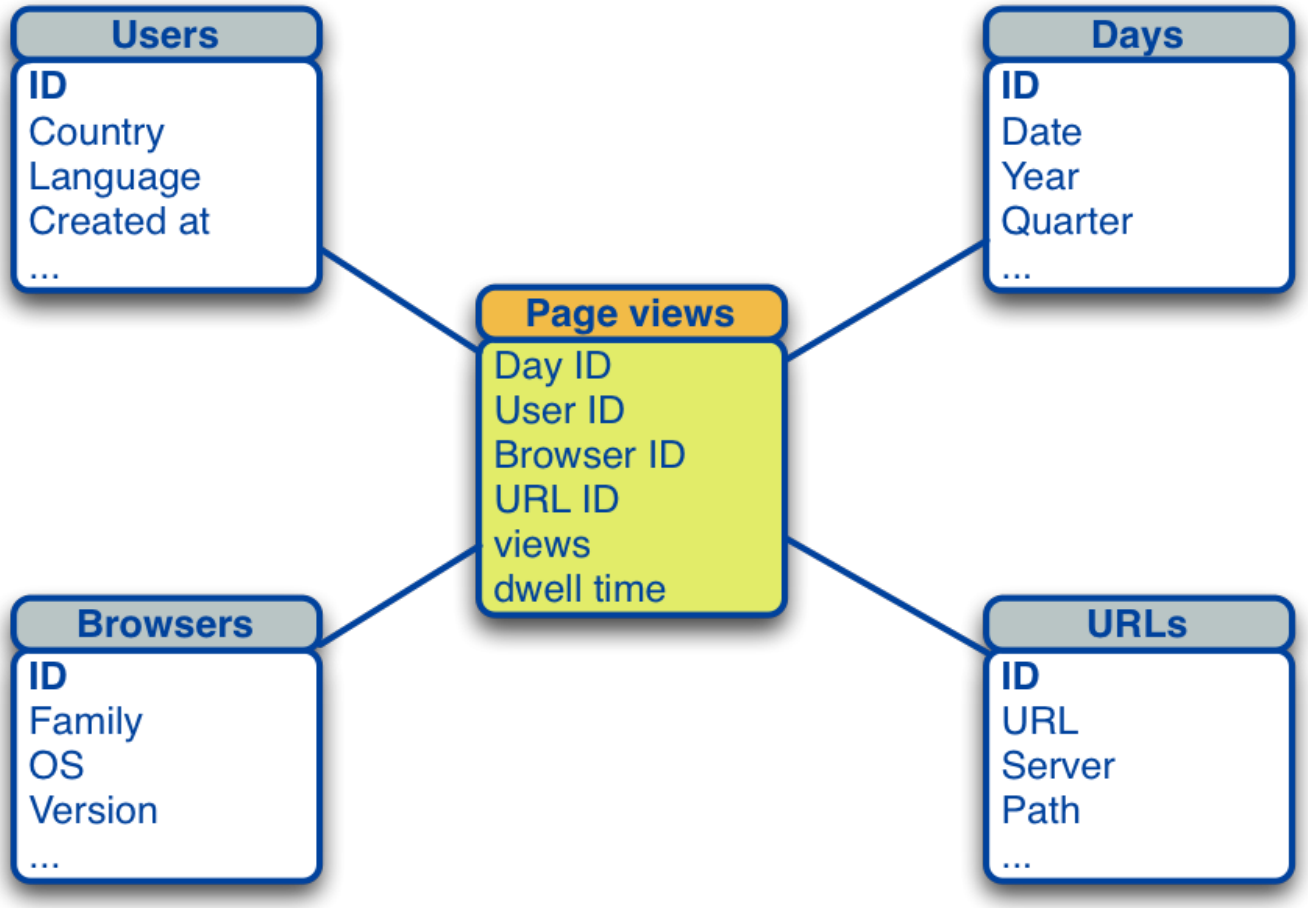
- The typical storage system for a data warehouse is a Relational DBMS
- Key aspects:
  - Standards compliance (e.g. SQL)
  - Integration with external tools for loading and analysis
- PostgreSQL 8.4 is an ideal candidate

Example of dimensional model

- Subject: commerce
- Process: sales
- Dimensions: customer, product
  - Analyse sales by customer and product over time



Star schema


Users
ID
Country
Language
Created at
...
Days
ID
Date
Year
Quarter
...
Page views
Day ID
User ID
Browser ID
URL ID
views
dwell time
Browsers
ID
Family
OS
Version
...
URLs
ID
URL
Server
Path
...

General concepts

- Keep the model simple (star schema is fine)
- Denormalise tables
- Keep track of changes that occur over time on dimension attributes
- Use **calendar tables** (static, read-only)

Example of calendar table

```
-- Days (calendar date)
CREATE TABLE calendar (
    -- days since January 1, 4712 BC
    id_day INTEGER NOT NULL PRIMARY KEY,
    sql_date DATE NOT NULL UNIQUE,
    month_day INTEGER NOT NULL,
    month INTEGER NOT NULL,
    year INTEGER NOT NULL,
    week_day_str CHAR(3) NOT NULL,
    month_str CHAR(3) NOT NULL,
    year_day INTEGER NOT NULL,
    year_week INTEGER NOT NULL,
    week_day INTEGER NOT NULL,
    year_quarter INTEGER NOT NULL,
    work_day INTEGER NOT NULL DEFAULT '1'
    ...
);
```

SOURCE: www.htminer.org

Part two: PostgreSQL and DW

- General features
- Stored procedures
- Tablespaces
- Table partitioning
- Schemas / namespaces
- Views
- Windowing functions and WITH queries

General features

- Connectivity:
  - PostgreSQL perfectly integrates with external tools or applications for data mining, OLAP and reporting
- Extensibility:
  - User defined data types and domains
  - **User defined functions**
    - **Stored procedures**

Stored Procedures

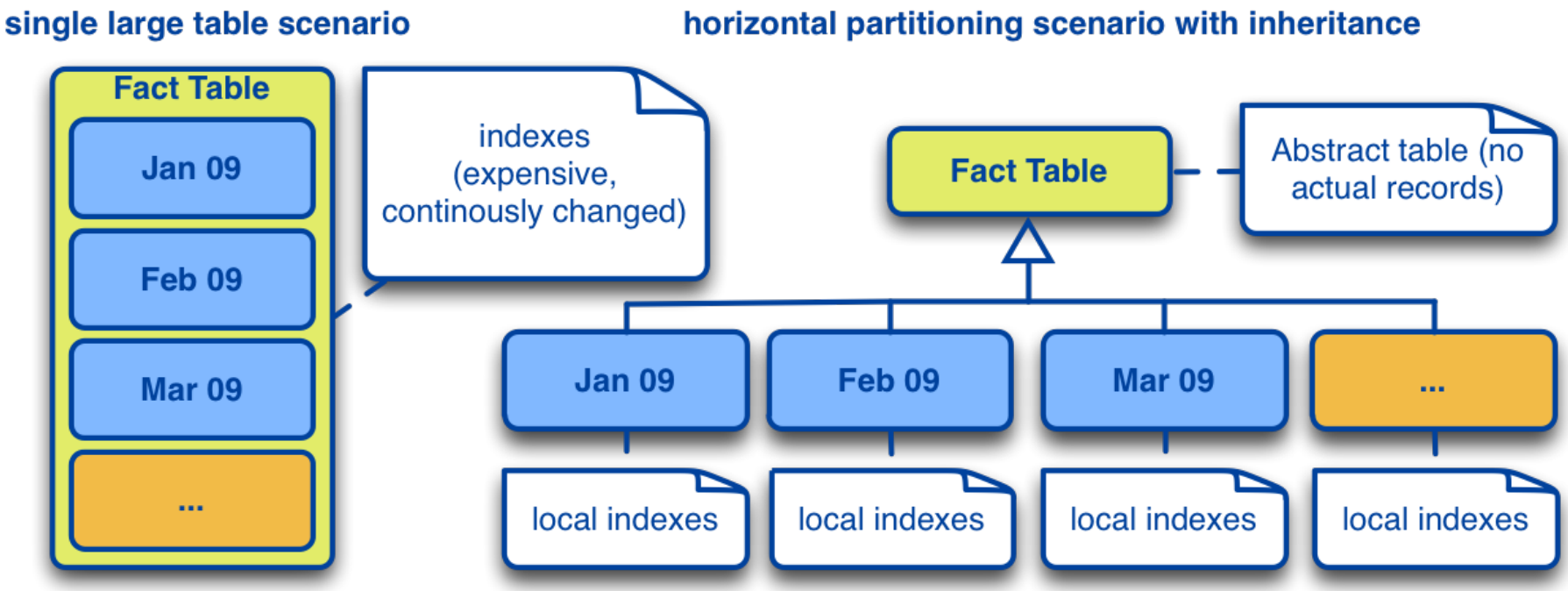
- Key aspects in terms of data warehousing
- Make the data warehouse:
  - flexible
  - **intelligent**
- Allow to analyse, transform, model and deliver data within the database server

Tablespaces

- Internal label for a physical directory in the file system
- Can be created or removed at anytime
- Allow to store objects such as tables and indexes on different locations
- Good for scalability
- Good for performances

Horizontal table partitioning 1/2

- A physical design concept
- Basic support in PostgreSQL through inheritance



Views and schemas

- Views:
  - Can be seen as "*placeholders*" for queries
  - PostgreSQL supports read-only views
  - Handy for summary navigation of fact tables
- Schemas:
  - Similar to the "*namespace*" concept in OOA
  - Allows to organise database objects in logical groups

Window functions and WITH queries

- Both added in PostgreSQL 8.4
- Window functions:
  - perform aggregate/rank calculations over partitions of the result set
  - more powerful than traditional "`GROUP BY`"
- WITH queries:
  - label a ***subquery* block**, execute it once
  - allow to reference it in a query
  - can be recursive

Part three: Optimisation techniques

- Surrogate keys
- Limited constraints
- Summary navigation
- Horizontal table partitioning
- Vertical table partitioning
- “Bridge tables” / Hierarchies

Use surrogate keys

- Record identifier within the database
- Usually a sequence:
  - `serial` (`INT` sequence, 4 bytes)
  - `bigserial` (`BIGINT` sequence, 8 bytes)
- Compact primary and foreign keys
- Allow to keep track of changes on dimensions

Limit the usage of constraints

- Data is already consistent
- No need for:
  - referential integrity (foreign keys)
  - check constraints
  - not-null constraints

Implement summary navigation

- Analysing data through hierarchies in dimensions is very time-consuming
- Sometimes *caching* these summaries is necessary:
  - real-time applications (e.g. web analytics)
  - can be achieved by simulating materialised views
  - requires careful management on latest appended data
    - Skytools' PgQ can be used to manage it
- Can be totally delegated to OLAP tools

Horizontal (table) partitioning

- Partition tables based on record characteristics (e.g. date range, customer ID, etc.)
- Allows to split fact tables (or dimensions) in smaller chunks
- Great results when combined with tablespaces

Vertical (table) partitioning

- Partition tables based on columns
- Split a table with many columns in more tables
- Useful when there are fields that are accessed more frequently than others
- Generates:
  - Redundancy
  - Management headaches (careful planning)

Bridge hierarchy tables

- Defined by Kimball and Ross
- Variable depth hierarchies (flattened trees)
- Avoid recursive queries in parent/child relationships
- Generates:
  - Redundancy
  - Management headaches (careful planning)

Example of bridge hierarchy table

```
 id_bridge_category  | integer | not null
 category_key        | integer | not null
 category_parent_key  | integer | not null
 distance_level      | integer | not null
 bottom_flag         | integer | not null default 0
 top_flag            | integer | not null default 0
```

id_bridge_category	category_key	category_parent_key	distance_level	bottom_flag	top_flag
1	1	1	0	0	1
2	586	1	1	1	0
3	587	1	1	1	0
4	588	1	1	1	0
5	589	1	1	1	0
6	590	1	1	1	0
7	591	1	1	1	0
8	2	2	0	0	1
9	3	2	1	1	0

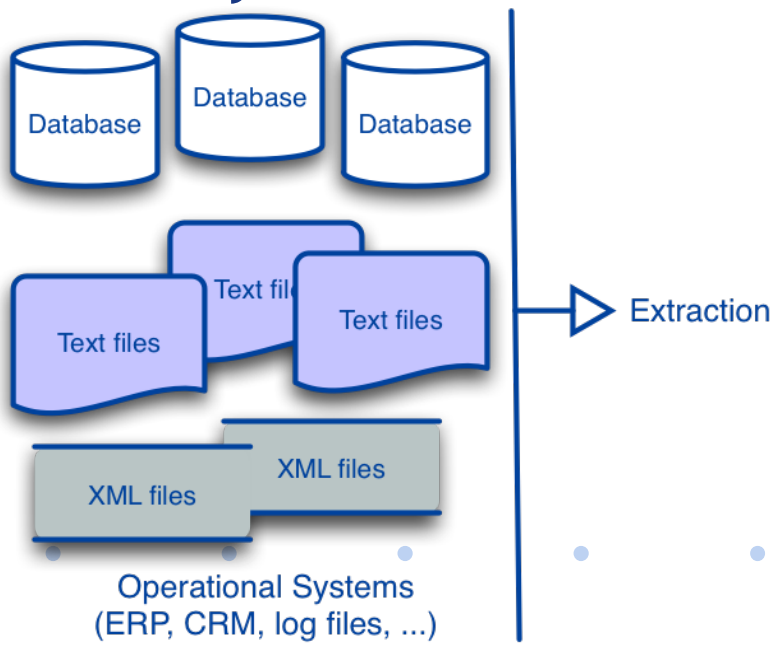
SOURCE: www.htminer.org

Part four: Data loading

- Extraction
- Transformation
- Loading
- ETL or ELT?
- Connecting to external sources
- External loaders
- Exploration data marts

Extraction

- Data may be originally stored:
  - in different locations
  - on different systems
  - in different formats (e.g. database tables, flat files)
- Data is extracted from source systems
- Data may be filtered



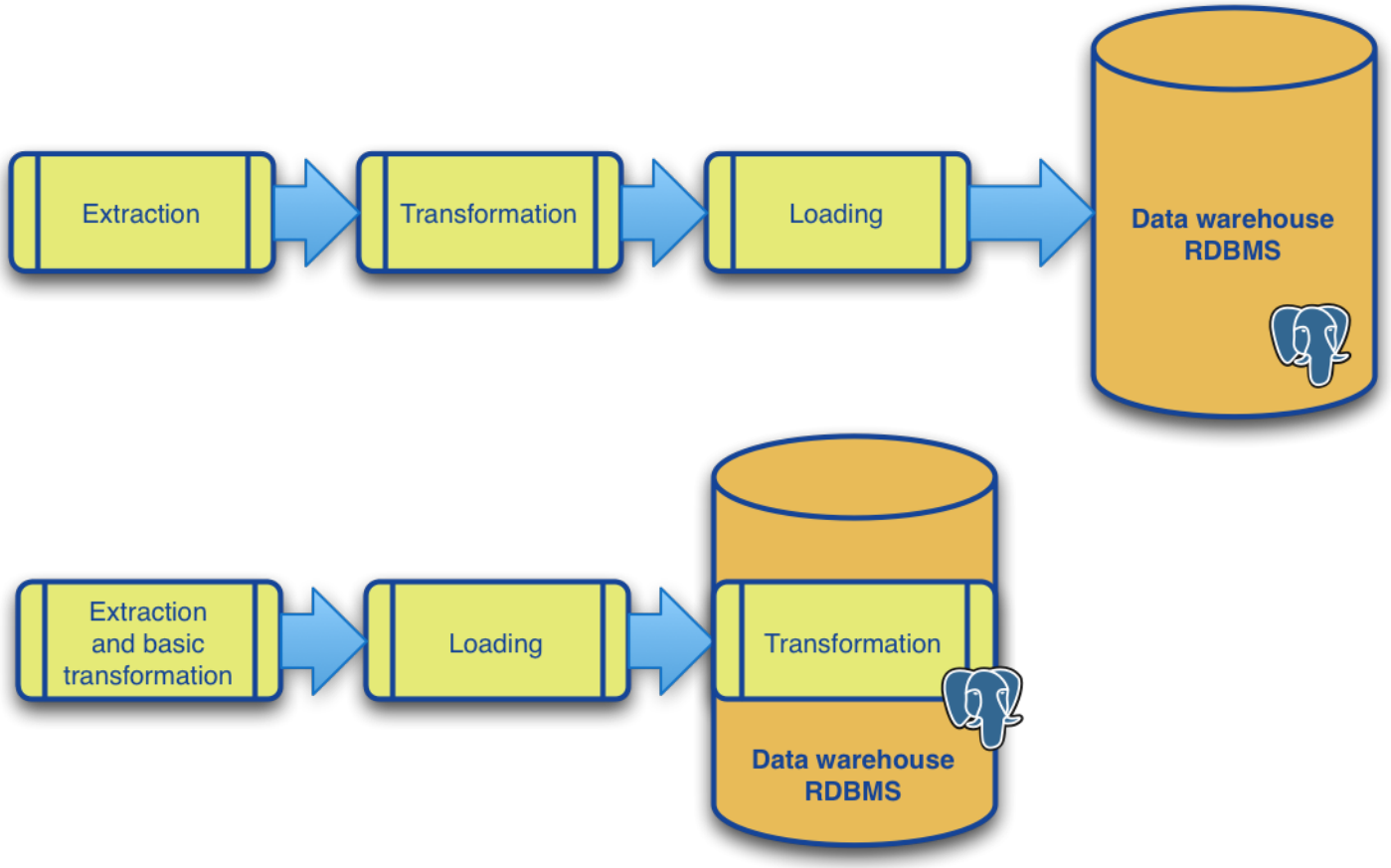
Transformation

- Data previously extracted is transformed
  - Selected, filtered, sorted
  - Translated
  - Integrated
  - Analysed
  - ...
- Goal: prepare the data for the warehouse

Loading

- Data is loaded in the warehouse database
- Which frequency?
- Facts are usually appended
  - Issue: aggregate facts need to be updated

ETL or ELT?


Extraction
Transformation
Loading
Data warehouse
RDBMS
Extraction
and basic
transformation
Loading
Transformation
Data warehouse
RDBMS

Connecting to external sources

- PostgreSQL allows to connect to external sources, through some of its extensions:
  - dblink
  - PL/Proxy
  - DBI-Link (any database type supported by Perl's DBI)
- External sources can be seen as database tables
- Practical for ETL/ELT operations:
  - `INSERT ... SELECT` operations

External tools

- External tools for ETL/ELT can be used with PostgreSQL
- Many applications exist
  - Commercial
  - Open-source
    - Kettle (part of Pentaho Data Integration)
- Generally use ODBC or JDBC (with Java)

Exploration data marts

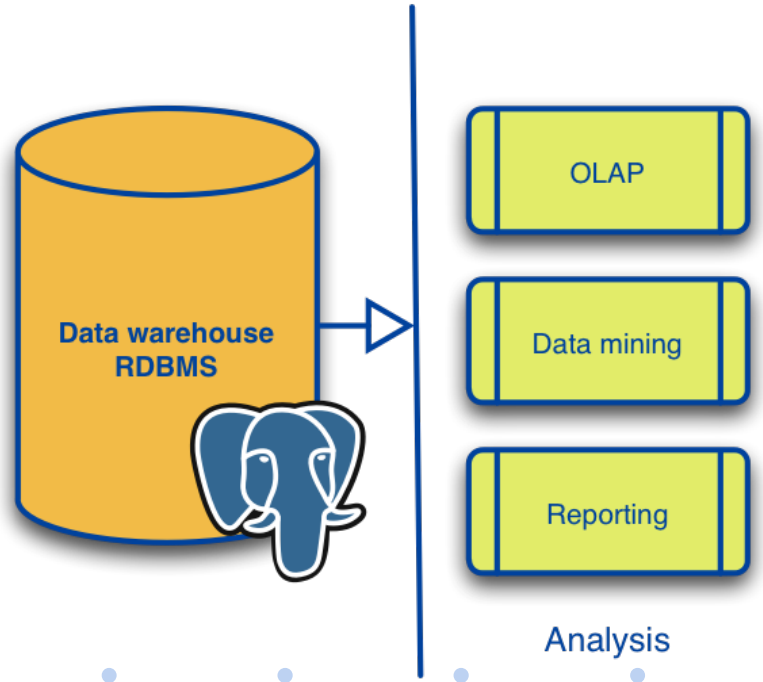
- Business requirements change, continuously
- The data warehouse must offer ways:
  - to explore the historical data
  - to create/destroy/modify data marts in a staging area
    - connected to the production warehouse
    - totally independent, safe
  - this environment is commonly known as *Sandbox*

Part five: Beyond PostgreSQL

- Data analysis and reporting
- Scaling a PostgreSQL warehouse with PL/Proxy

Data Analysis and reporting

- Ad-hoc applications
- External BI applications
  - Integrate your PostgreSQL warehouse with third-party applications for:
    - OLAP
    - Data mining
    - Reporting
  - Open-source examples:
    - Pentaho Data Integration



Scaling with PL/Proxy

- PL/Proxy can be directly used for querying data from a single remote database
- PL/Proxy can be used to speed up queries from a local database in case of multi-core server and partitioned table
- PL/Proxy can also be used:
  - to distribute work on several servers, each with their own part of data (known as *shards*)
  - to develop *map/reduce* type analysis over sets of servers

Part six: PostgreSQL's weaknesses

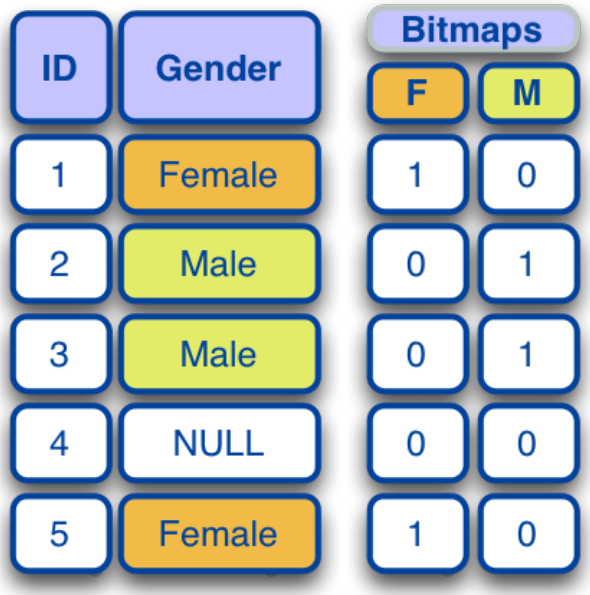
- Native support for data distribution and parallel processing
- On-disk bitmap indexes
- Transparent support for data partitioning
- Transparent support for materialised views
- Better support for “temporal” needs

Data distribution & parallel processing

- Shared nothing architecture
- Allow for (massive) parallel processing
- Data is partitioned over servers, in shards
- PostgreSQL also lacks a `DISTRIBUTED BY` clause
- PL/Proxy could potentially solve this issue

On-disk bitmap indexes

- Ideal for data warehouses
- Use bitmaps (vectors of bits)
- Would perfectly integrate with PostgreSQL in-memory bitmaps for **bitwise logical operations**



ID	Gender	Bitmaps F	Bitmaps M
1	Female	1	0
2	Male	0	1
3	Male	0	1
4	NULL	0	0
5	Female	1	0

Source: Wikipedia

Transparent table partitioning

- Native transparent support for table partitioning is needed
  - `PARTITION BY` clause is needed
  - Partition daily management

Materialised views

- Currently can be simulated through stored procedures and views
- A transparent native mechanism for the creation and management of materialised views would be helpful
  - Automatic Summary Tables generation and management would be cool too!

Temporal extensions

- Some of TSQL2 features could be useful:
  - Period data type
  - Comparison functions on two periods, such as
    - Precedes
    - Overlaps
    - Contains
    - Meets

Conclusions

- PostgreSQL is a suitable RDBMS technology for a **single node data warehouse**:
  - **FLEXIBILITY**
  - Performances
  - Reliability
  - Limitations apply
- For open-source **multi-node data warehouse**, use SkyTools (pgQ, Londiste and PL/Proxy)
- If **Massive Parallel Processing** is required:
  - Custom solutions can be developed using PL/Proxy
  - Easy to move up to commercial products based on PostgreSQL like Greenplum, if data volumes and business requirements need it

Recap

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- PostgreSQL strengths for data warehousing
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- Extending PostgreSQL for data warehousing
- PostgreSQL current weaknesses

Thanks to

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  - Hannu Krosing
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Questions?

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