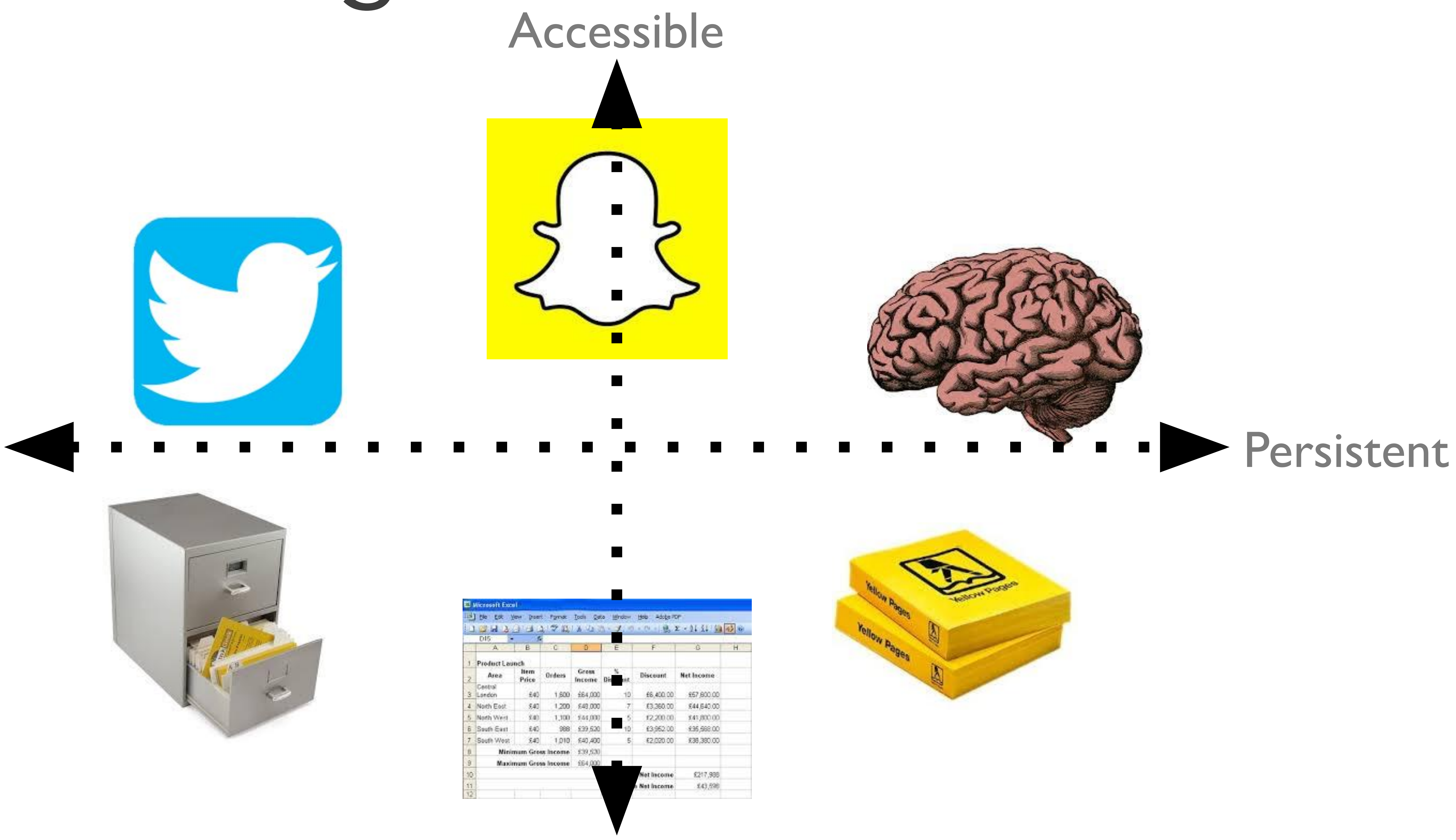
Intro to Databases

What is a database?

Things that hold info



A database persists information and is accessible via code

organized queryable manageable

Organized: Standard Storage Formatting

- DBs are a collection of Tables (or ***relations***)
- Tables have Columns (***attributes*** / ***fields***) that describe Rows (***instances*** / ***tuples***)
- Each row should be unique
- Rows often have a primary key (unique identifier)

Table / Relation

	Column / Attribute / Field	Column / Attribute / Field	Column / Attribute / Field
	ID	**Name**	**Type**
Row / Tuple / Instance	1	Pikachu	lightning
Row / Tuple / Instance	2	Squirtle	water
Row / Tuple / Instance	3	Charmander	fire
Row / Tuple / Instance	4	Bulbasaur	grass

Queryable: via a Standard Language

- A simple, structured query language: SQL
- Declarative (vs. imperative)
- No more hand-rolled algorithms / data structures
- DBMS picks an efficient execution strategy based on indexes, data, workload etc.

SQL

```sql
-- Pikachu, I choose you!
SELECT id, name
  FROM pokemon
  WHERE type = 'lightning'
  LIMIT 1
```

Manageable: Easy, Safe, Performant

- Offloads work and requisite understanding of programming
- Knowledge is portable
- Abstraction
- Transfer data between systems
- DBMS can make certain guarantees
  - prevent unsafe operations
  - built-in redundancies
  - handle multiple users, threads

ACID Guarantees

- Atomicity
- Consistency
- Isolation
- Durability

What happens if the database crashes?

- Suppose we have a banking system with client accounts
- Every debit must have a matching credit.
- Imagine a crash results in only one table being updated.
  - Database inconsistency → unexpected data and software crashes/bugs
  - Financial risk for clients

Atomic Transactions

- atomic transaction: A set of database operations that must occur together
  - i.e. A debit to one bank account, and a credit to another

- A transaction must either succeed or fail; it cannot partially complete.

- Every database query is represented by a transaction

Consistency

- Specify rules that columns need to follow. Examples:
  - Savings account must start with S or checking with C
  - Column cannot be null
- Protect the database from inconsistencies and simplify software logic
  - Allows software to make assumptions about underlying data

Resource Management

- Processes can be readers and writers
- Files can have many readers
- If a process has a writer, no other process can read from it, and no other process can write to it

Proposed File Scheme

- Suppose that we have decided not to use a database and instead store our data in a series of files.
- How might our setup fail to serve queries from multiple users?

Deadlock

Databases give us concurrency (Isolation)

- Multiple clients can make queries to read and update without the risk of deadlock or starvation.

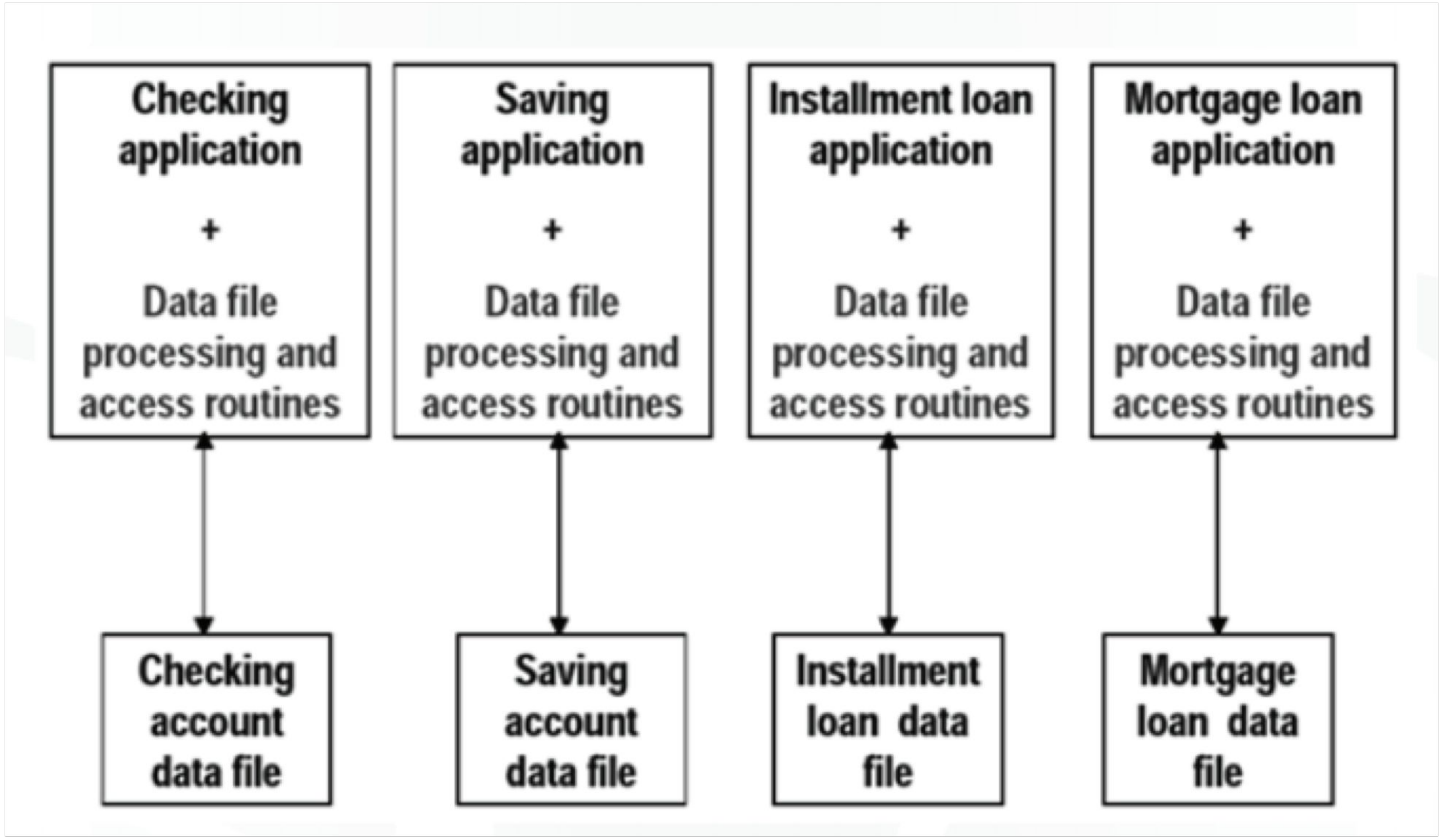
Persistence/Durability

- Databases are also persistent (store information without power)

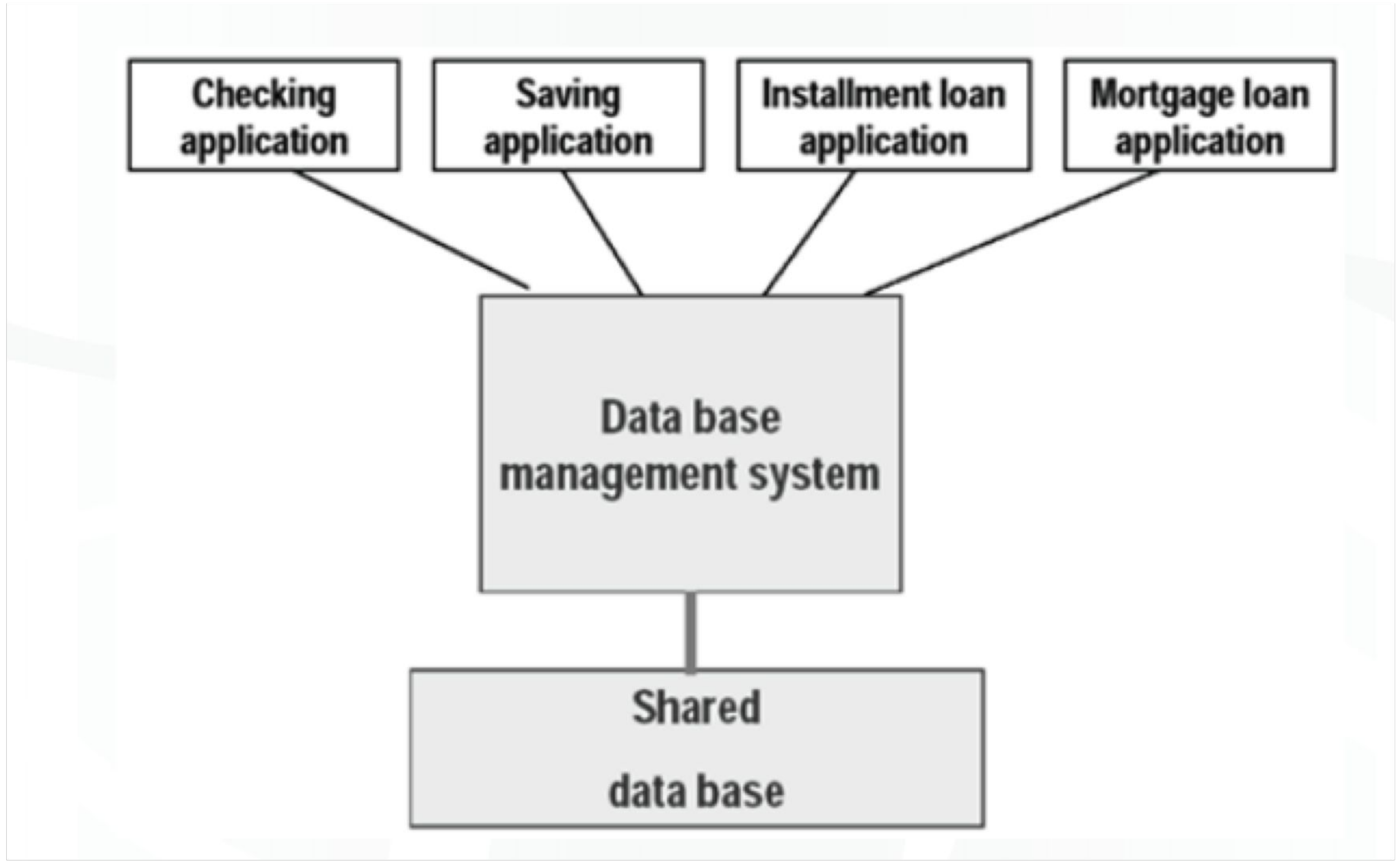
How Did We End Up Here?

Before Relational DBs (ca. < 1970s)

- Data stored in custom "data files"
- Queried via application-specific code
- Advantages
  - Middle layer not needed
  - Solutions customized for each application
- Disadvantages
  - Hard to change the system
  - Knowledge not compounding
  - Data-transfer is difficult



Database Management Systems (DBMS)

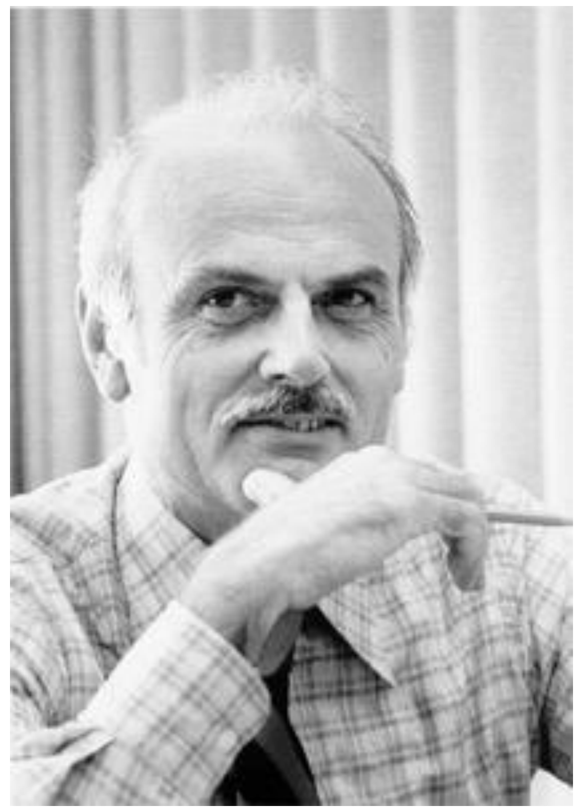


- One layer and language to store and access data
- Sold as a way for "non-technical people" to manage data

"Future users of large data banks must be protected from having to know how the data is organized in the machine (the internal representation)."

– E. F. CODD,
A RELATIONAL MODEL OF DATA FOR
LARGE SHARED DATA BANKS

Relational Databases & Logic



- 1969: Edgar Frank "Ted" Codd outlines ***relational model*** of data
- Wrote Alpha (never implemented) as a ***query language***
- IBM slow to adopt his ideas
  - Competitors started to do so
  - IBM team formed without Codd, created **S**tructured **E**nglish **Qu**ery **L**ang
- SEQUEL way better than what came before
  - 1979: copied by Larry Ellison (from pre-launch papers / talks!) as "SQL"
- SQL became the standard (ANSI 1986, ISO 1987)
  - Codd continued to fault SQL compared to his theoretical model
  - The Third Manifesto: solve the *object-relational impedance mismatch*

Appreciating Databases

- Ubiquitous
- Standardized
- Complex / deep
- Powerful: database admins are
  - Feared by developers
  - …but also taken for granted until things break
  - Befriended by business people
  - Contacted by the government for secret data (e.g. NSA)

Progression of Databases

- Navigational (< 1970s)
  - More common during tape era; entries had references to next entries.
- Relational (> 1970s)
  - Based on relational (table-based) logic, see E.F. Codd.
- NoSQL (> 2000s)
  - "Not only SQL" — document storage, for example.

RDBMS vs NoSQL

- A DBMS doesn't ***have*** to be relational
  - Remember, DBMS is just an application that intelligently stores data and can answer requests to manage that data
- Lately, many "NoSQL" or non-relational DBMSs have been gaining popularity
  - Graph databases (e.g. Neo4J)
  - Document databases (e.g. MongoDB)
  - Hybrids (e.g. PostgreSQL)
- RDBMSs still remain the #1 DB option for now

Some well-known rDBMSs

PostgreSQL

SQLite

MySQL®

PostgreSQL

Why PostgreSQL?

- Advanced, powerful, and popular
- Rapid open source development
- Highly extensible (stored procedures)
- Deep SQL standards compliance
- NoSQL ("Not Only SQL"), objective support
- Excellent transactions / ACID reliability; focus on integrity
- Multi-user management / administration

History of PostgreSQL

- 1970s at UC Berkeley:
  INteractive **G**raphics **RE**trieval **S**ystem (INGRES)
- 1980s: POSTGRES ("Post-Ingres")
- 1995: POSTQUEL and Postgres95.
  - monitor -> psql
- 1996: Adopted by the open source community
  - Ongoing: stability, testing, documentation, new features
  - PostgreSQL

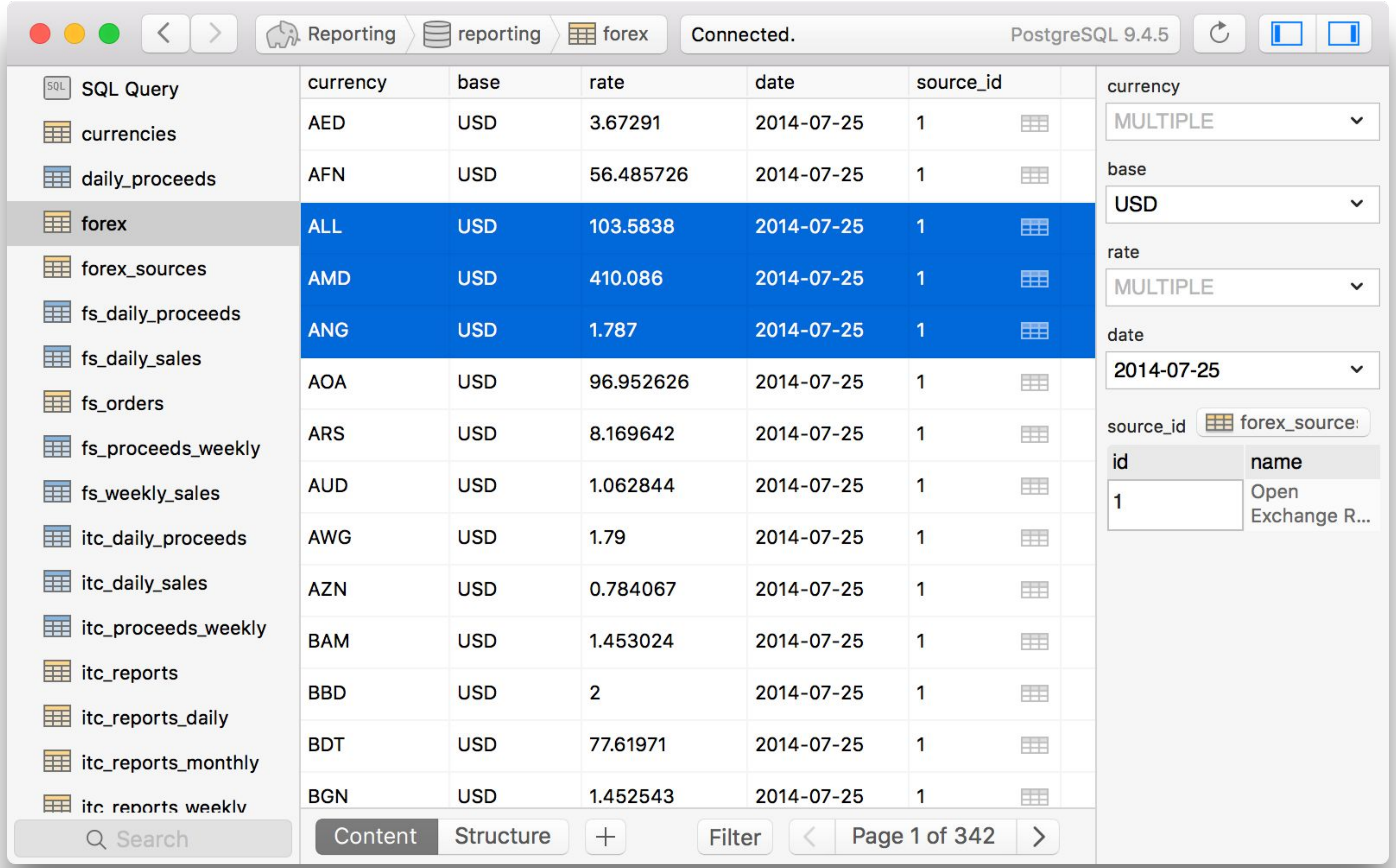
psql

```
1. psql (psql)
.../hello-world (zsh)  ⌘1   ...s/class-libs (zsh)  ⌘2   psql (psql)  ⌘3   postgres (postgres)  ⌘4

psql  [local]:5432  glebec # ~  \l
                                        List of databases
┌─────────────────────────────┬───────────┬──────────┬─────────────┬─────────────┬───────────────────┐
│            Name             │   Owner   │ Encoding │   Collate   │    Ctype    │ Access privileges │
├─────────────────────────────┼───────────┼──────────┼─────────────┼─────────────┼───────────────────┤
│ assessmentexpresssequelize  │ fullstack │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ auther                      │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ checkpoint_angular          │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ checkpoint_express_review   │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ glebec                      │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ juke                        │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ postgres                    │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ sequelizecheckpoint         │ fullstack │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ template0                   │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │ =c/glebec        ↵│
│                             │           │          │             │             │ glebec=CTc/glebec │
│ template1                   │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │ =c/glebec        ↵│
│                             │           │          │             │             │ glebec=CTc/glebec │
│ tripplanner                 │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ twitterdb                   │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
│ wikistack                   │ glebec    │ UTF8     │ en_US.UTF-8 │ en_US.UTF-8 │                   │
└─────────────────────────────┴───────────┴──────────┴─────────────┴─────────────┴───────────────────┘
(13 rows)


psql  [local]:5432  glebec # ~  \c auther
You are now connected to database "auther" as user "glebec".

psql  [local]:5432  glebec # auther  \dt
          List of relations
┌────────┬─────────┬───────┬────────┐
│ Schema │  Name   │ Type  │ Owner  │
├────────┼─────────┼───────┼────────┤
│ public │ stories │ table │ glebec │
│ public │ users   │ table │ glebec │
└────────┴─────────┴───────┴────────┘
(2 rows)


psql  [local]:5432  glebec # auther  |
```

pgcli

```
stayupdated_test> \d
+----------+-----------------------+----------+--------+
| Schema   | Name                  | Type     | Owner  |
|----------+-----------------------+----------+--------|
| public   | admins                | table    | amjith |
| public   | cpes                  | table    | amjith |
| public   | goose_db_version      | table    | amjith |
| public   | goose_db_version_id_seq | sequence | amjith |
| public   | packages              | table    | amjith |
| public   | packages_id_seq       | sequence | amjith |
| public   | users                 | table    | amjith |
| public   | users_id_seq          | sequence | amjith |
| public   | vulnerabilities       | table    | amjith |
| public   | vulnerabilities_cpes  | table    | amjith |
| public   | vulnerabilities_id_seq | sequence | amjith |
+----------+-----------------------+----------+--------+
SELECT 11
stayupdated_test> SELECT * FROM users;
+------+--------------+----------+---------------------+----------------------------+
|   id | display_name | password | email               | created_on                 |
|------+--------------+----------+---------------------+----------------------------|
|  177 | DisplayName1 | 1024cms  | user@ex.com         | 2014-11-15 15:02:50.094560 |
|  180 | testname2    | pas5w0rd | email@ex.com        | 2014-11-28 10:25:46.170660 |
|  181 | amjith       | password | amjith@amjith.amjith | 2014-11-28 18:39:48.195067 |
+------+--------------+----------+---------------------+----------------------------+
SELECT 3
stayupdated_test> SELECT * FROM 
                                admins
                                cpes
                                goose_db_version
                                packages
                                users
```

Postico



Reporting
reporting
forex
Connected.
PostgreSQL 9.4.5
SQL Query
currencies
daily_proceeds
forex
forex_sources
fs_daily_proceeds
fs_daily_sales
fs_orders
fs_proceeds_weekly
fs_weekly_sales
itc_daily_proceeds
itc_daily_sales
itc_proceeds_weekly
itc_reports
itc_reports_daily
itc_reports_monthly
itc_reports_weekly
Search
currency base rate date source_id
AED USD 3.67291 2014-07-25 1
AFN USD 56.485726 2014-07-25 1
ALL USD 103.5838 2014-07-25 1
AMD USD 410.086 2014-07-25 1
ANG USD 1.787 2014-07-25 1
AOA USD 96.952626 2014-07-25 1
ARS USD 8.169642 2014-07-25 1
AUD USD 1.062844 2014-07-25 1
AWG USD 1.79 2014-07-25 1
AZN USD 0.784067 2014-07-25 1
BAM USD 1.453024 2014-07-25 1
BBD USD 2 2014-07-25 1
BDT USD 77.61971 2014-07-25 1
BGN USD 1.452543 2014-07-25 1
Content
Structure
Filter
Page 1 of 342
currency
MULTIPLE
base
USD
rate
MULTIPLE
date
2014-07-25
source_id
forex_source:
id
name
1
Open Exchange R...

DEMO