# Introduction to Cloud Databases

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# Why do you need a database system?

To store data,

why not just use a file system?

# Advantages of a Database System

- It answers ***queries*** fast

  Q1: among a set of blog pages, find those pages written by Steven Sinofsky after 2011

  Q2: among a set of employers, increase the salary by 20% for those who have worked longer then 4 years

- Queries (from multiple users) can execute ***concurrently*** without affecting each other
- It ***recovers*** from crash
  - No corrupt data after restart

# Data Model and Queries (1/3)

Q1: among a set of blog pages, find those pages written by Steven Sinofsky after 2011

Step1: structure your data by following the ***relational data model***

- Identify ***records*** (e.g., web pages, authors, etc.) with the same ***fields*** in your data and place them into respective ***tables***

**blog_pages**

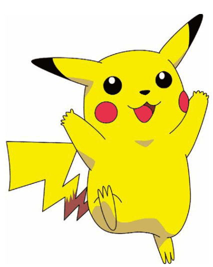
| blog_id | url | created | author_id |
|---|---|---|---|
| 33981 | ms.com/… | 2012/10/31 | 729 |
| 33982 | apache.org/… | 2012/11/15 | 4412 |

← record

field

**users**

| user_id | name | balance |
|---|---|---|
| 729 | Steven Sinofsky | 10,235 |
| 730 | Picachu | NULL |



# Data Model and Queries (2/3)

Q1: among a set of blog pages, find those pages written by Steven Sinofsky after 2011

```
CREATE TABLE blog_pages (
    blog_id INT NOT NULL AUTO_INCREMENT,
    url VARCHAR(60),
    created DATETIME,
    author_id INT);

INSERT INTO blog_pages (url, created, author_id)
    VALUES ('ms.com/...', 2012/09/18, 729);
```

**blog_pages**

| blog_id | url | created | author_id |
|---|---|---|---|
| 33981 | ms.com/… | 2012/10/31 | 729 |
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# Data Model and Queries (3/3)

Q1: among a set of blog pages, find those pages written by Steven Sinofsky after 2011

Step2: issue queries

```
SELECT b.blog_id
    FROM blog_pages b, users u
    WHERE b.author_id=u.user_id
        AND u.name='Steven Sinofsky'
        AND b.created >= 2011/1/1;
```

# Advantages of a Database System

- It answers ***queries*** fast

  Q1: among a set of web pages, find those pages written by Steven Sinofsky after 2011

  Q2: among a set of employers, increase the salary by 20% for those who have worked longer then 4 years

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# Transactions (1/3)

- Each query, by default, is placed in a ***transaction*** (***tx*** for short) automatically

```
BEGIN TRANSACTION;
    SELECT b.blog_id
        FROM blog_pages b, users u
        WHERE b.author_id=u.user_id
            AND u.name='Steven Sinofsky'
            AND b.created >= 2011/1/1;
COMMIT TRANSACTION;
```

# Transactions (2/3)

- You can group multiple queries in a transaction optionally
- For example, Steven wants to donate $100 to Picachu:

```
BEGIN TRANSACTION;
    UPDATE users
        SET balance=blance-100
        WHERE name='Steven Sinofsky';
    UPDATE users
        SET balance=blance+100
        WHERE name='Picachu';
COMMIT TRANSACTION;
```

# Transactions (3/3)

- A database ensures the ***ACID*** properties of transactions
- ***Atomicity***
  - All operations in a transaction either succeed (transaction commits) or fail (transaction rollback) together
- ***Consistency***
  - After/before each transaction (which commits or rollback), your data do not violate any rule you have set
  - E.g., blog_pages.author_id must be a valid users.user_id
- ***Isolation***
  - Multiple transactions can run concurrently, but cannot interfere with each other
- ***Durability***
  - Once a transaction commits, any change it made lives in DB permanently (unless overridden by other transactions)

So, why do you need
a cloud database system?

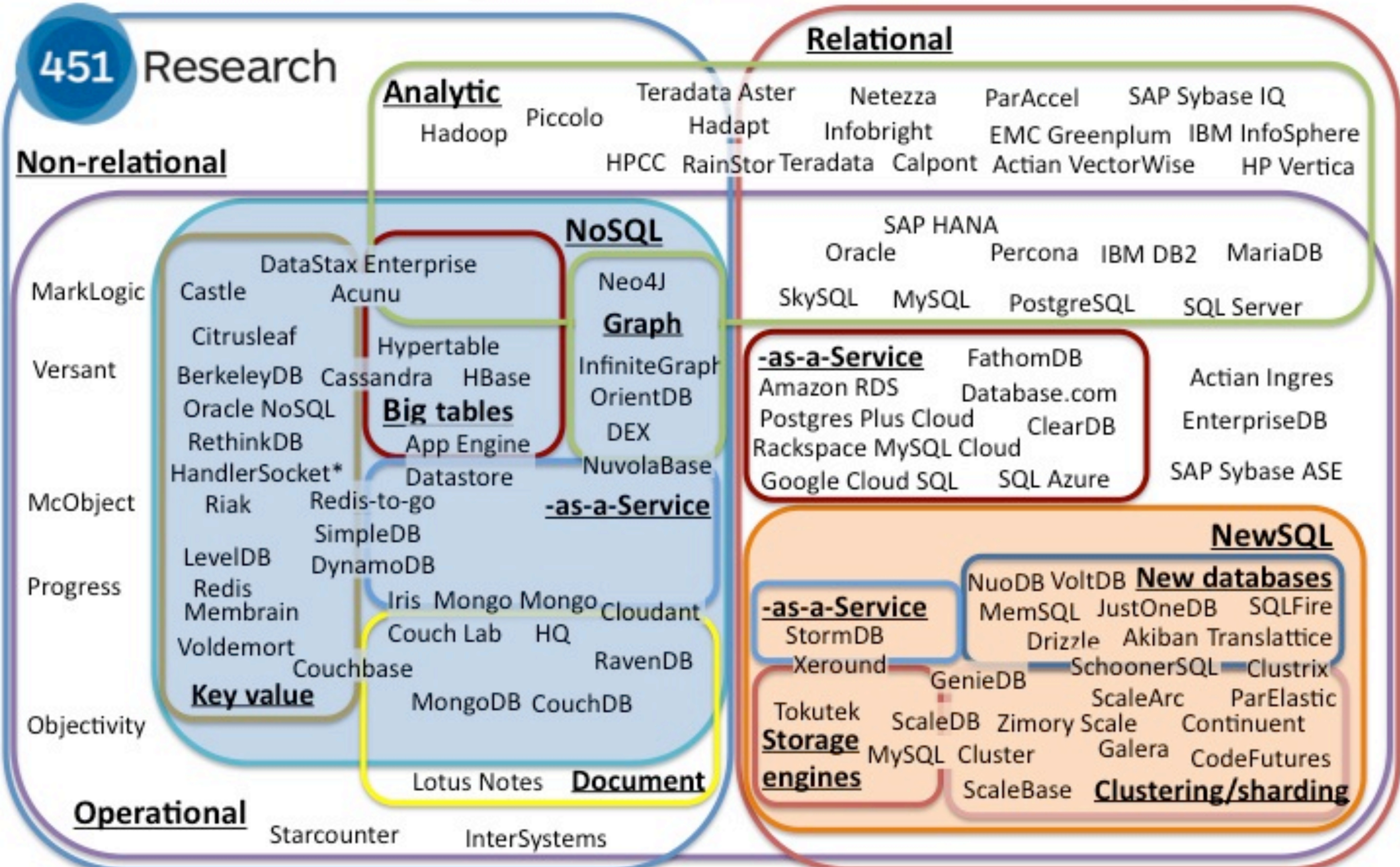
# Definition

- A ***cloud database*** is a database designed to run in the cloud
  - Manages data of tremendous applications (called ***tenants***)
- Is MySQL a cloud database?
  - I can run MySQL in a Amazon EC2 VM instance
- No

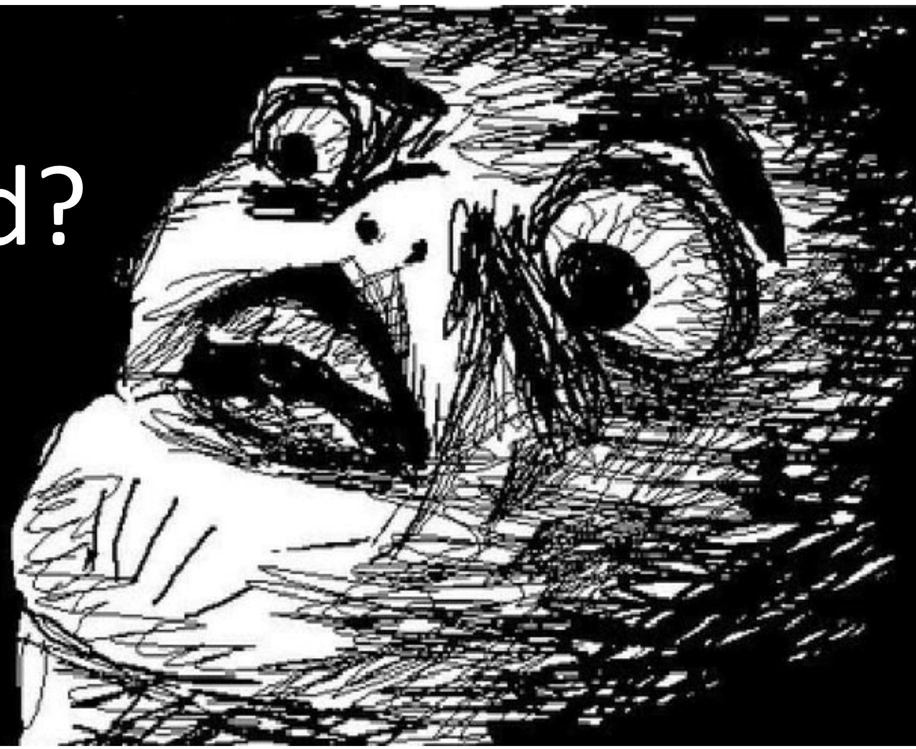
# What's the Difference

- Ideally, in addition to all features provided by a traditional database, a cloud database should ensure ***SAE***:
- ***high Scalability***
  – High max. throughput (measured by Tx/Query per second/minute)
- ***high Availability***
  – Stay on all the time, despite of server/network failure
- ***Elasticity***
  – Add/shutdown physical/virtual servers dynamically based on the current workload and/or capability

# The evolving database landscape



# Why So Complicated?



# Full DB functions + SAE = a goal no one can achieve (currently)

- Even with Oracle 11g + SPARC SuperCluster
  - 30,249,688 TPC-C transactions per minute
  - $30+ million USD

  you loss elasticity

# Primer Goal of This Class

- To guide you through the design trade-offs of existing database systems in the cloud
- ***NOT*** a comprehensive survey
- ***NOT*** on how to use the cloud databases

# Our Steps

- We spend the first half of the semester on the ***internals*** of a DB system
  - By walking through the VanillaDB
- And the second half on the ***implementation trade-offs*** in cloud DBs
  - With some case studies

# Prerequisites

- Data structure
- Good programming skill
  - OOP (in Java)
  - Multi-threaded programming
  - Project management tools like Git
- Knowing how to use a standalone DB
  - ER and Relational models
  - SQL

# Syllabus

- Here
  - Subject to change
- Tue 10am-12pm: ***video*** lecture
- Thu 10am-***12pm***: TA time
  - Explain your new assignment
  - Review your pass assignment
- Homework every 2 weeks
  - Not only code
  - But reports

# Grading

- Homework: 40%
- Midterm project: 30%
- Final project: 30%

# FAQ (1/2)

- Do I need to write programs in this course?
  - A lot!
  - ***We will give extensive coding assignments***
- Do I need to write code with others?
  - Yes, 1~2 students a team

# FAQ (2/2)

- Do we need to come to the class?
  - No, as long as you can pass
- Is this a light-loading class or heavy-loading class?
  - Should be ***heavy*** to most students
  - Assigned reading takes 2 ~ 4 hours per week
  - Assigned experiments take 2~ 10 hours per week
  - ***Reserve time, otherwise you will have high chance to fall***

# Resources

- Text Book
  - Lecture notes
  - Reference links
- Course page
  - http://www.cs.nthu.edu.tw/~shwu
- TODO
  - Register your team