Intro to Data Management
CSE 414

Final Review

Announcements

- Webquiz 7 due date extended to tomorrow
- Extra office hours tonight 6pm to 8pm on 4th floor CSE

Final Exam

- Thursday, Dec 13 2:30 - 4:20
- This room
- Closed books, no phones, no computers
- Allowed 2 pages of notes (both sides of each)
- Primary focus on the second half

Course Topics

1. Relational Data
2. Database Design & Implementation
3. Concurrency and Transactions
4. Semi-structured Data
5. Parallel Big Data Systems

When to Use a Database

- Of all the tools we know, how do pick?
- Depends on use case and role
- Easier to implement in database first than reverse engineer

Role: Scientist

- Data type: single csv file
  - Probably don't need database unless you love SQL
- Data type: many small csv files
  - Good time to use SQLite, easier to add data to one place
- Data type: multiple table catalog
  - Consider more powerful database like PostgreSQL or SQL Server

Role: Industry Data Analyst

- Very small company: see scientist case
  - Will have to think about database design
- Large company: definitely need database
  - System: whatever they tell you to use
    - Probably the parallel database system de jour (SQL or NoSQL)
  - Often very concerned with speed
    - Can take hours to run a query

Role: Industry Application Developer

- Database design
  - Single node or parallel database?
  - SQL or NoSQL/MapReduce?
  - Indexes

- Making app work with database
  - Transactions
  - Query execution

Relational Data

1a. Relational Data Model

- Tables with schemas
  - First normal form: no nested tables
  - types for attributes
  - primary and foreign keys
  - other constraints
- bag semantics

1b. Relational Queries

- Relational query = expressible in standard RA
- Simple SELECT-FROM-WHERE with no joins or aggregates is:
  - Expressible with nested-loop semantics
  - Always monotone
- Datalog adds recursion

SQL

- CREATE TABLE …
  - PRIMARY KEY, FOREIGN KEY
  - Constraints UNIQUE, NOT NULL
- CREATE [CLUSTERED] INDEX … ON ...
- INSERT INTO …
- UPDATE … SET ... WHERE ...
- DELETE FROM ... WHERE …

SQL (cont.)

- SELECT …
  - JOINs: inner vs outer, natural
  - GROUP BY, sum, count, avg, etc.
  - ORDER BY
- BEGIN TRANSACTION
- COMMIT / ROLLBACK

Database
Design & Implementation

2a. DB Design Process

Conceptual Model:

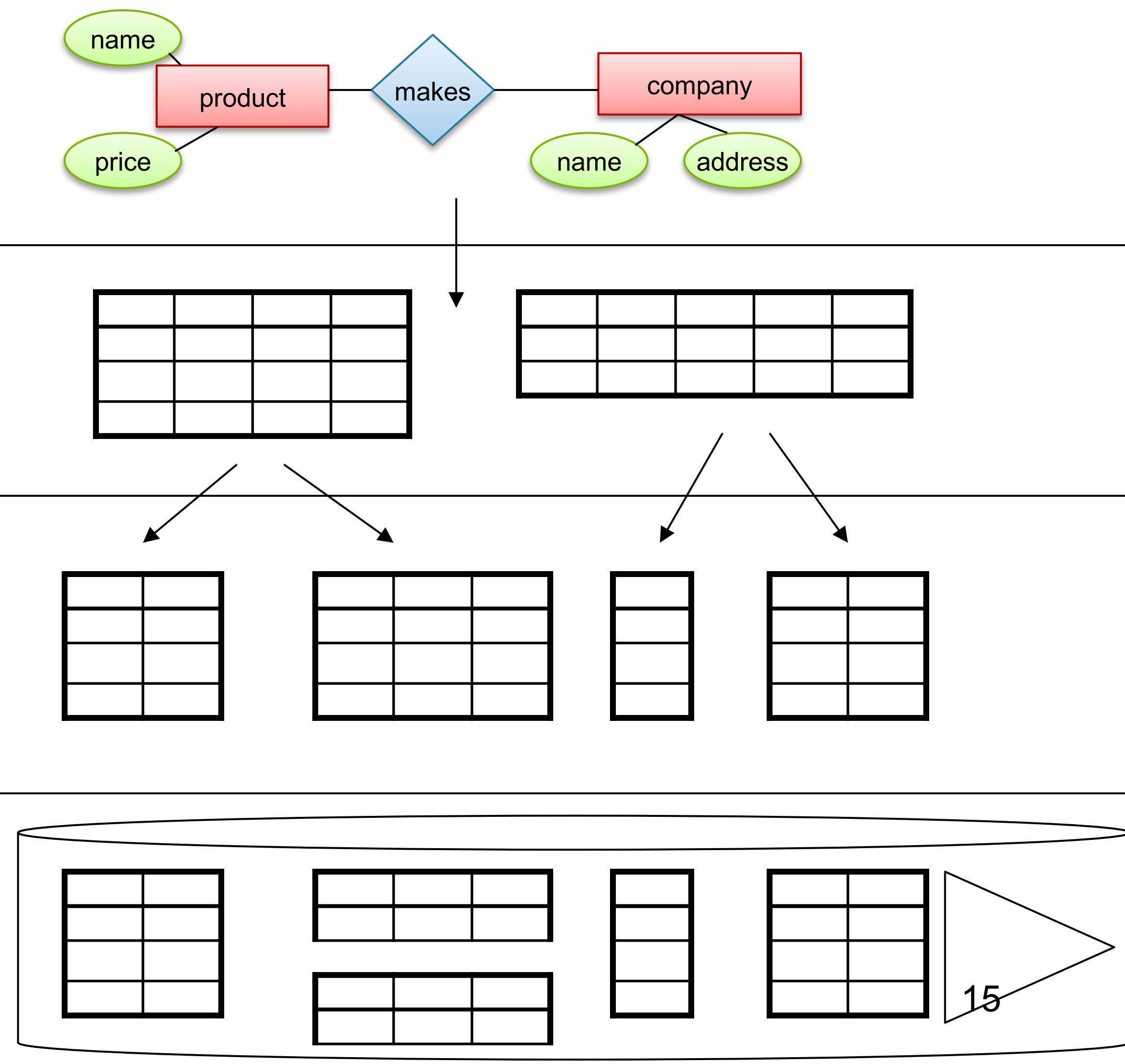
Relational Model:
Tables + constraints
And also functional dep.

Normalization:
Eliminates anomalies

Conceptual Schema

Physical storage details

Physical Schema



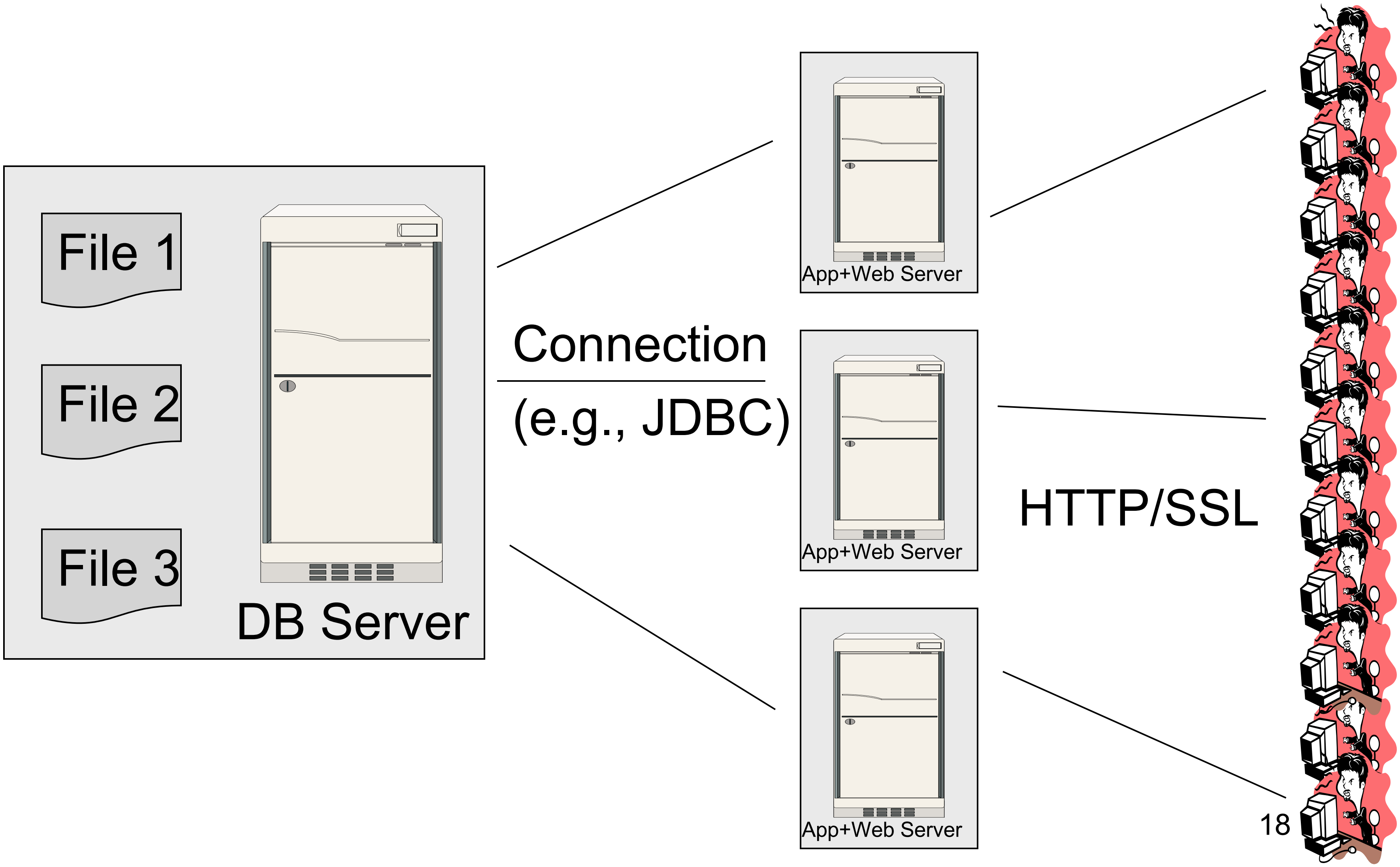
2a. DB Design Process

- E/R Diagrams
  - Entity sets, relations, & subclasses
  - Map each to relations
    - multiple ways to do this (many-many, one-many)
  - Design principles:
    - model accurately
    - neither too few nor too many entities

2a. DB Design Process

- Constraints
  - key, referential & other constraints
- Normalization
  - Eliminates anomalies
    - redundancy, update, and deletion anomalies
  - Occur from “bad” functional dependencies (FDs that aren’t superkeys)
  - Apply BCNF decomposition to remove them

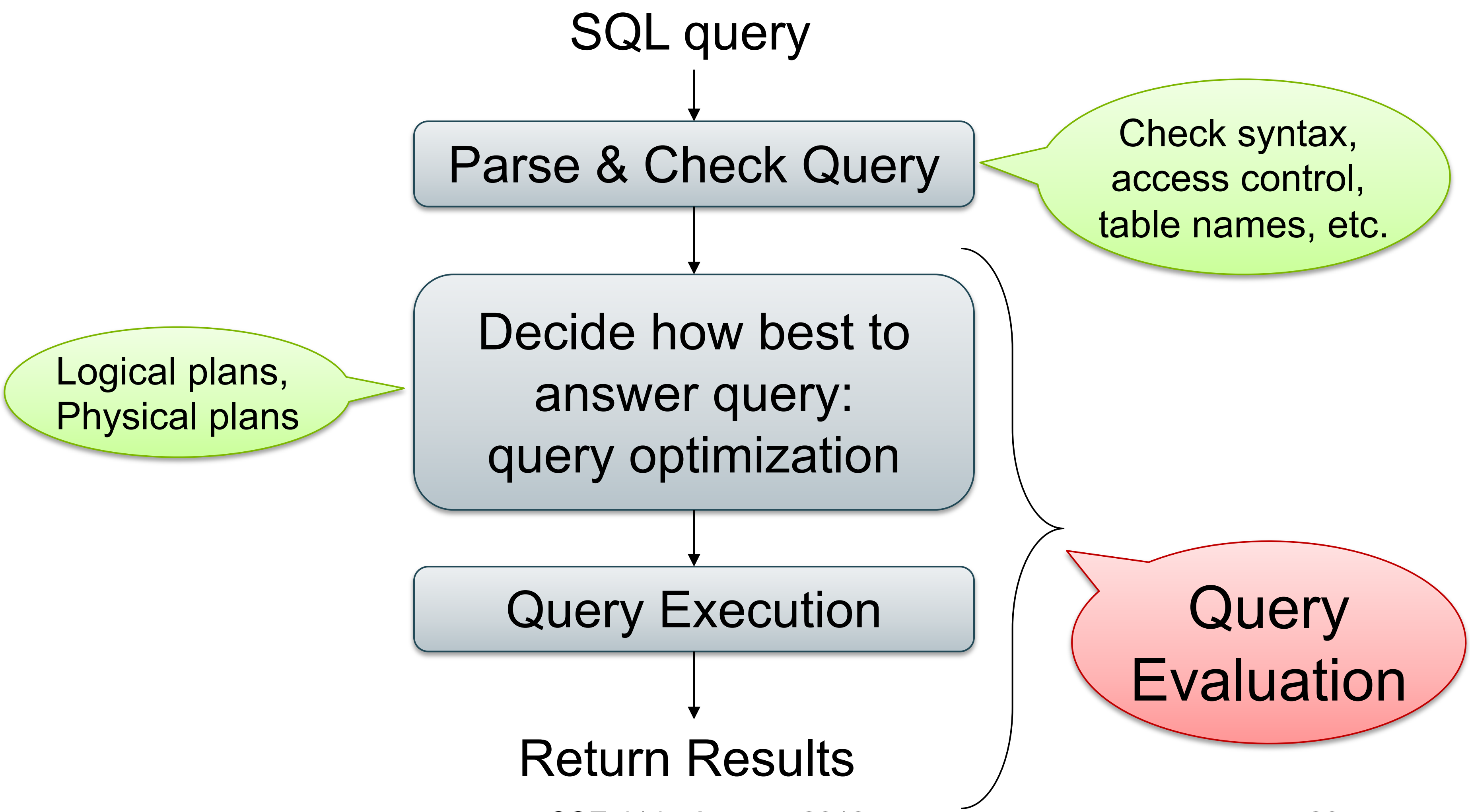
3-Tiered Architecture



2a. Storage & Indexing

- B+ tree & hash indexes
  - B+ tree index is sorted, best for range queries
- clustered vs unclustered
  - clustered always speeds up query
    but only one index per table can be clustered
  - unclustered only speed up selections if <1% tuples match

Query Evaluation Steps



3b. Query Optimization

- main cost is disk access
- many logical plans, many physical plans
  - logical plans are RA expressions with desired result
  - physical plans include e.g. choice of join algorithm
    - E.g. block nested loop join and index nest look join
- cost of many operations depends on selectivity
- optimization problem is hard
- realistic goal is to avoid really bad plans

Concurrency and Transactions

4c. Transactions

- goal to allow many clients to run simultaneously
  - OLTP workload: lots of clients with small read/writes
- need to provide ACID properties
  - Atomic
  - Consistent
  - Isolated
  - Durable

4c. Transactions II

- isolation achieved through serializable schedules
  - serializable means same behavior as a serial schedule
  - conflict serializable means non-conflicting read/writes can be swapped to make schedule serial
    - stronger than (so implies) serializable
- locks ensure conflict serializability if 2PL used

4c. Transactions III

  - 2PL: all locks proceed unlocks
  - Strict 2PL: must do all unlocks at commit/rollback time
    - needed for isolation if txns can roll back
  - need more to prevent phantom rows
    - phantom is a new row that shows up in a table
    - predicate locks are one solution (but expensive)

- default isolation level is usually not serializable
  - faster perf but harder to write app (i.e., bugs likely)

Semistructured Data

4a. Semistructured Data Model

- tree structured data: JSON, XML, etc.
- data is self-describing
  - so schema is not necessary
- easy to map relation to JSON but not opposite

Systems for Big Data

5a. NoSQL Systems

- goal to support heavy OLTP workloads
- provides simplified data model
  - key-value pairs, documents, or extensible records
- limited support for transactions
  - usually pair/document/record level
  - (some support for record groups… all on one node)

5b. Parallel Processing Systems

- for OLAP workloads (big reads, no txns)
- Goal is linear speed up or scale up
- MapReduce
  - programming model is one-to-many *map* function, shuffle sort (grouping), one-to-many *reduce* function
  - no built-in RA operators
  - stores intermediate data on disk
  - deals with stragglers by running backup map tasks

5c. Parallel Relational Databases

- Partition data across nodes (hash, range, etc.)
- Query evaluation
  - only one new element: reshuffle
    - move tuples to nodes based on values in certain columns
    - basically same as shuffle sort of MapReduce
    - use to implement all extended RA operations
  - new problem: skewed data

Things NOT on the final exam

- Datalog
- SQL++ queries (but there will be NoSQL conceptual questions)
- Join algorithms that were not in the slides
  - (no sort-merge joins but yes nested loop join)
- The difference between B+ tree vs. Hash indexes, can always assume B+ tree
- Isolation levels
- Writing Java code