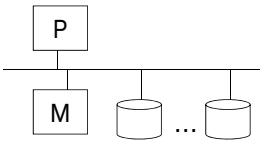
CS 347:
Distributed Databases and
Transaction Processing

Notes 01: Introduction

Hector Garcia-Molina

In CS245: Centralized DB system



Software:

Application
SQL Front End
Query Processor
Transaction Proc.
File Access

- Simplifications:
  - single front end
  - one place to keep locks
  - if processor fails, system fails, ...

In CS347

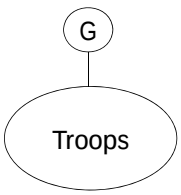
- Multiple processors (+ memories)
- Heterogeneity and autonomy of "components"

Multiple processors

- Opportunity for parallelism
- Opportunity for reliability
- Synchronization issues

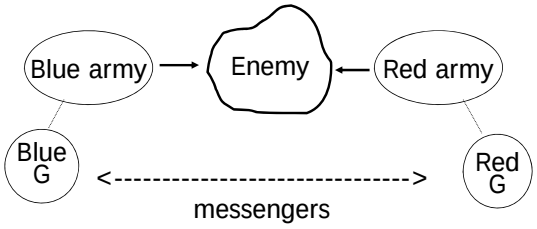
⇔ To illustrate synchronization problems:
Two Generals Problem

The one general problem (Trivial!)



➔ Battlefield

The two general problem:

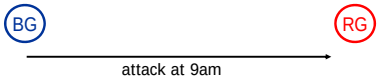


Rules:

- Blue and red army must attack at same time
- Blue and red generals synchronize through messengers
- Messengers can be lost

How Many Messages Do We Need?

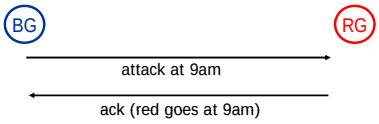
assume blue starts...



Is this enough??

How Many Messages Do We Need?

assume blue starts...



Is this enough??

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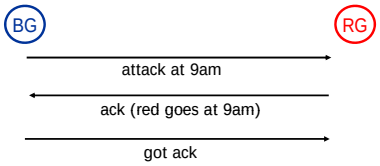


Is this enough??

Stated problem is Impossible!

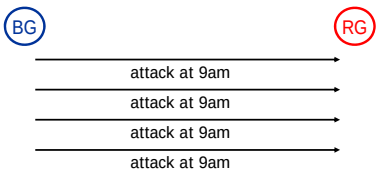
- **Theorem:** There is no protocol that uses a finite number of messages that solves the two-generals problem (as stated here)

Alternatives??

Probabilistic Approach?

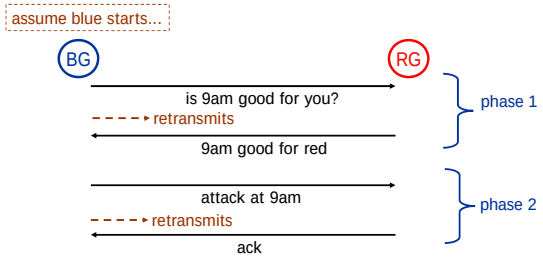
- Send as many messages as possible, hope one gets through...

assume blue starts...



Eventual Commit

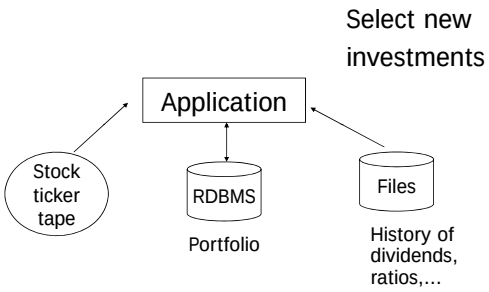
- Eventually both sides attack...



Commit Protocols

- Will study commit protocols like these...

Heterogeneity



Autonomy

Example: unable to get statistics for query optimization

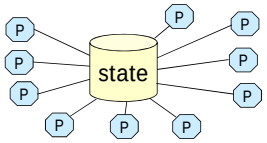
Example: blue general may have mind of his (or her) own!

- So, in CS347 we study data management with multiple processors and possible autonomy, heterogeneity
  - Impact on:
    - Data organization
    - Query processing
    - Access structures
    - Concurrency control
    - Recovery

- Renewed Interest in Distributed/Parallel Data Processing!
  - Massive web data, manage with many computers
  - How to crawl and search the web?
  - Peer-to-peer systems manage huge amounts of data
  - Data from many sources (e.g., comparison shopping): how to integrate?
  - Sensor Networks: data generated an many sensors/devices, need to analyze
  - Multi-player games (e.g., Second Life): tons of distributed data

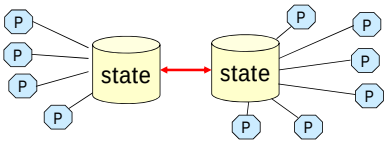
It's the ~~Economy~~ Data, Stupid!

- Example: Multi-player games



It's the ~~Economy~~ Data, Stupid!

- Example: Multi-player games



Logistics

- LECTURES: Mondays and Wednesdays 12:50pm to 2:05pm, Skilling 193
- INSTRUCTOR: Hector Garcia-Molina; Office: Gates Hall 434 Email: hector@cs.stanford.edu; Office Hours: Mondays, Wednesdays 11am to 12noon.
- ADDITIONAL INSTRUCTOR: Zoltan Gyongyi; Email: zoltan@cs.stanford.edu.
- TEACHING ASSISTANT: Paul Heymann; Office: Gates 424; Email: cs347-spr0809-staff@lists.stanford.edu; News Group: su.class.cs347; Office Hours: TBD
- SECRETARY: Marianne Siroker; Office: Gates Hall 436; Email: siroker@cs.stanford.edu; Phone: (650) 723-0872

Logistics

- TEXTBOOK: No required textbook. Some material for the lectures will be drawn from the following book:
  - M. Tamer Ozsu and Patrick Valduriez, "Principles of Distributed Database Systems," Second Edition, Prentice Hall 1999.
- CLASS WEB PAGE: http://www.stanford.edu/class/cs347 Will contain homework assignments, course news, etc. Be sure to check it periodically.
- ASSIGNMENTS: about 5 homeworks
- GRADING: Homeworks: 20%, Midterm 30%, Final: 50%.

Tentative Syllabus (Part I)

DATE	TOPIC
Wednesday April 1	Introduction [N01]
Monday April 6	Data Fragmentation [N02] Z
Wednesday April 8	Query processing [N03] Z
Monday April 13	Query processing [N03] Z
Wednesday April 15	Query Optimization [N04] Z
Monday April 20	Concurrency Control, Failures [N06]
Wednesday April 22	Reliable Data Management [N07]
Monday April 27	Reliable Data Management [N07]
Wednesday April 29	Replicated Data Management [N08]

Tentative Syllabus (Part II)

DATE	TOPIC
Monday May 4	Midterm
Wednesday May 6	Network Partitions [N09]
Monday May 11	Peer to Peer Systems [N05]
Wednesday May 13	Peer to Peer Systems [N05]
Monday May 18	Map-Reduce
Wednesday May 20	Distributed IR Z
Wednesday May 27	Distributed Entity Resolution [new]
Monday June 1	Time [N10]
Wednesday June 3	Heterogeneous Systems, Source Capabilities [N11, 12, 13] Z

Concepts you should be familiar with:

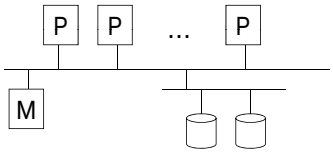
- CS245: query plan, cost estimation, join algorithms, recovery, logging,...
- Interconnection networks (bus, mesh, hypercube,...)
- Computer networks (LAN, WAN,...)

Introductory topics

- Database architectures
- Client-server systems
- Distributed vs. parallel DB systems
- Cloud Computing

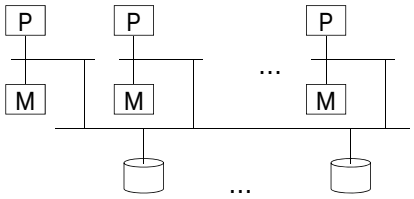
DB architectures

(1) Shared memory



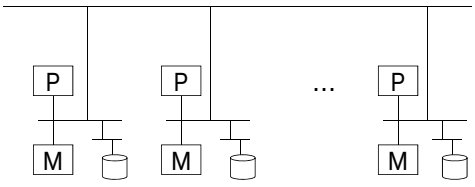
DB architectures

(2) Shared disk



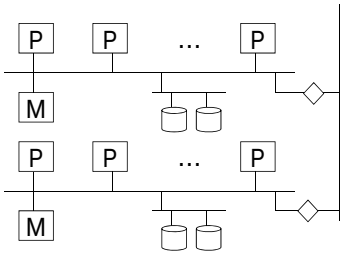
DB architectures

(3) Shared nothing



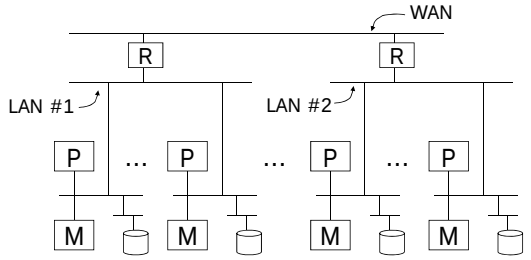
DB architectures

(4) Hybrid example



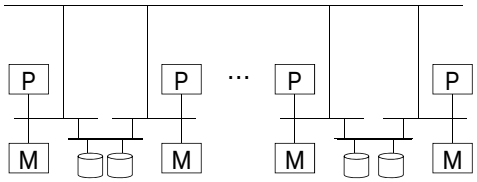
DB architectures

(4) Hybrid example 2



DB architectures

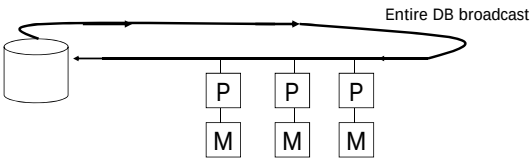
(4) Hybrid Tandem-like



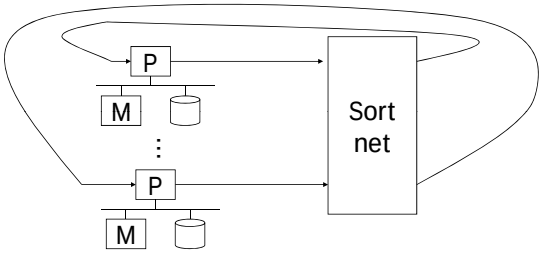
DB architectures

(5) Unusual?

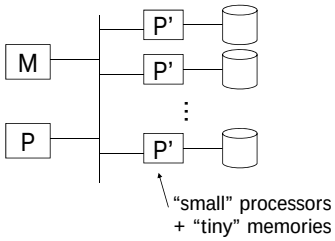
Datacycle (Broadcast disks)



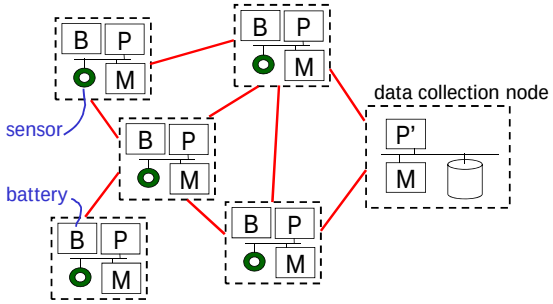
(5) Unusual Sorting network



(5) Unusual — processor per track or processor per disk



(6) Unusual — sensor networks

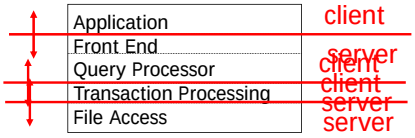


Issues for selecting architecture

- Reliability
- Scalability
- Geographic distribution of data
- Data "clusters"
- Performance
- Cost

Client-Server Systems

(or how to partition software)



Transaction Servers

- Clients ship transactions consisting of 1 or more SQL commands

E.g., Open DataBase Connectivity (ODBC)
(standard API)

Data Servers

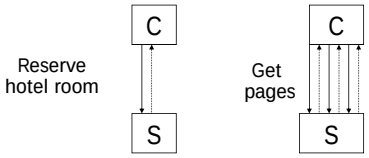
- Client requests pages or records
- Popular for OODB systems

Issues

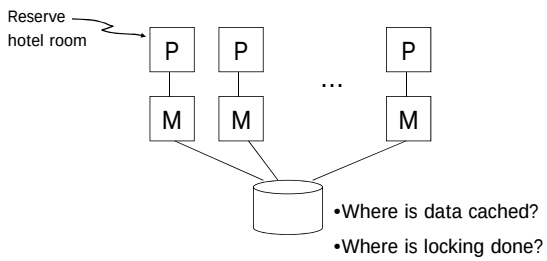
- Object granularity
- Where is data cached?
- Where is locking done?

Basic Tradeoff

- Offloading work to clients
- Data transmitted



Note: Similar issues arise when we partition software/functionality within server



Parallel or distributed DB system?

- More similarities than differences!

- Typically, parallel DBs:
  - Fast interconnect
  - Homogeneous software
  - High performance is goal
  - Transparency is goal

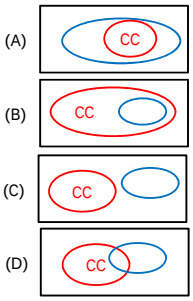
- Typically, distributed DBs:
  - Geographically distributed
  - Data sharing is goal (may run into heterogeneity, autonomy)
  - Disconnected operation possible

Cloud Computing

- Is CC just a marketing term??
  - utility (like power)
  - data or CPU cycles?
  - many processors, many storage units
  - business model

Is CC a subset, superset, disjoint from, or overlaps with:

- grid computing
- distributed computing
- Web 2.0
- Cluster Computing
- Peer-to-peer computing
- software as a service
- client-server computing
- data center as a computer
- massively parallel computing



CC Issues

- Customer lock-in
- Privacy
- Standards
- Software licensing

Next

- How to describe distributed data
- Query processing in parallel DBs
- Query processing in distributed DBs

Query processing in parallel DBs:

- Typically: we can distribute/ partition/ sort…. data to make certain DB operations (e.g., Join) fast

Query processing in distributed DBs:

- Typically: we are given data distribution; we need to find query processing strategy to minimize cost (e.g., communication cost)