db architectures
DATA SYSTEMS
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logistics

Use Piazza

Lab today: 6-9pm at Pierce 100F
(room will change in the future)

2 for notes?
today
basic db architecture
quiz+discussion
declarative interface
ask what you want

the db system decides how to “best store and access data”

db system

how is this possible
design/implement numerous possible algorithms + data representations

choose the best data source, algorithms and path for each query
\textbf{select} \text{min}(A) \textbf{from} R \textbf{where} B<10 \text{ and } C<80
applications

sql

database kernel

parser
optimizer
execution
storage

in/out
database kernel

applications

thread 1

thread 2

thread 3

thread 4

sql

client programs

db program

thread pool

database kernel
applications

sql

database kernel

parser
optimizer
execution
storage

in/out
thread pool
transactions
buffer pool

cpu
memory
disk
query plan

database kernel

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data

query plan

algorithms/ops\ors
data
select name
from student
where GPA > 3.0

scan all the data?

result

project
name

select
GPA > 3.0

student(id, name, GPA, address, class, ...)

logical plan
select name from student where GPA>3.0

physical plans
```sql
select avg(GPA)
from student
where class=2017
```
give me all students enrolled in cs165

**select** student.name

**from** students, enrolled, courses

**where** courses.name="cs165"

and enrolled.courseld=course.id

and student.id=enrolled.studentId
select student.name
from students, enrolled, courses
where courses.name = "cs165"
and enrolled.courseld = course.id
and student.id = enrolled.studentld

project student.name

join
student.id = enrolled.id

join
enrolled.id = course.id

select name = "cs165"
\textbf{select min}(A) \textbf{from} \textbf{R} \textbf{where} B<10 \textbf{and} C<80
is it “good” to have modules
can DBAs make wrong decisions?

can optimizers make wrong decisions?

should we ever drop module boundaries - how
is memory hierarchy important for db system design
100K

disk

Pluto 2 years

100

memory

New York 1.5 hr

10

on board cache

this building 10 min

2

on chip cache

this room 1 min

1

registers

my head
- **Cache miss**: looking for something which is not in the cache.

- **Memory miss**: looking for something which is not in memory.

The diagram illustrates the hierarchy of memory components: CPU, registers, on-chip cache, on-board cache, memory (SRAM and DRAM), and disk. The speed of these components decreases as you goes further down the hierarchy, with corresponding time increases: ~1ns for registers, ~10ns for on-chip cache, ~100ns for DRAM, and slower for memory and disk.
design of individual operators as well as overall system design should minimize

cache misses
memory misses

data misses
instruction misses
devices that store data work in **blocks/pages**
e.g., we always read X data from disk/memory/cache

implication ?
task: f(d) for all d

Level N

Level N-1

data blocks for d
each one contains N d values
**sequential access:**
read one block; consume it completely; discard it; read next
**sequential access:**
read one block; consume it completely; discard it; read **next**

---

in parallel/prefetching

**what is next?**
task: $f(d)$ for some $d$, e.g., $d<2$

Level N

Level N-1

$f()$

oracle/index

data blocks for $d$
each one contains $N$ $d$ values
random access:
read one block; consume it partially; discard it;
might have to read it again in future; read “random” next;

disk arms
memory buffers
os block size

device block size

os and db will typically refer to pages
Level N-1

buffer pool remember hot blocks

why not use OS caching

Level N
shared everything vs shared nothing

node/disk/memory/cache/register

```
data
```

```
cpu1  cpu2
```

```
data
```

```
cpu1  cpu2
```
Architecture of a Database System
by J. Hellerstein, M. Stonebraker and J. Hamilton

Sections 1,2,3,4

next class we start discussing data layouts and column-stores
it is summer 2014 - now you know all about data systems

you are building an augmented reality startup using Google Glass

people wearing Google Glass can tag places/objects - voice/image recognition works fine

tagging means assigning values, comments, etc to an object

you can then query this data - again assume voice recognition works fine and a black box translates natural language to SQL

how does the schema of your app look like? (tables, attributes, keys, relationships)
(assume a limited working environment/features, say walking around Harvard square/yard)

describe 2 interesting queries in SQL
db architectures

DATA SYSTEMS

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