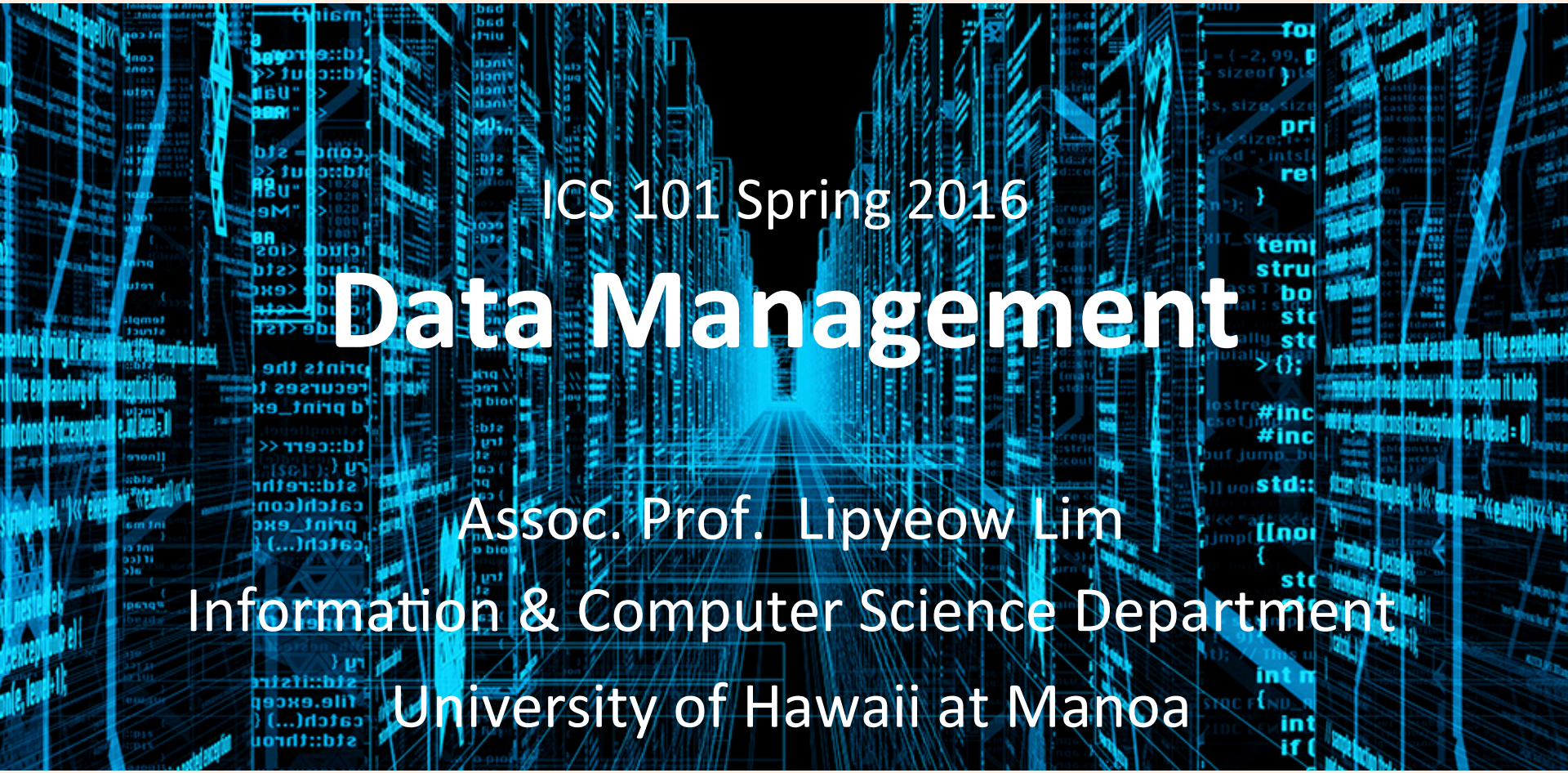

ICS 101 Spring 2016

Data Management

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Survey Question: What do you think data management is ?

A. How to file papers in a file cabinet.
B. How to put data files in the right directories on your computer.
C. How to organize, store, and find data using computers.
D. How to ensure that your data cannot be accessed or altered by an unauthorized person.

Objectives

At the end of this lecture, the successful student should know:

- What is data and where does it come from ?
- What is data management ?
- What is a database
- What is the relational model data
- How to search a database
- What is a transaction
- How to search unstructured data

What is ``data'' ?

- **Data** are known facts that can be recorded and that have implicit meaning.
- Three broad categories of data
  - Structured data
  - Semi-structured data
  - Unstructured data
- ``Structure'' of data refers to the organization within the data that is identifiable.

Where does data come from ?

- How much data do we have ?

Units of Data

Multiplier (Decimal)	Notation	Name
1	B	byte (= 8 bits)
1000	kB	kilobyte
1000^2	MB	megabyte
1000^3	GB	gigabyte
1000^4	TB	terabyte
1000^5	PB	petabyte
1000^6	EB	exabyte
1000^7	ZB	zettabyte
1000^8	YB	yottabyte

A music file

A DVD quality movie

All the data in a typical library

How much data is there in the world?

- According to IBM: 2.5 exabytes of data are was generated every day in 2012.

- 75% of data is unstructured coming from sources such as text, voice and video.

Who owns the data ?

Can we handle all that data ?

- How ?
- Structured data – Database technology
- Unstructured data – Search engine technology


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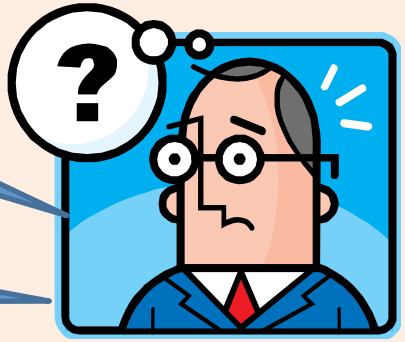
The Data Management Problem

Where is the photo I took last Christmas ?

Where did I read about "Turing Machines" ?

Where is the invoice for this computer ?

Which product is the most profitable ?

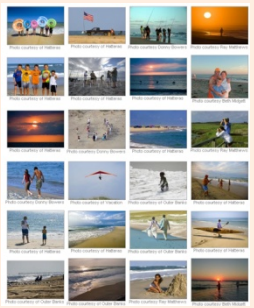


User

Queries

?

Data



What is a database ?

- A **database** : a collection of related data.
  - Represents some aspect of the real world (aka universe of discourse).
  - Logically coherent collection of data
  - Designed and built for specific purpose
- A **data model** is a collection of concepts for describing/organizing the data.
- A **schema** is a description of a particular collection of data, using the a given data model.

The Relational Data Model

- *Relational database:* a set of *relations*
- A *relation* is made up of 2 parts:
  - *Instance* : a *table,* with rows and columns. #Rows = *cardinality,* #fields = *degree / arity.*
  - *Schema* : specifies name of relation, plus name and domain/type of each column or attribute.
    - E.G. Students(sid: string, name: string, login: string, age: integer, gpa: real).
- Can think of a relation as a *set* of rows or *tuples* (i.e., all rows are distinct).

Example Instance of Students Relation

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

- Q1. What is the cardinality of the relation instance?
  (a) 1 (b) 2 (c) 3 (d) 4

- Q2. What is the degree/arity of the relation instance?
  (a) 2 (b) 3 (c) 4 (d) 5

Why is the relational model useful ?

- Supports simple and powerful query capabilities!
- Structured Query Language (SQL)

```
SELECT S.sname
FROM  Students S
WHERE  S.gpa>3.5
```

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

What is a DBMS ?

- A **database management system (DBMS)** is a *collection of programs* that enables users to
  - Create new DBs and specify the structure using data definition language (DDL)
  - Query data using a query language or data manipulation language (DML)
  - Store very large amounts of data
  - Support durability in the face of failures, errors, misuse
  - Control concurrent access to data from many users

Types of Databases

- On-line Transaction Processing (OLTP)
  - Banking
  - Airline reservations
  - Corporate records
- On-line Analytical Processing (OLAP)
  - Data warehouses, data marts
  - Business intelligence (BI)
- Specialized databases
  - Multimedia
  - XML
  - Geographical Information Systems (GIS)
  - Real-time databases (telecom industry)
- Special Applications
  - Customer Relationship Management (CRM)
  - Enterprise Resource Planning (ERP)
- Hosted DB Services
  - Amazon, Salesforce

A Bit of History

- 1970 Edgar F Codd (aka "Ted") invented the relational model in the seminal paper "A Relational Model of Data for Large Shared Data Banks"
  - Main concept: *relation* = a table with rows and columns.
  - Every relation has a *schema*, which describes the columns.
- Prior 1970, no standard data model.
  - Network model used by Codasyl
  - Hierarchical model used by IMS
- After 1970, IBM built System R as proof-of-concept for relational model and used **SQL** as the query language. SQL eventually became a standard.

Transactions

- A *transaction* is the DBMS's abstract view of a user program: a sequence of reads and writes.
  - Eg. User 1 views available seats and reserves seat 22A.
- A DBMS supports multiple users, ie, multiple transactions may be running concurrently.
  - Eg. User 2 views available seats and reserves seat 22A.
  - Eg. User 3 views available seats and reserves seat 23D.

ACID Properties of Transactions

- **A**tomicity : all-or-nothing execution of transactions
- **C**onsistency: constraints on data elements is preserved
- **I**solation: each transaction executes as if no other transaction is executing concurrently
- **D**urability: effect of an executed transaction must never be lost

Q3. Why use a DBMS ?

a) The data is too large to manage in excel files
b) I do not want to write my own programs to find something in the data
c) I do not want to write my own program to manage multiple users and transactions
d) All of the above.

The Data Management Problem

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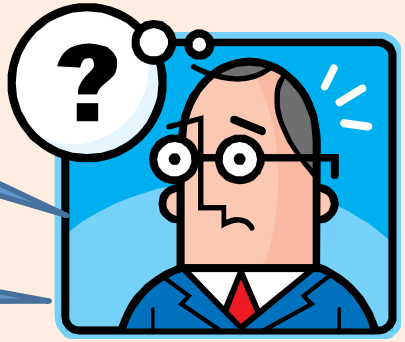

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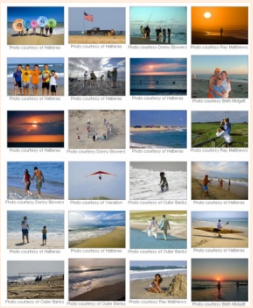


Unstructured Data

- What are some examples of unstructured data?
- How do we model unstructured data ?
- How do we query unstructured data ?
- How do we process queries on unstructured data ?
- How do we index unstructured data ?

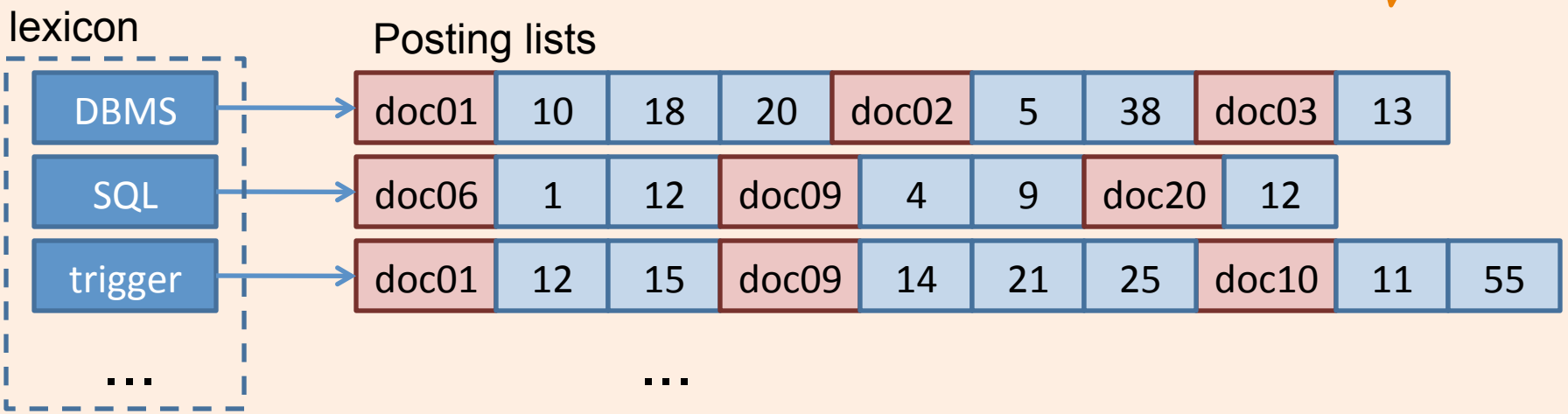
Unstructured Text Data

- Field of "Information Retrieval"
- Data Model
  - Collection of documents
  - Each document is a bag of words (aka terms)
- Query Model
  - Keyword + Boolean Combinations
  - Eg. DBMS and SQL and tutorial
- Details:
  - Not all words are equal. "Stop words" (eg. "the", "a", "his" ...) are ignored.
  - Stemming : convert words to their basic form. Eg. "Surfing", "surfed" becomes "surf"

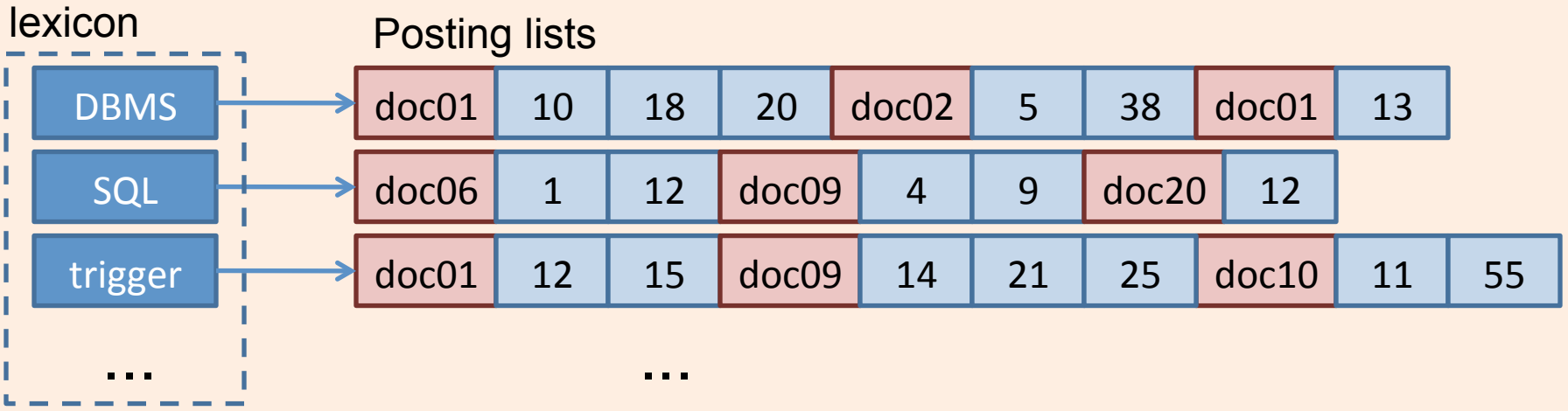
Inverted Indexes

- Recall: an index is a mapping of search key to data entries
  - What is the search key ?
  - What is the data entry ?
- Inverted Index:
  - For each term store a list of postings
  - A posting consists of <docid,position> pairs

What is the data in an inverted index sorted on ?



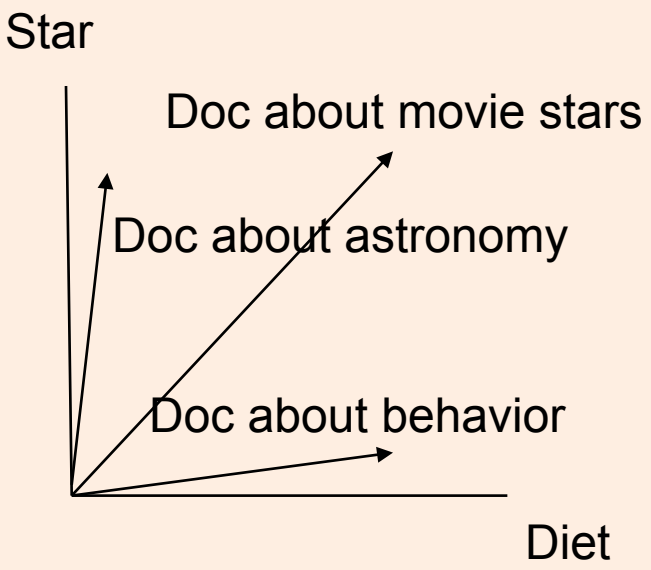
Lookups using Inverted Indexes



- Given a single keyword query "k" (eg. SQL)
  - Find k in the lexicon
  - Retrieve the posting list for k
  - Scan posting list for document IDs [and positions]
- What if the query is "k1 and k2" ?
  - Retrieve document IDs for k1 and k2
  - Perform intersection

Too Many Matching Documents

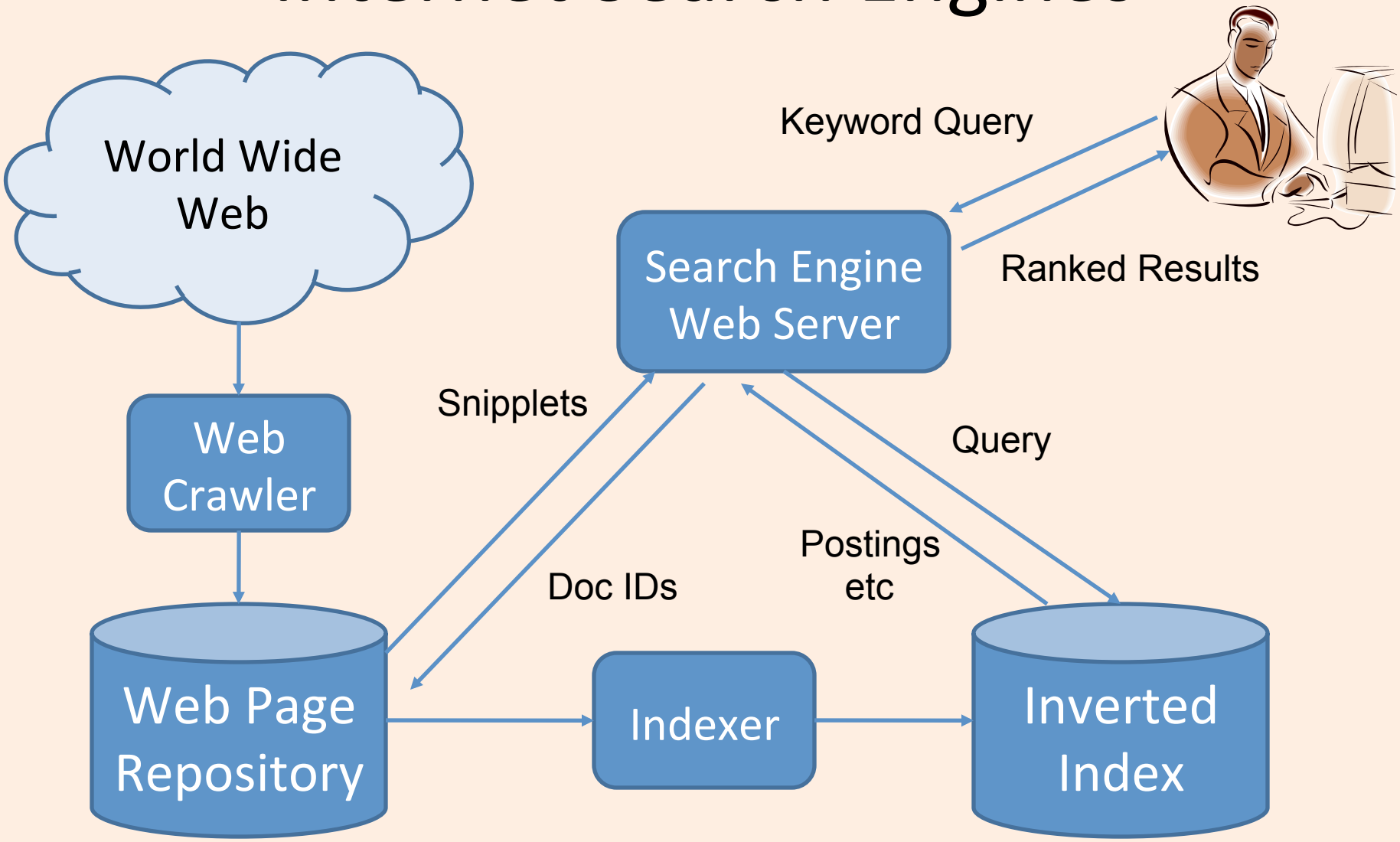
- Rank the results by “relevance”!
- Vector-Space Model
  - Documents are vectors in hi-dimensional space
  - Each dimension in the vector represents a term
  - Queries are represented as vectors similarly
  - Vector distance (dot product) between query vector and document vector gives ranking criteria
  - Weights can be used to tweak relevance
- PageRank (later)



Q4. Which of the following is the most similar to an inverted index ?

a) Bookmarks.
b) Content page of a book.
c) The index at the end of a book.
d) A deck of playing cards.

Internet Search Engines



Basic Web Search

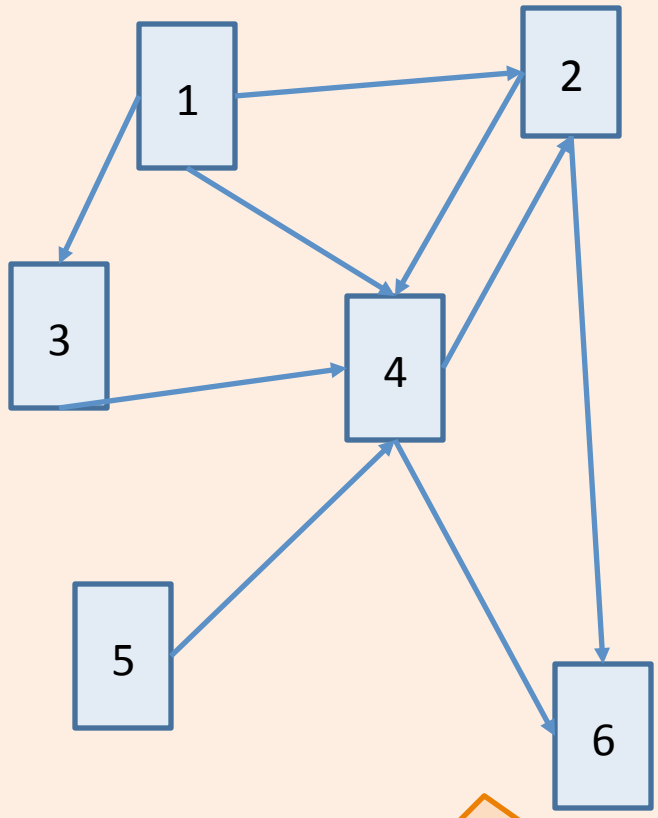
- http://www.googleguide.com/advanced_operators_reference.html

Query Expression	What it means
Biking italy	Biking **AND** italy
Recycle steel OR iron	Recycle **AND** (steel **OR** iron)
“I have a dream”	“I have a dream” treated as one term
Salsa -dance	Salsa **AND NOT** dance

Other nifty expressions	What it means
12 + 34 - 56 * 7 / 8	Evaluates the arithmetic expression
300 Euros in USD	Converts 300 euros to US currency

Ranking Web Pages

- Google's PageRank
  - Links in web pages provide clues to how important a webpage is.
- Take a random walk
  - Start at some webpage p
  - Randomly pick one of the links and go to that webpage
  - Repeat for all eternity
- The number of times the walker visits a page is an indication of how important the page is.



Vertices represent web pages.
Edges represent web links.

Semi-structured Search

Web pages are not really unstructured! Click “view source” to view HTML.

Query Expression	What it means
define:imbroglio	Find definitions of “imbroglio”
Halloween **site:**www.census.gov	Restrict search for “halloween” to US census website
Form 1098-T IRS **filetype:**pdf	Find the US tax form 1098-T in PDF format
link:warriorlibrarian.com	Find pages that link to Warrior Librarian's website
Dan Shugar **intext:**Powerlight	Find pages mentioning **Dan Shugar** where his company, **Powerlight**, is included in the text of the page, i.e., less likely to be from the corporate website.
allintitle: Google Advanced Operators	Search for pages with titles containing "Google," "Advanced,", and "Operators"

Summary

- Data Management Problem
  - How do we pose and answer queries on data?
- Structured data
  - Relational Data Model
  - SQL
  - Relational DBMS
  - Transactions
- Unstructured data
  - Bag of terms
  - Boolean combination of keyword queries
  - Inverted Indexes (Web Search Engines)
- Semi-structured data
  - Could use techniques from either structured or unstructured
  - More sophisticated keyword queries

Survey Question:
I learned a lot about data management from this lecture.

A. Strongly Agree
B. Agree
C. Neutral
D. Disagree
E. Strongly Disagree