INFORMATION RETRIEVAL SYSTEMS
IV B.Tech (CSE)-I Sem

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Information Retrieval Systems

- Information

  What is "information"?

- Retrieval

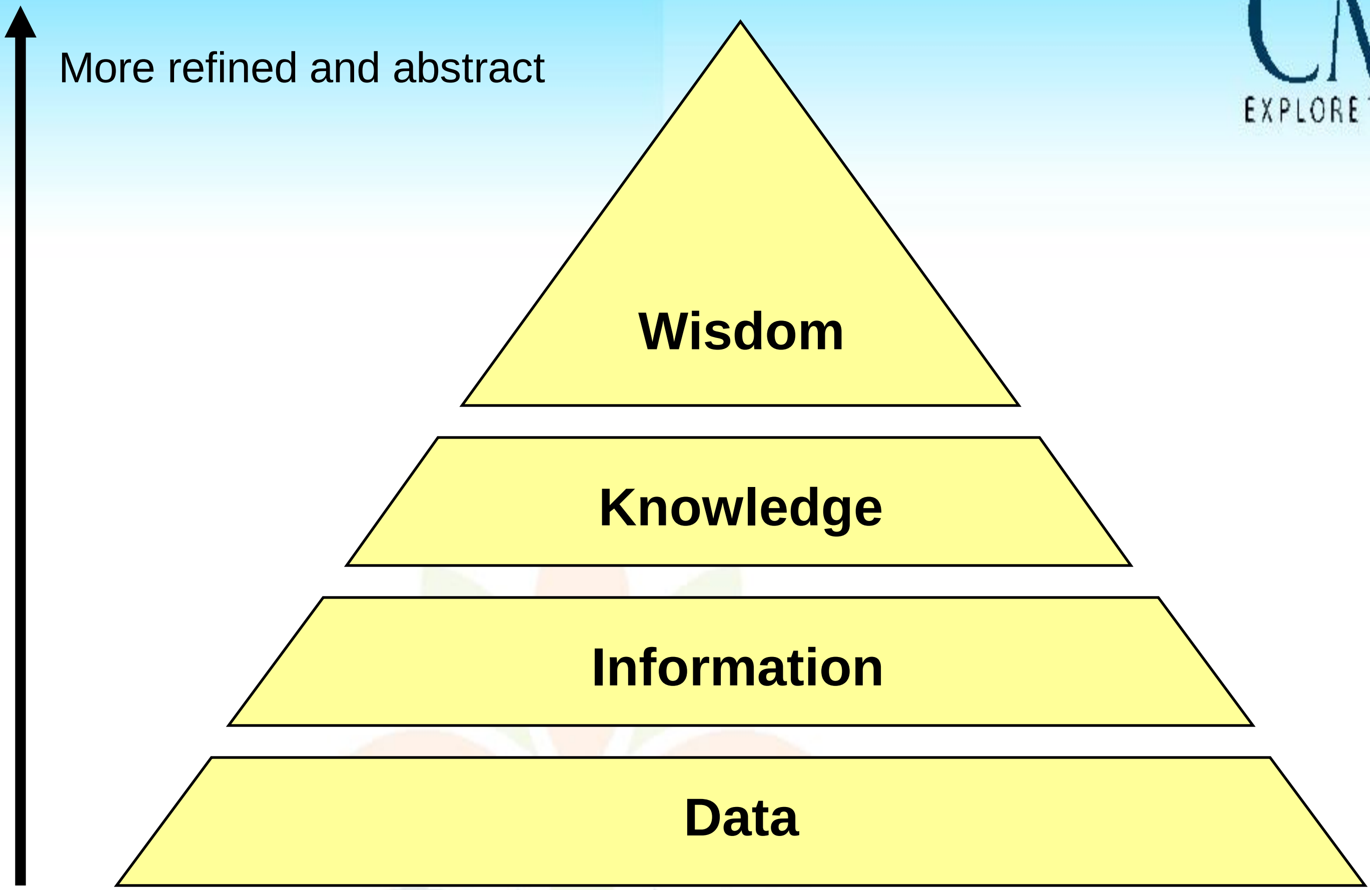
  What do we mean by "retrieval"?

  What are different types information needs?

- Systems

  How do computer systems fit into the ***human*** information seeking process?

Information Hierarchy



Information Hierarchy

- Data
  - The raw material of information
- Information
  - Data organized and presented in a particular manner
- Knowledge
  - “Justified true belief”
  - Information that can be acted upon
- Wisdom
  - Distilled and integrated knowledge
  - Demonstrative of high-level “understanding”

A (Facetious) Example

- Data

  98.6° F, 99.5° F, 100.3° F, 101° F, …

- Information

  Hourly body temperature: 98.6° F, 99.5° F, 100.3° F, 101° F, …

- Knowledge

  If you have a temperature above 100° F, you most likely have a fever

- Wisdom

  If you don’t feel well, go see a doctor

What types of information?

- Text
- Structured documents (e.g., XML)
- Images
- Audio (sound effects, songs, etc.)
- Video
- Programs
- Services

Outline of Unit-1

- Definition of IR Systems
- Objectives of IR Systems
- Functional Overview
- Relationship to DBMS

Definition of IR Systems

- An IR System is a system capable of storage, retrieval, and maintenance of information.

Information: text, image, audio, video, and other multi-media objects

Focus on textual information here

Item:

The smallest complete textual unit processed and manipulated by an IR system

Depend on how a specific source treats information

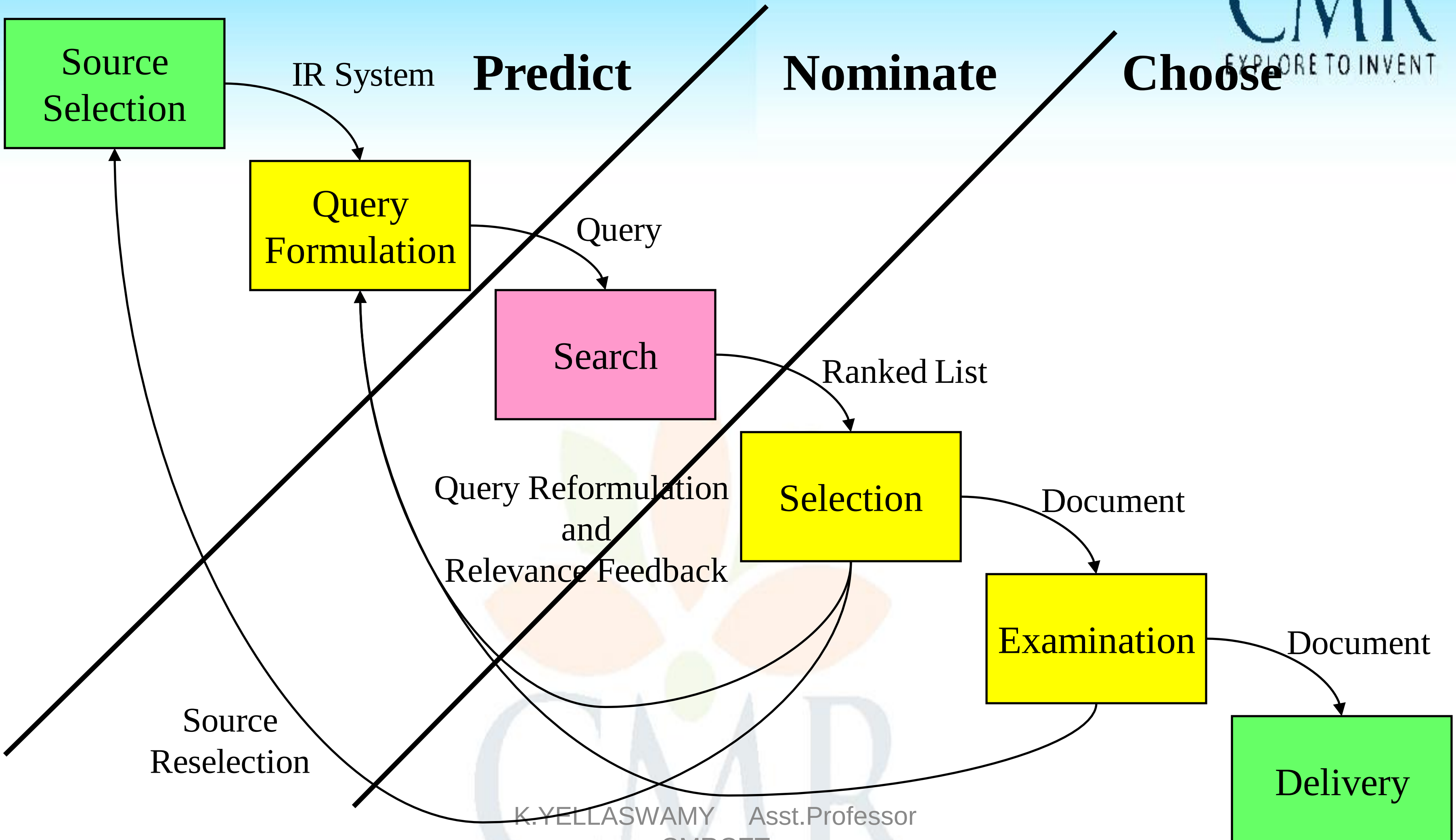
- Book? Chapter? Paragraph?

'Item' and 'Document' are used interchangeably

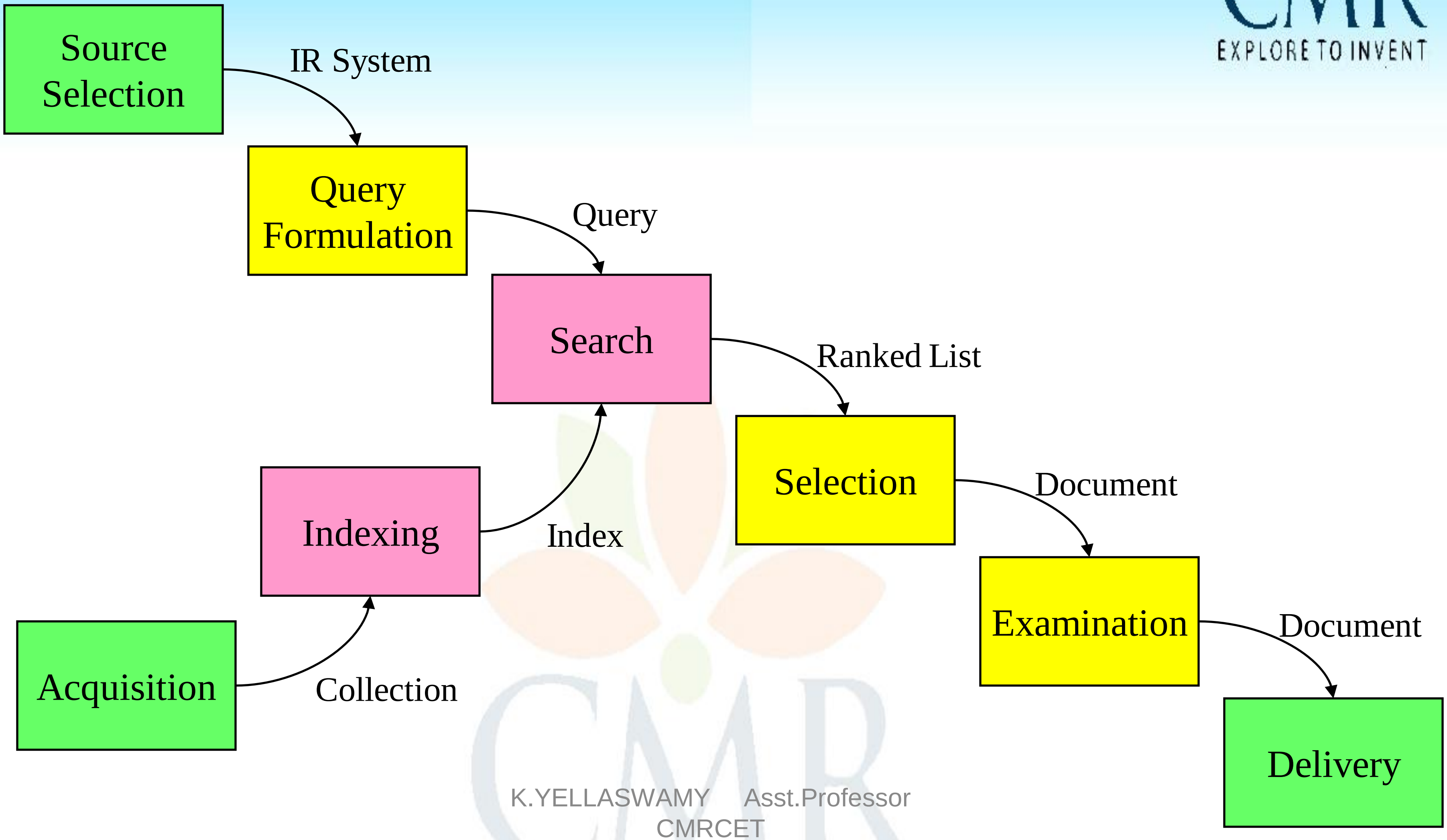
Definition of IR Systems (Cont.)

- An IR system facilitates a user in find the information the user needs.
- Success measure (Objectives of an IR System)
  - Minimize the overhead for finding information
  - Overhead:The time a user spends in all of the steps leading to reading an item containing needed information, excluding the time for actually reading the relevant data
    - Query generation
    - Search composition
    - Search execution
    - Scanning results of query to select items to read

Supporting the Search Process



Supporting the Search Process

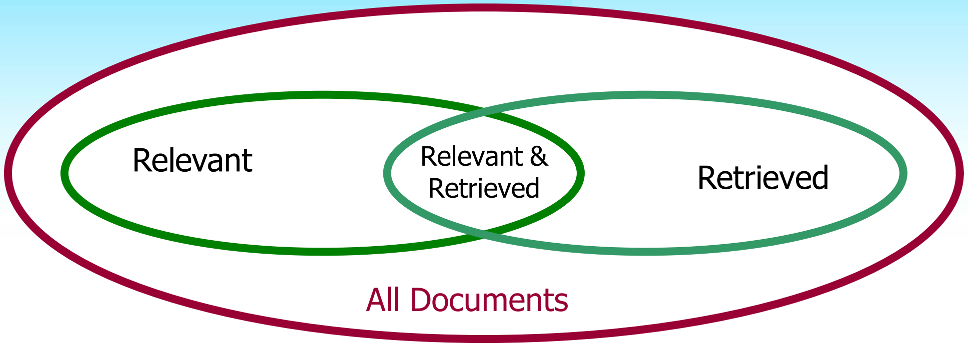


Objectives of IR Systems

Overview

- The general objective of an IR system is to minimize the overhead of a user locating needed information
- The two major measures commonly associated with information systems are precision and recall
- Support of user search generation
- How to present the search results in a format that facilitate the user in determining relevant items

Basic Measures for Text Retrieval



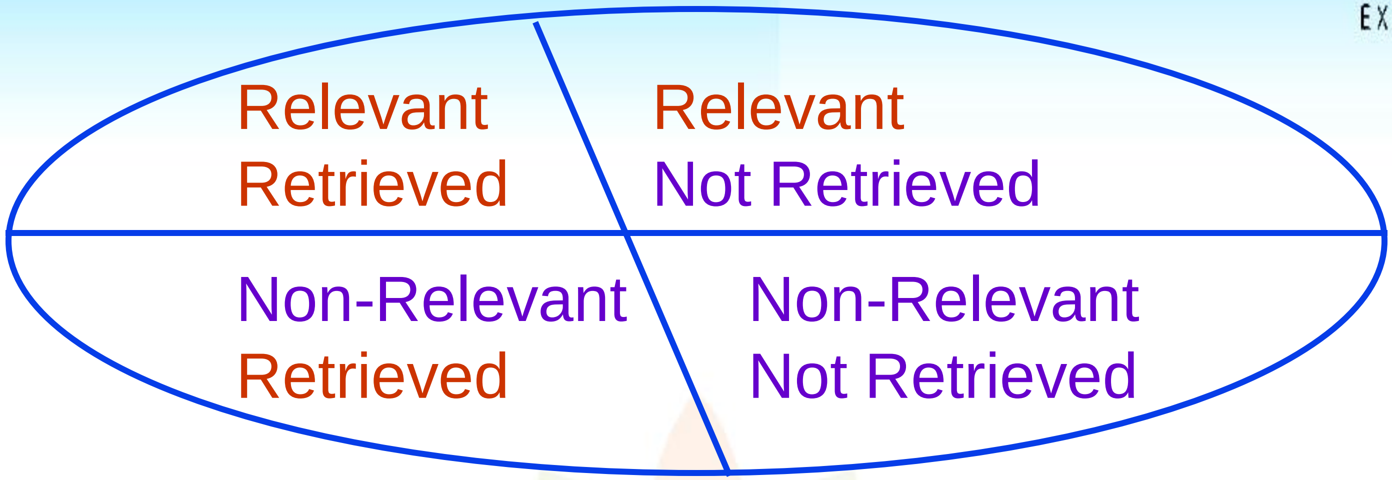
- Precision: the percentage of retrieved documents that are in fact relevant to the query (i.e., “correct” responses)

$$precision = \frac{|\{Relevant\} \cap \{Retrieved\}|}{|\{Retrieved\}|}$$

- Recall: the percentage of documents that are relevant to the query and were, in fact, retrieved

$$precision = \frac{|\{Relevant\} \cap \{Retrieved\}|}{|\{Relevant\}|}$$

Precision and Recall



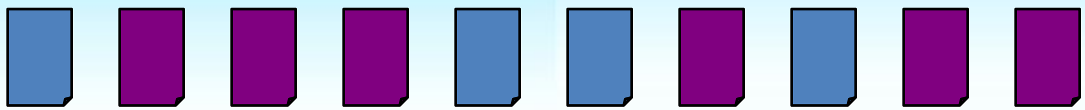
$$Precision = \frac{Number\_Retrieved\_Relevant}{Number\_Total\_Retrieved}$$

$$Recall = \frac{Number\_Retrieved\_Relevant}{Number\_Possible\_Relevant}$$

Measuring Precision and Recall

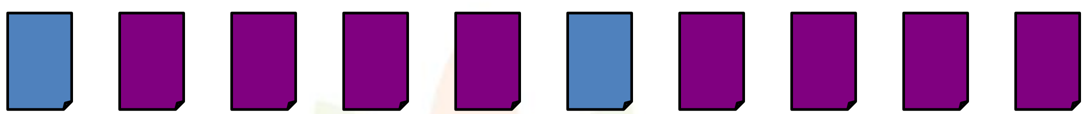
Assume there are a total of 14 relevant documents

Hits 1-10

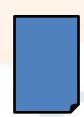


Precision	**1/1**	1/2	1/3	1/4	**2/5**	**3/6**	3/7	**4/8**	4/9	4/10
Recall	**1/14**	1/14	1/14	1/14	**2/14**	**3/14**	3/14	**4/14**	4/14	4/14

Hits 11-20

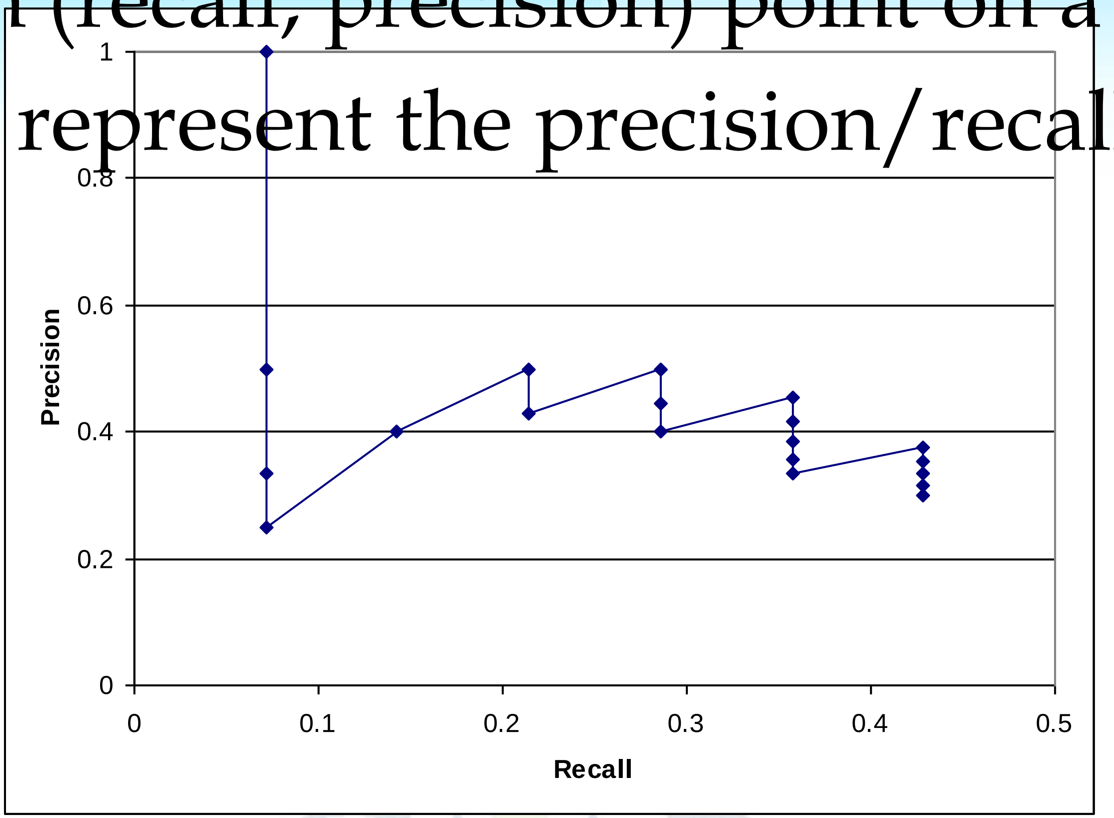


Precision	**5/11**	5/12	5/13	5/14	5/15	**6/16**	6/17	6/18	6/19	6/20
Recall	**5/14**	5/14	5/14	5/14	5/14	**6/14**	6/14	6/14	6/14	6/14

 **= relevant document**

Graphing Precision and Recall

- Plot each (recall, precision) point on a graph
- Visually represent the precision/recall tradeoff



Precision and Recall (Cont.)

- Precision

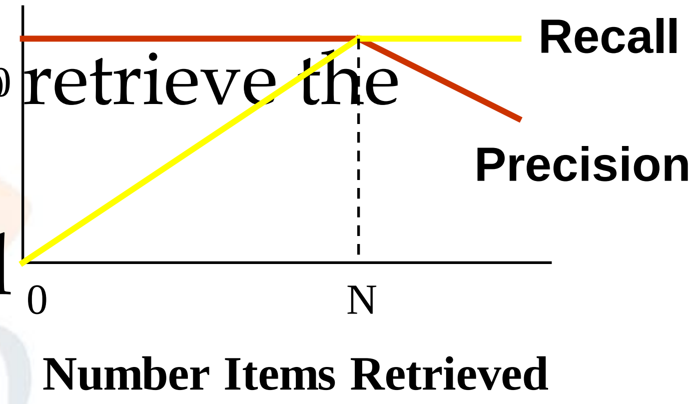
  Measures retrieval overheard for a particular query

  In the WWW-world, precision is more important than recall

- Recall

  How well a system is able to retrieve the relevant items for users

- Ideal Precision and Recall



Two More Objectives of IR Systems

- Support of user search generation
  - How to specify the information a user needs
    - Language ambiguities – “field”
    - Vocabulary corpus of a user and item authors
  - Must assist users automatically and through interaction in developing a search specification that represents the need of users and the writing style of diverse authors
- How to present the search results in a format that facilitate the user in determining relevant items
  - Ranking in order of potential relevance
  - Item clustering and link analysis…

Functional Overview

Functional Overview

- Four major functional process

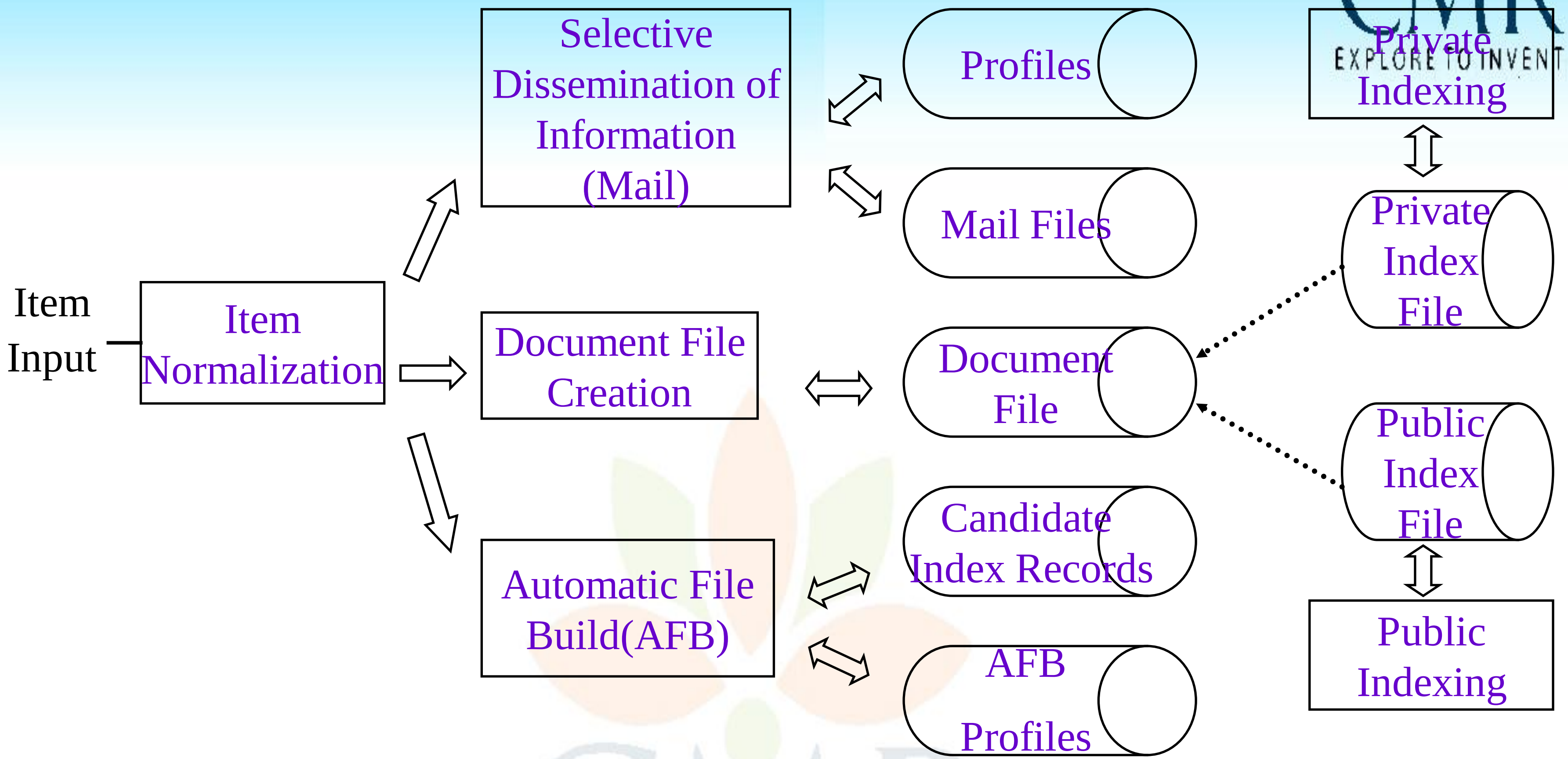
  Item Normalization

  Selective Dissemination of Information

  Archival Document Database Search

  Index Database Search + Automatic File Build Process (Support index files)

Total IR System

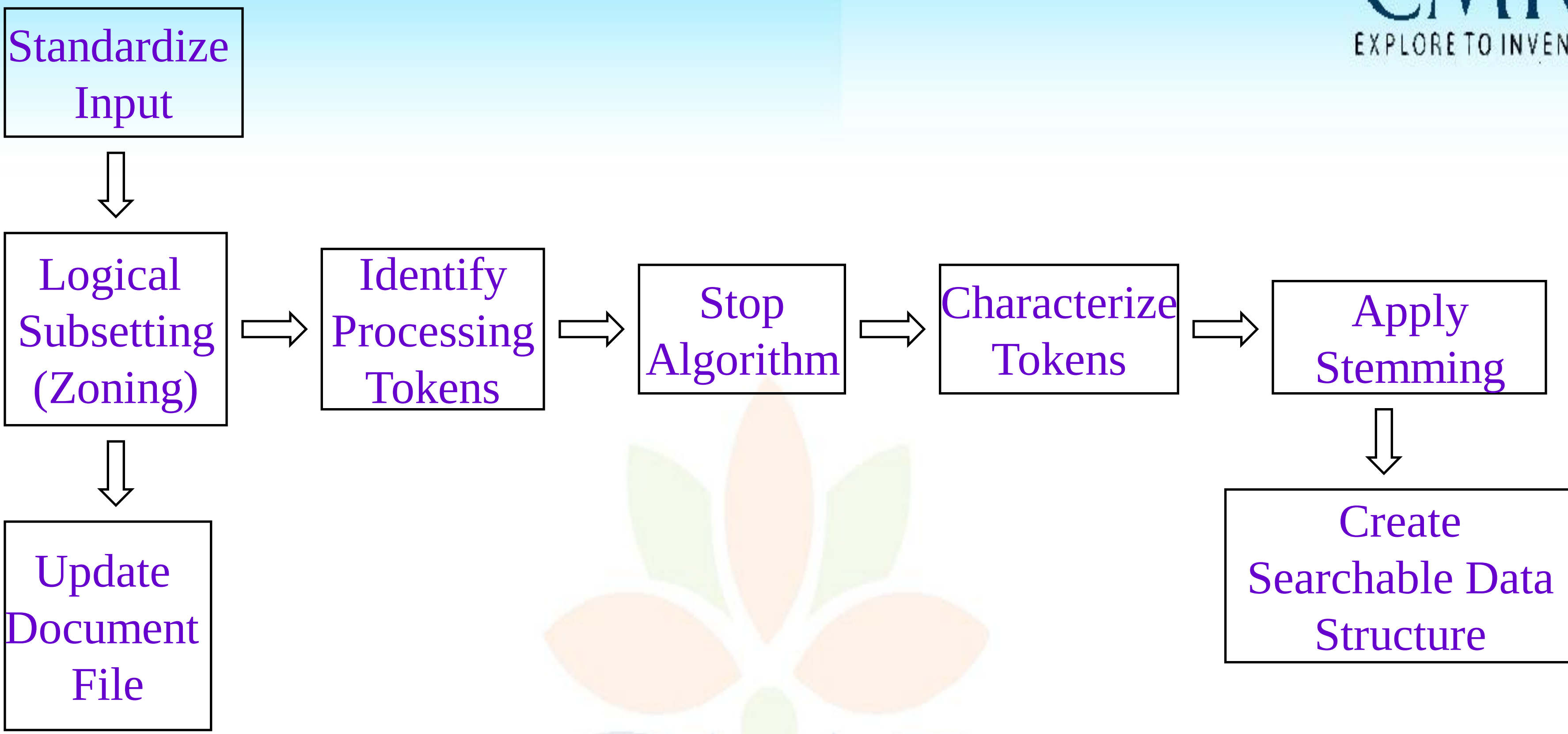


Item Normalization

- Normalize incoming items to a standard format
  - Language encoding
  - Different file formats…
- Logical restructuring – zoning
- Create a searchable data structure (Indexing)
  - Identification of processing tokens
  - Characterization of the tokens – single words, or phrase
  - Stemming of the tokens

Functional Overview – Item Normalization

Overview


Standardize Input
Logical Subsetting (Zoning)
Identify Processing Tokens
Stop Algorithm
Characterize Tokens
Apply Stemming
Create Searchable Data Structure
Update Document File

Standardize Input

- Standardizing the input takes the different external format of input data and performs the translation to the formats acceptable to the system.
- Translate foreign language into Unicode
  - Allow a single browser to display the languages and potentially a single search system to search them
- Translate multi-media input into a standard format
  - Video: MPEG-2, MPEG-1, AVI, Real Video…
  - Audio: WAV, Real Audio
  - Image: GIF, JPEG, BMP…

Logical Subsetting (Zoning)

- Parse the item into logical sub-divisions that have meaning to user
  - Title, Author, Abstract, Main Text, Conclusion, References, Country, Keyword…
- Visible to the user and used to increase the precision of a search and optimize the display
  - The zoning information is passed to the processing token identification operation to store the information, allowing searches to be restricted to a specific zone
  - display the minimum data required from each item to allow determination of the possible relevance of that item (display zones such as Title, Abstract…

Identify Processing Tokens

- Identify the information that are used in the search process – *Processing Tokens (Better than Words)*
- The first step is to determine a word

  Dividing input symbols into three classes

  - Valid word symbols: alphabetic characters,numbers
  - Inter-word symbols: blanks, periods, semicolons (non-searchable)
  - Special processing symbols: hyphen (-)

  A word is defined as a contiguous set of word symbols bounded by inter-word symbols

Stop Algorithm

- Save system resources by eliminating from the set of searchable processing tokens those have little value to the search

  Whose frequency and/or semantic use make them of no use as a searchable token

  - Any word found in almost every item
  - Any word only found once or twice in the database

  Frequency * Rank = Constant

  Stop algorithm v.s. Stop list

Characterize Tokens

- Identify any specific word characteristics

  Word sense disambiguation

  Part of speech tagging

  Uppercase – proper names, acronyms, and organization

  Numbers and dates

Stemming Algorithm

- Normalize the token to a standard semantic representation

  Computer, Compute, Computers, Computing

  - Comput
- Reduce the number of unique words the system has to contain
  - ex: “computable”, “computation”, “computability”
  - small database saves 32 percent of storages
  - larger database : 1.6 MB ➔ 20 %

    50 MB ➔ 13.5%
- Improve the efficiency of the IR System and to improve recall ➔ Decline precision

  Expand a search term to similar token representations in run time?

Create Searchable Data Structure

- Processing tokens ➔ Stemming Algorithm ➔ update to the searchable data structure
- Internal representation (not visible to user)

  Signature file, Inverted list, PAT Tree…
- Contains

  Semantic concepts represent the items in database

  Limit what a user can find as a result of the search

Functional Overview – Selective Dissemination of Information

Selective Dissemination of Information (SDI)

- Provides the capability to dynamically compare newly received items in the information system against standing statements of interest of users and deliver the item to those users whose statement of interest matches the contents of the items
- Consist of

  Search process

  User statements of interest (Profile)

  User mail file

Selective Dissemination of Information (Cont.)

- A profile contains a typically broad search statement along with a list of user mail files that will receive the document if the search statement in the profile is satisfied

As each item is received, it is processed against every user's profile

When the search statement is satisfied, the item is placed in the mail file(s) associated with the process

User search profiles are different than ad hoc queries in that they contain significant more search terms and cover a wider range of interests

Functional Overview – Document Database Search

- Provides the capability for a query to search against all items received by the system
- Composed of the search process, user entered queries and document database.
- Document database contains all items that have been received, processed and store by the system
  - Usually items in the Document DB do not change
  - May be partitioned by time and allow for archiving by the time partitions
- Queries differ from profiles in that they are typically short and focused on a specific area of interest

Functional Overview – Index Database Search

- When an item is determined to be of interest, a user may want to save it (file it) for future reference
  - Accomplished via the index process
- In the index process, the user can logically store an item in a file along with additional index terms and descriptive text the user wants to associate with the item
  - An index can reference the original item, or contain substantive information on the original item
  - Similar to card catalog in a library
- The Index Database Search Process provides the capability to create indexes and search them

Functional Overview – Index Database Search (Cont.)

- The user may search the index and retrieve the index and/or the document it references
- The system also provides the capability to search the index and then search the items referenced by the index records that satisfied the index portion of the query

  Combined file search

- In an ideal system the index record could reference portions of items versus the total item

Functional Overview – Index Database Search (Cont.)

- Two classes of index files: public and private index files
  - Every user can have one or more private index files leading to a very large number of files, and each private index file references only a small subset of the total number of items in the Document database
  - Public index files are maintained by professional library services personnel and typically index every item in the Document database
- The capability to create private and public index files is frequently implemented via a structured Database Management System (RDBMS)

Functional Overview – Index Database Search (Cont.)

- To assist the users in generating indexes, the system provides a process called Automatic File Build (Information Extraction)
  - Process selected incoming documents and automatically determine potential indexing for the item
    - Authors, date of publication, source, and references
  - The rules that govern which documents are processed for extraction of index information and the index term extraction process are stored in Automatic File Build Profiles
  - When an item is processed it results in creation of Candidate Index Records ➔ for review and edit by a user prior to actual update of an index file

What about databases?

- What are examples of databases?
  - Banks storing account information
  - Retailers storing inventories
  - Universities storing student grades
- What exactly is a (relational) database?
  - Think of them as a collection of tables
  - They model some aspect of “the world”

A (Simple) Database Example

Student Table

Student ID	Last Name	First Name	Department ID	email
1	Kandula	Ashok	EE	ashok@gmail.com
2	R	Vishnu	HIST	vishnu@gmail.com
3	Kandula	Srinandan	HIST	Srinandan@gmail.con
4	Kandula	Yellaswamy	CLIS	toyellaswamy@gmail.

Department Table

Department ID	Department
EE	Electrical Engineering
HIST	History
CLIS	Information Studies

Course Table

Course ID	Course Name
lbsc690	Information Technology
ee750	Communication
hist405	American History

Enrollment Table

Student ID	Course ID	Grade
1	lbsc690	90
1	ee750	95
2	lbsc690	95
2	hist405	80
3	hist405	90
4	lbsc690	98

Database Queries

- What would you want to know from a database?
  - What classes is John Arrow enrolled in?
  - Who has the highest grade in LBSC 690?
  - Who's in the history department?
  - Of all the non-CLIS students taking LBSC 690 with a last name shorter than six characters and were born on a Monday, who has the longest email address?

Databases vs. IR

	Databases	IR
What we're retrieving	Structured data. Clear semantics based on a formal model.	Mostly unstructured. Free text with some metadata.
Queries we're posing	Formally (mathematically) defined queries. Unambiguous.	Vague, imprecise information needs (often expressed in natural language).
Results we get	Exact. Always correct in a formal sense.	Sometimes relevant, often not.
Interaction with system	One-shot queries.	Interaction is important.
Other issues	Concurrency, recovery, atomicity are all critical.	Issues downplayed.