

Introduction to Ad-hoc Retrieval

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INLS 509: Information Retrieval

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Ad-hoc Retrieval

- Text-based retrieval
- Given a **query** and a **corpus**, find the **relevant** items
 - ▶ **query**: textual description of information need
 - ▶ **corpus**: a collection of textual documents
 - ▶ **relevance**: satisfaction of the user's information need
- “Ad-hoc” because the number of possible queries is (in theory) infinite.



Examples web search

evo screen capture



▶ [How to screen capture on evo? - PPCGeeks](#) 🔍

[forum.ppcgeeks.com](#) › ... › [Android HTC Devices](#) › [HTC Evo 4G](#) - [Cached](#)

Jul 6, 2010 – Is there any app for that? Sent from my PC36100 using Tapatalk.

[Is it possible to screen capture before rooting?](#) - Jul 8, 2011

[Print Screen / Screen capture](#) - Sep 12, 2010

[Print Screen / Screen capture - Page 2](#) - Jun 21, 2010

[More results from forum.ppcgeeks.com](#) »

[How to take screenshots on the HTC EVO 4G - Know Your Cell](#) 🔍

[www.knowyourcell.com/...evo.../evo.../how_to_take_screenshots_o...](#) - [Cached](#)

Apr 15, 2010 – On the HTC EVO 4G: HTC Desire screen shot. Press the Home icon, ... Click on the Device menu and select **Screen Capture** or use the CTRL-S key ...

[HTC Evo 4G Apps](#) 🔍

[www.evo4gforum.net](#) › [HTC Evo Media and Miscellaneous](#) - [Cached](#)

HTC Evo 4G Apps - Talk about HTC Evo 4G Apps here. ... Advanced search · Scratch-Proof your HTC Evo 4G · Best Screen Protector for HTC Evo 4G · Good Price on HTC Evo 4G ... **Screen Capture** (updated 9/27/10) « 1 2

[Android Screenshots: No Root Required with EVO](#) › [AndroidGuys](#) 🔍

[www.androidguys.com/2010/05/.../android-screenshots-root-require...](#) - [Cached](#)

May 24, 2010 – We tested this on a stock HTC EVO 4G distributed at Google I/O. Let us know in the comments if other **screen capture** apps work on your ...

[How to take screenshots on the HTC EVO 4G](#) 🔍

[www.goodandevo.net/.../how-to-take-screenshots-on-the-htc-evo-4...](#) - [Cached](#)

May 24, 2010 – **Evo-ss** In general, there are two ways to take screenshots on an Android phone: 1) root it and install a **screen capture** app and 2) connect to ...

[Screen Capture/Print Screen App for EVO 2.2 - Android Forums](#) 🔍

[androidforums.com](#) › ... › [HTC EVO 4G](#) › [EVO 4G - Tips and Tricks](#) - [Cached](#)

3 posts - 3 authors - Last post: Aug 11, 2010

I've read several post on **screen capture**, most of which seem to be for advanced users and also risk bricking your phone. Is there a screen ...

Examples scientific search

PubMed

- [Metabolic and behavioural effects of sucrose and fructose/glucose drinks in the rat.](#)
 1. Sheludiakova A, Rooney K, Boakes RA.
Eur J Nutr. 2011 Jul 29. [Epub ahead of print]
PMID: 21800086 [PubMed - as supplied by publisher]
[Related citations](#)

- [The impact of fructose on renal function and blood pressure.](#)
 2. Kretowicz M, Johnson RJ, Ishimoto T, Nakagawa T, Manitius J.
Int J Nephrol. 2011;2011:315879. Epub 2011 Jul 17.
PMID: 21792388 [PubMed - in process] **Free PMC Article**
[Free full text](#) [Related citations](#)

- [The role of salt in the pathogenesis of fructose-induced hypertension.](#)
 3. Soleimani M, Alborzi P.
Int J Nephrol. 2011;2011:392708. Epub 2011 Jul 18.
PMID: 21789281 [PubMed - in process] **Free PMC Article**
[Free full text](#) [Related citations](#)

- [Survey of American food trends and the growing obesity epidemic.](#)
 4. Shao Q, Chin KV.
Nutr Res Pract. 2011 Jun;5(3):253-9. Epub 2011 Jun 21.
PMID: 21779530 [PubMed - in process] **Free PMC Article**
[Free full text](#) [Related citations](#)

- [Obesity and energy balance: is the tail wagging the dog?](#)
 5. Wells JC, Siervo M.
Eur J Clin Nutr. 2011 Jul 20. doi: 10.1038/ejcn.2011.132. [Epub ahead of print]
PMID: 21772313 [PubMed - as supplied by publisher]
[Related citations](#)

Examples

discussion forum search

Q thunderbird installation

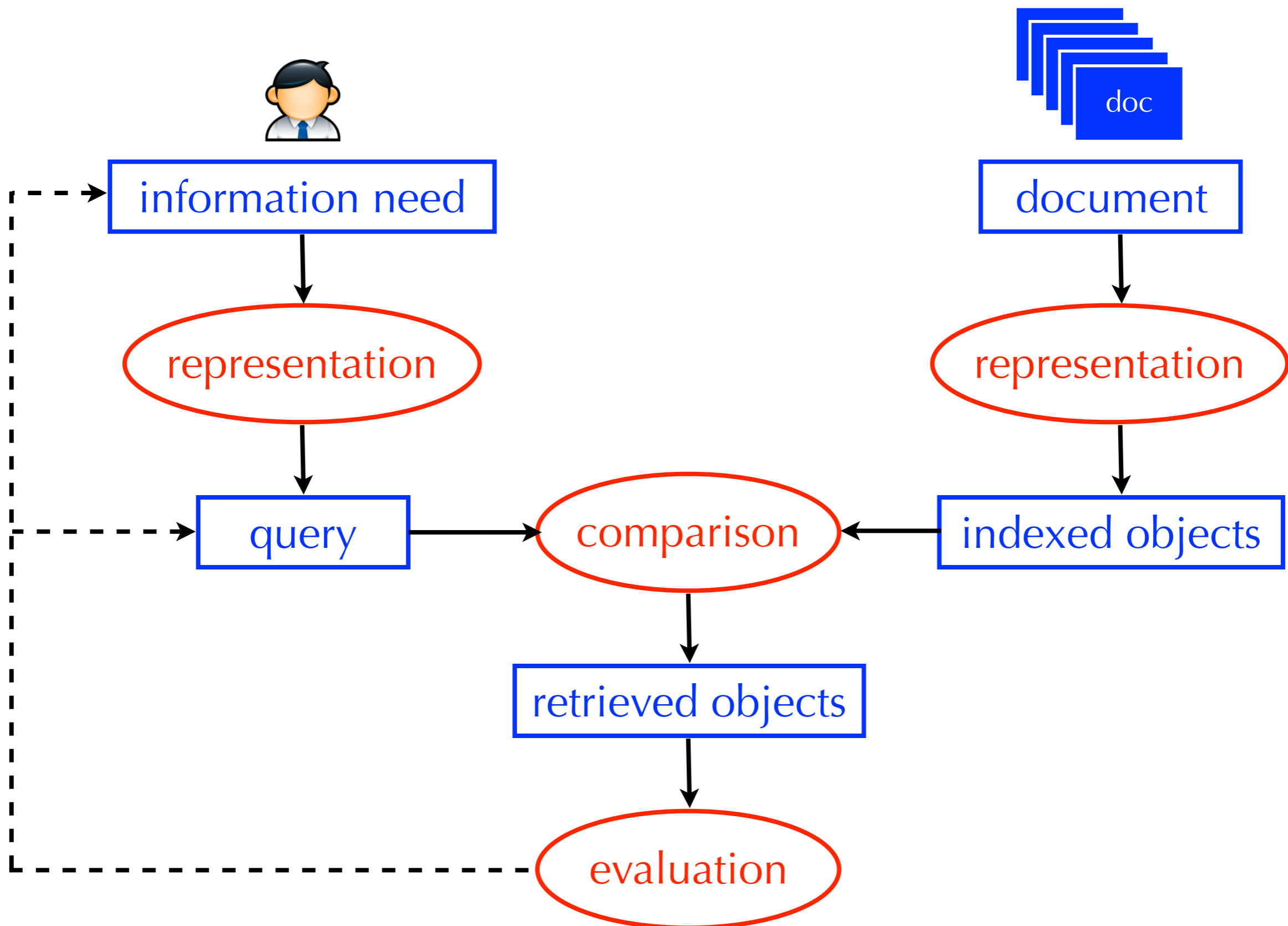
Search: Keyword(s): thunderbird, installation Showing results 1 to 25 of 38
Search took **0.02** seconds.

	Thread / Thread Starter	Last Post	Replies	Views	Forum
	Pre-Installed Mac Applications (1 2) 'riSen	Jul 18, 2011 02:21 AM by RasmusM	34	1,953	Mac Applications and Mac App Store
	Translucent mail notify BLOND37	Jun 12, 2011 11:45 PM by jive turkey	8	277	Mac Applications and Mac App Store
	How do I move Thunderbird e-mail from PC to Mac donhnick	Oct 12, 2010 08:41 AM by tommcdonald	7	35,011	Mac Applications and Mac App Store
	Re-installing 10.6 while preserving user data? Bunker	Feb 28, 2010 10:45 AM by TonyK	5	708	Mac OS X
	New to MAC - Dissappointed - text size (1 2 3 4 5 6 ... Last Page) MariekeFJ	Jan 19, 2010 12:14 PM by Don Crosswhite	157	10,115	Mac Basics and Help
	Anyone have to "switch back" due to \$\$? (1 2 3) Schtibbie	Oct 20, 2009 09:30 PM by Kat King123	52	2,688	MacBook
	The Saga of Switching ready2switch	May 21, 2009 04:24 PM by Chris.L	4	493	Mac Basics and Help
	Apple Mail vs Entourage DJAKO	May 8, 2009 06:30 PM by Benquitar	20	16,768	Mac Applications and Mac App Store
	Teacher accuses student using linux of copyright infringement! (1 2 3) LeoFio	Dec 15, 2008 10:14 AM by dilbert4life	56	1,763	Community Discussion
	Timemachine Duplicates? MBX	Nov 27, 2008 09:16 AM by scuac	18	2,206	Mac OS X

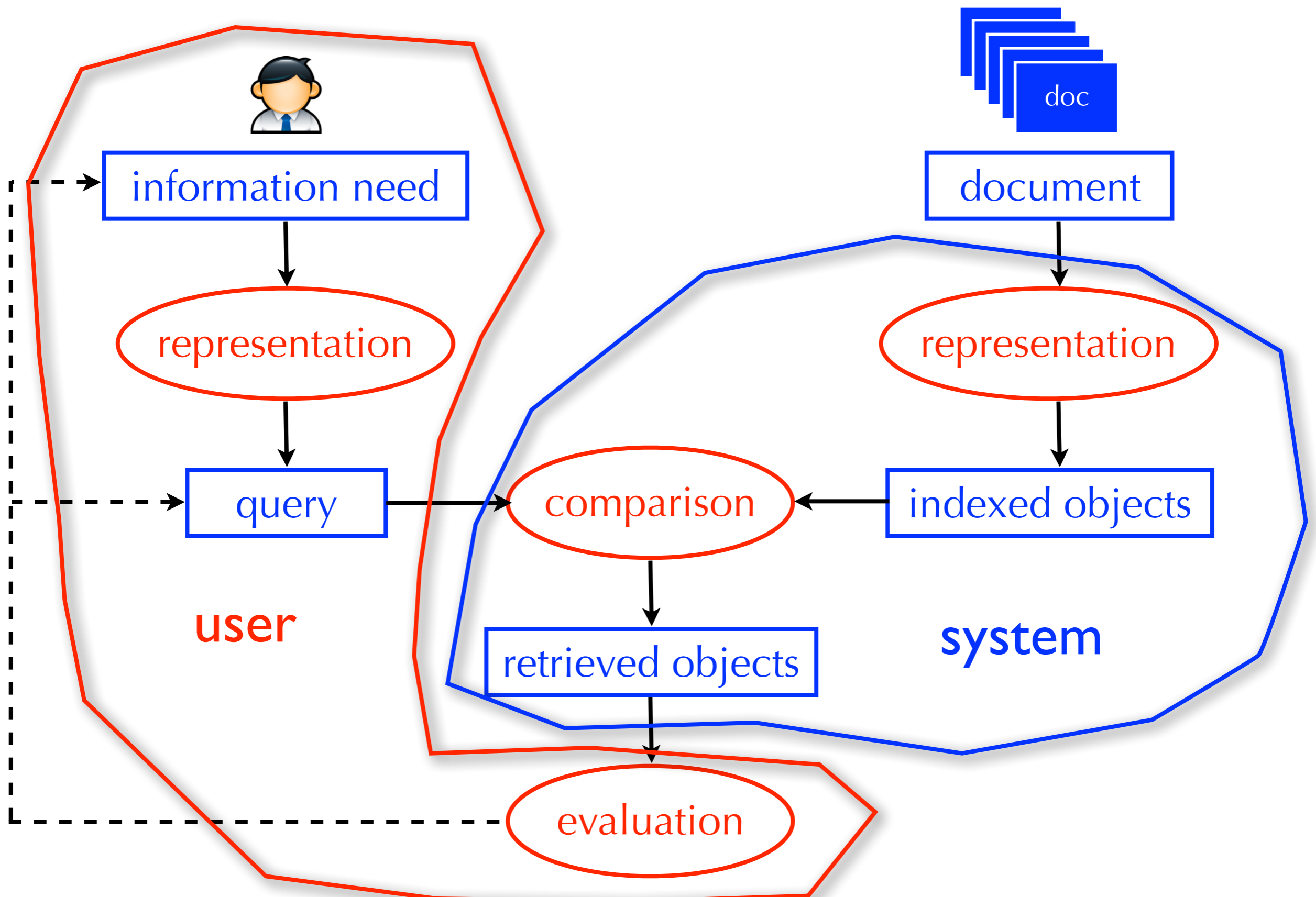
Ad-hoc Retrieval

- We will focus on **non-web** ad-hoc retrieval
 - ▶ more is known about how these systems work
 - ▶ more stable solutions - not constantly tweaked
 - ▶ not heavily tuned using user-interaction data (e.g., clicks)
 - ▶ very common: digital libraries, government and corporate intranets, large information service providers (e.g., Thompson Reuters), social media, your own personal computers

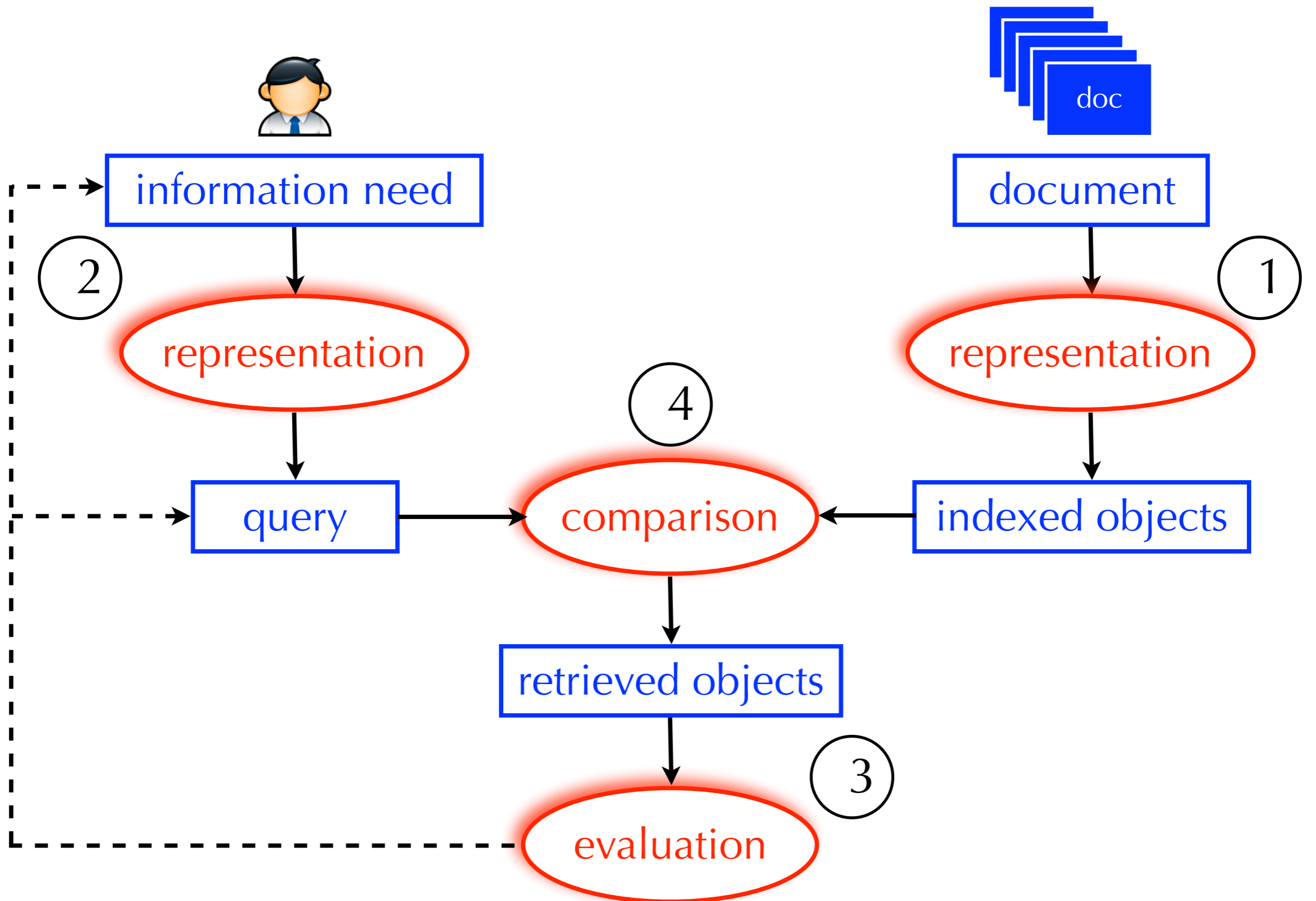
Basic Information Retrieval Process



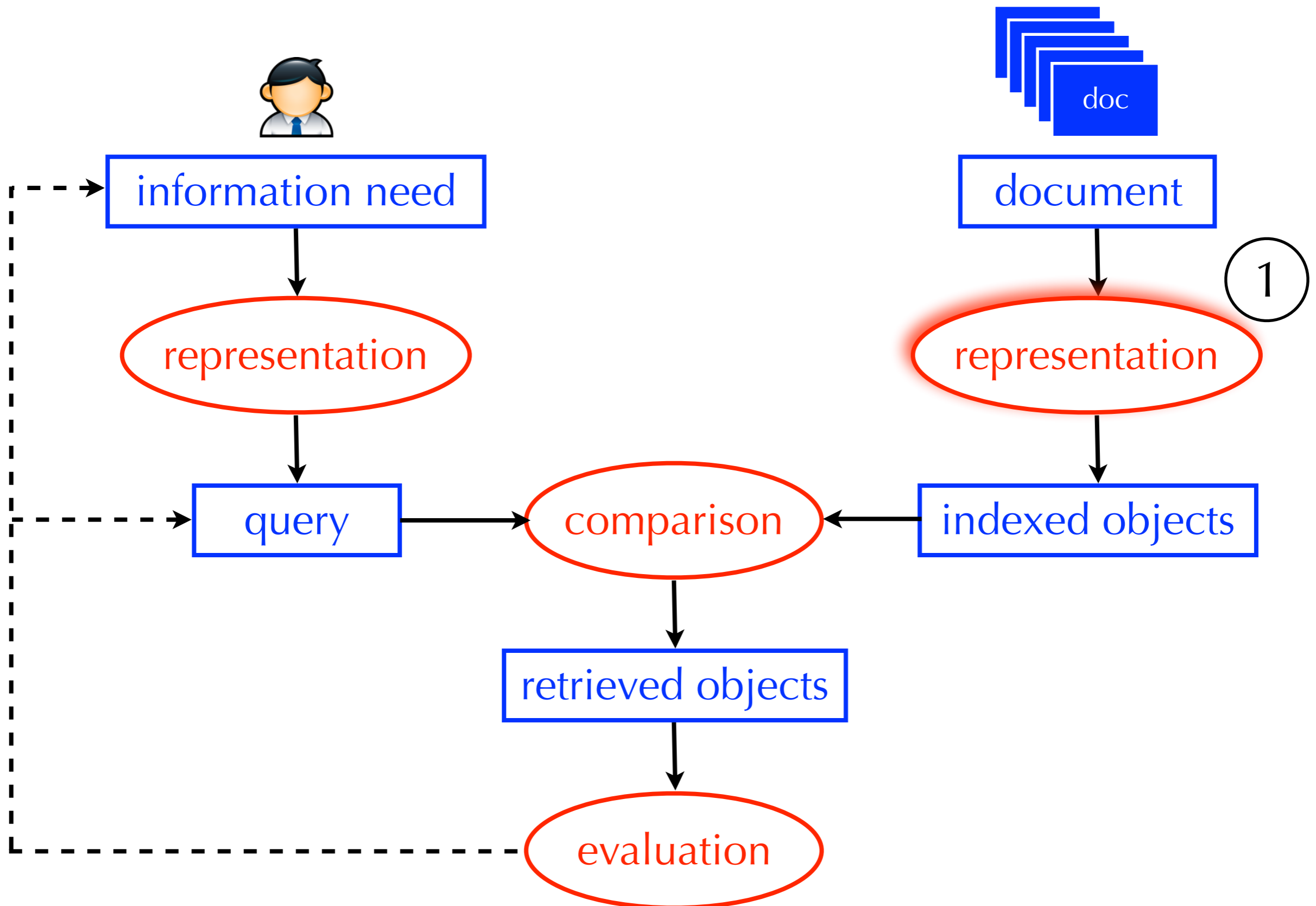
Basic Information Retrieval Process



Next Two Lectures



Document Representation



Most Basic View of a Search Engine

- A search engines does not scan each document to see if it satisfies the query
- It uses an index to quickly locate the relevant documents
- **Index:** a list of concepts with pointers to documents (in this case, pages) that discuss them

L_2 distance, 131
 χ^2 feature selection, 275
 δ codes, 104
 γ encoding, 99
 k nearest neighbor classification, 297
 k -gram index, 54, 60
1/0 loss, 221
11-point interpolated average precision, 159
20 Newsgroups, 154

A/B test, 170
access control lists, 81
accumulator, 113, 125
accuracy, 155
active learning, 336
ad hoc retrieval, 5, 253
add-one smoothing, 260
adjacency table, 455
adversarial information retrieval, 429
Akaike Information Criterion, 367
algorithmic search, 430
anchor text, 425
any-of classification, 257, 306
authority score, 474
auxiliary index, 78
average-link clustering, 389

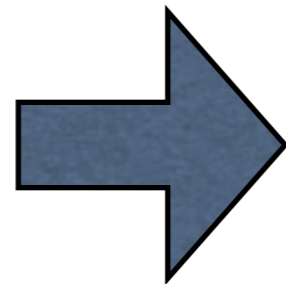
B-tree, 50
bag of words, 117, 267
bag-of-words, 269
balanced F measure, 156
Bayes error rate, 300
Bayes Optimal Decision Rule, 222
Bayes risk, 222

Bayes' Rule, 220
Bayesian networks, 234
Bayesian prior, 226
Bernoulli model, 263
best-merge persistence, 388
bias, 311
bias-variance tradeoff, 241, 312, 321
biclustering, 374
bigram language model, 240
Binary Independence Model, 222
binary tree, 50, 377
biword index, 39, 43
blind relevance feedback, *see* pseudo relevance feedback
blocked sort-based indexing algorithm, 71
blocked storage, 92
blog, 195
BM25 weights, 232
boosting, 286
bottom-up clustering, *see* hierarchical agglomerative clustering
bowtie, 426
break-even, 334
break-even point, 161
BSBI, 71
Buckshot algorithm, 399
buffer, 69

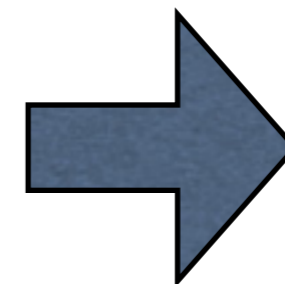
caching, 9, 68, 146, 447, 450
capture-recapture method, 435
cardinality
 in clustering, 355
CAS topics, 211
case-folding, 30

Most Basic View of a Search Engine

input query:
A/B testing



L_2 distance, 131	Bayes' Rule, 220
χ^2 feature selection, 275	Bayesian networks, 234
δ codes, 104	Bayesian prior, 226
γ encoding, 99	Bernoulli model, 263
k nearest neighbor classification, 297	best-merge persistence, 388
k -gram index, 54, 60	bias, 311
1/0 loss, 221	bias-variance tradeoff, 241, 312, 321
11-point interpolated average	bicustering, 374
precision, 159	bigram language model, 240
20 Newsgroups, 154	Binary Independence Model, 222
A/B test, 170	binary tree, 50, 377
access control lists, 81	biword index, 39, 43
accumulator, 113, 125	blind relevance feedback, see pseudo
accuracy, 155	relevance feedback
active learning, 336	blocked sort-based indexing
ad hoc retrieval, 5, 253	algorithm, 71
add-one smoothing, 260	blocked storage, 92
adjacency table, 455	blog, 195
adversarial information retrieval, 429	BM25 weights, 232
Akaike Information Criterion, 367	boosting, 286
algorithmic search, 430	bottom-up clustering, see hierarchical
anchor text, 425	agglomerative clustering
any-of classification, 257, 306	bowtie, 426
authority score, 474	break-even, 334
auxiliary index, 78	break-even point, 161
average-link clustering, 389	BSBI, 71
B-tree, 50	Buckshot algorithm, 399
bag of words, 117, 267	buffer, 69
bag-of-words, 269	caching, 9, 68, 146, 447, 450
balanced F measure, 156	capture-recapture method, 435
Bayes error rate, 300	cardinality
Bayes Optimal Decision Rule, 222	in clustering, 355
Bayes risk, 222	CAS topics, 211
	case-folding, 30



output
document:
docid: 170

- So, what goes in the index is important!
- How might we combine concepts (e.g., patent search + A/B testing)?

Document Representation

- **Document representation:** deciding what concepts should go in the index
- **Option 1 (controlled vocabulary):** a set a manually constructed concepts that describe the major topics covered in the collection
- **Option 2 (free-text indexing):** the set of individual terms that occur in the collection

Document Representation

- If we view **option 1** and **option 2** as two extremes, where does this particular index fit in?

L_2 distance, 131
 χ^2 feature selection, 275
 δ codes, 104
 γ encoding, 99
 k nearest neighbor classification, 297
 k -gram index, 54, 60
1/0 loss, 221
11-point interpolated average precision, 159
20 Newsgroups, 154

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B-tree, 50
bag of words, 117, 267
bag-of-words, 269
balanced F measure, 156
Bayes error rate, 300
Bayes Optimal Decision Rule, 222
Bayes risk, 222

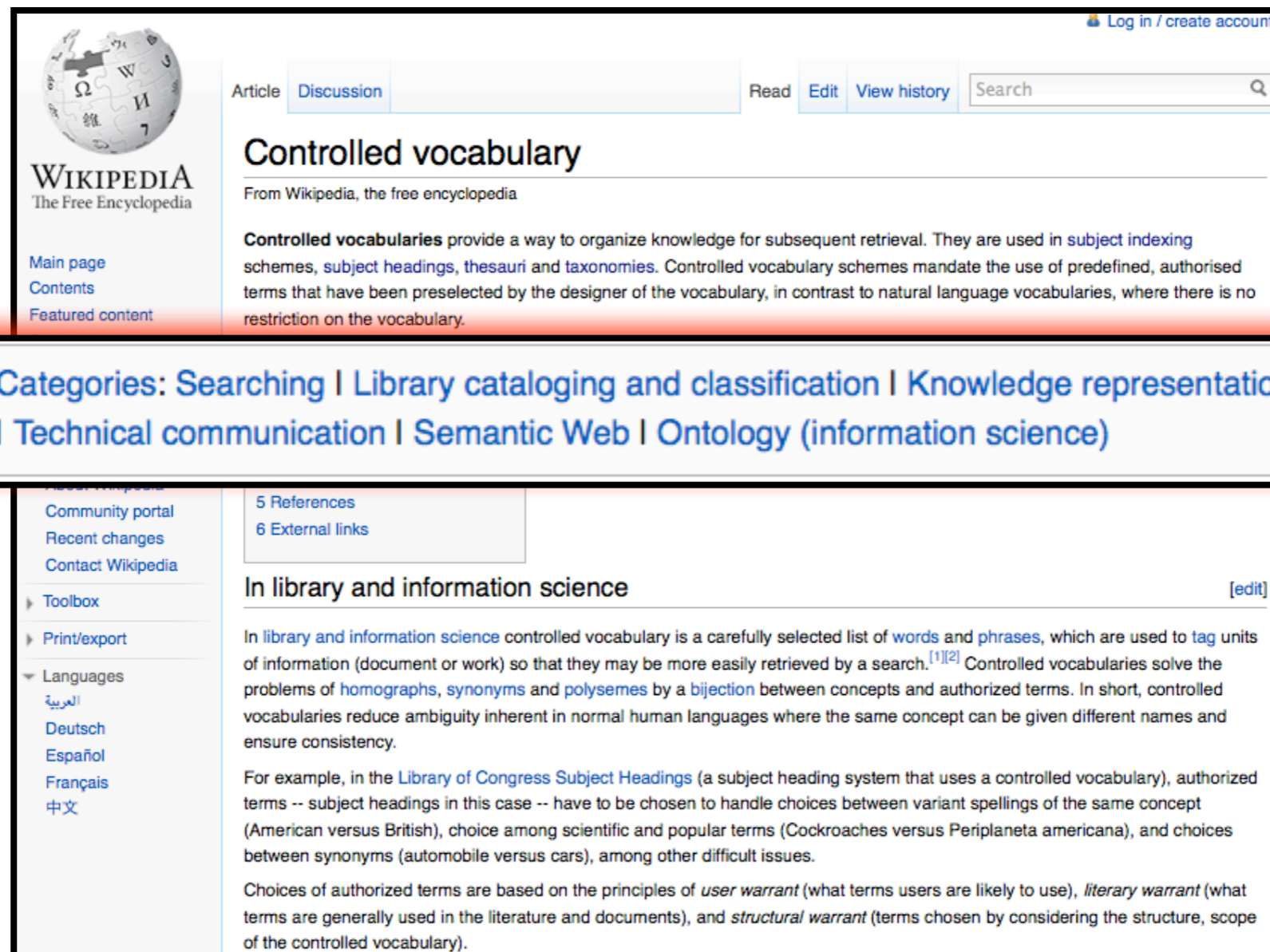
Bayes' Rule, 220
Bayesian networks, 234
Bayesian prior, 226
Bernoulli model, 263
best-merge persistence, 388
bias, 311
bias-variance tradeoff, 241, 312, 321
biclustering, 374
bigram language model, 240
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blog, 195
BM25 weights, 232
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bottom-up clustering, *see* hierarchical agglomerative clustering
bowtie, 426
break-even, 334
break-even point, 161
BSBI, 71
Buckshot algorithm, 399
buffer, 69

caching, 9, 68, 146, 447, 450
capture-recapture method, 435
cardinality
 in clustering, 355
CAS topics, 211
case-folding, 30

Document Representation

option 1: controlled vocabulary

- **Controlled vocabulary:** a set of well-defined concepts
- Assigned to documents by humans (or automatically)



The screenshot shows a Wikipedia article page for "Controlled vocabulary". The page includes a navigation bar with "Article" and "Discussion" tabs, and a search box. The main content area contains the title "Controlled vocabulary" and a sub-header "From Wikipedia, the free encyclopedia". The article text explains that controlled vocabularies are used for organizing knowledge and subject indexing. A red box highlights a list of categories: "Categories: Searching | Library cataloging and classification | Knowledge representation | Technical communication | Semantic Web | Ontology (information science)". Below this, the article continues with a sub-section "In library and information science" and further text about the application of controlled vocabularies in library systems.

Categories: [Searching](#) | [Library cataloging and classification](#) | [Knowledge representation](#) | [Technical communication](#) | [Semantic Web](#) | [Ontology \(information science\)](#)

In library and information science [edit]

In [library and information science](#) controlled vocabulary is a carefully selected list of [words](#) and [phrases](#), which are used to [tag](#) units of information (document or work) so that they may be more easily retrieved by a search.^{[1][2]} Controlled vocabularies solve the problems of [homographs](#), [synonyms](#) and [polysemes](#) by a [bijection](#) between concepts and authorized terms. In short, controlled vocabularies reduce ambiguity inherent in normal human languages where the same concept can be given different names and ensure consistency.

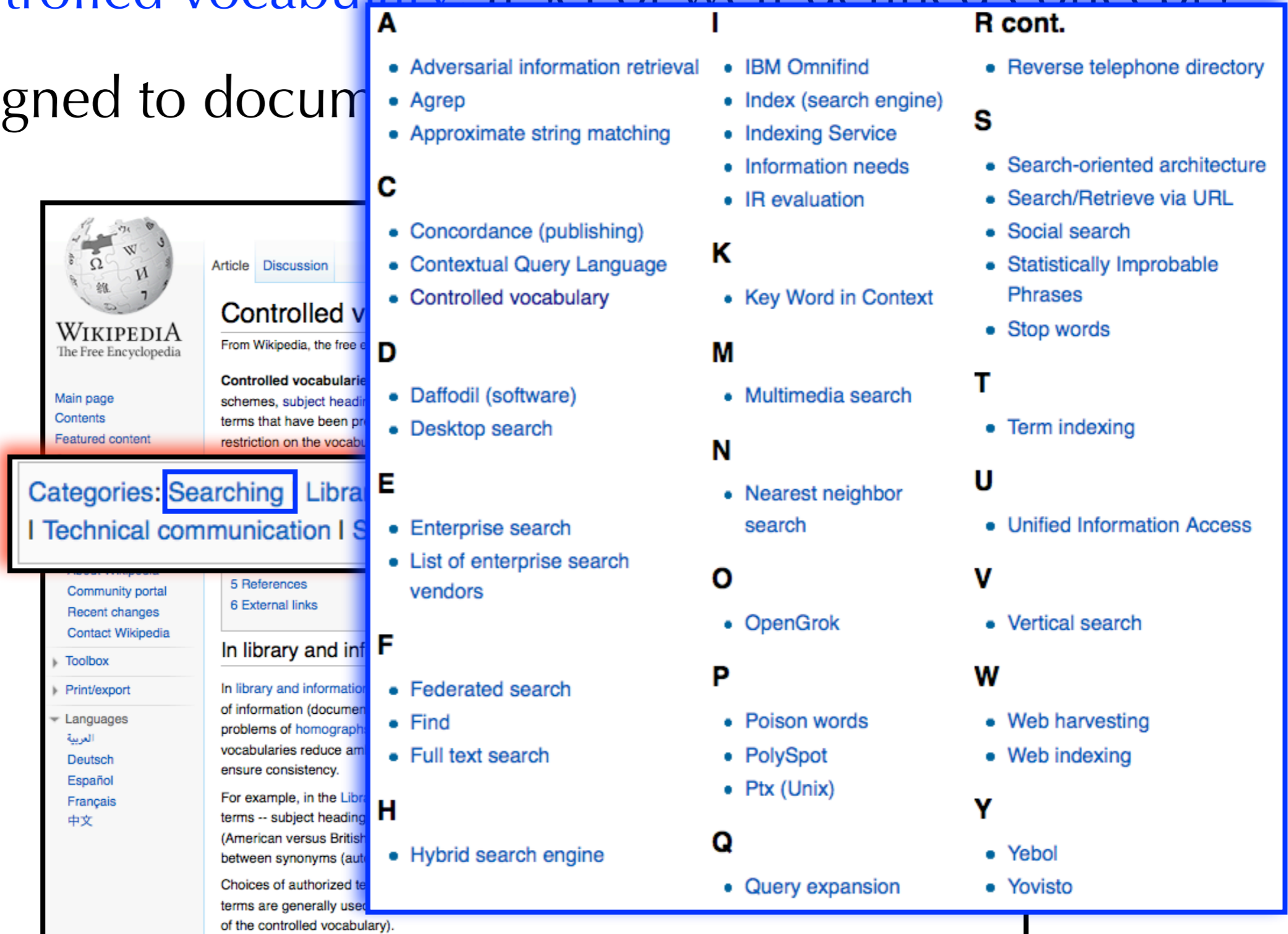
For example, in the [Library of Congress Subject Headings](#) (a subject heading system that uses a controlled vocabulary), authorized terms -- subject headings in this case -- have to be chosen to handle choices between variant spellings of the same concept (American versus British), choice among scientific and popular terms (Cockroaches versus *Periplaneta americana*), and choices between synonyms (automobile versus cars), among other difficult issues.

Choices of authorized terms are based on the principles of *user warrant* (what terms users are likely to use), *literary warrant* (what terms are generally used in the literature and documents), and *structural warrant* (terms chosen by considering the structure, scope of the controlled vocabulary).

Document Representation

option 1: controlled vocabulary

- Controlled vocabulary: a set of well-defined concepts
- Assigned to documents



The image shows a screenshot of a Wikipedia article titled "Controlled vocabulary". The article text is partially visible, discussing schemes, subject headings, and terms that have been pre-approved for use to ensure consistency. A large blue-bordered box is overlaid on the right side of the page, containing a list of search-related terms organized alphabetically from A to Y. The terms include concepts like "Adversarial information retrieval", "Index (search engine)", "Key Word in Context", and "Query expansion".

A	I	R cont.
<ul style="list-style-type: none">• Adversarial information retrieval• Agrep• Approximate string matching	<ul style="list-style-type: none">• IBM Omnifind• Index (search engine)• Indexing Service• Information needs• IR evaluation	<ul style="list-style-type: none">• Reverse telephone directory
C <ul style="list-style-type: none">• Concordance (publishing)• Contextual Query Language• Controlled vocabulary	K <ul style="list-style-type: none">• Key Word in Context	S <ul style="list-style-type: none">• Search-oriented architecture• Search/Retrieve via URL• Social search• Statistically Improbable Phrases• Stop words
D <ul style="list-style-type: none">• Daffodil (software)• Desktop search	M <ul style="list-style-type: none">• Multimedia search	T <ul style="list-style-type: none">• Term indexing
E <ul style="list-style-type: none">• Enterprise search• List of enterprise search vendors	N <ul style="list-style-type: none">• Nearest neighbor search	U <ul style="list-style-type: none">• Unified Information Access
F <ul style="list-style-type: none">• Federated search• Find• Full text search	O <ul style="list-style-type: none">• OpenGrok	V <ul style="list-style-type: none">• Vertical search
H <ul style="list-style-type: none">• Hybrid search engine	P <ul style="list-style-type: none">• Poison words• PolySpot• Ptx (Unix)	W <ul style="list-style-type: none">• Web harvesting• Web indexing
	Q <ul style="list-style-type: none">• Query expansion	Y <ul style="list-style-type: none">• Yebol• Yovisto

Controlled Vocabularies

- May include (parent-child) relations b/w concepts
- Facilitates non-query-based browsing and exploration

dmoz open directory project In partnership with AOL Search.

[about dmoz](#) | [dmoz blog](#) | [suggest URL](#) | [help](#) | [link](#) | [editor login](#)

Search [advanced](#)

Arts
[Movies](#), [Television](#), [Music](#)...

Business
[Jobs](#), [Real Estate](#), [Investing](#)...

Computers
[Internet](#), [Software](#), [Hardware](#)...

Games
[Video Games](#), [RPGs](#), [Gambling](#)...

Health
[Fitness](#), [Medicine](#), [Alternative](#)...

Home
[Family](#), [Consumers](#), [Cooking](#)...

Kids and Teens
[Arts](#), [School Time](#), [Teen Life](#)...

News
[Media](#), [Newspapers](#), [Weather](#)...

Recreation
[Travel](#), [Food](#), [Outdoors](#)...

Reference
[Maps](#), [Education](#), [Libraries](#)...

Regional
[US](#), [Canada](#), [UK](#), [Europe](#)...

Science
[Biology](#), [Psychology](#), [Physics](#)...

Shopping
[Clothing](#), [Food](#), [Gifts](#)...

Society
[People](#), [Religion](#), [Issues](#)...

Sports
[Baseball](#), [Soccer](#), [Basketball](#)...

World
[Català](#), [Dansk](#), [Deutsch](#), [Español](#), [Français](#), [Italiano](#), [日本語](#), [Nederlands](#), [Polski](#), [Русский](#), [Svenska](#)

[Become an Editor](#) Help build the largest human-edited directory of the web

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4,916,463 sites - 91,672 editors - over 1,007,856 categories

Open Directory Project (ODP)

Top: Computers: Software: Information Retrieval (96)

- [Classification@](#) (16)
- [Data Clustering@](#) (166)
- [Fulltext](#) (32)
- [GILS](#) (1)
- [Internet Search Engines@](#) (314)
- [Ranking](#) (35)
- [References](#) (1)
- [Text Clustering@](#) (11)
- [Visual Information](#) (6)
- [Web Clustering](#) (6)

See also:

- [Computers: Software: File Management: Search](#) (37)
- [Computers: Software: Internet: Servers: Search](#) (41)
- [Reference: Knowledge Management: Knowledge Retrieval](#) (40)
- [Reference: Libraries: Library and Information Science: Software](#) (93)

Controlled Vocabularies

example

- **MeSH:** Medical Subject Headings
- Created by the National Library of Medicine to index biomedical journals and books
- About 25,000 subject headings arranged in a hierarchy
- Used to search PubMed



Controlled Vocabularies

example

1. Anatomy [A]
2. Organisms [B]
3. Diseases [C]
4. Chemicals and Drugs [D]
5. Analytical, Diagnostic and Therapeutic Techniques and Equipment [E]
6. Psychiatry and Psychology [F]
7. Phenomena and Processes [G]
8. Disciplines and Occupations [H]
9. Anthropology, Education, Sociology and Social Phenomena [I]
10. Technology, Industry, Agriculture [J]
11. Humanities [K]
12. Information Science [L]
13. Named Groups [M]
14. Health Care [N]
15. Publication Characteristics [V]
16. Geographicals [Z]

Controlled Vocabularies

example

1. Anatomy [A]
2. Organisms [B]
 - [Eukaryota \[B01\]](#)
 - [Archaea \[B02\]](#)
 - [Bacteria \[B03\]](#)
 - [Viruses \[B04\]](#)
 - [Organism Forms \[B05\]](#)
3. Diseases [C]
4. Chemicals and Drugs [D]
5. Analytical, Diagnostic and Therapeutic Techniques and Equipment [E]
6. Psychiatry and Psychology [F]
7. Phenomena and Processes [G]
8. Disciplines and Occupations [H]
9. Anthropology, Education and Society [I]
10. Technology, Industry, Agriculture [J]
11. Humanities [K]
12. Information Science [L]
13. Named Groups [M]
14. Health Care [N]
15. Publication Characteristics [O]
16. Geographicals [Z]

MeSH Heading	Eukaryota
Tree Number	B01
Annotation	do not confuse with EUKARYOTIC CELLS ; specific algae and protozoa are located under various groups treed under Eukaryota
Scope Note	One of the three domains of life (the others being BACTERIA and ARCHAEA), also called Eukarya. These are organisms whose cells are enclosed in membranes and possess a nucleus. They comprise almost all multicellular and many unicellular organisms, and are traditionally divided into groups (sometimes called kingdoms) including ANIMALS ; PLANTS ; FUNGI ; and various algae and other taxa that were previously part of the old kingdom Protista.
Entry Term	Eucarya
Entry Term	Eukarya
Entry Term	Eukaryotes
Allowable Qualifiers	CH CL CY DE EN GD GE IM IP ME PH PY RE UL VI
Previous Indexing	Eukaryotic Cells (1986-2009)
History Note	2010
Date of Entry	20090706
Unique ID	D056890

Controlled Vocabularies

example

NCBI Resources ▾ How To ▾

MeSH MeSH light therapy Search

Phototherapy

Treatment of disease by exposure to light, especially by variously concentrated light rays or specific wavelengths.

Year introduced: 1981

PubMed search builder options

[Subheadings:](#)

sub-headings

<input type="checkbox"/> adverse effects	<input type="checkbox"/> instrumentation	<input type="checkbox"/> statistics and numerical data
<input type="checkbox"/> classification	<input type="checkbox"/> methods	<input type="checkbox"/> supply and distribution
<input type="checkbox"/> contraindications	<input type="checkbox"/> nursing	<input type="checkbox"/> trends
<input type="checkbox"/> economics	<input type="checkbox"/> psychology	<input type="checkbox"/> utilization
<input type="checkbox"/> history	<input type="checkbox"/> standards	<input type="checkbox"/> veterinary

[All MeSH Categories](#)

[Analytical, Diagnostic and Therapeutic Techniques and Equipment Category](#)

[Therapeutics](#)

Phototherapy

- [Color Therapy](#)
- [Heliotherapy](#)
- [Laser Therapy, Low-Level](#)
- [Photochemotherapy](#)
- [Hematoporphyrin Photoradiation](#)
- [Ultraviolet Therapy](#)
- [PUVA Therapy +](#)

Entry Terms:

- Phototherapies
- Therapy, Photoradiation
- Photoradiation Therapies
- Therapies, Photoradiation
- **Light Therapy**
- Light Therapies
- Therapies, Light
- Therapy, Light
- Photoradiation Therapy

sub-tree within the hierarchy

entry-terms

Controlled Vocabularies

example

NCBI Resources How To

PubMed.gov
US National Library of Medicine
National Institutes of Health

PubMed phototherapy/adverse effects Search

RSS Save search Limits Advanced

Results: 1 to 20 of 2697

<< First < Prev Page 1 of 135 Next > Last >>

- [Burning daylight: balancing vitamin D requirements with sensible sun exposure.](#)
 1. Stalgis-Bilinski KL, Boyages J, Salisbury EL, Dunstan CR, Henderson SI, Talbot PL.
Med J Aust. 2011 Apr 4;194(7):345-8.
PMID: 21470084 [PubMed - indexed for MEDLINE]
[Related citations](#)
- [Time-lag between subretinal fluid and pigment epithelial detachment reduction after polypoidal choroidal vasculopathy treatment.](#)
 2. Chae JB, Lee JY, Yang SJ, Kim JG, Yoon YH.
Korean J Ophthalmol. 2011 Apr;25(2):98-104. Epub 2011 Mar 11.
PMID: 21461221 [PubMed - indexed for MEDLINE] **Free PMC Article**
[Free full text](#) [Related citations](#)
- [Metal stenting to resolve post-photodynamic therapy stricture in early esophageal cancer.](#)
 3. Cheon YK.
World J Gastroenterol. 2011 Mar 14;17(10):1379-82.
PMID: 21455341 [PubMed - indexed for MEDLINE] **Free PMC Article**
[Free full text](#) [Related citations](#)
- [A study of multiple full-face treatments with low-energy settings of a 2940-nm Er:YAG fractionated laser.](#)
 4. Goldberg DJ, Hussain M.
J Cosmet Laser Ther. 2011 Apr;13(2):42-6.
PMID: 21401375 [PubMed - indexed for MEDLINE]
[Related citations](#)

Controlled Vocabularies

example

Burning daylight: balancing vitamin D requirements with sensible sun exposure.

Stalgis-Bilinski KL, Boyages J, Salisbury EL, Dunstan CR, Henderson SI, Talbot PL.

Westmead Breast Cancer Institute, University of Sydney, Sydney, NSW, Australia. Kellie.Bilinski@bci.org.au

Abstract

OBJECTIVE: To examine the feasibility of balancing sunlight exposure to meet vitamin D requirements with sun protection guidelines.

DESIGN AND SETTING: We used standard erythemal dose and Ultraviolet Index (UVI) data for 1 June 1996 to 30 December 2005 for seven Australian cities to estimate duration of sun exposure required for fair-skinned individuals to synthesise 1000 IU (25 µg) of vitamin D, with 11% and 17% body exposure, for each season and hour of the day. Periods were classified according to whether the UVI was < 3 or ≥ 3 (when sun protection measures are recommended), and whether required duration of exposure was ≤ 30 min, 31-60 min, or > 60 min.

MAIN OUTCOME MEASURE: Duration of sunlight exposure required to achieve 1000 IU of vitamin D synthesis.

RESULTS: Duration of sunlight exposure required to synthesise 1000 IU of vitamin D varied by time of day, season and city. Although peak UVI periods are typically promoted as between 10 am and 3 pm, UVI was often ≥ 3 before 10 am or after 3 pm. When the UVI was < 3, there were few opportunities to synthesise 1000 IU of vitamin D within 30 min, with either 11% or 17% body exposure.

CONCLUSION: There is a delicate line between balancing the beneficial effects of sunlight exposure while avoiding its damaging effects. Physiological and geographical factors may reduce vitamin D synthesis, and supplementation may be necessary to achieve adequate vitamin D status for individuals at risk of deficiency.

MeSH Terms

Australia

Dose-Response Relationship, Radiation

Guideline Adherence

Health Policy*

Heliotherapy/adverse effects

Heliotherapy/methods*

Humans

Seasons

Skin Pigmentation

Sunlight/adverse effects*

Time Factors

Vitamin D/biosynthesis*

Vitamin D Deficiency/prevention & control*

Controlled Vocabularies

advantages

- Concepts do not need to appear explicitly in the text
- Relationships between concepts facilitate non-query-based navigation and exploration (e.g., ODP)
- Developed by experts who know the data and the users
- Represent the concepts/relationships that users (presumably) care the most about
- Describe the concepts that are most central to the document
- Concepts are unambiguous and recognizable (necessary for annotators and good for users)

Document Representation

option 2: free-text indexing

- Represent documents using terms within the document
- Which terms? Only the most descriptive terms? Only the unambiguous ones? All of them?
- Usually, all of them (a.k.a. full-text indexing)
- The user will use term-combinations to express higher level concepts
- Query terms will hopefully disambiguate each other (e.g., “volkswagen golf”)
- The search engine will determine which terms are important (we’ll talk about this during “retrieval models”)

Free-text Indexing

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Salton was perhaps most famous for his work on [information retrieval](#). In this model, both document and a query are represented as vectors. The similarity between a document and a query is measured by the ratio of the number of terms which that term occurs in both. He introduced [TF-IDF](#), or [term frequency-inverse document frequency](#), in 1972 by [Karen Sparck Jones](#) as well as automatic hypothesis testing.

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Free-text Indexing

mark-up vs. content

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```


Free-text Indexing

mark-up

- Describes how the content should be presented
 - ▶ e.g., your browser interprets HTML mark-up and presents the page as intended by the author
- Can also define relationships with other documents (e.g., hyperlinks)
- Can provide evidence of what text is important for search
- It may also provide useful, “unseen” information!

Free-text Indexing

mark-up

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Free-text Indexing

text-processing

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- Step 1: mark-up removal

Free-text Indexing

text-processing

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Free-text Indexing

text-processing

gerard salton (8 march 1927 in nuremberg 28 august 1995), also known as gerry salton, was a Professor of computer science at cornell university . salton was perhaps the leading computer scientist working in the field of information retrieval during his time. his group at cornell developed the smart information retrieval system , which he initiated when he was at harvard.

- Step 2: down-casing
- Can change a word's meaning, but we do it anyway
 - ▶ Information = information ???
 - ▶ SMART = smart ???

Free-text Indexing

text-processing

gerard salton 8 march 1928 in nuremberg 28 august 1995 also know as gerry salton was professor of computer science at cornell university salton was perhaps the leading computer scientist working in the field of information retrieval during his time his group at cornell developed the smart information retrieval system which he initiated when he was at harvard

- Step 3: tokenization
- **Tokenization:** splitting text into words (in this case, based on sequences of non-alphanumeric characters)
- Problematic cases: ph.d. = ph d, isn't = isn t

Free-text Indexing

text-processing

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- **Step 4:** stopword removal
- **Stopwords:** words that we choose to ignore because we expect them to not be useful in distinguishing between relevant/non-relevant documents for any query

Free-text Indexing

text-processing

gerard salton 8 march 1978 nuremberg 28 august 1995 know gerry salton
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Free-text Indexing

text-processing

gerard salton 8 march 1978 nuremberg 28 august 1995 gerry salton professor
computer science cornell university salton leading computer scientist working field
information retrieval during time group cornell developed smart information retrieval
system initiated harvard

- **Step 5:** do this to every document in the collection and create an index using the all terms appearing in the collection

Document Representation

controlled vocabulary vs. free-text indexing

	Cost of assigning index terms	Ambiguity of index terms	Detail of representation
Controlled Vocabularies	High/Low?	Ambiguous/ Unambiguous?	Can represent arbitrary level of detail?
Free-text Indexing	High/Low?	Ambiguous/ Unambiguous?	Can represent arbitrary level of detail?

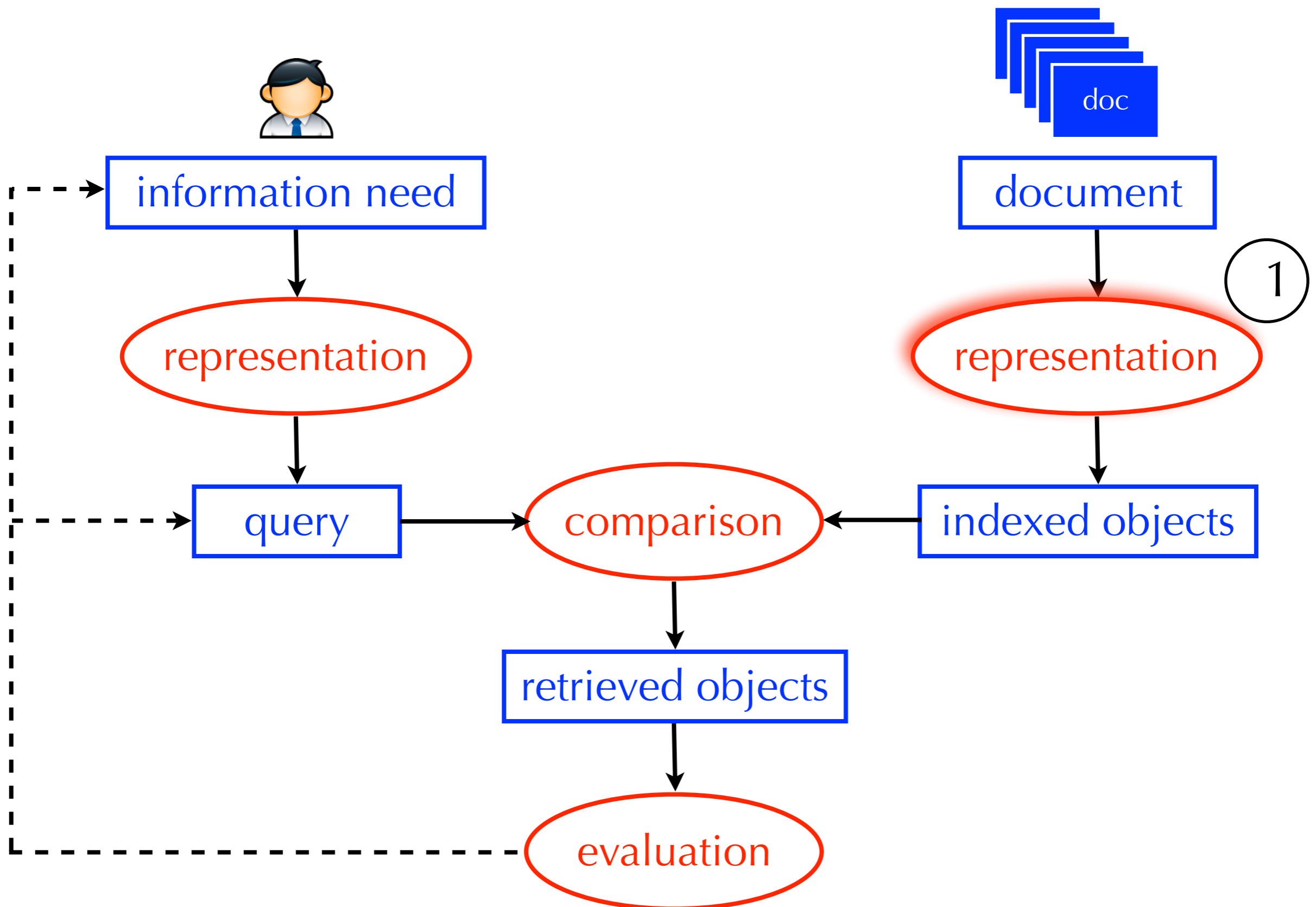
Document Representation

controlled vocabulary vs. free-text indexing

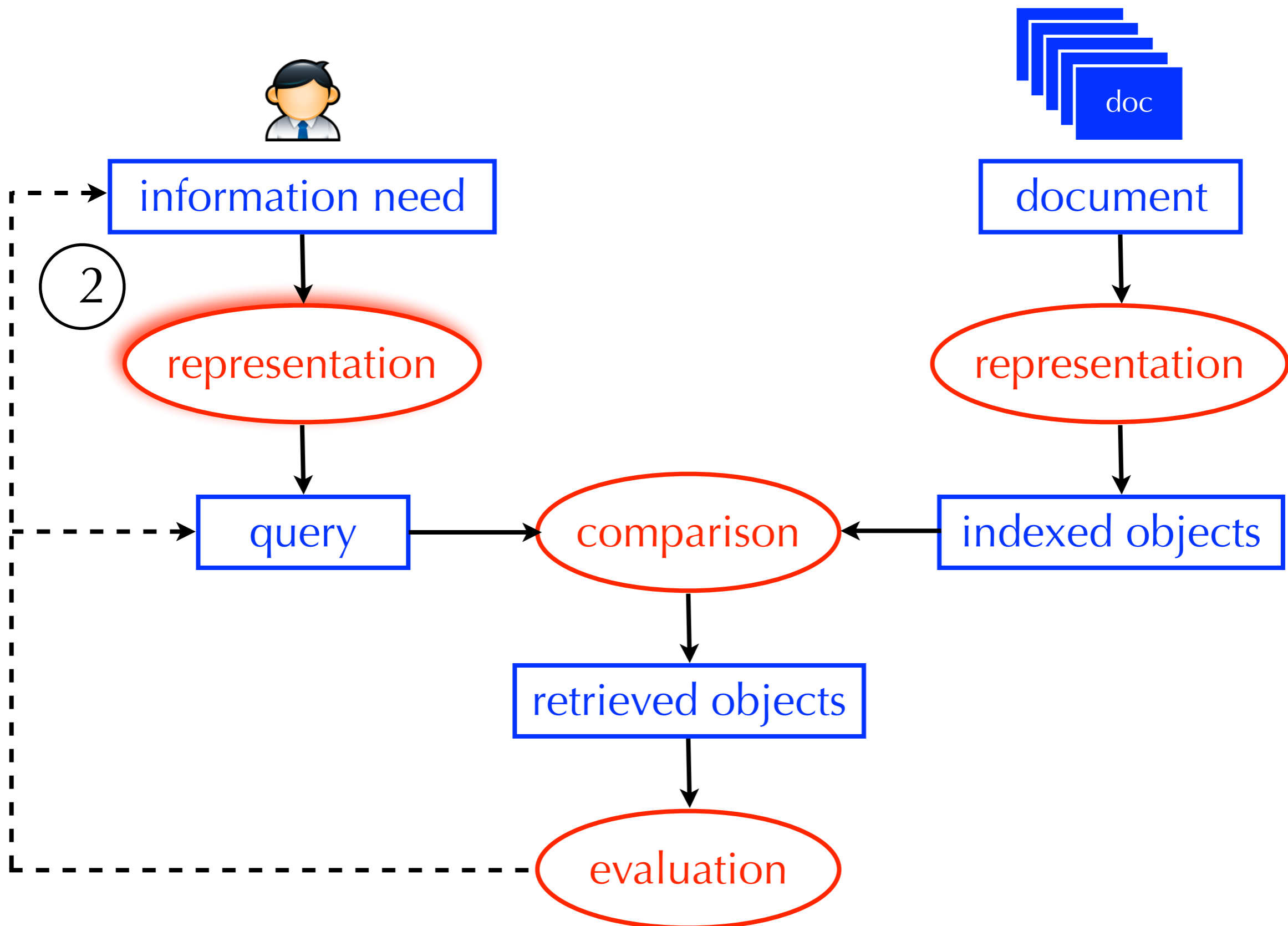
	Cost of assigning index terms	Ambiguity of index terms	Detail of representation
Controlled Vocabularies	High	Not ambiguous	Can't represent arbitrary detail
Free-text Indexing	Low	Can be ambiguous	Any level of detail

- Both are effective and used often
- We will focus on free-text indexing in this course
 - ▶ cheap and easy
 - ▶ most search engines use it (even those that adopt a controlled vocabulary)

Document Representation



Information Need Representation

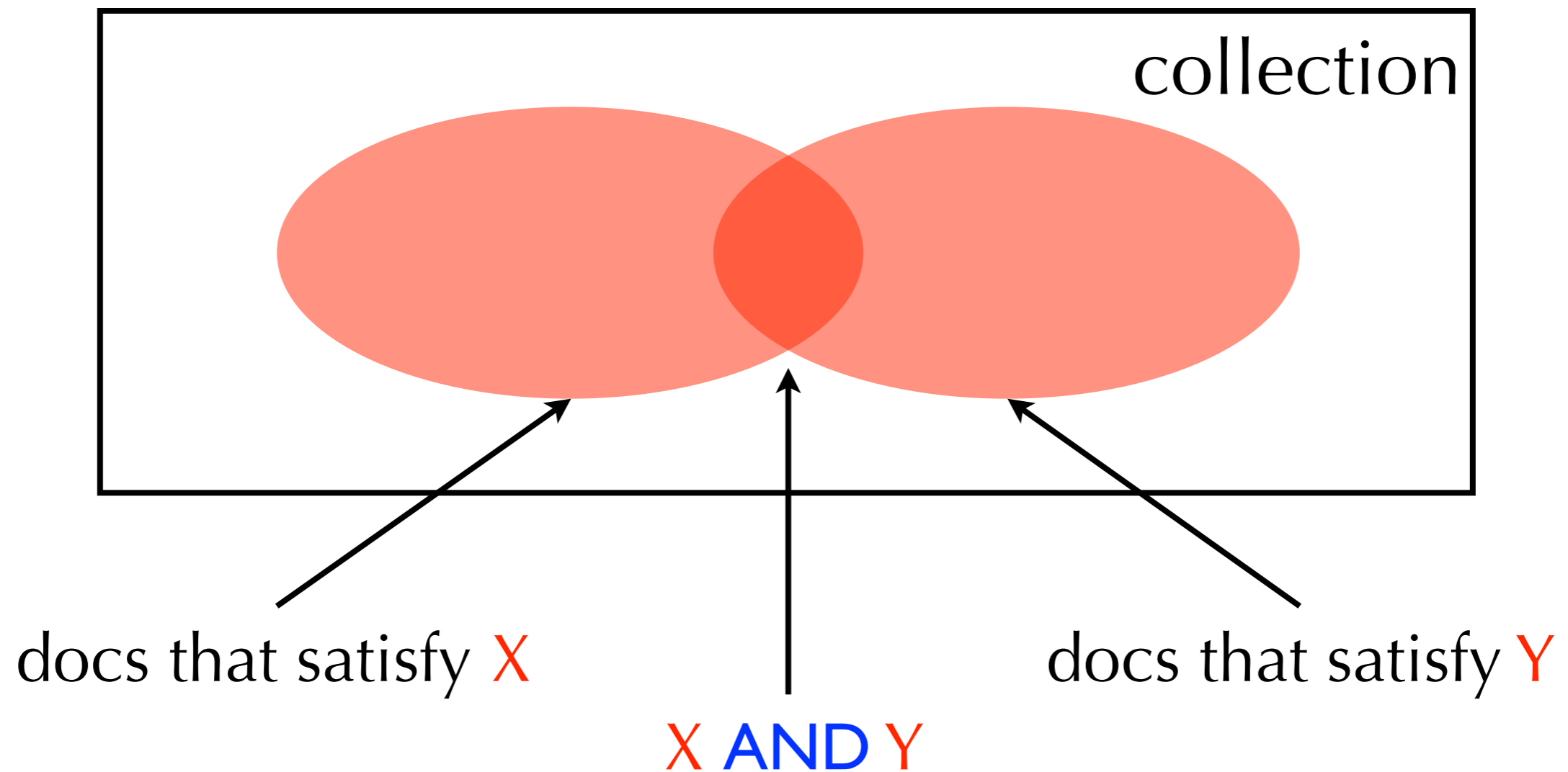


Boolean Retrieval

- **Assumption:** the user can represent their information need using boolean constraints: **AND**, **OR**, and **AND NOT**
 - ▶ lincoln
 - ▶ president **AND** lincoln
 - ▶ president **AND** (lincoln **OR** abraham)
 - ▶ president **AND** (lincoln **OR** abraham) **AND NOT** car
 - ▶ president **AND** (lincoln **OR** abraham) **AND NOT** (car **OR** automobile)
- Parentheses specify the order of operations
 - ▶ A **OR** (B **AND** C) does not equal (A **OR** B) **AND** C

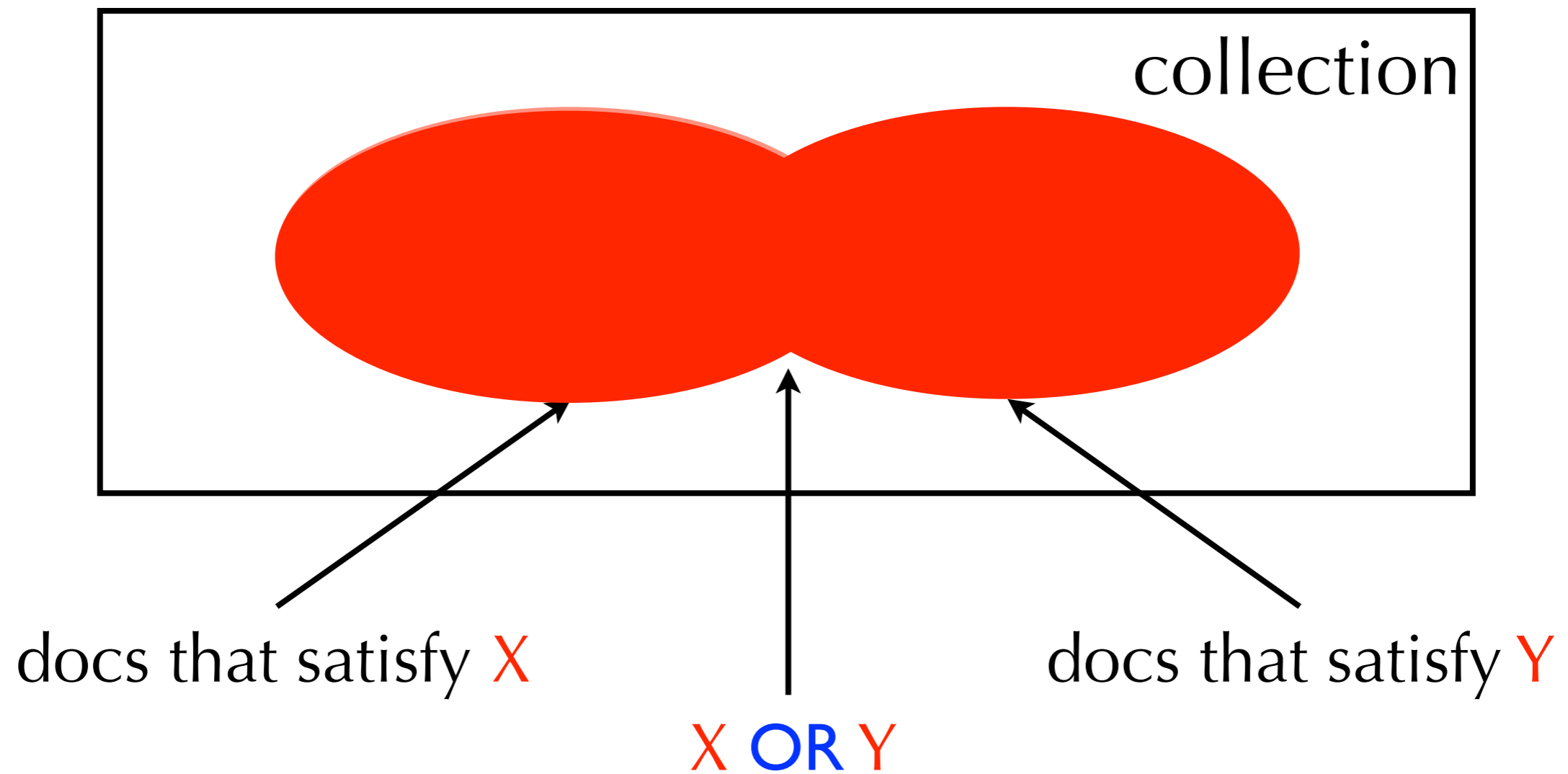
Boolean Retrieval

- **X AND Y**



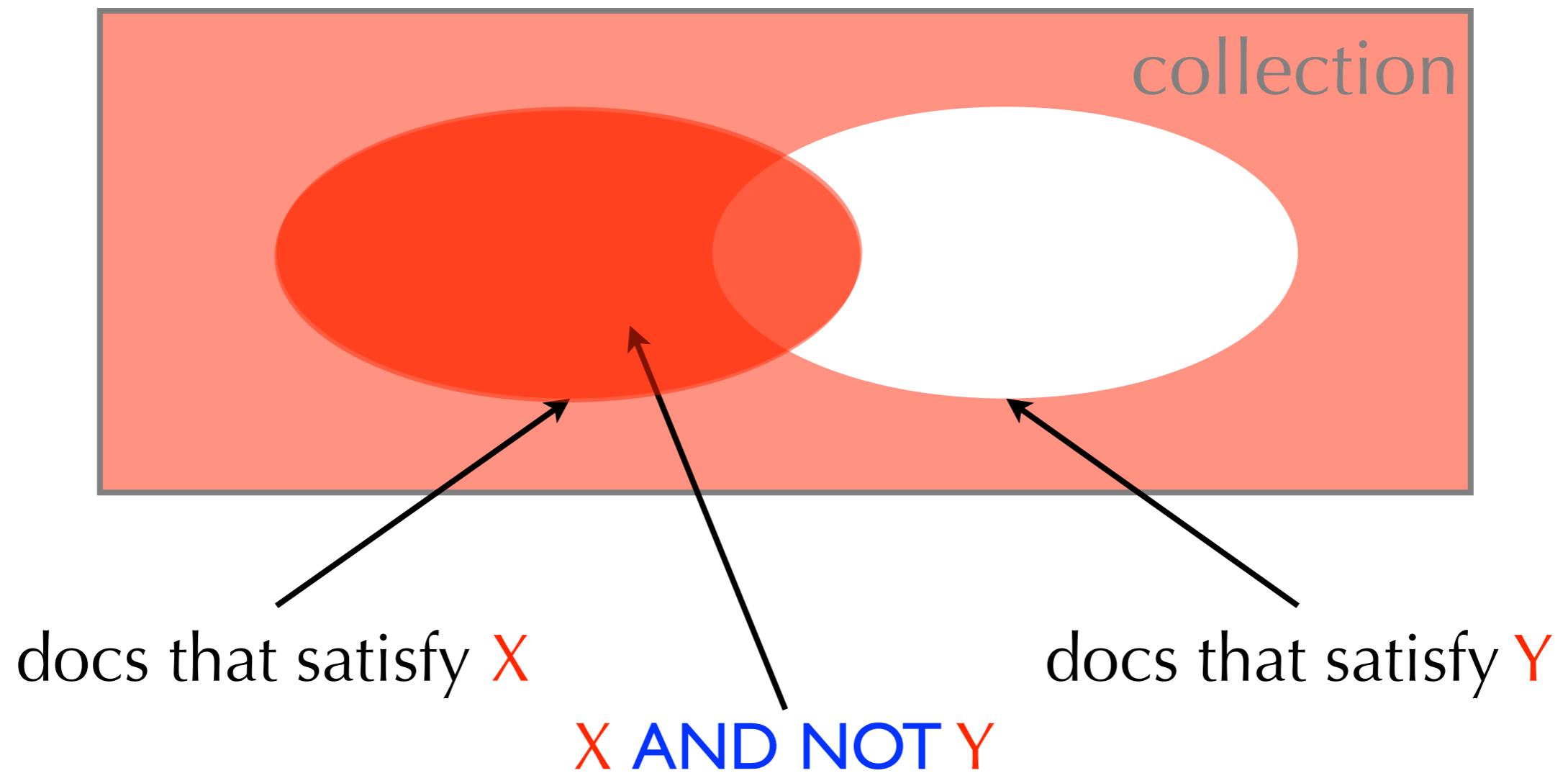
Boolean Retrieval

- $X \text{ OR } Y$



Boolean Retrieval

- **X AND NOT Y**

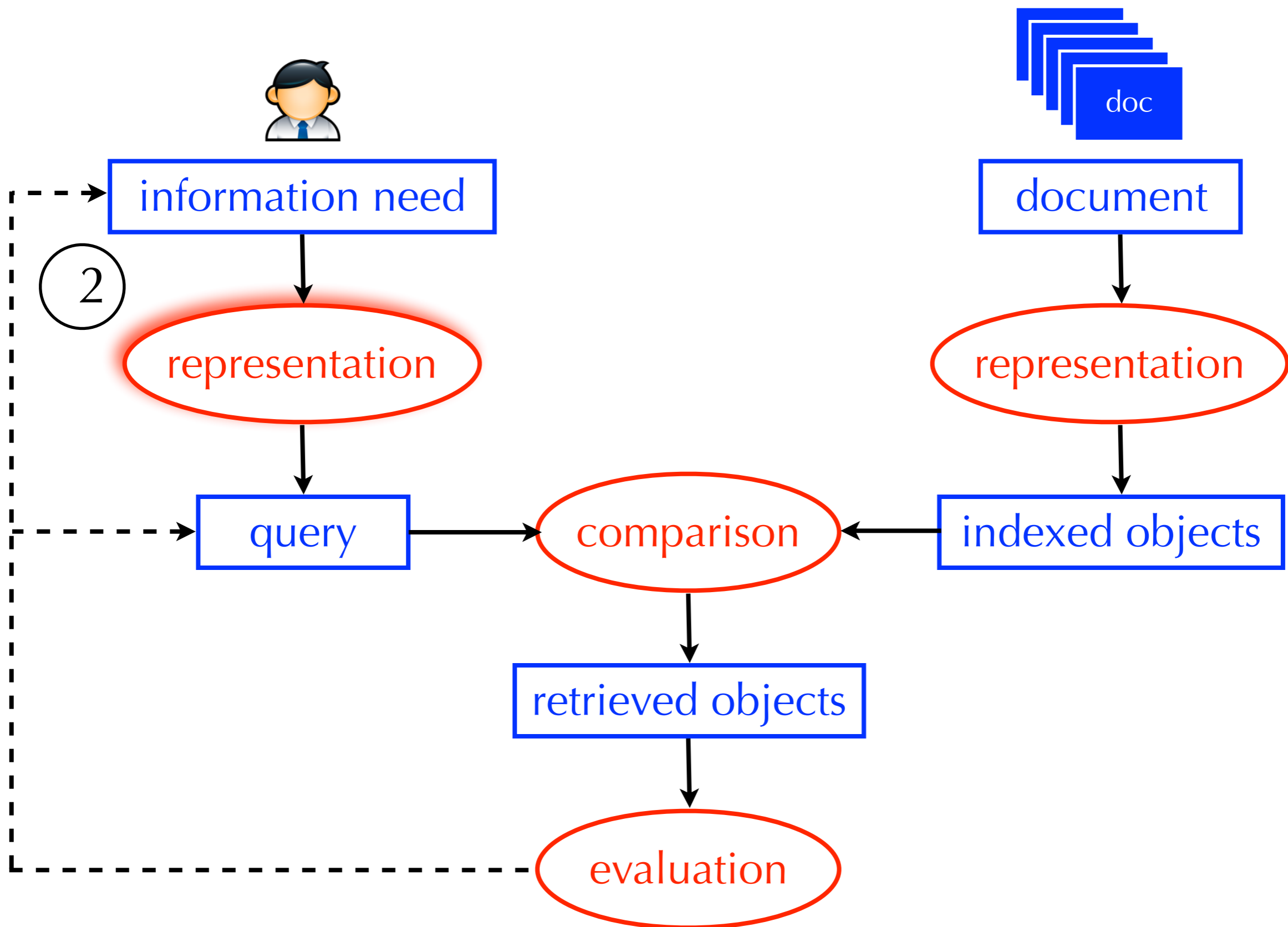


Boolean Retrieval

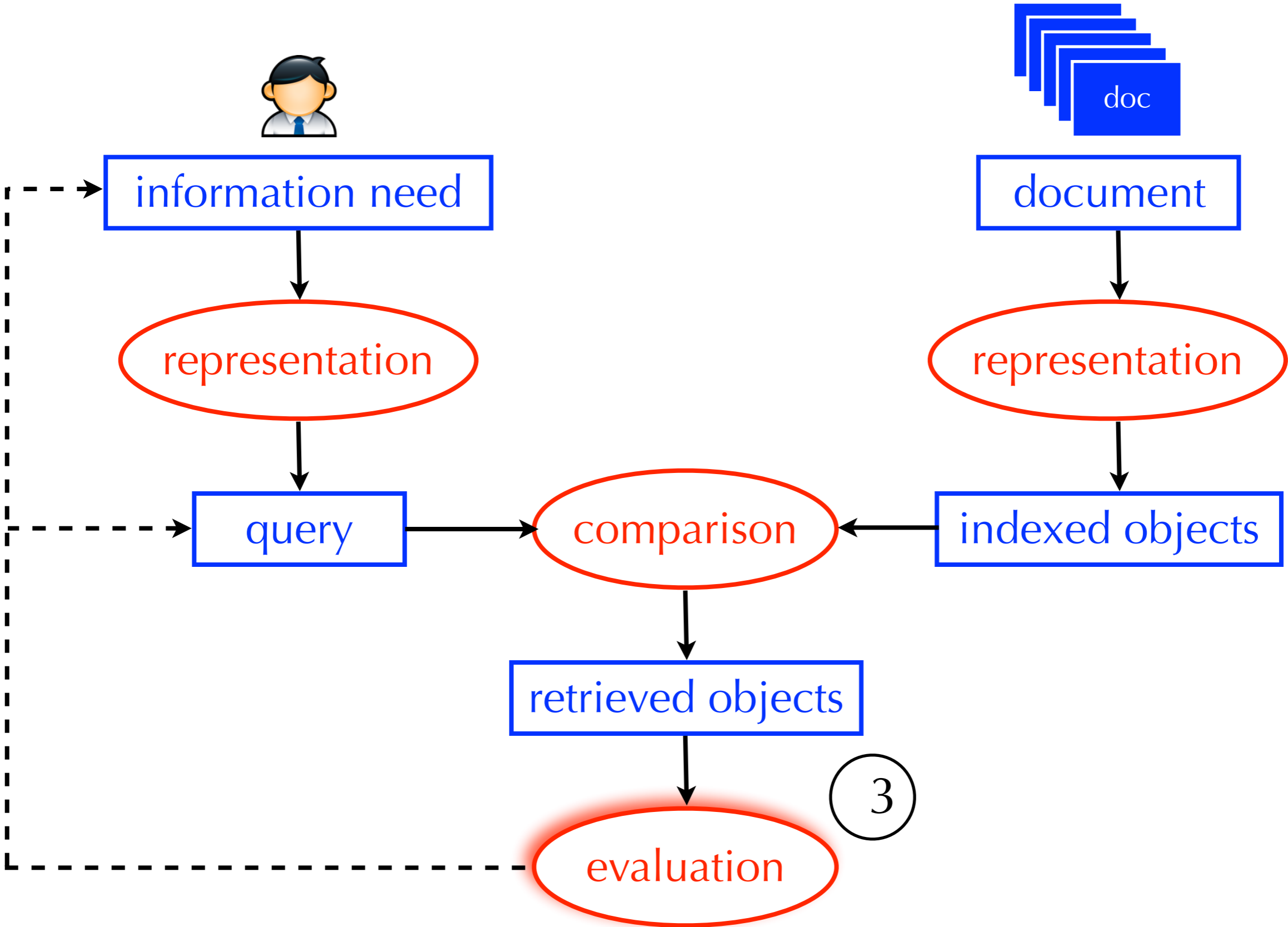
advantages

- Easy for the system (no ambiguity in the query)
 - ▶ the burden is on the user to formulate the right query
- The user gets **transparency** and **control**
 - ▶ lots of results → the query is too broad
 - ▶ no results → the query is too narrow
- Common strategy for finding the right balance:
 - ▶ if the query is too broad, add **AND** or **AND NOT** constraints
 - ▶ if the query is too narrow, add **OR** constraints

Information Need Representation

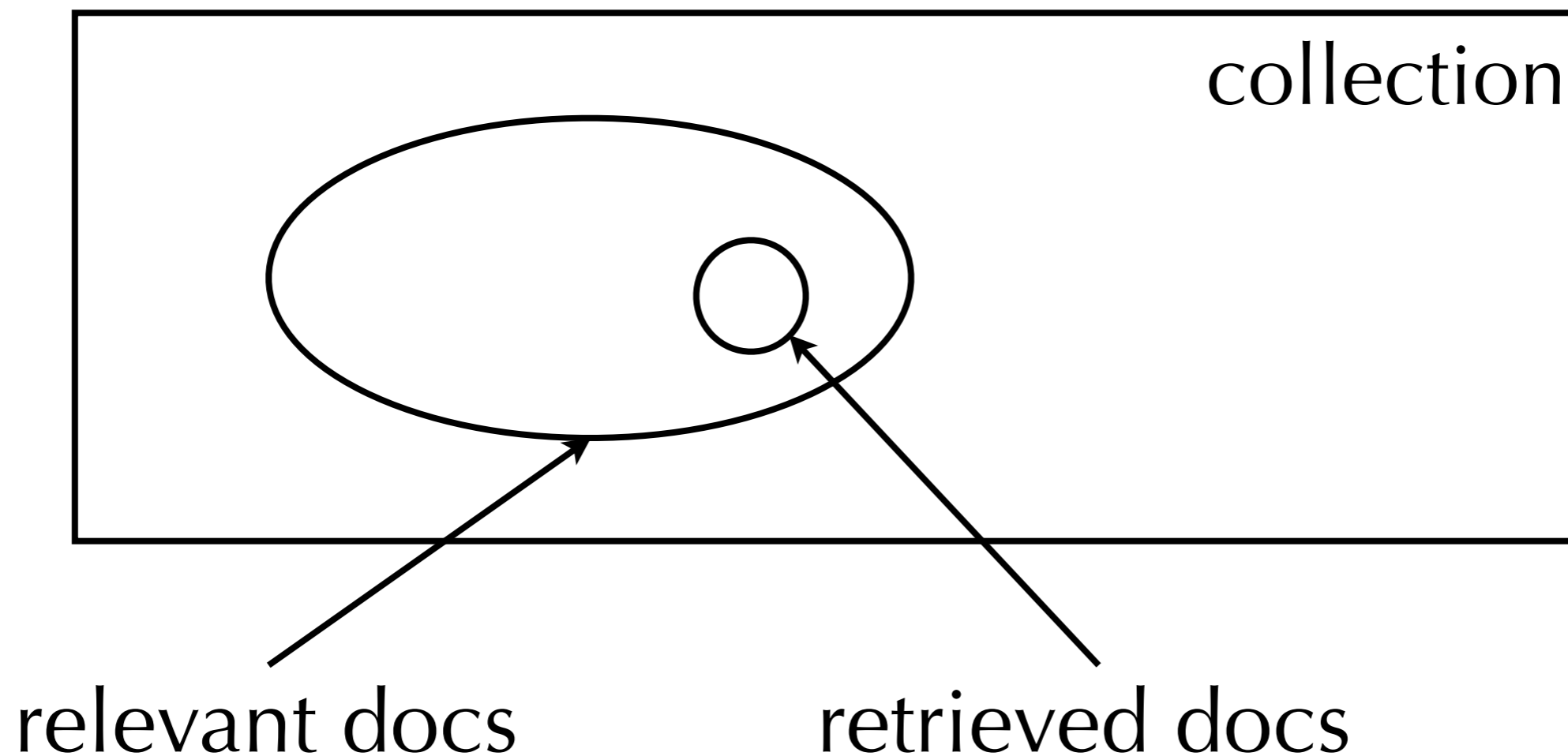


Evaluation



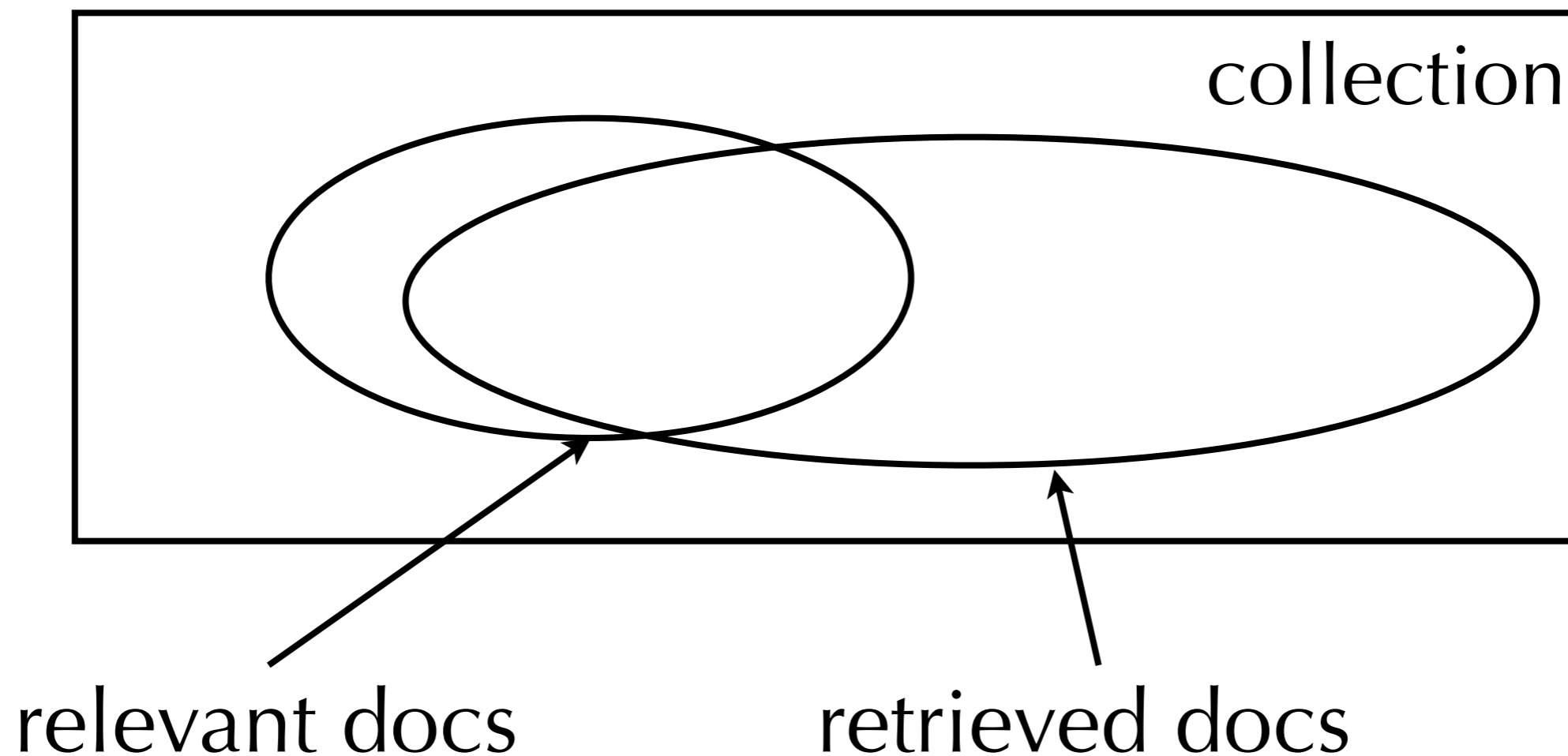
Boolean Retrieval evaluation

- **Assumption:** the user wants to find all the relevant documents and only the relevant documents
- If the query is too specific, it may retrieve relevant documents, but not enough



Boolean Retrieval evaluation

- **Assumption:** the user wants to find all the relevant documents and only the relevant documents
- If the query is too broad, it may retrieve many relevant documents, but also many non-relevant ones



Boolean Retrieval

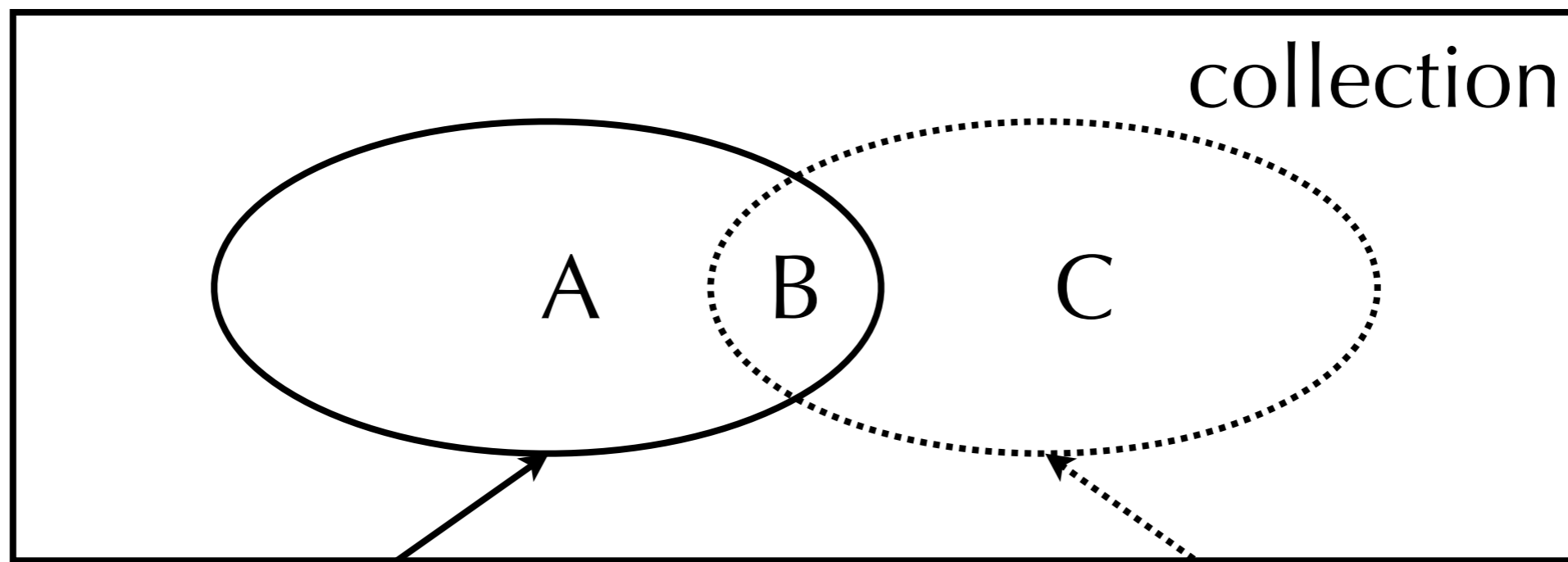
evaluation

- **Assumption:** the user wants to find all the relevant documents and only the relevant documents
- **Precision:** the percentage of retrieved documents that are relevant
- **Recall:** the percentage of relevant documents that are retrieved
- The goal of the user is to find the right balance between **precision** and **recall**
- These are important evaluation measures that we will see over and over again

Boolean Retrieval evaluation

- Precision = $\frac{|B|}{|C|}$

B = intersection of A and C



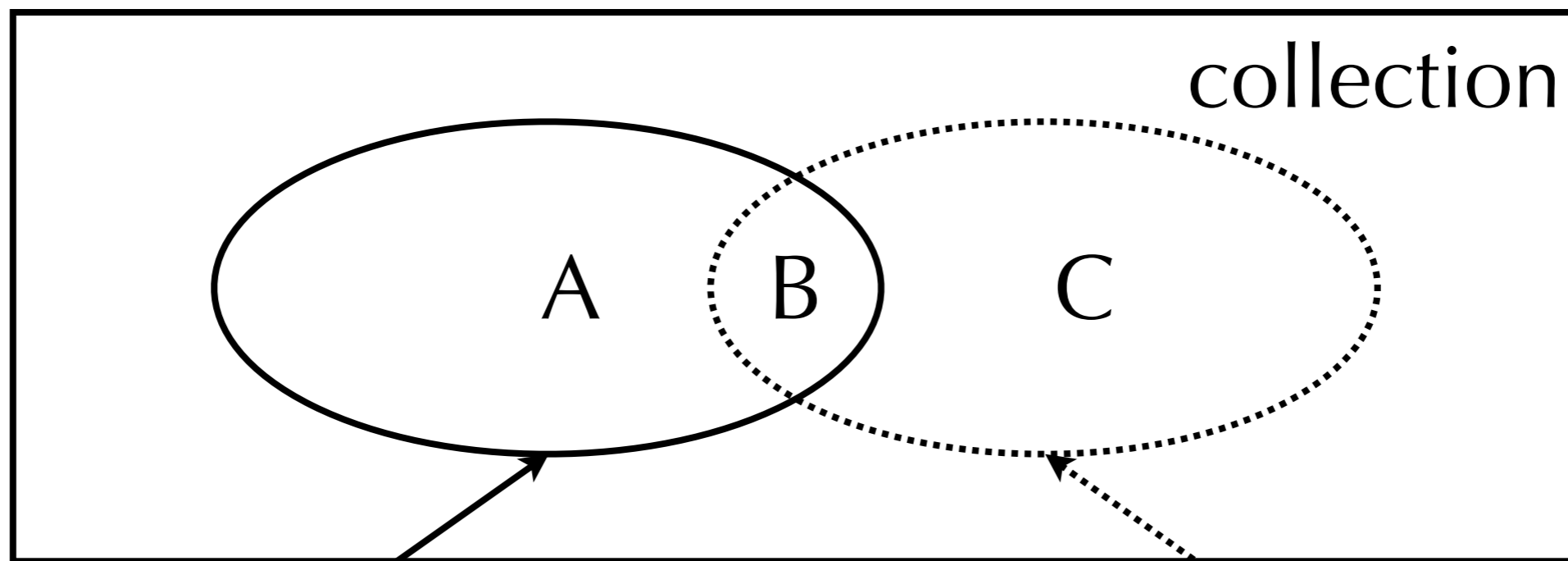
A = relevant docs

C = retrieved docs

Boolean Retrieval evaluation

- $\text{Recall} = \frac{|B|}{|A|}$

B = intersection of A and C



A = relevant docs

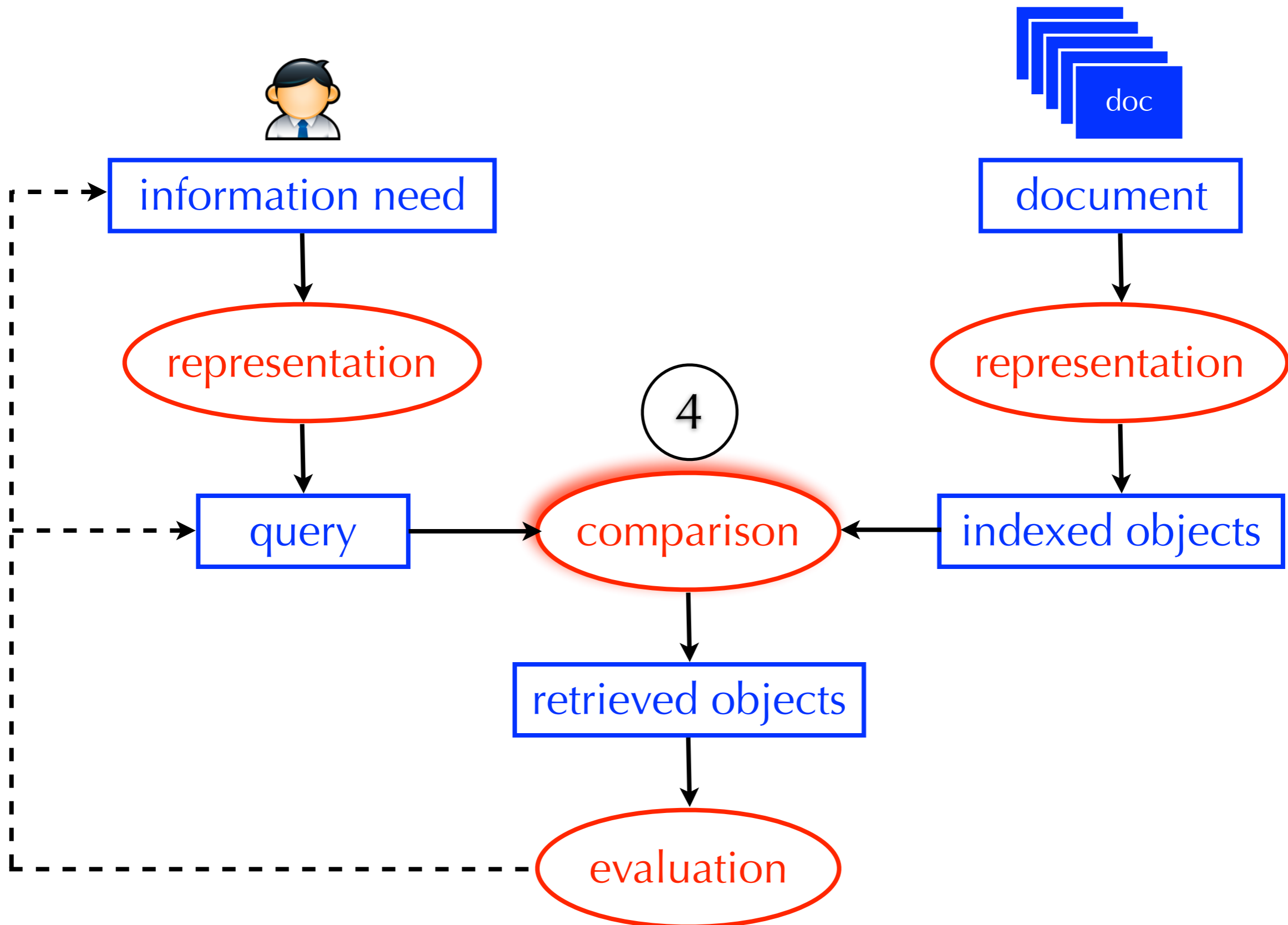
C = retrieved docs

Boolean Retrieval

evaluation

- If the query is too specific, **precision** may be high, but **recall** will probably be low
- If the query is too broad, **recall** may be high, but **precision** will probably be low
- Extreme cases:
 - ▶ a query that retrieves a single relevant document will have perfect **precision**, but low **recall** (unless only that one document is relevant)
 - ▶ a query that retrieves the entire collection will have perfect **recall**, but low **precision** (unless the entire collection is relevant)

Performing Retrieval



Most Basic View of a Search Engine

- A search engines does not scan each document to see if it satisfies the query
- That may be effective, but not efficient
- It uses an index to quickly locate the relevant documents
- **Index:** a list of concepts and pointers to documents that discuss them

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Inverted Index Full-text Representation

<i>a</i>	<i>aardvark</i>	<i>abacus</i>	<i>abba</i>	<i>able</i>	...	<i>zoom</i>
<i>df=3421</i>	<i>df=22</i>	<i>df=19</i>	<i>df=2</i>	<i>df=44</i>		<i>df=1</i>
1	33	2	33	66		54
33	56	10	150	134		
45	86	15		176		
::	::	::		::		
1022	1011	231		432		

- Variable-length inverted lists
- Each document has a unique identifier (**docid**)
- Why are the inverted lists sorted by docid?
- Why do we store the *df*'s in the index?

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=1
1	1	1
3	3	
5	4	
	5	
	8	

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=2
1	1	1
3	3	3
5	4	
	5	
	8	

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=2
1	1	1
3	3	3
5	4	
	5	
	8	

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=3
1	1	1
3	3	3
5	4	5
	5	
	8	

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=3
1	1	1
3	3	3
5	4	5
	5	
	8	

stop!

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, increment pointer with lowest docid
3. Repeat until (1) end of one list and (2) docid from other list is greater

Jack	and	Jack AND and
df=3	df=5	count=3
1	1	1
3	3	3
5	4	5
	5	
	8	
	10	
	35	

If the inverted list for “and” was longer, would it make sense to continue? Why or why not?

Merging (Variable-Length) Inverted Lists AND

- Query: Jack **AND** and

	Jack	and	Jack AND and
1. If docids are equal, add docid to results and increment both pointers	5	5	count=3
2. If docids are not equal, increment pointer to lowest docid	8	4	1 3 5
3. Repeat until (1) end of one list <u>and</u> (2) docid from other list is greater	10	3	
	35		

This is why the inverted lists are sorted in ascending order of docid!

If the inverted list for “and” was longer, would it make sense to continue? Why or why not?

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	4
	5	5
	8	8

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	
5	4	
	5	
	8	

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	
	5	
	8	

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	4
	5	
	8	

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	4
	5	5
	8	

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack OR and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	4
	5	5
	8	8

stop!

Merging (Variable-Length) Inverted Lists

OR

- Query: Jack **OR** and

1. If docids are equal, add docid to results and increment both pointers
2. If docids are not equal, add lowest docid and increment its pointer
3. Repeat until end of both lists

Jack	and	Jack OR and
df=3	df=5	count=5
1	1	1
3	3	3
5	4	4
	5	5
	8	8

- Which is more expensive (on average) **AND** or **OR**?

Merging (Variable-Length) Inverted Lists

- In some cases, the search engine has a choice in the order of operations
- Query: *Abraham AND Lincoln AND President*
 - ▶ option 1: *(Abraham AND Lincoln) AND President*
 - ▶ option 2: *Abraham AND (Lincoln AND President)*
 - ▶ option 3: *(Abraham AND President) AND Lincoln*
- Which is probably the least effective order of operations?

Merging (Variable-Length) Inverted Lists

- Which is probably the most effective order of operations?

<i>president</i>	<i>abraham</i>	<i>lincoln</i>
<i>df=302</i>	<i>df=45</i>	<i>df=5</i>
XX	XX	XX
XX	XX	XX
XX	XX	XX
XX	XX	XX
XX	XX	XX
⋮	⋮	
XX	XX	

Retrieval Model 1: Unranked Boolean

- Retrieves the set of documents that match the boolean query (an “exact-match” retrieval model)
- Returns results in no particular order (ordered by date?)
- This is problematic with large collections
 - ▶ requires complex queries to reduce the result set to a manageable size
- Can we do better?

Retrieval Model 2: Ranked Boolean

<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>UNC</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>df=5</i>
1, 4	1, 4	1, 4	1, 4
10, 1	10, 5	10, 5	10, 1
15, 2	16, 1	16, 1	16, 4
16, 1	68, 1		33, 2
33, 5			56, 10
67, 7			

- *docid = document identifier*
- *tf = term frequency (# of times the term appears in the document)*

Retrieval Model 2: Ranked Boolean

- At each step, keep a list of documents that match the query and their scores (a.k.a. a “priority queue”)
- Score computation:
 - ▶ A **AND** B: adjust the document score based on the **minimum** frequency/score associated with expression A and expression B
 - ▶ A **OR** B: adjust the document score based on the **sum** of frequencies/scores associated with expression A and expression B

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>UNC</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>df=5</i>
1, 4	1, 4	1, 4	1, 4
10, 1	10, 5	10, 5	10, 1
15, 2	16, 1	16, 1	16, 4
16, 1	68, 1		33, 2
33, 5			56, 10
68, 7			

- AND → min
- OR → sum

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>Result_1</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>count=??</i>
1, 4	1, 4	1, 4	
10, 1	10, 5	10, 5	
15, 2	16, 1	16, 1	
16, 1	68, 1		
33, 5			
68, 7			

- AND → min
- OR → sum

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>Result_1</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>count=3</i>
1, 4	1, 4	1, 4	1, 4
10, 1	10, 5	10, 5	10, 1
15, 2	16, 1	16, 1	16, 1
16, 1	68, 1		
33, 5			
68, 7			

- AND → min
- OR → sum

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>Result_1</i>	<i>UNC</i>	<i>Query</i>
<i>count=3</i>	<i>df=5</i>	<i>count=??</i>
1, 4	1, 4	
10, 1	10, 1	
16, 1	16, 4	
	33, 2	
	56, 10	

- AND → min
- OR → sum

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>Result_1</i>	<i>UNC</i>	<i>Query</i>
<i>count=3</i>	<i>df=5</i>	<i>count=5</i>
1, 4	1, 4	1, 8
10, 1	10, 1	10, 2
16, 1	16, 4	16, 5
	33, 2	33, 2
	56, 10	56, 10

- AND → min
- OR → sum

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>UNC</i>	<i>Query</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>df=5</i>	<i>count=5</i>
1, 4	1, 4	1, 4	1, 4	1, 8
10, 1	10, 5	10, 5	10, 1	10, 2
15, 2	16, 1	16, 1	16, 4	16, 5
16, 1	68, 1		33, 2	33, 2
33, 5			56, 10	56, 10
68, 7				

- Conceptually, what do these document scores indicate?

Retrieval Model 2: Ranked Boolean

- Query: (University AND North AND Carolina) OR UNC

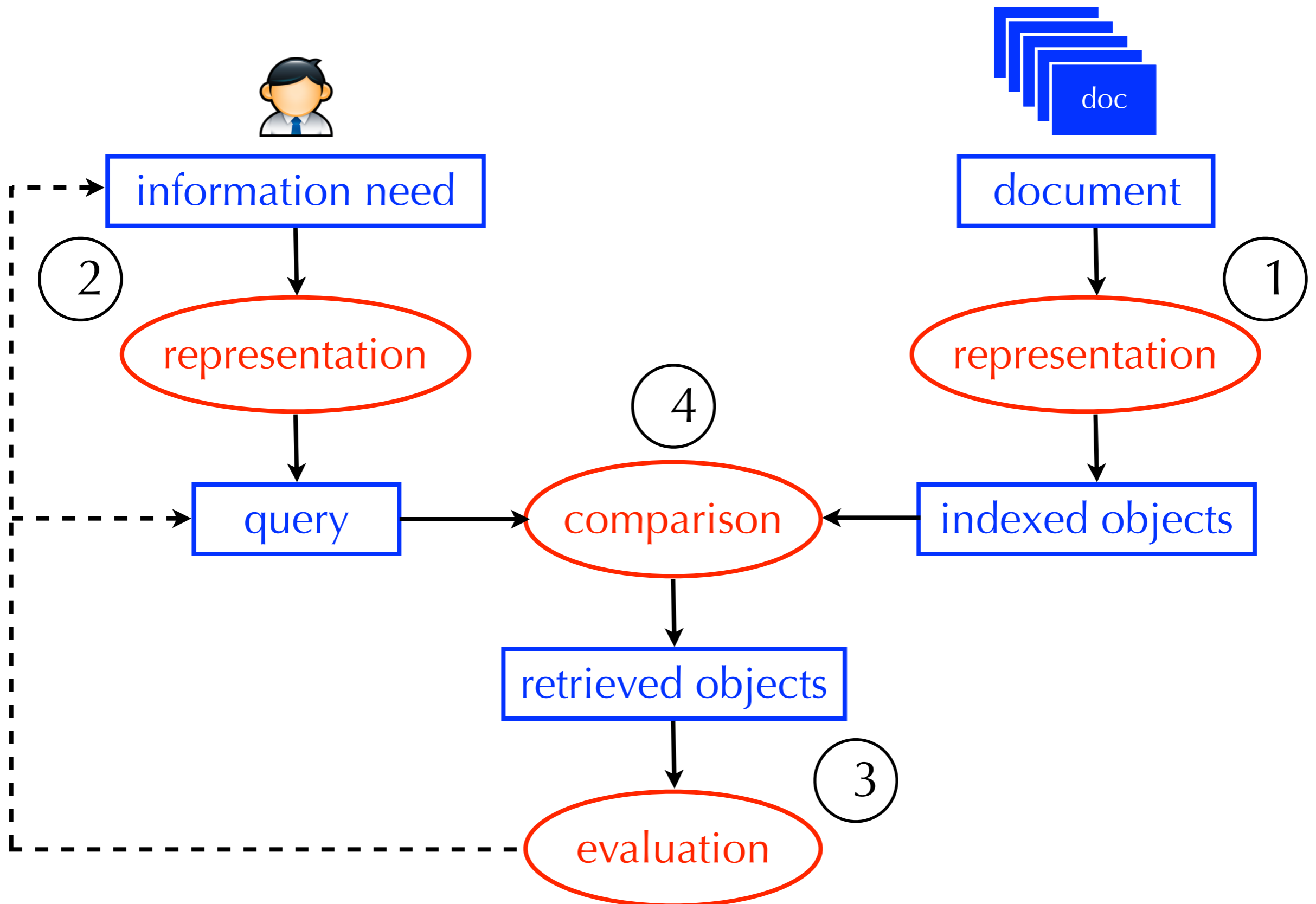
<i>University</i>	<i>North</i>	<i>Carolina</i>	<i>UNC</i>	<i>Query</i>
<i>df=6</i>	<i>df=4</i>	<i>df=3</i>	<i>df=5</i>	<i>count=5</i>
1, 4	1, 4	1, 4	1, 4	1, 8
10, 1	10, 5	10, 5	10, 1	10, 2
15, 2	16, 1	16, 1	16, 4	16, 5
16, 1	68, 1		33, 2	33, 2
33, 5			56, 10	56, 10
68, 7				

- The **scores** correspond to the number of ways in which the document redundantly satisfies the query

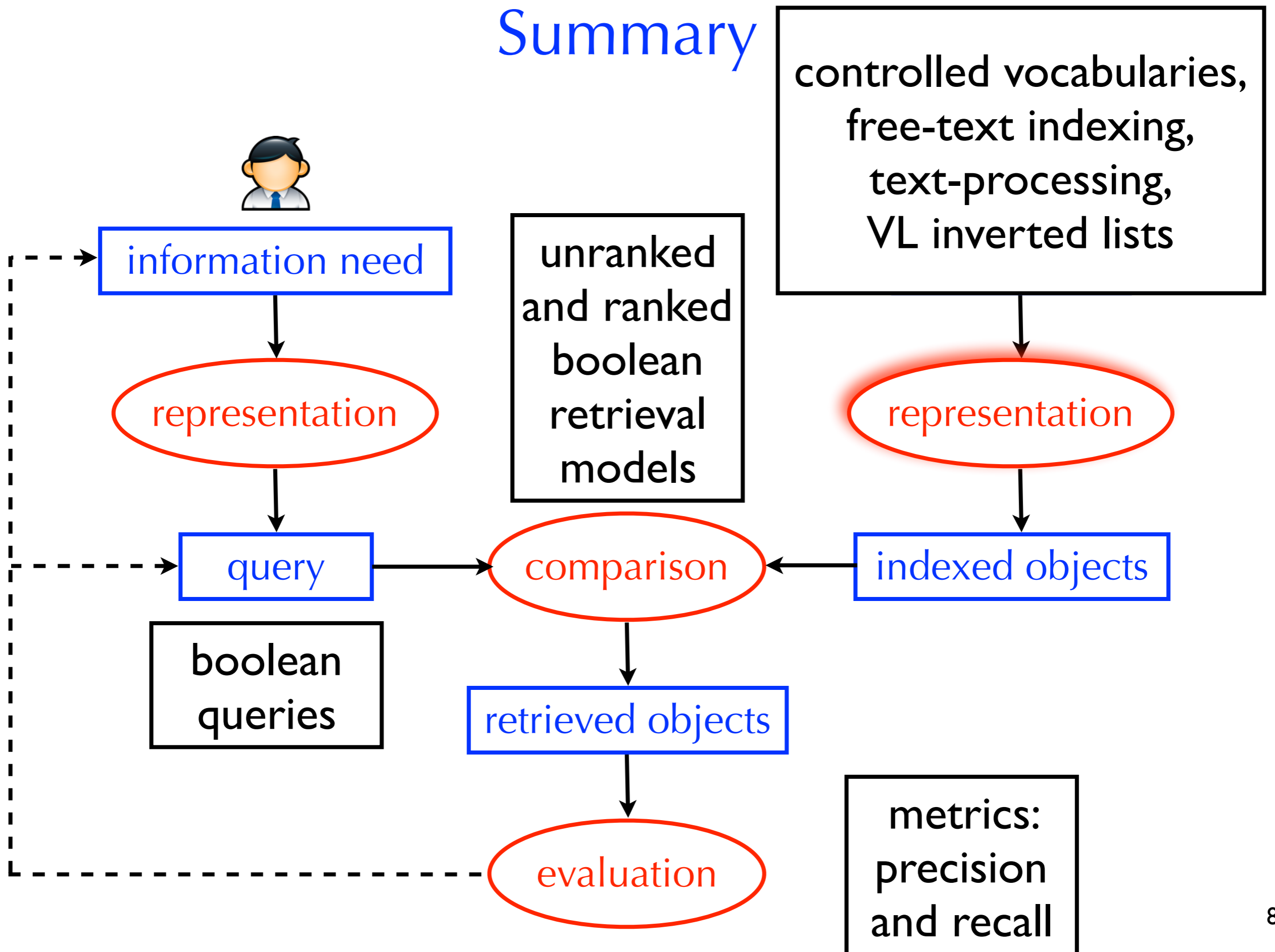
Retrieval Model 2: Ranked Boolean

- Advantages:
 - ▶ same as unranked boolean: efficient, predictable, easy to understand, works well when the user knows what to look for
 - ▶ the user may be able to find relevant documents quicker and may not need to examine the entire result set
- Disadvantages:
 - ▶ same as unranked boolean: works well when the user knows what to look for
 - ▶ difficult to balance precision and recall

Summary



Summary



Take Home Message

- Congratulations! Now, you know how a boolean search engine works
- How are indexes structured?
- How are boolean queries processed quickly?
- What are some time-saving hacks?
- How are boolean retrieval sets evaluated?
- How can we prioritize documents based on how much they satisfy the boolean constraints?