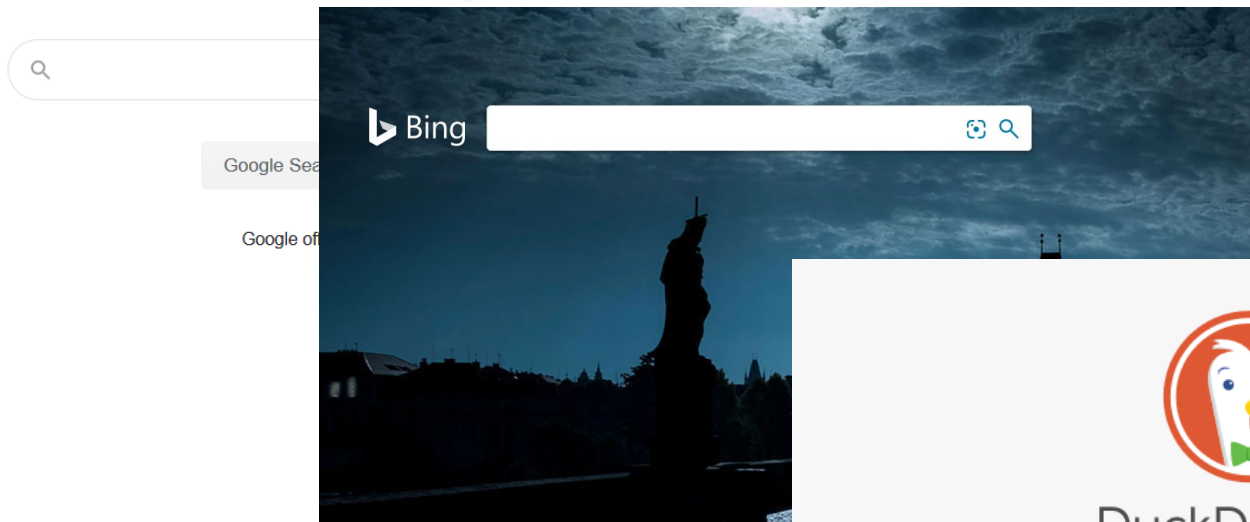# Question Answering
Type of questions, passage retrieval, answer extraction
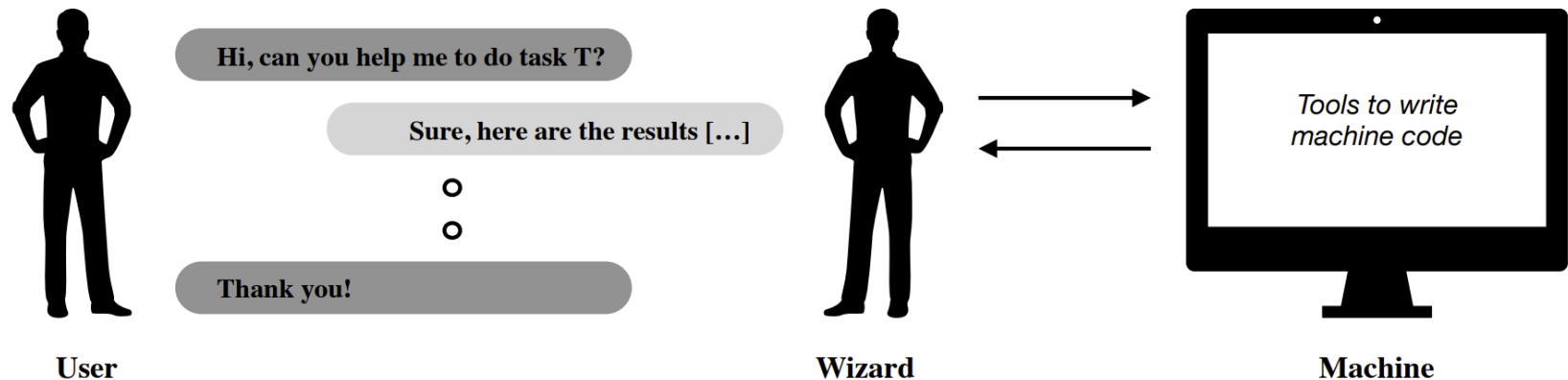
Information Retrieval

Beyond simple search?

Language based systems

de Vries, H., Bahdanau, D., & Manning, C. (2020). Towards ecologically valid research on language user interfaces. *arXiv preprint arXiv:2007.14435*.
https://arxiv.org/abs/2007.14435

Paradigms

- Question answering
  - Information seeking tasks

- Task oriented conversation
  - Online shopping, booking, etc.

- Open ended conversation
  - Information seeking tasks

Single turn Human-Agent interaction

Multi-turn Human-Agent interaction

Mobile QA

Move to mobile favors a move to **speech** which favors **natural language information search**

- Will we move to a time when over half of searches are spoken?

Question Answering: IBM's Watson

Won Jeopardy on
February 16, 2011!

WILLIAM WILKINSON'S "AN ACCOUNT OF THE PRINCIPALITIES OF WALLACHIA AND MOLDOVIA" INSPIRED THIS AUTHOR'S MOST FAMOUS NOVEL

→ Bram Stoker

Types of Questions in Modern Systems

- Factoid questions (**this lecture**)
    - Who wrote "The Universal Declaration of Human Rights"?
    - How many calories are there in two slices of apple pie?
    - What is the average age of the onset of autism?
    - Where is Apple Computer based?

- Complex (narrative) questions (**your project**)
    - In children with an acute febrile illness, what is the efficacy of acetaminophen in reducing fever?
    - What do scholars think about Jefferson's position on dealing with pirates?

Commercial systems: mainly factoid QA

Where is the Louvre Museum located?	In Paris, France
What's the abbreviation for limited partnership?	L.P.
What are the names of Odin's ravens?	Huginn and Muninn
What currency is used in China?	The yuan
What kind of nuts are used in marzipan?	almonds
What instrument does Max Roach play?	drums
What is the telephone number for Stanford University?	650-723-2300

Paradigms for QA

- IR-based approaches
  - TREC; IBM Watson; Google

- Structured knowledge-based approaches
  - IBM Watson; True Knowledge Evi, Apple Siri, Wolfram Alpha, Facebook Graph Search

- Hybrid approaches
  - IBM Watson

IR-based Question Answering

People also ask

Where should we go in Portugal? ⌄

How much does it cost to travel to Portugal? ⌄

How do I plan a trip to Portugal? **Question** ⌃

Planning a trip to Portugal? These are our go to tips

1. Go out of Season. Choosing when to travel really is everything, especially where you're visiting one of the hottest destinations of the moment. ...
2. Eat like a local. ...
3. Venture off the beaten track. ...
4. Pack a factor 30+ ...
5. Get yourself a discount card. ...
6. Beware of the transport. ...
7. Pack Comfortable Shoes. ...
8. Try the coffee.

Nov 10, 2017

Answer (passage retrieval)

Planning a trip to Portugal? These are our go to tips | six-two by Contiki

https://www.contiki.com › six-two › trip-to-portugal-tips

Search for: How do I plan a trip to Portugal?

Is Portugal safe? ⌄

What is the cheapest month to fly to Portugal? ⌄

What is the most beautiful place in Portugal? ⌄

Expansion questions

People also ask

Where should we go in Portugal?

How much does it cost to travel to Portugal?

How do I plan a trip to Portugal?

Is Portugal safe?

Feedback

11

IR-based Factoid QA

- QUESTION PROCESSING
  - Detect question type, answer type, focus, relations
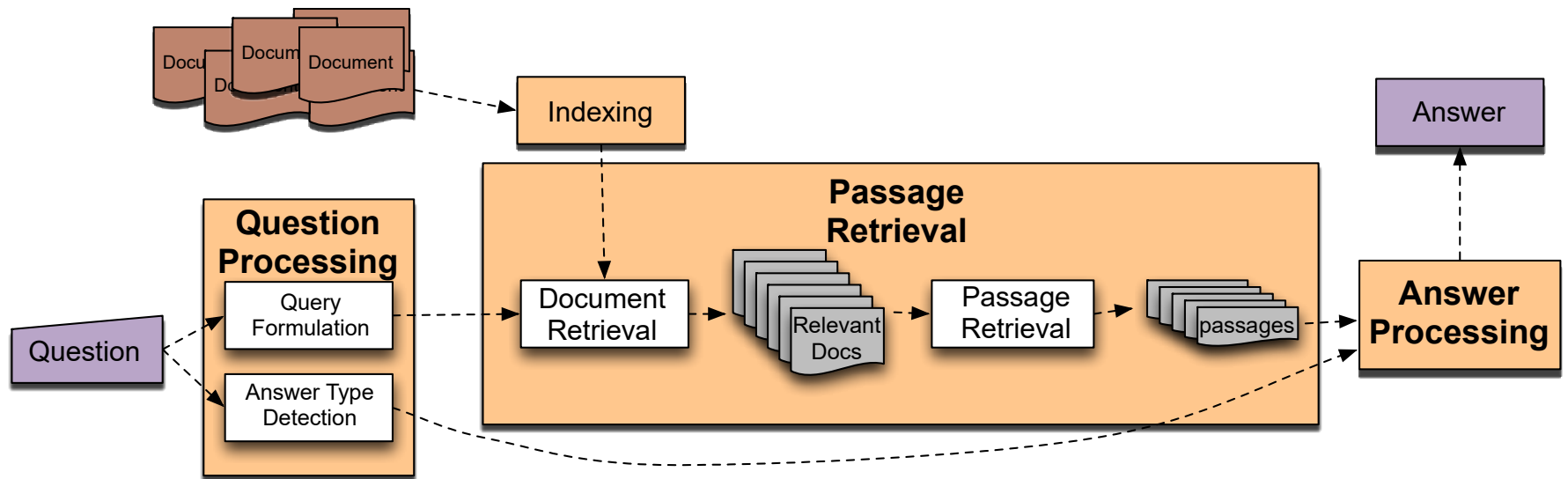 - Formulate queries to send to a search engine

- PASSAGE RETRIEVAL
  - Retrieve ranked documents
  - Break into suitable passages and rerank

- ANSWER PROCESSING
  - Extract candidate answers
  - Rank candidates
    - using evidence from the text and external sources

Factoid Q/A

Open-domain Question Answering

SQuAD
Q: How many of Warsaw's inhabitants spoke Polish in 1933? **A:** 833,500

TREC
Q: What U.S. state's motto is "Live free or Die"? **A:** New Hampshire

WebQuestions (Berant et al, 2013)
Q: What part of the atom did Chadwick discover? **A:** neutron

WikiMovies (Miller et al, 2016)
Q: Who wrote the film Gigli? **A:** Martin Brest

Knowledge-based approaches

- Build a semantic representation of the query
  - Times, dates, locations, entities, numeric quantities

- Map from this semantics to query structured data or resources
  - Geospatial databases
  - Ontologies (Wikipedia infoboxes, dbPedia, WordNet, Yago)
  - Restaurant review sources and reservation services
  - Scientific databases

Wolfram Alpha

Knowledge bases

English Wikipedia

TREC Complex Answer Retrieval v2.1 (may increase to 3.0 pending availability)

Article paragraph content from Wikipedia (Wikipedia dump from December 20, 2016)

Approximately 5 Million articles

This data is publicly available

Web data

MS MARCO Passage Reranking data

10 million answer candidates from Bing search

This data is publicly available

Washington Post news collection

TREC Washington Post Corpus used by the TREC News Track

608,180 news articles and blog posts from 2012 through 2017

NOTE: This collection requires a data license agreement.

# Hybrid approaches (IBM Watson)

- Build a shallow semantic representation of the query

- Generate answer candidates using IR methods
  - Augmented with ontologies and semi-structured data

- Score each candidate using richer knowledge sources
  - Geospatial databases
  - Temporal reasoning
  - Taxonomical classification

Question Answering

Answer Types and Query Formulation

Factoid Q/A
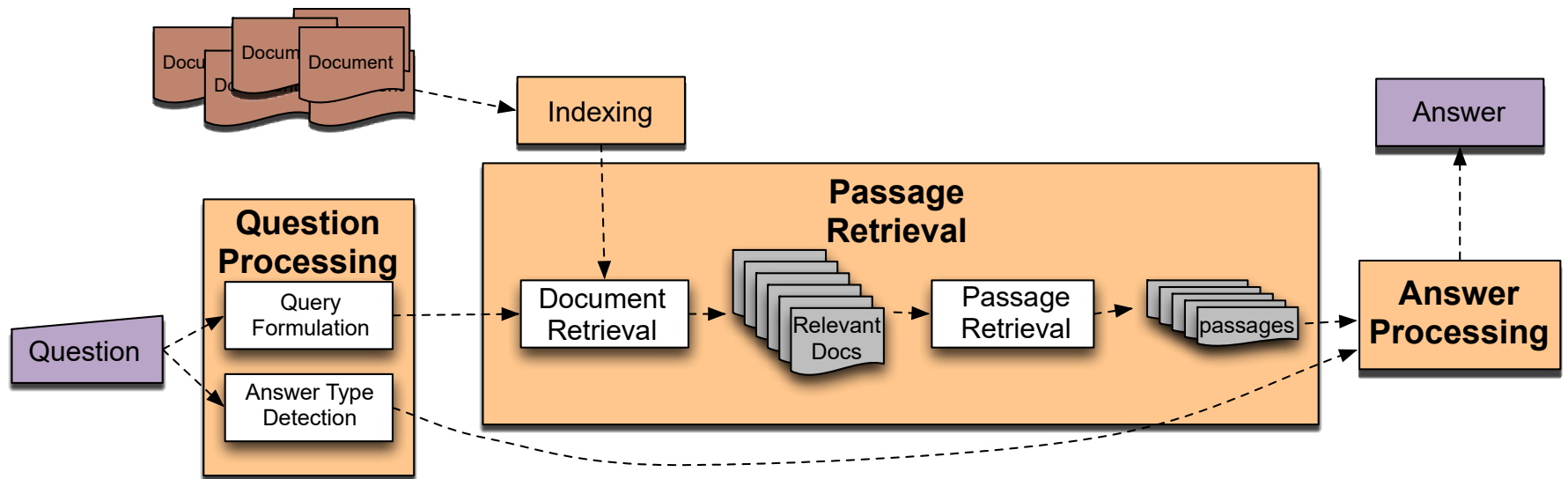
Question Processing
Things to extract from the question

- ## Answer Type Detection
  - Decide the **named entity type** (person, place) of the answer

- ## Query Formulation
  - Choose **query keywords** for the IR system

- ## Question Type classification
  - Is this a definition question, a math question, a list question?

- ## Focus Detection
  - Find the question words that are replaced by the answer

- ## Relation Extraction
  - Find relations between entities in the question

Question Processing

They're the two states you could be reentering if you're crossing Florida's northern border

- Answer Type: US state

- Query: two states, border, Florida, north

- Focus: the two states

- Relations: borders(Florida, ?x, north)

Answer Type Detection: Named Entities

- *Who founded Virgin Airlines?*
  - PERSON

- *What Canadian city has the largest population?*
  - *CITY.*

Answer Type Taxonomy

- 6 coarse classes
  - ABBEVIATION, ENTITY, DESCRIPTION, HUMAN, LOCATION, NUMERIC

- 50 finer classes
  - LOCATION: city, country, mountain...
  - HUMAN: group, individual, title, description
  - ENTITY: animal, body, color, currency...

Xin Li, Dan Roth. 2002. Learning Question Classifiers. COLING'02

Part of Li & Roth's Answer Type Taxonomy
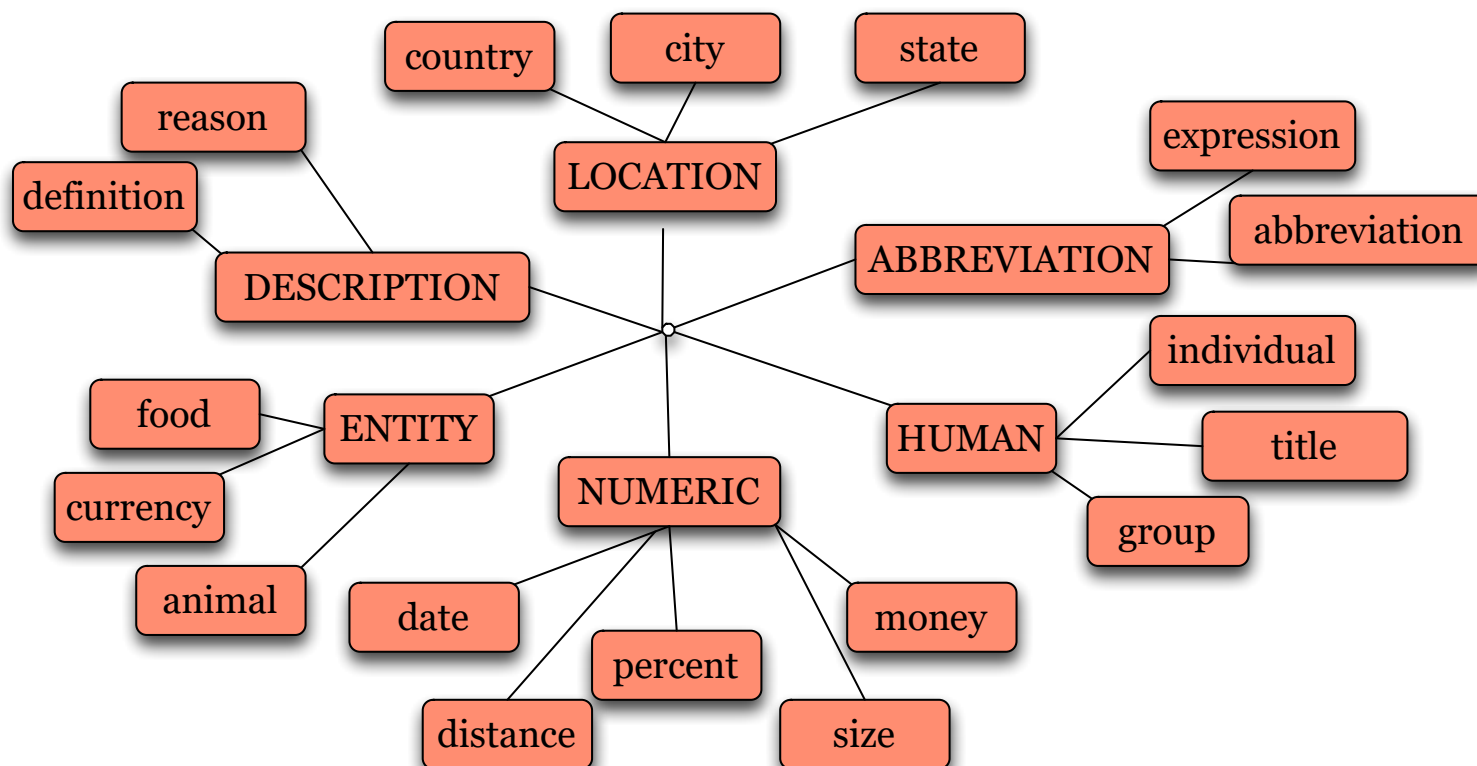
Answer Types

ENTITY	
animal	What are the names of Odin's ravens?
body	What part of your body contains the corpus callosum?
color	What colors make up a rainbow ?
creative	In what book can I find the story of Aladdin?
currency	What currency is used in China?
disease/medicine	What does Salk vaccine prevent?
event	What war involved the battle of Chapultepec?
food	What kind of nuts are used in marzipan?
instrument	What instrument does Max Roach play?
lang	What's the official language of Algeria?
letter	What letter appears on the cold-water tap in Spain?
other	What is the name of King Arthur's sword?
plant	What are some fragrant white climbing roses?
product	What is the fastest computer?
religion	What religion has the most members?
sport	What was the name of the ball game played by the Mayans?
substance	What fuel do airplanes use?
symbol	What is the chemical symbol for nitrogen?
technique	What is the best way to remove wallpaper?
term	How do you say " Grandma " in Irish?
vehicle	What was the name of Captain Bligh's ship?
word	What's the singular of dice?

More Answer Types

HUMAN	
description	Who was Confucius?
group	What are the major companies that are part of Dow Jones?
ind	Who was the first Russian astronaut to do a spacewalk?
title	What was Queen Victoria's title regarding India?
LOCATION	
city	What's the oldest capital city in the Americas?
country	What country borders the most others?
mountain	What is the highest peak in Africa?
other	What river runs through Liverpool?
state	What states do not have state income tax?
NUMERIC	
code	What is the telephone number for the University of Colorado?
count	About how many soldiers died in World War II?
date	What is the date of Boxing Day?
distance	How long was Mao's 1930s Long March?
money	How much did a McDonald's hamburger cost in 1963?
order	Where does Shanghai rank among world cities in population?
other	What is the population of Mexico?
period	What was the average life expectancy during the Stone Age?
percent	What fraction of a beaver's life is spent swimming?
speed	What is the speed of the Mississippi River?
temp	How fast must a spacecraft travel to escape Earth's gravity?
size	What is the size of Argentina?
weight	How many pounds are there in a stone?

Answer Types in Jeopardy

- 2500 answer types in 20,000 Jeopardy question sample

- The most frequent 200 answer types cover < 50% of data

- The 40 most frequent Jeopardy answer types

  - he, country, city, man, film, state, she, author, group, here, company, president, capital, star, novel, character, woman, river, island, king, song, part, series, sport, singer, actor, play, team, show, actress, animal, presidential, composer, musical, nation, book, title, leader, game

Answer Type Detection

- Hand-written rules

- Machine Learning

- Hybrids

Answer Type Detection

- Regular expression-based rules can get some cases:
  - Who {is|was|are|were} PERSON
  - PERSON (YEAR – YEAR)

- Other rules use the **question headword**:

  (the headword of the first noun phrase after the wh-word)

  - Which **city** in China has the largest number of foreign financial companies?
  - What is the state **flower** of California?

Answer Type Detection

- Most often, we treat the problem as machine learning classification
  - **Define** a taxonomy of question types
  - **Annotate** training data for each question type
  - **Train** classifiers for each question class using a rich set of features.
    - features include those hand-written rules!

Features for Answer Type Detection

- Question words and phrases

- Part-of-speech tags

- Parse features (headwords)

- Named Entities
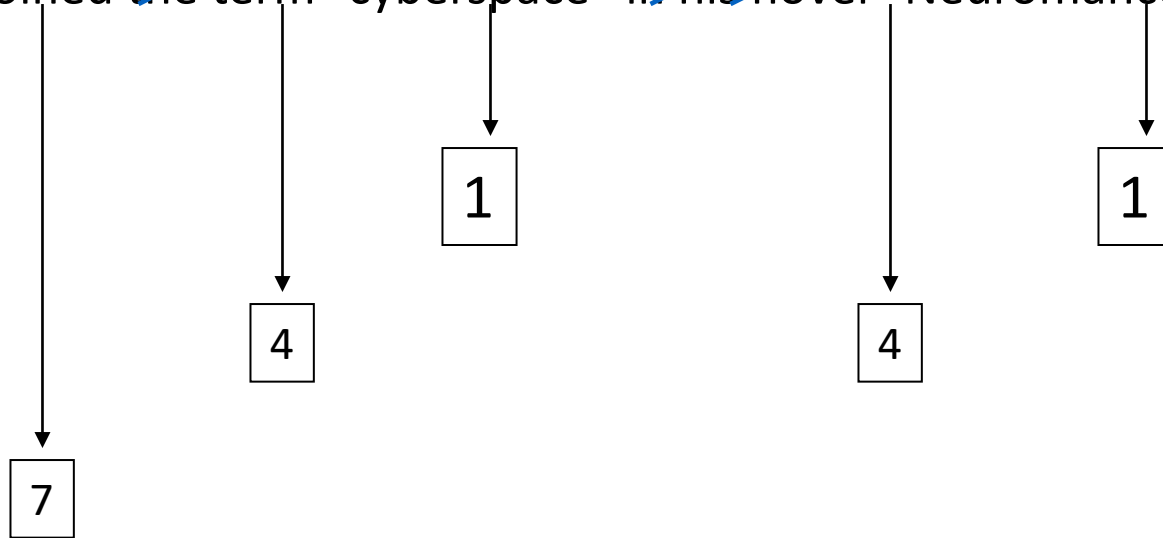
- Semantically related words

Keyword Selection Algorithm

1. Select all non-stop words in quotations

2. Select all NNP words in recognized named entities

3. Select all complex nominals with their adjectival modifiers

4. Select all other complex nominals

5. Select all nouns with their adjectival modifiers

6. Select all other nouns

7. Select all verbs

8. Select all adverbs

9. Select the QFW word (skipped in all previous steps)

10. Select all other words

Dan Moldovan, Sanda Harabagiu, Marius Paca, Rada Mihalcea, Richard Goodrum, Roxana Girju and Vasile Rus. 1999. Proceedings of TREC-8.

Choosing keywords from the query

Who coined the term "cyberspace" in his novel "Neuromancer"?

1

1

4

4

7

cyberspace/1 Neuromancer/1 term/4 novel/4 coined/7

34

Question Answering

Passage Retrieval and Answer Extraction

Passage Retrieval

- Step 1: IR engine retrieves documents using query terms

- Step 2: Segment the documents into shorter units

  - something like paragraphs

- Step 3: Passage ranking

  - Use answer type to help rerank passages

Features for Passage Ranking

Either in rule-based classifiers or with supervised machine learning

- Number of Named Entities of the right type in passage

- Number of query words in passage

- Number of question N-grams also in passage

- Proximity of query keywords to each other in passage

- Longest sequence of question words

- Rank of the document containing passage

Factoid Q/A
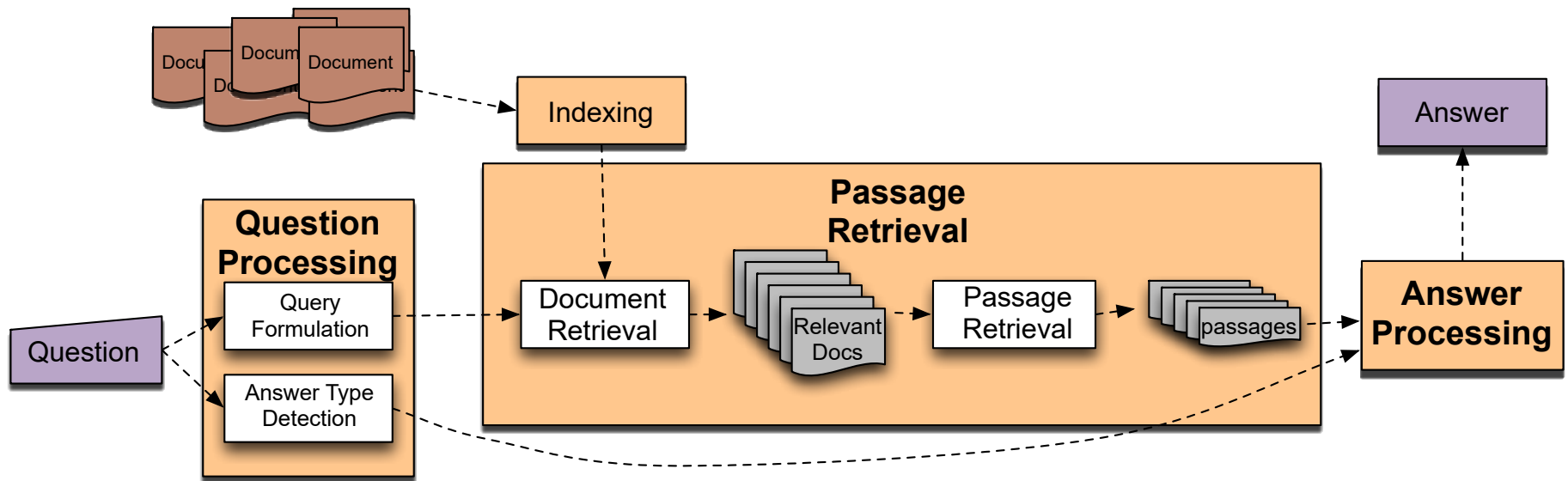
Answer Extraction

- Run an answer-type named-entity tagger on the passages
  - Each answer type requires a named-entity tagger that detects it
  - If answer type is CITY, tagger has to tag CITY
    - Can be full NER, simple regular expressions, or hybrid

- Return the string with the right type:
  - `Who is the prime minister of India` (PERSON)

    `Manmohan Singh``, Prime Minister of India, had told left leaders that the deal would not be renegotiated.`
  - `How tall is Mt. Everest?` (LENGTH)

    `The official height of Mount Everest is` **`29035 feet`**

Ranking Candidate Answers

- But what if there are multiple candidate answers!

Q: Who was Queen Victoria's second son?

- Answer Type: **Person**

- Passage:

The Marie biscuit is named after Marie Alexandrovna, the daughter of Czar Alexander II of Russia and wife of Alfred, the second son of Queen Victoria and Prince Albert

Ranking Candidate Answers

- But what if there are multiple candidate answers!

Q: Who was Queen Victoria's second son?

- Answer Type: **Person**

- Passage:

The Marie biscuit is named after **Marie Alexandrovna**, the daughter of **Czar Alexander II of Russia** and wife of **Alfred**, the second son of **Queen Victoria** and **Prince Albert**

Features for ranking candidate answers

- **Answer type match:** Candidate contains a phrase with the correct answer type.

- **Pattern match:** Regular expression pattern matches the candidate.

- **Question keywords:** # of question keywords in the candidate.

- **Keyword distance:** Distance in words between the candidate and query keywords

- **Novelty factor:** A word in the candidate is not in the query.

- **Apposition features:** The candidate is an appositive to question terms

- **Punctuation location:** The candidate is immediately followed by a comma, period, quotation marks, semicolon, or exclamation mark.

- **Sequences of question terms:** The length of the longest sequence of question terms that occurs in the candidate answer.

Candidate Answer scoring in IBM Watson

- Each candidate answer gets scores from >50 components
  - (from unstructured text, semi-structured text, triple stores)

  - logical form (parse) match between question and candidate
  - passage source reliability
  - geospatial location
    - California is "southwest of Montana"
  - temporal relationships
  - taxonomic classification

IBM Watson Jeopardy
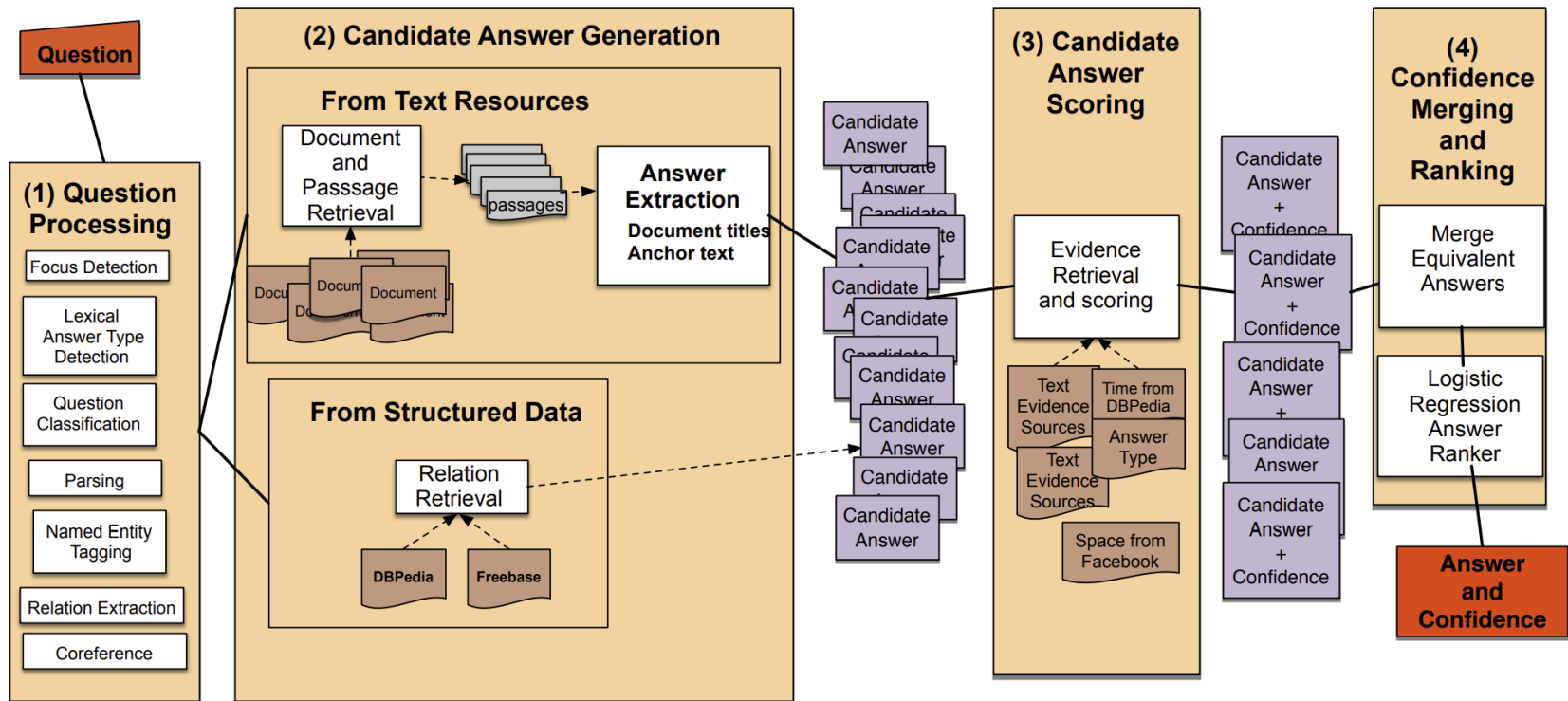
Summary: Question-Answering

- QUESTION PROCESSING
    - Detect question type, answer type, focus, relations
    - Formulate queries to send to a search engine

- PASSAGE RETRIEVAL
    - Retrieve ranked documents
    - Break into suitable passages and rerank

- ANSWER PROCESSING
    - Extract candidate answers
    - Rank candidates
        - using evidence from the text and external sources

- Readings:
    - Dan Jurafsky and James H. Martin, Speech and Language Processing, Chapter 25, Question-Answering.
        - https://web.stanford.edu/~jurafsky/slp3/25.pdf

Types of Questions in Modern Systems

- Factoid questions (**this lecture**)
  - Who wrote "The Universal Declaration of Human Rights"?
  - How many calories are there in two slices of apple pie?
  - What is the average age of the onset of autism?
  - Where is Apple Computer based?

- Complex (narrative) questions (**your project**)
  - In children with an acute febrile illness, what is the efficacy of acetaminophen in reducing fever?
  - What do scholars think about Jefferson's position on dealing with pirates?

Yes / No questions

- The turn seeks a passage that answers a question and provides a brief justification or explanation to support the answer.

- The highest-quality responses give the answer and an explanation that provides confidence that the answer is correct.

List questions

- The question seeks a passage that provides a list.

- When the system must make choices they should be popular, well-known, or with the most important elements preferred.

- For example, for the turn, "shark species that are endangered", the most endangered species of sharks, or species that most people would know, are preferred. Variations of a lesser-known species are OK, but less preferred.

"Describe, what is/are" questions

- This question seeks a brief, general description or summary of the subject.

- When there is a lot of information about the subject, the highest-quality responses focus on the most well-known aspects of the subject.

- For example, high-quality responses for "Tell me more about Tesla" would describe the kinds of cars it manufactures, its battery business, its likelihood of surviving financially, and/or its celebrity CEO, but not less important facets like its location or overly detailed facets like its 2018 Q2 financial statement.

Comparison or Connection Questions
(asking about the relation/difference between two concepts)

- This question seeks passages containing comparisons or connection between the concepts discussed.

- It should include details of the relationships between the two, which are also the main-focus of the topic.

Compositional Questions

- Compositional questions (when and why) ask about two aspects of one concept.

- For example, <u>when</u> and <u>why</u> something happened.

- This type of question can be considered a combination of two questions.