Question Answering
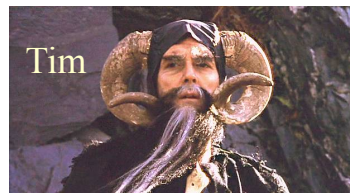
Question answering

- **Overview and task definition**
- **History**
- **Open-domain question answering**
- **Basic system architecture**
  - Watson architecture

Question Answering

text collection

answer + supporting text

What was the name of the character with the large earpieces played by John Cleese in the movie "Monty Python and the Holy Grail"?

Trivia: John Cleese was a Cornell A.D. White professor-at-large.

IR solution

3

QA: not so easy for people either…

Question answering

- **Overview and task definition**
- → **History**
- **Open-domain question answering**
- **Basic system architecture**

History

- **Closed-domain** QA systems
  - LUNAR [Woods & Kaplan, 1977]
  - WOLFIE [Thompson & Mooney, 1998]
  - Q/A [Lehnert, 1978]

- **Open-domain** QA systems
  - TREC QA evaluations [1999, 2000, 2001, …]

LUNAR

- **Answered questions about moon rocks and soil gathered by the Apollo 11 mission**
  - Data base of information for all collected samples
- **Architecture**
  - Parse English question into a data base query
    - Syntactic analysis via **augmented transition network** parser and heuristics (including some for shallow semantics)
    - Semantic analysis maps parsed request into query language; query denotes unambiguous meaning of the request
  - Run query on data base to produce answer

LUNAR

- **Resources required**
  - Parser for a subset of English (size unclear)
  - Handled tense, modality, some anaphora, some conjunctions, some relative clauses, some adjective modifiers (dealing with quantification)
  - Vocabulary of about 3,500 words
- **Sample questions**
  - What is the average concentration of aluminum in high alkali rocks?
  - What samples contain P205?
  - Give me the modal analyses of P205 in those samples.

LUNAR example

- **Do any samples have greater than 13 percent aluminum?**

- **Data base query**
  (TEST (FOR SOME X1 / (SEQ SAMPLES):   class to test
    T;   No restriction on class
   (CONTAIN   Proposition
    X1
    (NPR* X2 / ʿAL203)
    (GREATERTHAN 13 PCT))))
- **Answer:**
  - Yes

LUNAR assessment

- **System characteristics**
  - Closed domain (lunar geology and chemistry)
  - Structured data (information contained in a data base)
  - Structured answers (information contained in a data base)
    - Avoided dialogue problems as much as possible
  - Context: sophisticated users demanding high accuracy
- **Labor intensive to build**
  - Complex system
  - High accuracy required
  - Few general-purpose NLP resources available at the time

LUNAR assessment

- **Research on systems like LUNAR continued for another decade**
- **Focused on**
  - Syntactic parsing
  - Incorporating domain knowledge
  - Dialogue management
- **Problems**
  - Expensive to build
  - Brittle…prone to unexpected sudden failure

WOLFIE

- **WOrd Learning From Interpreted Examples**
  [Thompson and Mooney, 1998]

  - Closed domain, structured data, structured answers
  - Avoids labor-intensive system development
  - Uses *inductive logic programming* methods to acquire parsers that can map natural language queries into executable logical form (i.e. data base queries)
    - Requires examples of NL queries and their logical form
  - Indirectly evaluate the parser based on the number of queries that system gets right/wrong.

Lehnert's Q/A system

- **Implemented a broader theory of question answering**
  - motivated by issues of cognitive plausibility
  - relied on the linguistic/cognitive theories of *conceptual dependency*, *scripts, plans,* etc. [Schank, 1970's]
  - used a question taxonomy
  - somewhat closed domain (actions), unstructured data, generated answers
  - answered questions about an arbitrary input text (usually event-based)

Q/A example 1

- **Input text**

  John threw the baseball to Mary. She missed the ball and it hit her on the head.

- **Questions:**
  - Was Mary happy?
  - Who has the baseball?
  - Why did John throw the baseball to Mary?

Question answering

- **Overview and task definition**
- **History**
- ⟹ **Open-domain question answering**
- **Basic system architecture**

Which country has the largest part of the Amazon rain forest?

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries and leading scientists from around the world.

"That's some of the most encouraging news about the Amazon rain forest in recent years," said Thomas Lovejoy, a tropical ecologist at the Smithsonian Institution and an Amazon specialist.

"It contrasts markedly with a year ago, when there was nothing to read about conservation in the Amazon, especially in **Brazil,** except bad news," Lovejoy said in a recent interview.

Sixty percent of the Amazon, the world's largest tropical rain forest, **lies in Brazil**, but the forest also covers parts of the eight surrounding countries.

Lovejoy was one of the organizers of an unusual workshop held in mid-January in Manaus, **Brazil**, a sprawling city of 1 million people in the heart of the Amazon. It was the center of **Brazil**'s once-thriving rubber trade.

TReC Question Answering

- **Simplifications**
  - short-answer, fact-based questions
  - answer exists in the collection as a text fragment
  - supporting info can be found in a single document
  - system returns up to 5 guesses per question

- **Sample questions**
  - How many calories are there in a Big Mac?
  - Who is the voice of Miss Piggy?
  - Who was the first American in space?
  - Where is the Taj Mahal?

TREC QA: evaluation

- **3GB collection**
- **Human assessors judge the answers**
  - Allowed to accept multiple answers
- **Systems scored on *mean reciprocal rank* (MRR) of first correct answer**
  - if first answer correct = 1 point,
  - else if second answer correct = ½ point,
  - else if third answer correct = 1/3 point, …
  - 0 if none of the *n* answers are correct
  - Average of the *reciprocal rank* across all questions
- **Also reported on the number of questions answered correctly**

Question Answering

- **Performance**

	%correct	avg rank 1st
TREC-8 (1999):	70%	1.4
TREC-9 (2000):	65%	1.7
TREC-10 (2001):	70%	1.3
TREC-11 (2002):	83%	1
TREC-12 (2003):	70%	1
TREC-13 (2004):	84%	1

harder questions

NIL answers

1 guess, exact

Question answering

- Overview and task definition
- History
- Open-domain question answering
➡ **Basic system architecture**

Basic system architecture

question   document
collection

IR Subsystems → documents, text passages → Linguistic Filters → answer hypotheses → 1st Guess / 2nd Guess / 3rd Guess / 4th Guess / 5th Guess
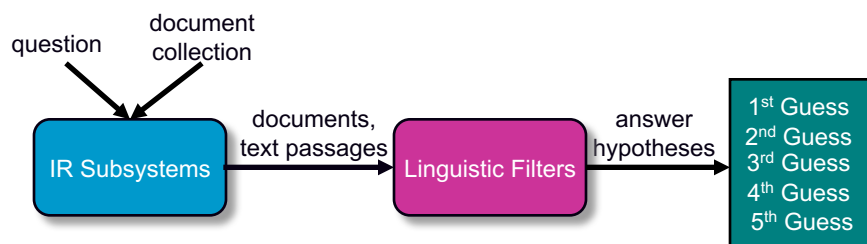
Cardie et al. (2000)

System architecture: document retrieval

question   document
                  collection

documents,
text passages   answer
                     hypotheses

**Document
Retrieval**   Linguistic Filters

IR Subsystems

1st Guess
2nd Guess
3rd Guess
4th Guess
5th Guess
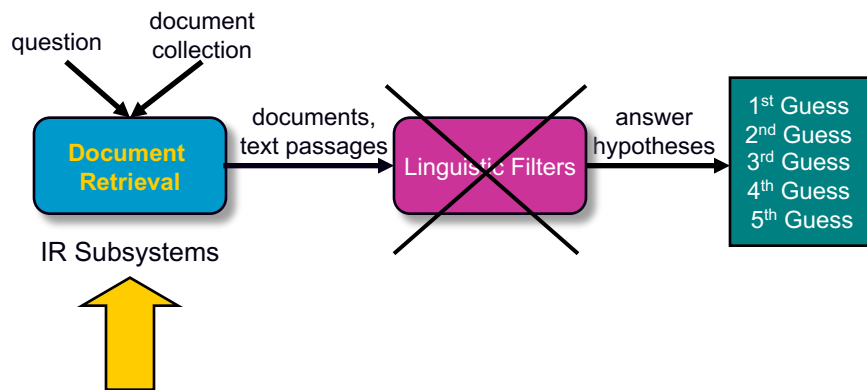
Document retrieval

- **Standard (ad-hoc) IR using full-text indexing**

- **Example QA system uses**
  - vector space model
  - text retrieval system: Smart
  - standard term-weighting strategies (tfidf)
  - no automatic relevance feedback

Sample query

Which country has the largest part of the Amazon rain forest?

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries and leading scientists from around the world.

"That's some of the most encouraging news about the Amazon rain forest in recent years," said Thomas Lovejoy, a tropical ecologist at the Smithsonian Institution and an Amazon specialist.

"It contrasts markedly with a year ago, when there was nothing to read about conservation in the Amazon, especially in **Brazil,** except bad news," Lovejoy said in a recent interview.

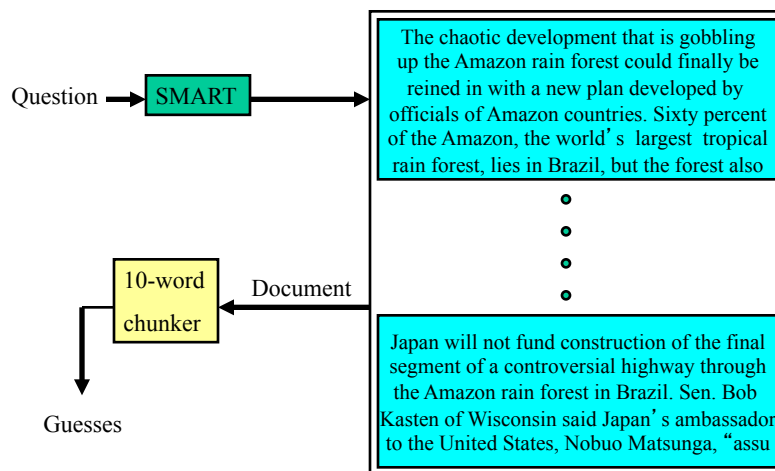**Sixty percent of the Amazon**, the world's largest tropical rain forest, **lies in Brazil**, but the forest also covers parts of the eight surrounding countries.

Lovejoy was one of the organizers of an unusual workshop held in mid-January in Manaus, **Brazil**, a sprawling city of 1 million people in the heart of the Amazon. It was the center of **Brazil**'s once-thriving rubber trade.

QA as document retrieval

Question → **SMART** →

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries. Sixty percent of the Amazon, the world's largest tropical rain forest, lies in Brazil, but the forest also

Japan will not fund construction of the final segment of a controversial highway through the Amazon rain forest in Brazil. Sen. Bob Kasten of Wisconsin said Japan's ambassador to the United States, Nobuo Matsunga, "assu

10-word chunker ← Document

→ Guesses

Baseline evaluation

- **Document retrieval only**
- **Corpus**
    - TREC-8 development corpus (38 questions)
    - TREC-8 test corpus (200 questions)

	Development (38)		Test (200)	
	Correct	**MAR**	**Correct**	**MAR**
Smart	3	3.33	29	3.07

MAR = Mean Answer Rank

Baseline evaluation

- **Smart performs better than its scores would suggest**
    - Development corpus
        - For 18 of 38 questions, the answer appears in the top-ranked document
        - For 33 of 38 questions, the answer appears in one of the top 7 documents
        - For only 2 questions does Smart fail to retrieve the answer in one of the top 25 documents
    - Test corpus
        - Over half (110) of the questions are answered in the top-ranked document
        - Over 75% of the questions (155) are answered in the top 5 documents
        - 19 questions were not answered in the top 20 documents

System architecture: passage retrieval

question   document
            collection

Doc Retrieval
Passage Retrieval

IR Subsystems

documents,
text passages

Linguistic Filters

answer
hypotheses

1st Guess
2nd Guess
3rd Guess
4th Guess
5th Guess
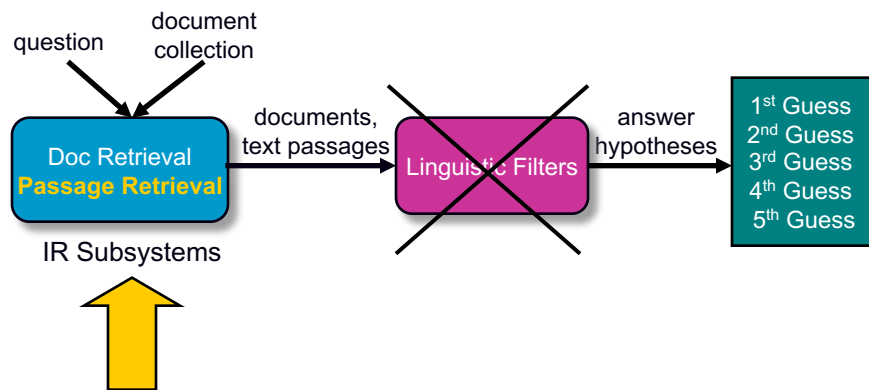
Passage Retrieval

Passage retrieval

[Salton *et al.*]

Which country has the largest part of the
Amazon rain forest?

[The chaotic development that is gobbling up the
Amazon rain forest could finally be reined in with
a new plan developed by leading scientists from
around the world.] ["That's some of the most
encouraging news about the Amazon rain forest in
recent years," said Thomas Lovejoy, an Amazon
specialist.] ["It contrasts markedly with a year
ago, when there was nothing to read about
conservation in the Amazon."]

[Sixty percent of the Amazon, the world's largest
tropical rain forest, lies in Brazil.]

Extract passages
that best match
the query

Passage retrieval

- **Basic algorithm**

1. Decide what counts as a passage. (sentence, paragraph, 200-word chunk, …)
2. Use standard ad-hoc retrieval algorithm to retrieve top *k* documents.
3. *Treat each passage (i.e. sentence, paragraph, …) in these top k documents as a document itself.*

   Use standard document similarity equations to assign a similarity score to the passage.
4. Return *n* highest-scoring passages as the answer, subject to the length constraint.

Passage retrieval

[Salton *et al.*]

Which country has the largest part of the Amazon rain forest?

[The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by leading scientists from around the world.] ["That's some of the most encouraging news about the Amazon rain forest in recent years," said Thomas Lovejoy, an Amazon specialist.] ["It contrasts markedly with a year ago, when there was nothing to read about conservation in the Amazon."]

[Sixty percent of the Amazon, the world's largest tropical rain forest, lies in Brazil.]

Sort passages in the top k documents

ordered list of answer extracts

answer hypotheses

QA as passage retrieval

Question → SMART

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries. Sixty percent of the Amazon, the world's largest tropical rain forest, lies in Brazil, but the forest also

● ● ● ●

Japan will not fund construction of the final segment of a controversial highway through the Amazon rain forest in Brazil. Sen. Bob Kasten of Wisconsin said Japan's ambassador to the United States, Nobuo Matsunga, "assu

passages

Sentence reordering

answer extracts

10-word chunker

Guesses

Evaluation: passage retrieval

	Development (38)		Test (200)	
	Correct	**MAR**	**Correct**	**MAR**
Smart	3	3.33	29	3.07
Passage retrieval	4	2.25	45	2.67

MAR = Mean Answer Rank

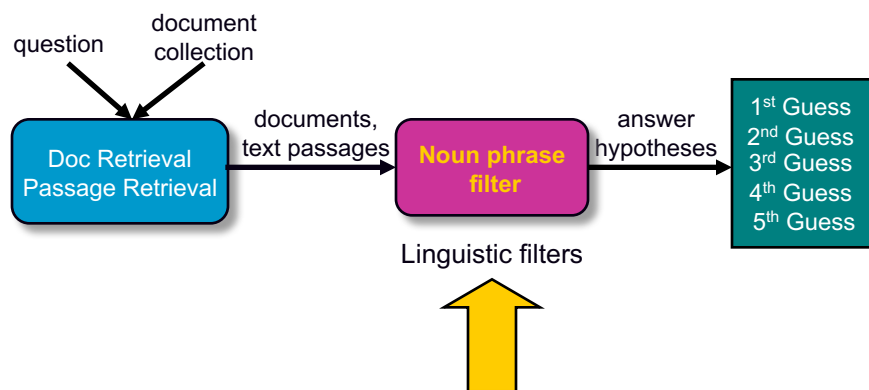
Evaluation: passage retrieval

- **Can limit performance**
  - Development corpus
    - In only 23 of the 38 developments questions (61%) does the correct answer appear in the answer for one of the top n=7 passages
  - Test corpus
    - In only 135 of the 200 developments questions (67.5%) does the correct answer appear in the answer for one of the top (n=6) passages

Linguistic filters

- **50 byte answer length effectively eliminates *how*, *why,* and *definition* questions**
- **almost all of the remaining question types are likely to have noun phrases as answers**
  - development corpus: 36 of 38 questions have noun phrase answers
- **consider adding at least a simple linguistic filter that considers only noun phrases as answer hypotheses**

System architecture: linguistic filters

question   document
            collection

documents,   answer
text passages   hypotheses

| Doc Retrieval Passage Retrieval | → | Noun phrase filter | → | 1st Guess 2nd Guess 3rd Guess 4th Guess 5th Guess |

Linguistic filters

The noun phrase filter

Which country has the largest part of the Amazon rain forest?

ordered list of summary extracts

[The huge Amazon rain forest] is regarded as vital to [the global environment].

[Japan] will not fund [the construction] of [the final segment] of [a controversial highway] through [the Amazon rain forest] in [Brazil], according to [a senior Republican senator].

● ● ●

ordered list of NPs → answer hypotheses

QA using the NP filter

Question → SMART

Sentence reordering ← Summaries

Summaries ↓

NP finder

NPs ↓

10-word chunker

↓

Guesses

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries. Sixty percent of the Amazon, the world's largest tropical rain forest, lies in Brazil, but the forest also
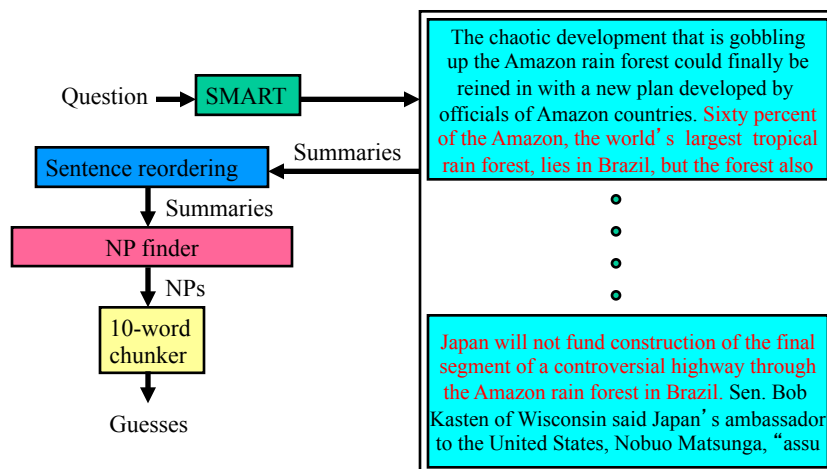
○ ○ ○ ○

Japan will not fund construction of the final segment of a controversial highway through the Amazon rain forest in Brazil. Sen. Bob Kasten of Wisconsin said Japan's ambassador to the United States, Nobuo Matsunga, "assu

Chunking answer hypotheses: BAD

Which country has the largest part
of the Amazon rain forest?

⬇

Question-Answering System

⬇

"Japan Brazil a new plan Amazon countries A section"

"Northwestern Brazil A plan the Amazon region"

"eight surrounding countries A Brazilian company"

"union leader his modest wooden house The people"
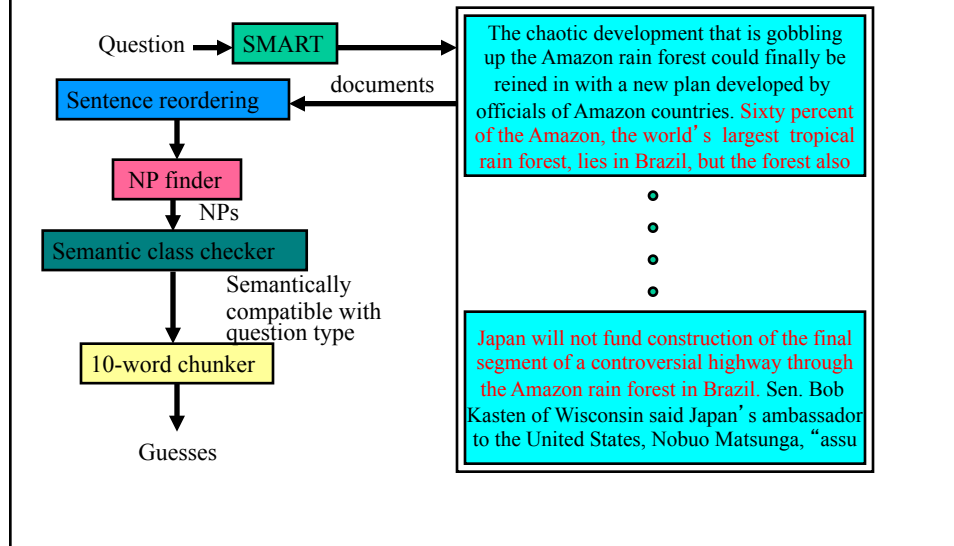
"defense Brazilian wealth the international market"

Evaluation: NP filter

	Development (38)		Test (200)	
	Correct	MAR	Correct	MAR
Smart	3	3.33	29	3.07
Passage retrieval	4	2.25	45	2.67
PR + NPs	7	2.29	50	2.66

MAR = Mean Answer Rank

- **Using NP finder of Cardie & Pierce (1998)**
  - ~94% precision and recall on Wall Street Journal text
- **How much does the (unnatural) NP answer "chunking" help?**
  - Without it, only 1 and 20 questions answered for each corpus, respectively
  - NP filter is extracting good guesses, but better linguistic processing is needed to promote the best guesses to the top of the ranked guess list
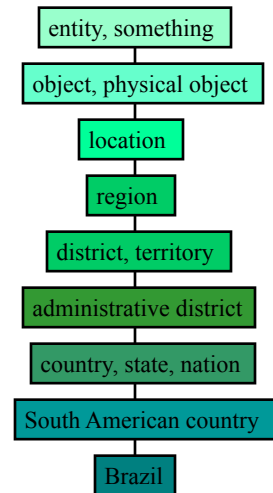
Semantic class checking

Question → **SMART**

documents

Sentence reordering

NP finder

NPs

Semantic class checker

Semantically compatible with question type

10-word chunker

Guesses

The chaotic development that is gobbling up the Amazon rain forest could finally be reined in with a new plan developed by officials of Amazon countries. Sixty percent of the Amazon, the world's largest tropical rain forest, lies in Brazil, but the forest also

Japan will not fund construction of the final segment of a controversial highway through the Amazon rain forest in Brazil. Sen. Bob Kasten of Wisconsin said Japan's ambassador to the United States, Nobuo Matsunga, "assu

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Semantic class checking

- **Approximate question type using question word**

  Who is the president of the U.S.?

  person

  Which country has the largest part of the Amazon rain forest?

  country

  Where is the Connecticut River?

  state? county? country? location?

  What fabric should one use to make curtains?

  fabric???

- **Check that head noun (i.e. the last noun) of answer NP is of the same type**

  a man = person

  Massachusetts = state, location

Semantic type checking

- **Use lexical resource to determine semantic compatibility**
  - WordNet
- **Proper names handled separately since they are unlikely to appear in WordNet**
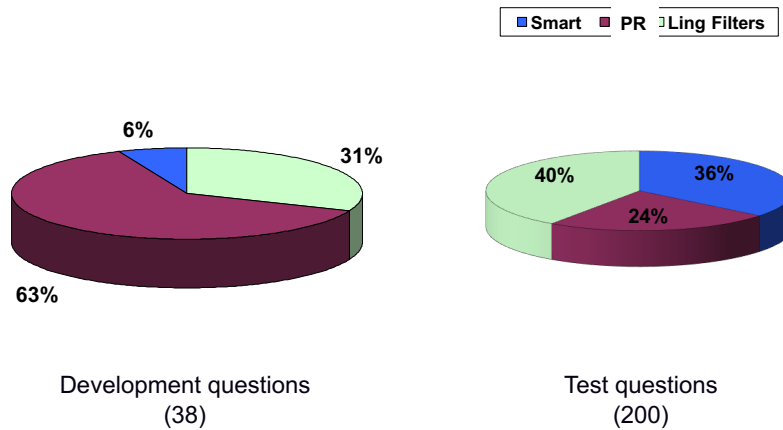 - Small set (~20) rules

entity, something

object, physical object

location

region

district, territory

administrative district

country, state, nation

South American country

Brazil

Evaluation: semantic class filter

	Development (38)		Test (200)	
	Correct	**MAR**	**Correct**	**MAR**
Smart	3	3.33	29	3.07
Passage retrieval	4	2.25	45	2.67
PR + NPs	7	2.29	50	2.66
PR + NPs + Semantic Type	21	1.38	86	1.90

MAR = Mean Answer Rank

- **Weak syntactic and semantic information allows large improvements**
- **Problems?**

Sources of error

Smart ■ PR □ Ling Filters

6%

31%

63%

Development questions
(38)

40% 36%

24%

Test questions
(200)

Question answering

- **Overview and task definition**
- **History**
- **Open-domain question answering**
- **Basic system architecture**
  - Watson architecture
- **Predictive indexing methods**
- **Pattern-matching methods**
- **Advanced techniques**