How Watson Works

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Watson Technical Sales

1/22/14
What Watson isn't

- Search engine
- New-fangled database system
- Skynet or HAL 9000

What Watson is

- Cognitive system
- Combines information retrieval and natural language processing (NLP)
- Builds its domain knowledge from sources comprising structured and unstructured data
- A core set of technologies that can be customized and targeted to specific industries
- Runs on Apache UIMA (Unstructured Information Management Architecture) technology
<table>
<thead>
<tr>
<th><strong>Watson at Play</strong></th>
<th><strong>Watson at Work</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 User</td>
<td>10s of thousands concurrent users</td>
</tr>
<tr>
<td>Max. input was two sentences</td>
<td>Pages of input (e.g. medical record)</td>
</tr>
<tr>
<td>5+ days to retrain</td>
<td>Dynamic content ingestion</td>
</tr>
<tr>
<td>Evidence not present</td>
<td>Supporting evidence integral</td>
</tr>
<tr>
<td>Text-only input</td>
<td>Text, tables and images as input</td>
</tr>
<tr>
<td>Q&amp;A model</td>
<td>Both Q&amp;A + Conversation model</td>
</tr>
<tr>
<td>Basic security</td>
<td>High security (e.g. HIPAA)</td>
</tr>
</tbody>
</table>
Traditional approaches to engaging with customers come up short

270B Calls made annually to call center costing $600B

1 in 2 incoming calls require escalation or go unresolved

61% of all calls could have been resolved with better access to information

4.6% Market value gain from a single point customer sat gain

*Case studies based on Coremetrics, Sterling Commerce and Unica solutions
IBM Watson represents a bold step into a new era of computing

...enabling new opportunities and outcomes
Process Overview

Question/Topic Analysis

Primary Search

Candidate Answer Generation

Answer Scoring

Filter

Synthesis

Final Merging & Ranking

Evidence Retrieval

Deep Evidence Scoring

A. Sources

Context Independent Scoring

Context Dependent Scoring

Evidence Retrieval

Deep Evidence Scoring

Trained Models

Answer, Confidence

Teach

Train

Q&A

Watson States (Simplified)
Beyond Simple Search & Key Words

Question:
In May 1898 Portugal celebrated the 400th anniversary of this explorer’s arrival in India

Supporting Evidence:
- In May, Gary arrived in India after he celebrated his anniversary in Portugal

Keywords:
- arrived in
- celebrated
- 400th anniversary
- explorer
- India
- Portugal
- anniversary
- Gary

Legend:
- Keyword “Hit”
- Reference Text
- Answer
- Weak evidence

This evidence suggests “Gary” is the answer BUT the system must learn that keyword matching may be weak relative to other types of evidence.
In May 1898 Portugal celebrated the 400th anniversary of this explorer’s arrival in India.

On the 27th of May 1498, Vasco da Gama landed in Kappad Beach.

Legend
- Temporal Reasoning
- Statistical Paraphrasing
- GeoSpatial Reasoning
- Reference Text
- Answer

Stronger evidence can be much harder to find and score...

- Search far and wide
- Explore many hypotheses
- Find judge evidence
- Many inference algorithms
Ingestion

- Data must be preprocessed into TREC (Text Retrieval Conference) format
- Does allow for multiple corpora to be generated and used by a single pipeline
- Process for ingestion is its own pipeline which can be run via LiteScale

- Creates Indexes, and dictionaries such as Concept Annotator

Future:
- Frequent ingestion
Question Analysis and Query Building

- Rounds of teaching and training
- Core NLP
- Named entity recognizers/Detectors (NER/NED)
  - Type identification (places, people, dates, and so on)
  - Slot grammar parsers (XSG)
- Relationship detection
- Conference/Anaphora (pronoun) ID
- Keyword identification
- Term/Lexical answer type (LAT) identification
- Machine learning to determine most likely LATs to consider further
- Multiple queries formed, based on full question, LAT, and terms, or inferences
Category/Topic: MICHIGAN

Question: In 1894 C.W. Post created his warm cereal drink Postum in this Michigan city

**Focus:** this Michigan city

LAT: Michigan city

Keywords:
- 1894
- C.W. Post created
- warm cereal drink,
- Postum
- Michigan City
Search and Candidate Generation

• Primary search (PS)
  - Take previously constructed queries and search among many available sources.
    - Lucene
    - Indri (multiple index types)

• Candidate answer generation
  • Parse PS results to build candidates of possible answers based on:
    - Titles
    - Anchor text
    - Passages and their parts: headwords, numbers, dates
    - Checking candidates against constraints
Step 2: Primary search

The keywords (1894, C.W. Post, created, warm, cereal, drink, Postum, Michigan, city) are used to search over millions of documents to find relevant hits. 55 documents are found, and 30 passages are found.
Step 3: Candidate hypothesis generation

Category/Topic: MICHIGAN

Question: In 1894 C.W. Post created his warm cereal drink Postum in this Michigan city

Candidate Answers (possible answers to the question) are identified in the search results. They are found by looking at document titles (including a variety of title variants and expansions) and possible answers in the text of the documents and passages, such as named entities, noun phrases, anchor text, dates, etc. The Candidate Answers are get their first evidence feature scores from their corresponding document search rank and passage search rank.

<table>
<thead>
<tr>
<th>Candidate Answers</th>
<th>Evidence Feature Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Foods</td>
<td>Doc Rank: 0 Pass Rank: 1</td>
</tr>
<tr>
<td>Post Foods</td>
<td>Doc Rank: 2 Pass Rank: 1</td>
</tr>
<tr>
<td>Battle Creek</td>
<td>Doc Rank: 1 Pass Rank: 2</td>
</tr>
<tr>
<td>Will Keith Kellogg</td>
<td>Doc Rank: 3 Pass Rank: 0</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td>Doc Rank: 1895 Pass Rank: 0</td>
</tr>
</tbody>
</table>

Will Keith Kellogg

Britannica Concise Encyclopedia: Will Keith Kellogg

Birth: 1868
Death: 1951
Known for: Inventor of the breakfast cereal

General Foods Corporation was a company whose direct predecessor was established in the USA by Charles William Post as the Postum Cereal Company in 1894. The name General Foods was adopted in 1929, after several corporate acquisitions. In November 1965 General Foods was acquired by Philip Morris Companies (now Altria Group, Inc.). The acquisition, the largest non-oil acquisition to that time. In December 1968, Philip Morris acquired Kraft, Inc., and in 1990 combined the two food companies as Kraft General Foods (KGF).

General Foods dropped from the corporate name in 1995 and now exists only as part of a brand name for a flavored coffee-based beverage, General Foods International.

General Foods Corporation purchased the Postum Cereal Company in 1968 and became the dominant player in the breakfast cereal business. The company has since diversified into other areas, including baked goods, snack foods, and pet food. Today, General Foods Corporation is a subsidiary of the larger food and beverage company, Nestlé.

History

- C.W. Post established his company in Battle Creek, Michigan, in 1891, when he was a patient at an oncology sanatorium operated by Dr. Kellogg. With his brother, William, he invented and developed a nutritive cereal beverage in response to the patients' diet. Postum's first product, introduced in the summer of 1905, was a chocolate-flavored drink composed of wheat berries, corn, and rice. The company was named Postum Cereal Company in 1919.

- In 1920, Postum Cereal Company merged with General Foods Corporation, and the resulting company was called General Foods Corporation.

- In 1965, General Foods Corporation merged with Philip Morris Companies, and in 1995 the company was acquired by Nestlé.

Grand Rapids

- The company was founded in 1895.

- Will Keith Kellogg was an influential figure in the company, known for his contributions to the breakfast cereal industry. He was a co-founder of the company and played a key role in its early success.

- Kellogg was a prolific inventor, holding over 1,000 patents. His most famous invention, the Kellogg's Toasted Marshmallow, is still a popular snack food today.

- Kellogg was also active in the field of education, founding the School of Practical Science and the Institute of Applied Science in Battle Creek.

- The company's success in the early 20th century was due in large part to Kellogg's vision and leadership. He was a strong advocate for the benefits of breakfast cereals and played a key role in popularizing the concept of breakfast as a daily ritual.

- As the company grew, Kellogg continued to be a driving force behind its development, working to expand the company's product line and diversify its operations.
Scoring

- Responsible for confidence of answers
- Indexes used
  - PRISMATIC (relationship search)
  - Semantic relations (DBpedia)
- More than 50 scoring components:
  - Taxonomic
  - Geospatial (location)
  - Temporal
  - Source reliability
  - Gender
  - Name consistency
  - Relational
  - Passage support
  - Theory consistency
- Context dependent (deep evidence)
- Context independent
- Features for machine language
Step 4: Answer scoring

Category/Topic: MICHIGAN

Question: In 1894 C.W. Post created his warm cereal drink Postum in this Michigan city

Next, the Candidate Answers are scored using a large number of answer scoring analytics. Some of the analytics use only the candidate answer and the question, along with a large amount of general background knowledge, e.g., the ensemble of Type Coercion (TyCor) scorers. The TyCor scorers estimate the likelihood of a candidate answer being an instance of the Lexical Answer Type (LAT) in the question. In this example, the LAT is “city”, i.e., the correct answer will be a city.

<table>
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<tr>
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<td>2</td>
</tr>
<tr>
<td>Battle Creek</td>
<td>1</td>
</tr>
<tr>
<td>Will Keith Kellogg</td>
<td>3</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td></td>
</tr>
<tr>
<td>1895</td>
<td></td>
</tr>
</tbody>
</table>

isA(“General Foods”, “city”) = 0.1
isA(“Post Foods”, “city”) = 0.1
isA(“Battle Creek”, “city”) = 0.8
isA(“Will Keith Kellogg”, “city”) = 0.1
isA(“Grand Rapids”, “city”) = 0.9
isA(“1895”, “city”) = 0.0
Step 5: Supporting Evidence

- Passage search
  - Much like a primary search, but requires candidate answer as a term
  - Further scored to ensure candidate answer context

- Shared scoring solutions:
  - Passage term match
  - Skip-bigram
  - Text alignment
  - Logical form answer candidate scoring
Final Merger

• Merging
  • Due to candidate count usually duplicates exist
  • Requires normalizing scores per feature to make merger

• Ranking
  • Use of ML and IBM® SPSS® over training data to create the model to rank future results
  • Linear and logistic regression techniques

• Teach-train-execute cycle
  • 10,000 training questions and 2000 test questions
  • Estimate 48 hours with 11 blade subordinates
Step 6: Merging candidate answers and scoring the confidence

**Category/Topic: MICHIGAN**

**Question:** In 1894 C.W. Post created his warm cereal drink Postum in this Michigan city

In the final processing step, Watson detects variants of the same answer and merges their feature scores together. Watson then computes the final confidence scores for the candidate answers by applying a series of Machine Learning models that weight all of the feature scores to produce the final confidence scores.

<table>
<thead>
<tr>
<th>Candidate Answers</th>
<th>Evidence Feature Scores</th>
<th>Doc Rank</th>
<th>Pass Rank</th>
<th>Ty Cor</th>
<th>Geo</th>
<th>LFACS</th>
<th>Term Match</th>
<th>Temporal</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Foods</td>
<td></td>
<td>0</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
<td>0.2</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Post Foods</td>
<td></td>
<td>2</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
<td>0.4</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>Battle Creek</td>
<td></td>
<td>1</td>
<td>2</td>
<td>0.8</td>
<td>1</td>
<td>0.5</td>
<td>30</td>
<td>0.9</td>
</tr>
<tr>
<td>Will Keith Kellogg</td>
<td></td>
<td>3</td>
<td></td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0.5</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>1895</td>
<td></td>
<td>0</td>
<td></td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Machine Learning Model Application**

**Correct Answer**

<table>
<thead>
<tr>
<th>Final Answers</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battle Creek</td>
<td>0.946</td>
</tr>
<tr>
<td>Post Foods</td>
<td>0.152</td>
</tr>
<tr>
<td>1895</td>
<td>0.040</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td>0.033</td>
</tr>
<tr>
<td>General Foods</td>
<td>0.014</td>
</tr>
</tbody>
</table>
Complete to Answer

**Question /Topic Analysis**

- LAT: Mitchigan City

**Document Search Results**

<table>
<thead>
<tr>
<th>R</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>General Foods</td>
</tr>
<tr>
<td>1</td>
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</table>

**Candidate Answers**

- General Foods
- Post Foods
- Battle Creek

**Evidence Features**

<table>
<thead>
<tr>
<th>Ty Cor</th>
<th>Geo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>0.8</td>
<td>1</td>
</tr>
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</table>

**Final Answers**

<table>
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</table>
Example

Watson Engagement Advisor
Ask Watson

Watson: You can ask a question in the same way you would ask another person.

I'm a first time buyer. Where do I begin?
Melissa: I'm a first time buyer. Where do I begin?

Watson: A typical starting point is getting a rough idea of how much house you can afford.
Melissa: I'm a first time buyer. Where do I begin?

Watson: A typical starting point is getting a rough idea of how much house you can afford.

Melissa: What are prices like near me?
Melissa: What are prices like near me?

Watson: Two bedroom condos in Austin average $218,000.
Below are the latest housing price statistics for the Austin area.

### Average Condo Prices (Austin, Texas):

<table>
<thead>
<tr>
<th>Bedroom</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$172,000</td>
</tr>
<tr>
<td>2</td>
<td>$218,000</td>
</tr>
<tr>
<td>3</td>
<td>$259,000</td>
</tr>
</tbody>
</table>

### Average House Prices (Austin, Texas):

<table>
<thead>
<tr>
<th>Bedroom</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$168,000</td>
</tr>
<tr>
<td>2</td>
<td>$228,000</td>
</tr>
<tr>
<td>3</td>
<td>$299,000</td>
</tr>
<tr>
<td>4</td>
<td>$349,000</td>
</tr>
<tr>
<td>5</td>
<td>$395,000</td>
</tr>
</tbody>
</table>
Melissa: What are prices like near me?

Watson: Two bedroom condos in Austin average $218,000.

Melissa: How about financing?
Melissa: How about financing?

Watson: Young professionals typically select 30 year fixed rate mortgages.

Would you like to try a price calculator?

Yes, open the calculator...
Repeatable Solutions

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IBM Watson Engagement Advisor

What it does:

- **Transforms client engagement** by knowing, engaging and empowering clients where they are

- **Develops client relationships** by reaching out to clients who do not leverage traditional channels

- **Empowers consumers and contact center agents** to take informed action with confidence

How it does it:

- **Answers questions and guides users** through processes with plain-English dialogue

- **Leverages natural language** to interact with users and build knowledge and expertise

- **Utilizes evidence evaluation and learning** to provide informed and effective responses to users
Financial Services Firm plans to use Watson to strengthen relationships with previously under-engaged customers

Need
• Get customer’s attention
• Educate customers

Solution
• Direct access to Watson for omni-channel Q&A

Expected Benefits
• Improve customer satisfaction
• Strengthen relationship
• Increase revenue through cross-sell
Mobile Phone Provider plans to use Watson to differentiate the company with personalized service and support

Need
• Meet changing expectations
• Reduce churn
• Beat competition

Solution
• Omni-channel self-service
• Guide through processes

Expected Benefits
• Increase loyalty
• Decrease churn
• Grow customer base
IBM is working with industry leaders to address this opportunity.

“We believe Watson is going to be a key facilitator to this critically important priority.”

“We expect Watson to have a significant impact on our customer’s experience.”

“We believe technology, like Watson, can create a competitive differentiator for us.”

“We envision Watson as a key strategy for engaging our customers in dialog.”
Questions or comments? dmobley@us.ibm.com Or dave.mobley@uky.edu

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