Watson, the IBM Jeopardy! Challenge and the future of optimized systems design

Ondrej Tejnecky, Manager, IBM Power Systems, Central and Eastern Europe
An IBM Grand Challenge

Build a system that rivals a human’s ability to answer questions posed in natural language with accuracy, confidence, and speed.
Jeopardy!

- Questions covers a broad range of topics
  - History, literature, politics, arts, science etc

- Fast responses, with accuracy and confidence

- Word plays, subtle meaning, ironies, riddles
Grand Challenges advance the science of computing

**Chess:** *Deep Blue 1997*
- Limited number of moves and states
- Explicit, unambiguous **mathematical rules**

**Human Language:** *Watson 2011*
- Ambiguous, contextual and implicit
- Grounded in **human understanding**
- Infinite expressions with same meaning
Unstructured data is complex

Where was Einstein born?

<table>
<thead>
<tr>
<th>Person</th>
<th>Born In</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Einstein</td>
<td>Ulm</td>
</tr>
</tbody>
</table>

“One day, from among his city views of Ulm, Otto chose a watercolor to send to Albert Einstein as a remembrance of Einstein’s birthplace.”
Broad Domain

- A sample of 20,000 clues contained 2,500 distinct types
- The most frequent occurring <3% of the time
- The distribution has a very long tail
- For each type, 1000s of potential questions
In May 1898 Portugal celebrated the 400th anniversary of this explorer’s arrival in India. In May, Craig arrived in India after he celebrated his anniversary in Portugal.
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.

- Temporal Reasoning
- Statistical Paraphrasing
- GeoSpatial Reasoning

• Search Far and Wide
• Explore many hypotheses
• Find & judge evidence
• Many inference algorithms
Five dimensions of complexity

- Broad/Open Data Domain
- Complex Language
- High Precision
- Accuracy Confidence
- High Speed

EU, The European Union

Each year the EU selects capitals of culture; one of the 2010 cities was this Turkish "meeting place of cultures"

Istanbul
Each year the EU selects capitals of culture; one of the 2010 cities was this Turkish "meeting place of cultures"
Watson – a Workload Optimized System

**Hardware**
- 90 x IBM Power 750 servers
- 2880 POWER7 3.55 GHz cores
- 500 GBps on-chip bandwidth
- 15 Terabytes of memory
- 500 GB of data (in memory)

**Software**
- IBM DeepQA,
- UIMA and UIMA AS
- Apache Hadoop

**Domain knowledge**
- Dr David Ferrucci and the IBM Research unstructured text analytics team
Watson – a Workload Optimized System

Apache UIMA used to develop IBM DeepQA
- UIMA supports scale-out of text and multimodal analysis applications
- DeepQA components are implemented as *UIMA annotators*
- Analyze text and produce *annotations* or assertions about the text

UIMA-AS (Asynchronous Scaleout) add-on for UIMA
- enables scale-out using asynchronous messaging
- Used to scale out across 2,880 POWER7 cores
- Manages all of the inter-process communication

Apache Hadoop pre-processes large volume of data
- Software library that represents a framework that allows for the distributed processing of large data sets across clusters of computers using a simple programming model
- Designed to scale up from single servers to thousands of machines, each offering local computation and storage
- Creates in-memory datasets used at run-time
- Distributes UIMA annotators across processors in the cluster.
- Contributes to optimal CPU utilization
Watson’s progress to accuracy and confidence, 2007-10

Blue Dots = *Jeopardy!* winners
Red Dots = Ken Jennings
Sparring Matches

In 55 real-time sparring against former Tournament of Champion Players in 2010, Watson won 71% of the games
Watson’s Growing Pains

THE AMERICAN DREAM
Decades before Lincoln, Daniel Webster spoke of government "made for", "made by" & "answerable to" them

MILESTONES
In 1994, 25 years after this event, 1 participant said, "For one crowning moment, we were creatures of the cosmic ocean"

FATHERLY NICKNAMES
This Frenchman was "The Father of Bacteriology"
Como Era Gostoso o Meu Francês (1971)

84 min - Adventure | Comedy

★★★★★ ★★★★ 6.8/10

Users: (354 votes) 13 reviews | Critics: 9 reviews

In 1594 in Brazil, the Tupinambás Indians are friends of the Frenches and their enemies are the Tupiniquins... See full summary »

Director: Nelson Pereira dos Santos
Writers: Humberto Mauro (Tupi dialogue), Nelson Pereira dos Santos
Stars: Arduíno Colassanti, Ana Maria Magalhães and Eduardo Imbassahy Filho

3 photos | full cast and crew »
Watson has much to learn about Chicago!

Its largest airport is named for a World War II hero, its second largest for a World War II battle.

Ken: Chicago

Brad: Chicago

Watson: Toronto???
What’s next for Watson?

- Healthcare and life sciences
  - Diagnostic Assistance
  - Evidence-based
  - Collaborative Medicine

- Technical support: help-desk, call centers

- Enterprise knowledge management and business intelligence

- Government citizen services

“In healthcare, we talk about turning data into knowledge. That’s really what Watson does.”

Joe Jasinski
Program Director,
IBM Healthcare and Life Sciences Research
WellPoint and IBM Watson

12 Sep 2011: WellPoint and IBM to create the first commercial applications of the IBM Watson technology

WellPoint will develop Watson-based solutions to help improve patient care through the delivery of up-to-date, evidence-based health care

IBM will develop the base Watson healthcare technology
The Science Behind an Answer

Watson performs so fast that it can rival the greatest human contestants in understanding a Jeopardy! clue and arriving at a single, precise answer. The significance of this accomplishment can be difficult to comprehend.

Watch the video to see how the computing system designed to play Jeopardy! works.

The first person mentioned by name in 'The Man in the Iron Mask' is this hero of a previous book by the same author.
Full Stats on Exhibition Matches

<table>
<thead>
<tr>
<th>NONFICTION</th>
<th>LEGAL &quot;E&quot;s</th>
<th>WHAT TO WEAR?</th>
<th>U.S. GEOGRAPHIC NICKNAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$400</strong> 17</td>
<td><strong>$400</strong> 18</td>
<td><strong>$400</strong> 23</td>
<td><strong>$400</strong> 25</td>
</tr>
<tr>
<td>In 2010 this former First Lady published the memoir &quot;Spoken from the Heart&quot;</td>
<td>In English law, it's a title above a gentleman &amp; below a knight. In the U.S., it's usually added to the name of an attorney</td>
<td>This plain-weave, sheer fabric made with tightly twisted yarn is also used to describe a pie or cake</td>
<td>Cape Hatteras is known as the cemetery synonym &quot;of the Atlantic&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>$800</strong> 19</th>
<th><strong>$800</strong> 21</th>
<th><strong>$800</strong> 24</th>
<th><strong>$800</strong> 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>This book by Michael Lewis subtitled &quot;Evolution of a Game&quot; focused on left tackle prodigy Michael Oher</td>
<td>One definition of this is entering a private place with the intent of listening secretly to private conversations</td>
<td>A bit longer than a cocktail dress, one hemmed to end at the shins is this beverage &quot;length&quot;</td>
<td>Appropriately enough, this New York metropolis is &quot;Bison City&quot;</td>
</tr>
</tbody>
</table>

### Final scores:

- **Ken**: $19,200
- **Watson**: $41,413
- **Brad**: $11,200

### Cumulative scores:

- **Ken**
  - $24,000
  - Challenge champion: $500,000 to World Vision + $500,000 to World Community Grid
  - 1st runner-up: $150,000 + $150,000 to VillageReach
- **Watson**
  - $77,147
  - 2nd runner-up: $100,000 + $100,000 to the Lancaster County Community Foundation
- **Brad**
  - $21,600

### Game dynamics:

### Coryat scores:

- **Ken**: $15,200
  - 17 R (including 1 DD), 1 W
- **Watson**: $26,800
  - 26 R (including 1 DD), 3 W
- **Brad**: $5,600
  - 12 R, 2 W
Watson – A System Design for Answers

The future of workload optimized systems design

Designers of commercially available Power 710 servers have made a deliberate choice to create more rapid adoption of optimized systems in industries such as healthcare and financial services. That goal was a fundamental difference between Watson and Deep Blue, which was a highly optimized supercomputer. Deep Blue was based on an earlier generation of Power processor technology, featuring a 16 node S8900 SP system, with each node containing a single 120 MHz POWER2 processor. But in addition to these regular POWER2 processors, Deep Blue’s performance was enhanced with 56 special purpose chess processor chips.

The same Power 710 server used by Watson is already deployed today by thousands of organizations in optimized systems that provide for both complex analytics and transaction processing. Rice University in Houston, Texas, for example, uses IBM Power 710 systems to accelerate the understanding of the modern brain of cancer through the application of genomic analysis technologies. POWER7 systems have given Rice more flexibility and efficiency, enabling them to pursue a broader range of research beyond a single system than was possible before.

A system designed for answers

After four years of intense research and development by a team at IBM Research, Watson has demonstrated its ability to compete on Jeopardy! against champion players, performing at human-expert levels in terms of precision, confidence and speed. The project has advanced the fields of unstructured data analysis, natural language processing, and the design of workload-optimized systems. Beyond Jeopardy!, the technology behind Watson can be adapted to solve business and societal problems—for example, diagnosing disease, handling online technical support questions, and parsing summaries of legal documents—and to drive progress across industries.

Watson’s ability to understand the meaning and context of human language, and rapidly process information to find precise answers to complex questions, holds enormous potential to transform how companies can help people accomplish tasks in business and their personal lives.