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Silence Phones

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More information on the DL program available at:

www.ashrae.org/distinguishedlecturers

LEADERSHIP WANTED!

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**BECOME A FUTURE LEADER IN ASHRAE –
WRITE THE NEXT CHAPTER IN YOUR CAREER**

ASHRAE Members who are active at their chapter and society become leaders and bring information and technology back to their job.

YOU ARE NEEDED FOR:

- ❖ Society Technical Committees
- ❖ Society Standard Committees
- ❖ Young Engineers in ASHRAE
- ❖ Chapter Membership Promotion
- ❖ Chapter Research Promotion
- ❖ Chapter Student Activities
- ❖ Chapter Technology Transfer



Find your Place in ASHRAE and volunteer



AI in HVAC Industry: Past, Present and Future

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Acknowledgements

- Ben Bartling, Smart Building Engineer, Intellimation LLC
- Bilal Sher, CEO, Building Diagnostic Robotics
- Kevin Lawson, Ripple Automated Building Design
- Nathaniel Jones, ARUP

Outline/Agenda

- From calculators/computers to AI - How did we get here?
- Why is AI now different from the 80's hype?
- What are some myths and realities of chatbots?
- How can ASHRAE members benefit from the recent trends in AI?

What is special about this number?

1729

Hardy–Ramanujan number

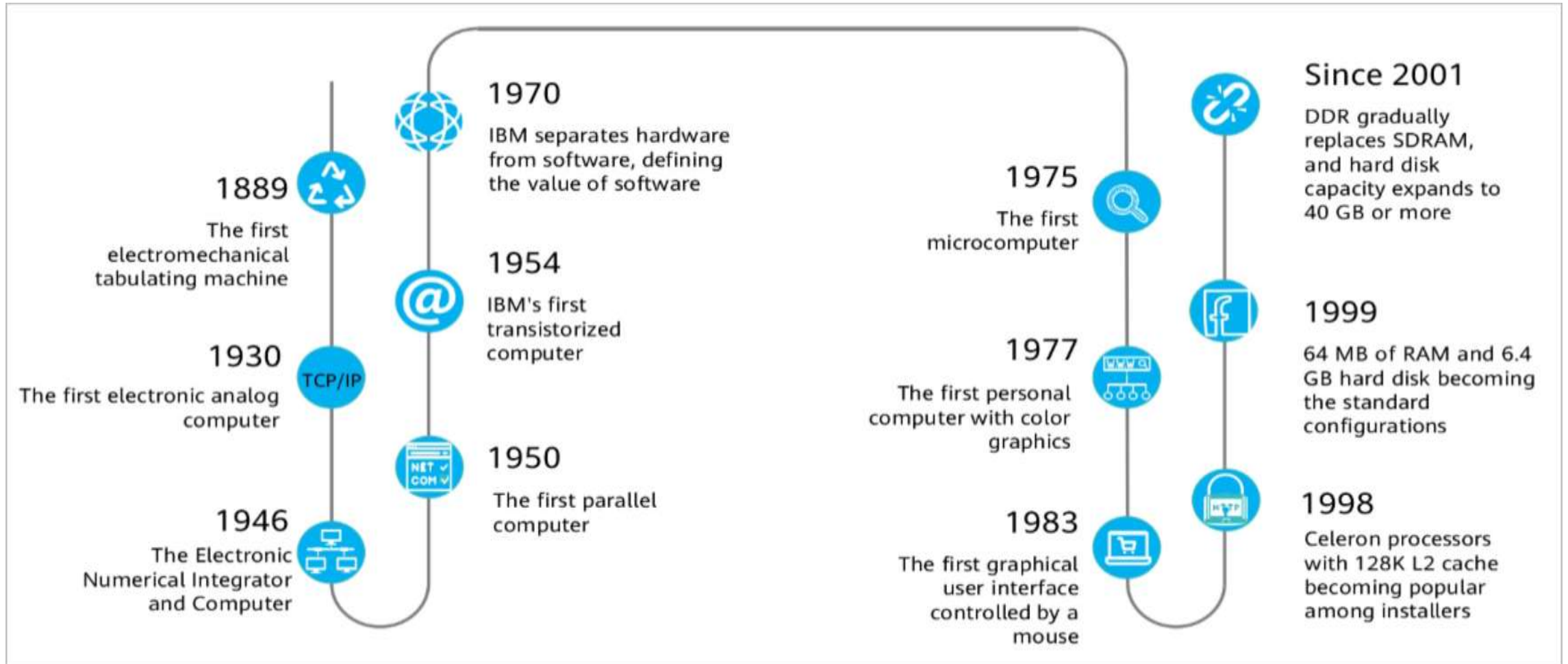
"I remember once going to see him when he was ill at Putney. I had ridden in taxi cab number 1729 and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavorable omen. "No," he replied, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways."

-Hardy

$$1729 = 1^3 + 12^3 = 9^3 + 10^3$$

- Just a four digit number – nothing special
- Represents sum of two cubes
- Represents sum of two cubes in two different ways
- Represents smallest number expressible as sum of two cubes in two different ways
- Represents smallest number expressible as sum of two positive cubes in two different ways

Computer Technology Evolution



(Source: <https://fastvoicemedia.de/image-collection/what-is-the-timeline-of-computer-history.aspx>)

Computers and Mathematics - Timeline

Computer x mathematics timeline

300 BCE

The Babylonians invent the world's earliest calculator, the abacus.

1622

William Oughtred invents the slide rule, a mechanical analogue computer designed to both multiply as well as divide numbers.

1849

Charles Babbage designs 'Difference Engine #2', which is a mechanical contraption that solves equations autonomously. He never sees the machine in action.

1936

Alan Turing publishes his seminal paper 'On Computable Numbers'.

1949

George Reitwiesner, Clyde Hauff, Homé McAllister and W Barkley Fritz use the newly invented ENIAC computer to compute π to 2 035 decimal places.

1967

The first handheld digital calculator, Texas Instruments' CalTech, is invented. It costs \$85.

1976

A computer cracks the Four Colour Theorem, making it the first computer-assisted proof to be solved.

1984

The software MATLAB debuts.

1996

The first volunteer computing project, the Great Internet Mersenne Prime Search, kicks off.

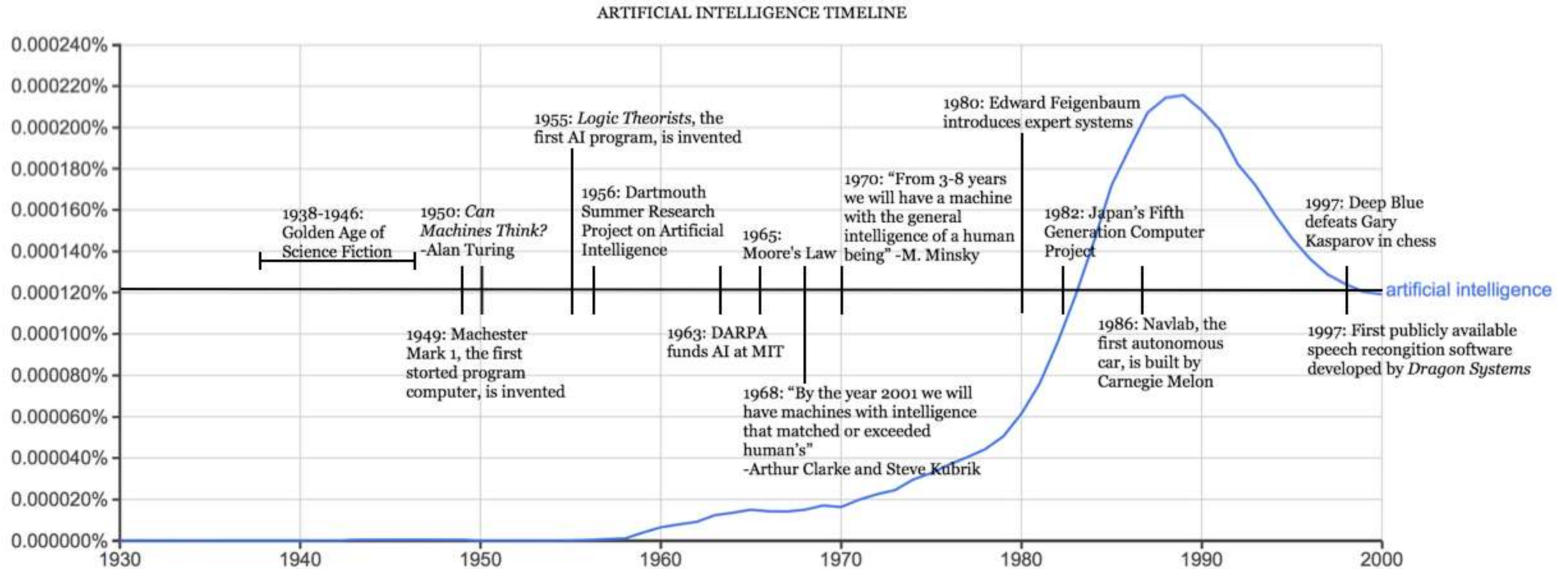
2014

Mathematician Thomas Hales formally proves the Kepler conjecture by using proof assistant software.

2019

Emma Haruka Iwao uses Google's cloud computing service to calculate π to a staggering 31 trillion decimal places.

Artificial Intelligence - Timeline



(Source: The history of Artificial Intelligence, Harvard student blog available at: <https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/>)

Artificial Intelligence in the 1980's

Goal of AI:

“Replication of the **functionality** of human mind”

Technologies:

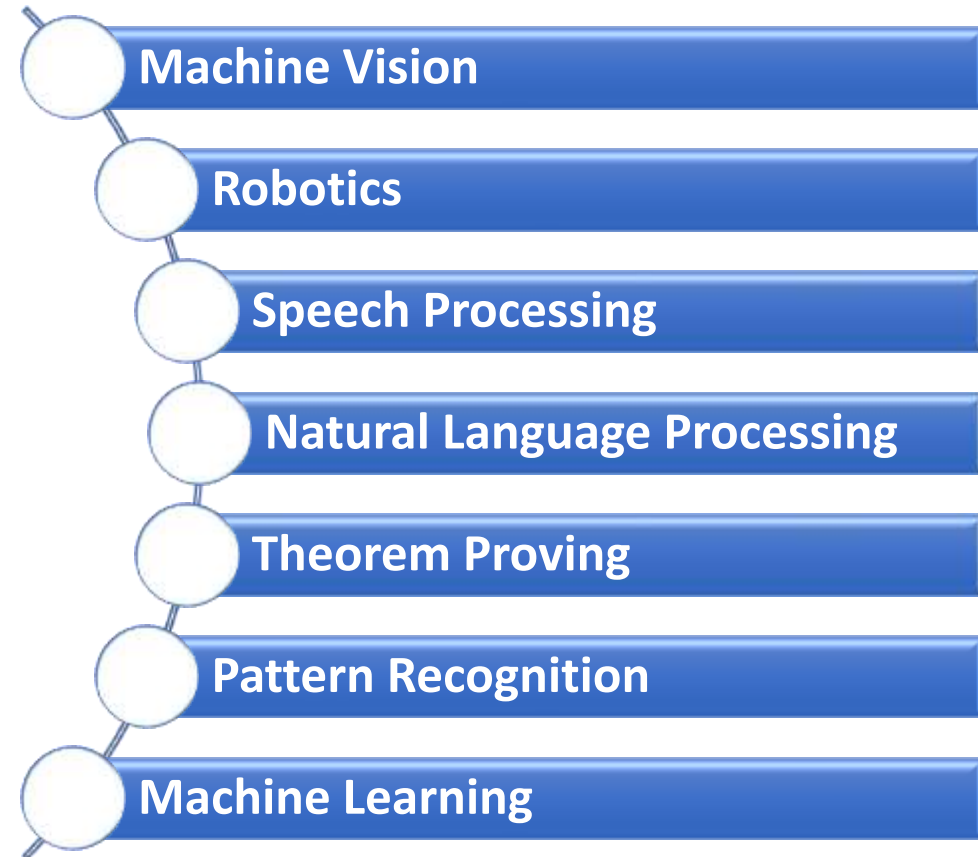
Expert Systems or Knowledge-Based Systems

Neural Networks

Fuzzy Logic

New Career Title e.g.:

Knowledge Engineer



Expert Systems / Knowledge-Based Systems

Goal of Expert Systems:

“Represent heuristic knowledge in an automated system”

Components:

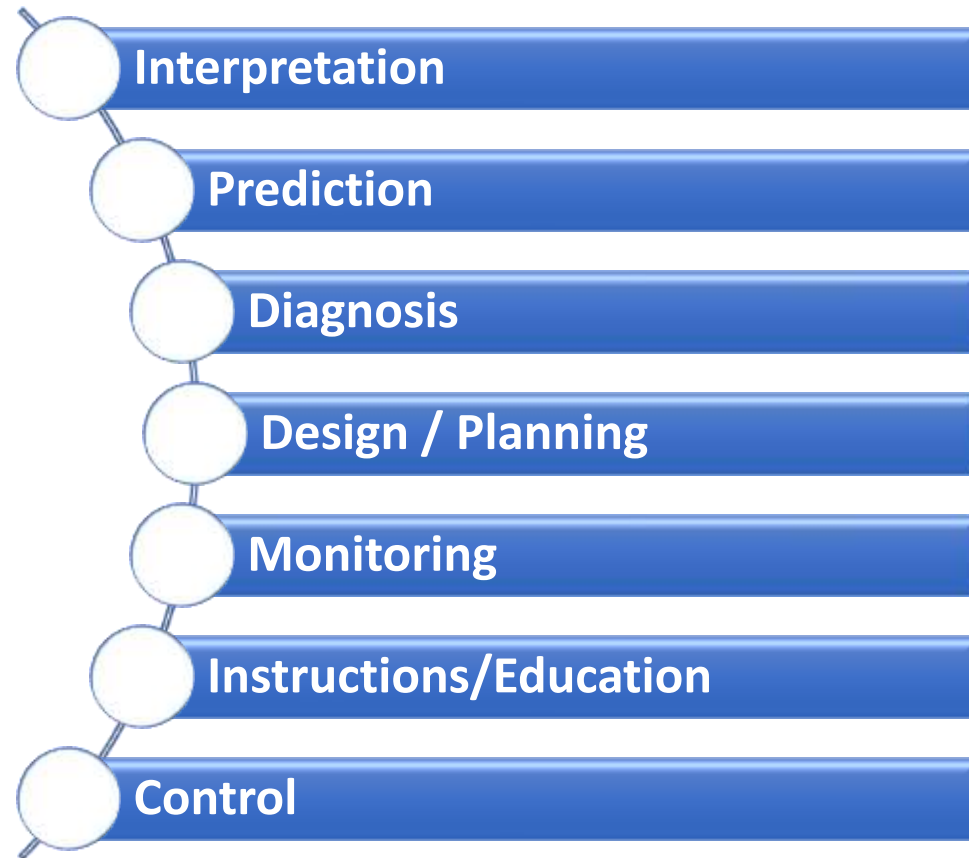
Facts/Data – Knowledge Base

Rules – Knowledge Base

Inference Engine

Language Processor

Agenda Control (Event Manager)



Early Expert System Examples

DENDRAL

- 1965: Mass-spectrometry Chemical Analysis
- Edward Feigenbaum, Stanford

MYCIN EMYCIN

- 1972: Identifying and treating blood infections
- Edward Shortliffe, Stanford

BEACON

- 1986: **B**uilding **E**nergy **A**nalysis **CON**sultant
- Jeff Haberl, Colorado

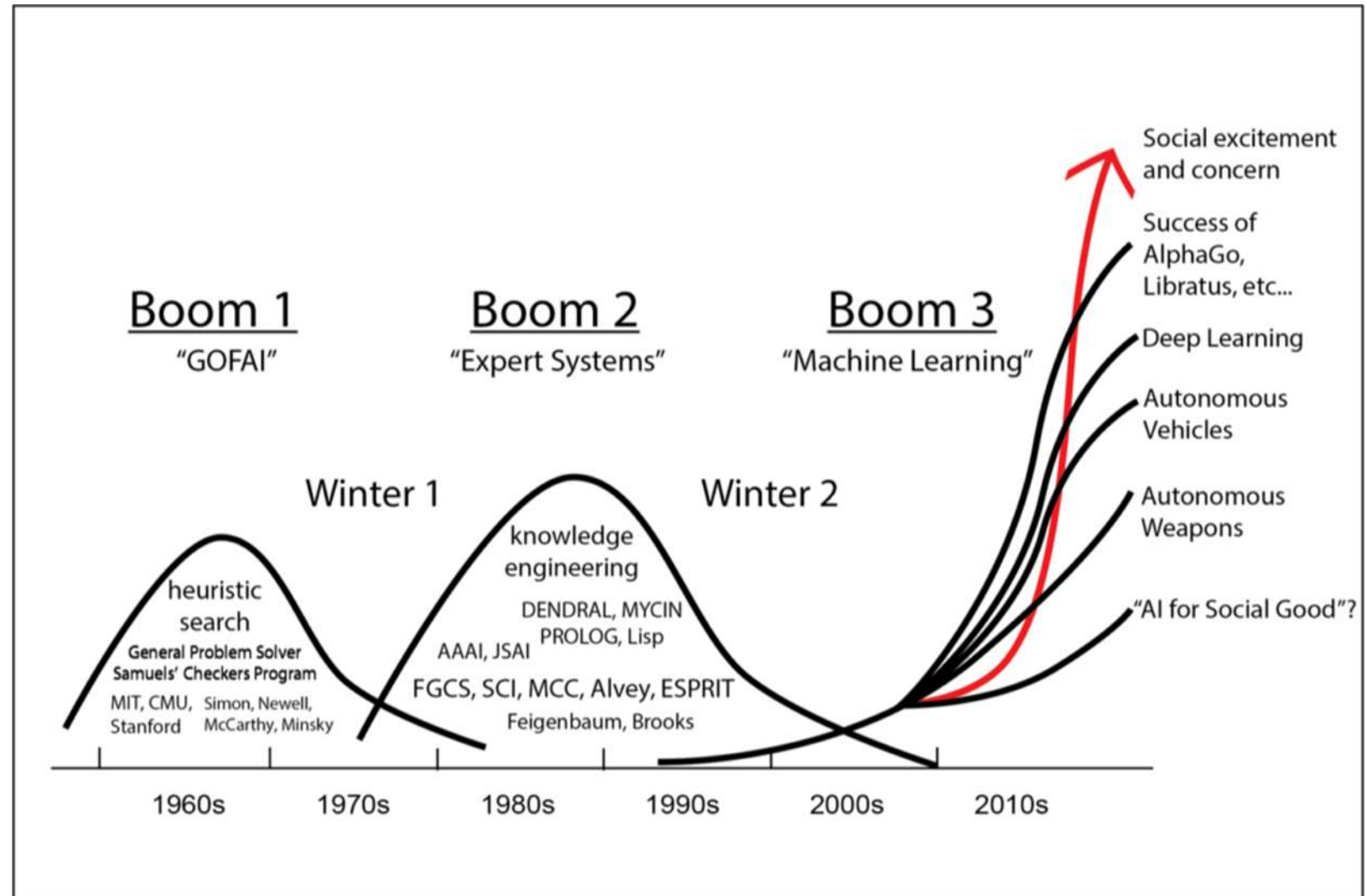
Kaggle Data science competition in 2018

HVAC-KBCD

- 2004: Conceptual Design of HVAC Systems
- Itzhak Maor and Agami Reddy, Drexel

Expert Systems and AI Limitations of 1980s

- ❖ Lack of computing power for text processing and collapse of the LISP machine market
- ❖ Slowdown in development and deployment of Commercial Expert systems - they could solve only well-defined problems in narrow domains



Technology Advancements Triggering AI Revolution in 2022

The AI innovations on the Hype Cycle reflect priorities across four main categories:

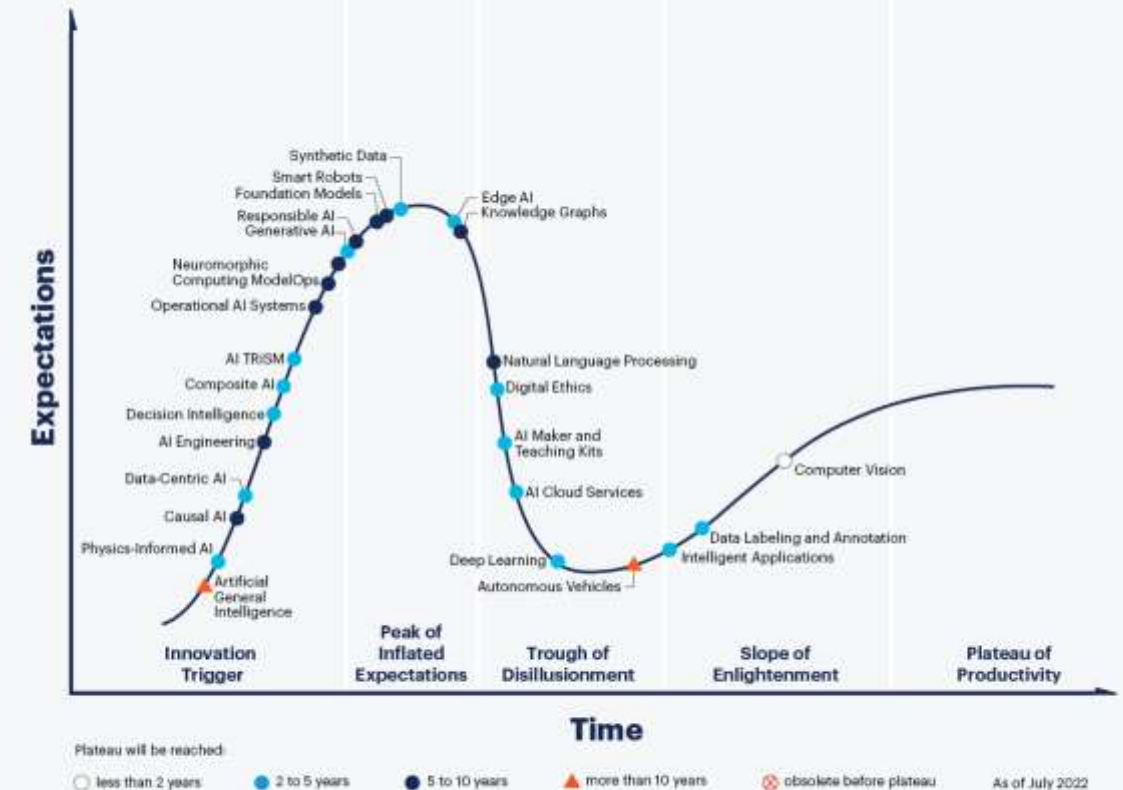
1. Data-centric AI
2. Model-centric AI
3. Applications-centric AI
4. Human-centric AI

Technologies Triggering the Hype:

1. Big Data
2. Cloud Computing
3. Data Science
4. Machine Learning
5. Large Language Models

(Source: <https://www.gartner.com/en/articles/what-s-new-in-artificial-intelligence-from-the-2022-gartner-hype-cycle>)

Hype Cycle for Artificial Intelligence, 2022



gartner.com

Source: Gartner
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Gartner

Large Language Models

- Deep learning models trained on vast amounts of linguistic data, so they understand and respond in natural language text



Capabilities

Natural Language Understanding (NLU)
Natural Language Generation (NLG)
Context Awareness

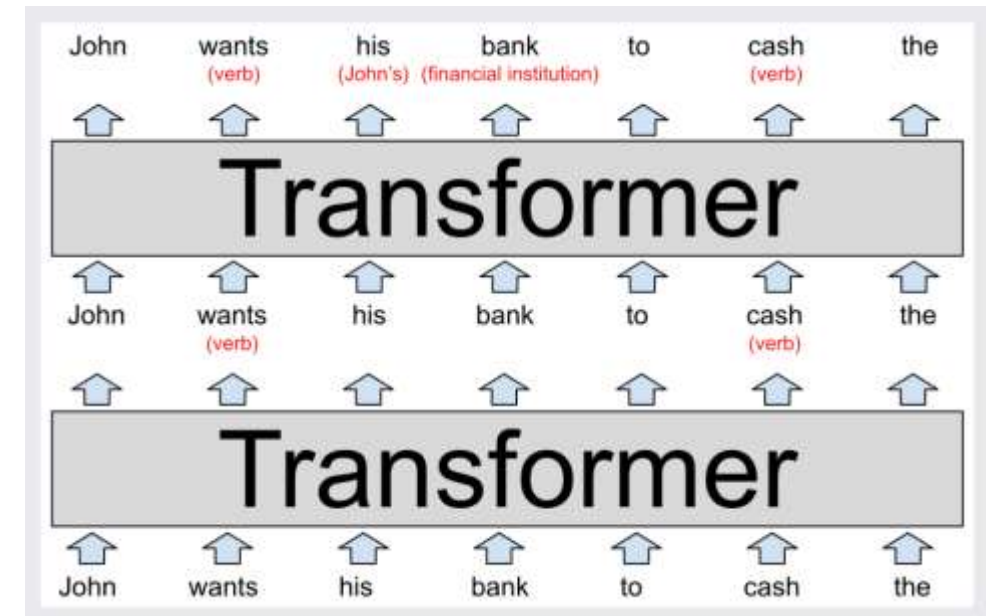
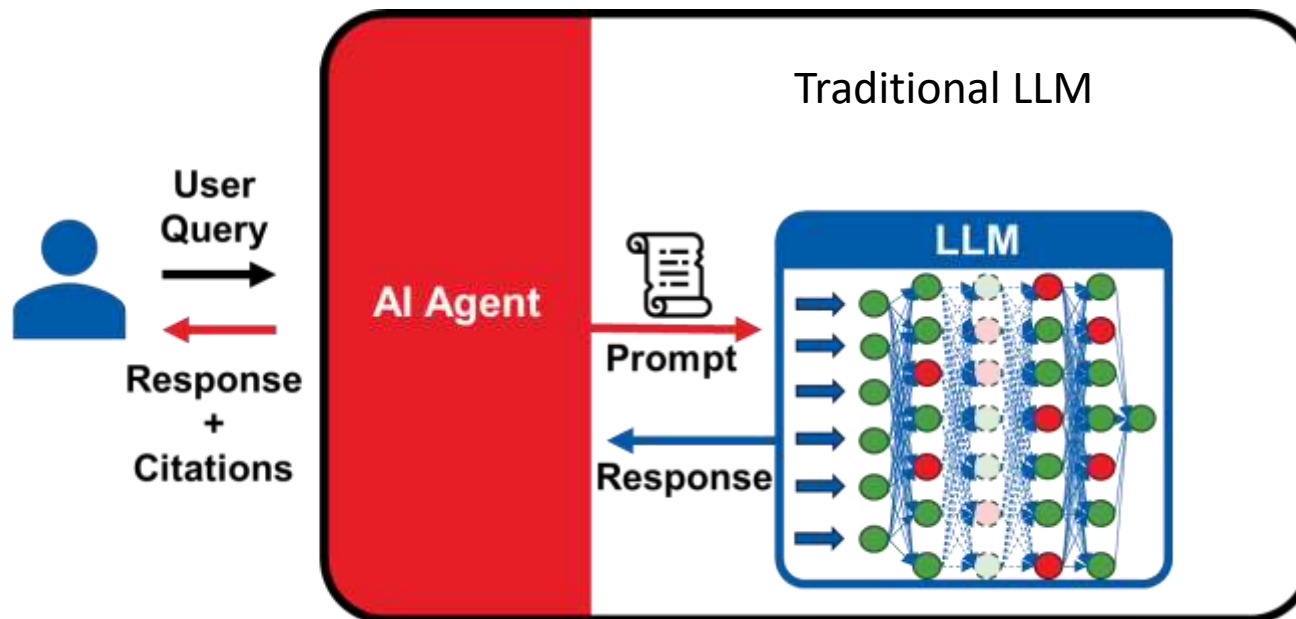


Components

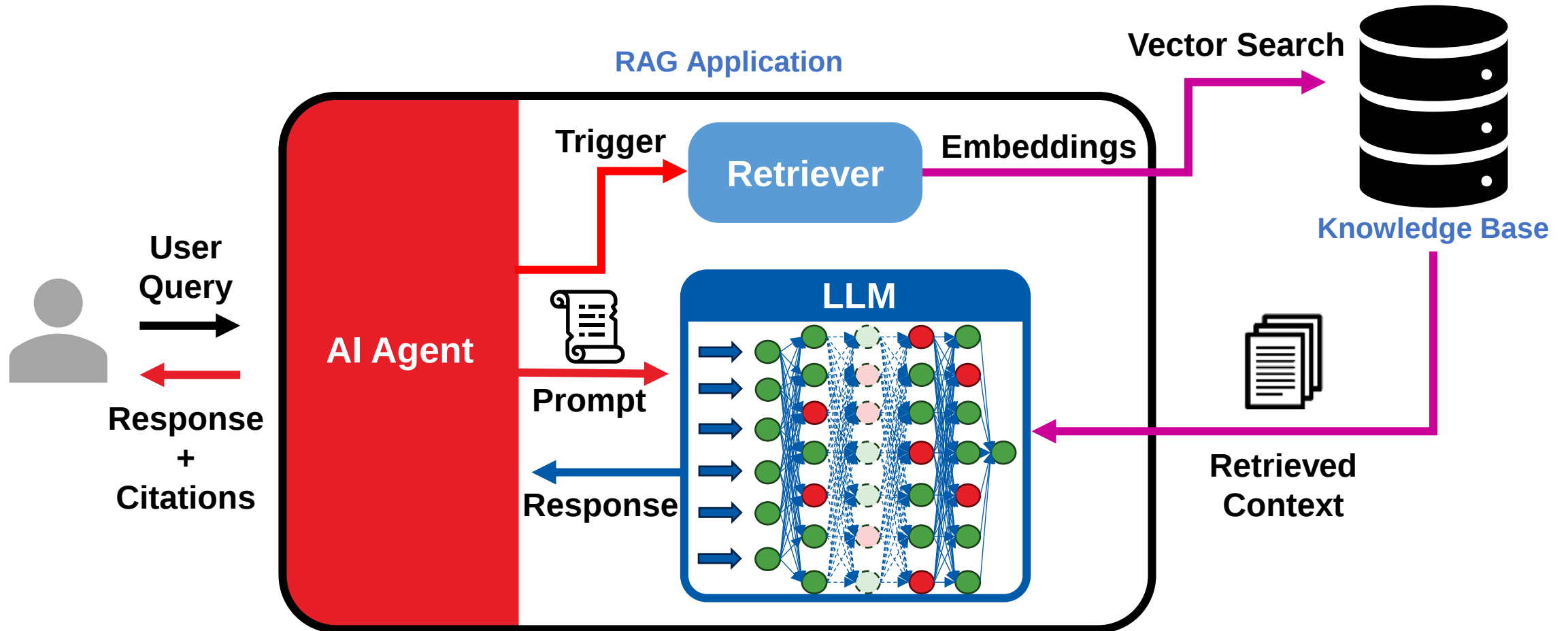
Transformers
Large Datasets
Learning Models



Generative AI Chatbot - How does it work?



Retrieval Augmented Generation (RAG)



Generative AI and Conversational AI

Generative AI

Designed to create original content based on a user's prompt by using existing data.

Applications:

- Generate text
- Form realistic images
- Design products and strategies
- Make music
- Create games
- Format videos
- Write computer code

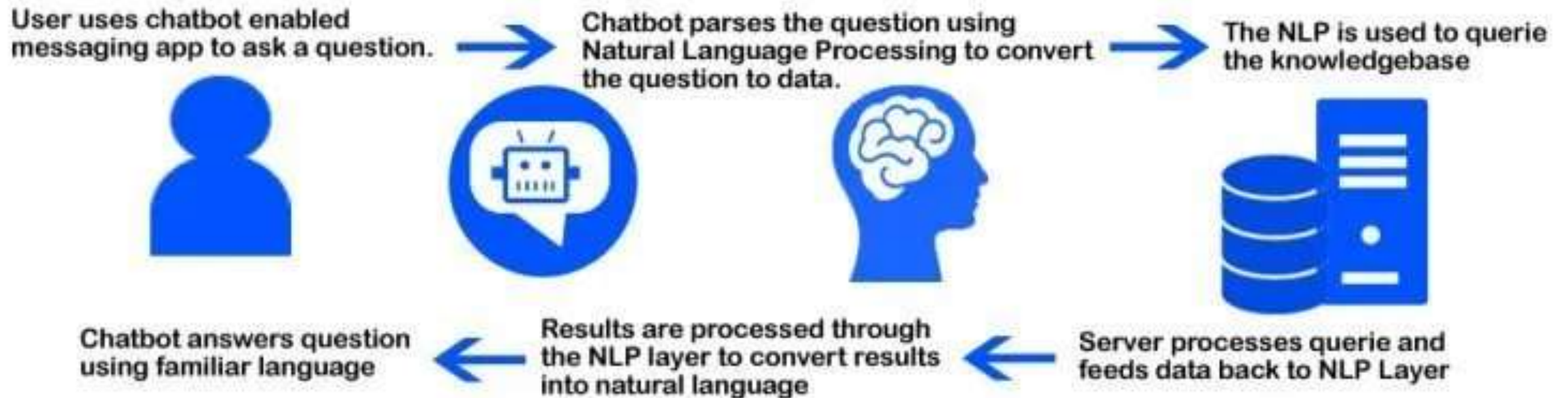
Conversational AI

Designed to understand and respond to human language on focused topics.

Applications:

- On-line customer support
- Virtual Assistants
- HR Processes
- IoT Devices (e.g Alexa)
- Software Commands
- Speech to text

AI Chatbots



Generative AI Chatbots for Consultants



AUTOMATING DATA
ANALYSIS (TEXT
BASED)



GENERATING
REPORTS



ANSWERING
ROUTINE CUSTOMER
QUERIES



SUMMARIZING
EMAILS



POINT FORM-TO-
PARAGRAPH



RATING FOR CLARITY



MOCK INTERVIEWS

How to use LLMs in HVAC design?

“What the large language models are good at is saying what an answer should sound like, which is different from what an answer should be.”

—Rodney Brooks, Robust.AI

Helpful prompts for HVAC design:

- Rephrase this technical report for a non-technical audience.

- Write an abstract for this report.

- Explain this architectural concept to me.

- Make this email sound more polite/professional.

HVAC Operational Data Analysis – Experiments

- Provide data to Chatbot in small batches.
 - *i.e., a weeks worth of electrical power meter data on 15-minute intervals.*
- Can be useful to the smart building IoT sectors where logic and data processing can be automated to provide a “virtual analyst” in describing results to the end client.
- Typical commissioning efforts or building retuning require an “expert” to explain results to the client where AI can potentially provide a “virtual expert.”

Common Use Cases in Facilities Management



Troubleshooting HVAC Control Systems via BAS Graphics

BAS platforms feature unique, animated schematic representations of mechanical equipment

LLMs can assist in interpreting these graphics and identifying issues



Staffing and Training Challenges

Facilities management staff may be understaffed or undertrained

Lack of experience in troubleshooting complex HVAC control systems

AI can provide guidance and step-by-step troubleshooting support



Complex HVAC Systems

HVAC systems can be intricate and difficult to understand

AI can simplify complex information and provide actionable insights

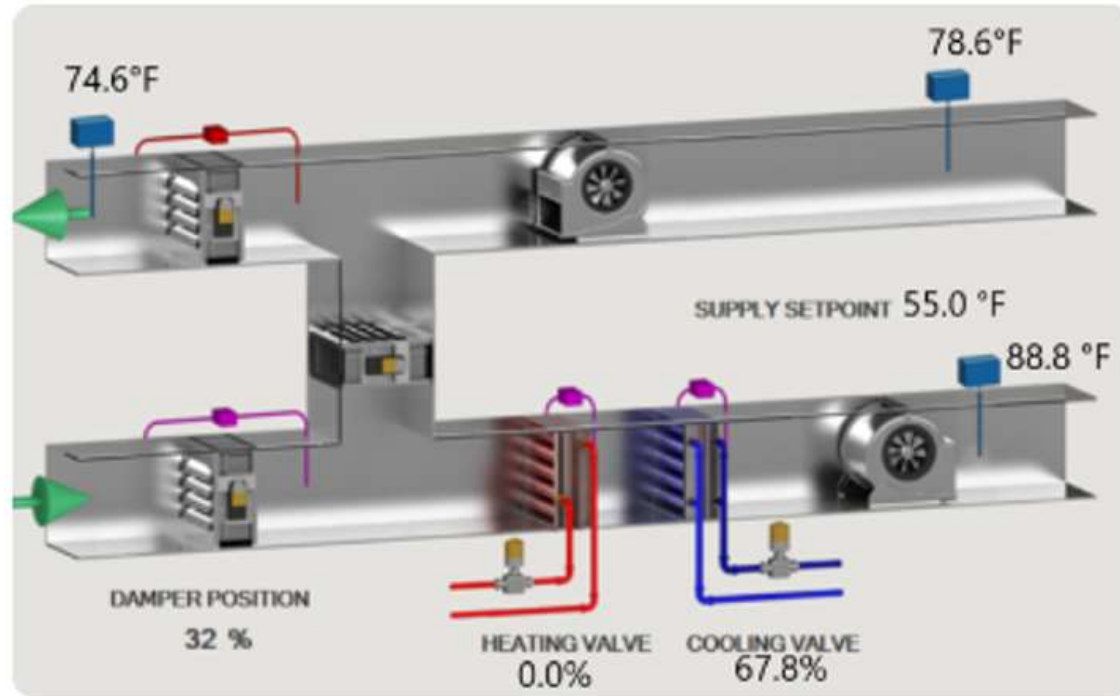


Indoor Air Quality (IAQ)

Ensuring optimal IAQ is critical for occupant health and comfort

AI can monitor IAQ parameters and alert operators to issues, recommending corrective actions

Broken AHU Heating Coil BAS Graphics



can you tell me what is wrong with this air handling unit and please layout some steps in troubleshooting it?

Results on Broken AHU Heating Coil

(LLM response)

Based on the image of the air handling unit (AHU) with its current readings and component states, here are some observations and potential issues:

- **Temperature Discrepancy:** The temperature readings show significant variation:
 - Left side: 74.6°F
 - Right side: 78.6°F and 88.8°F
 - Supply Setpoint: 55.0°F
- The supply setpoint temperature (55.0°F) is much lower than the actual temperatures, indicating the system is not cooling effectively.

Results on Broken AHU Heating Coil

(LLM response continued)

- **Cooling Valve Position:** The cooling valve is 67.8% open, which suggests the system is trying to cool the air but is not reaching the setpoint.
- **Heating Valve Position:** The heating valve is 0% open, indicating no heating is being applied, which is correct since cooling is needed.
- **Damper Position:** The damper position is 32%, which might be insufficient for proper airflow. The damper position should be checked to ensure it is providing the right amount of outside air and return air for effective cooling.

Troubleshooting Steps

1. Check the Cooling Coil
2. Inspect the Cooling Valve
3. Assess Airflow
4. Evaluate Temperature Sensors
5. System Controls
6. Check for Air Leaks
7. Review Historical Data

ASHRAE Policy for Use of AI (Feb 9, 2025)



ASHRAE Policy for Use of Artificial Intelligence (AI)

Board of Directors Approved February 9, 2025

Purpose:

The purpose of this Artificial Intelligence (AI) policy is to guide the ethical and effective use of AI technologies to serve ASHRAE members. As a publisher of technical guidelines and standards, organizer of conferences, provider of educational programs, and a research institution, ASHRAE strives to ensure that AI is used in ways that align with our mission, upholds intellectual property rights, and promotes fairness, transparency, and accountability.

SUMMARY

- Generative and Conversational AI applications will transform the internet research and processing of electronic information for analysis and reporting.
- Machine learning and data analytics will transform HVAC controls, building operation and maintenance integrating AI for real time changes.
- HVAC Design and analysis will greatly change from using design algorithms and integrate project-based learning as part of the design process.
- Though ChatBot and Machine learning will automate and improve productivity, these still will require expert, trained professionals for meaningful application of the technology.

Questions

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