

Developing Selective Question Answering @ Bloomberg

Engineering

Bloomberg

Search Solutions 2022
November 23, 2022

Mohamed Yahya
Software Engineer & Team Lead, Question Answering
AI Engineering Group

TechAtBloomberg.com

What is the Bloomberg Terminal?

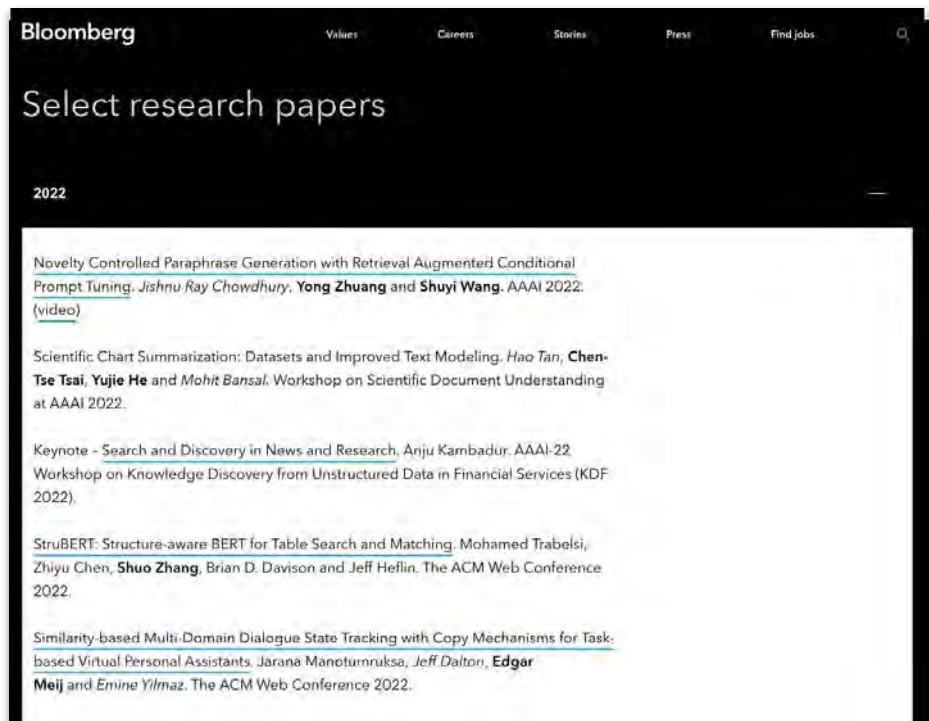


350,000+ subscribers

Software that delivers a diverse array of information, news and analytics to facilitate financial decision-making

Bloomberg by the numbers

- 7K+ software engineers
- 200+ data scientists & engineers working on AI/IR/NLP & related problems
- Increased presence in academic research



Bloomberg Values Careers Stories Press Find jobs

Select research papers

2022

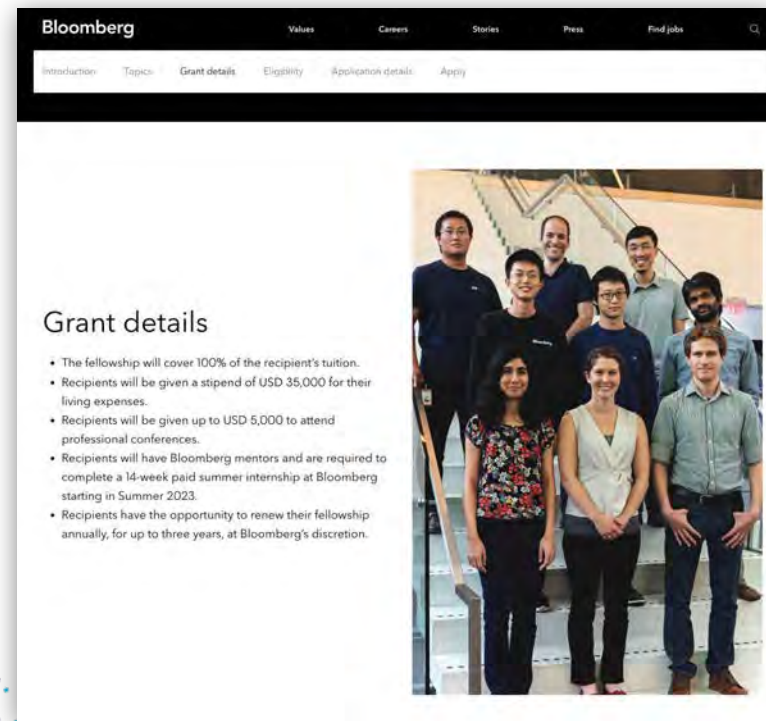
[Novelty Controlled Paraphrase Generation with Retrieval Augmented Conditional Prompt Tuning](#), [Jishnu Ray Chowdhury](#), [Yong Zhuang](#) and [Shuyi Wang](#), AAAI 2022. [\(video\)](#)

Scientific Chart Summarization: Datasets and Improved Text Modeling, [Hao Tan](#), [Chen-Tse Tsai](#), [Yujie He](#) and [Mohit Bansal](#), Workshop on Scientific Document Understanding at AAAI 2022.

Keynote - Search and Discovery in News and Research, Anju Kambadur, AAAI-22 Workshop on Knowledge Discovery from Unstructured Data in Financial Services (KDF 2022).

StruBERT: Structure-aware BERT for Table Search and Matching, Mohamed Trabelsi, Zhiyu Chen, [Shuo Zhang](#), Brian D. Davison and Jeff Heflin, The ACM Web Conference 2022.

Similarity-based Multi-Domain Dialogue State Tracking with Copy Mechanisms for Task-based Virtual Personal Assistants, Jaranā Manotumruksa, [Jeff Dalton](#), [Edgar Mej](#) and [Emine Yilmaz](#), The ACM Web Conference 2022.

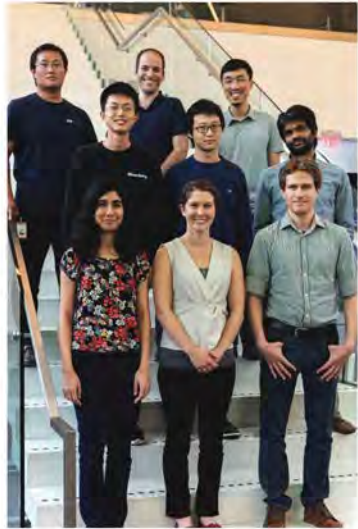


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[Introduction](#) [Topics](#) [Grant details](#) [Eligibility](#) [Application details](#) [Apply](#)

Grant details

- The fellowship will cover 100% of the recipient's tuition.
- Recipients will be given a stipend of USD 35,000 for their living expenses.
- Recipients will be given up to USD 5,000 to attend professional conferences.
- Recipients will have Bloomberg mentors and are required to complete a 14-week paid summer internship at Bloomberg starting in Summer 2023.
- Recipients have the opportunity to renew their fellowship annually, for up to three years, at Bloomberg's discretion.



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Outline

- **Context: Search & QA @ Bloomberg**
- **Why QA now?**
- **Selective Question Answering**
- **Takeaways and future work**

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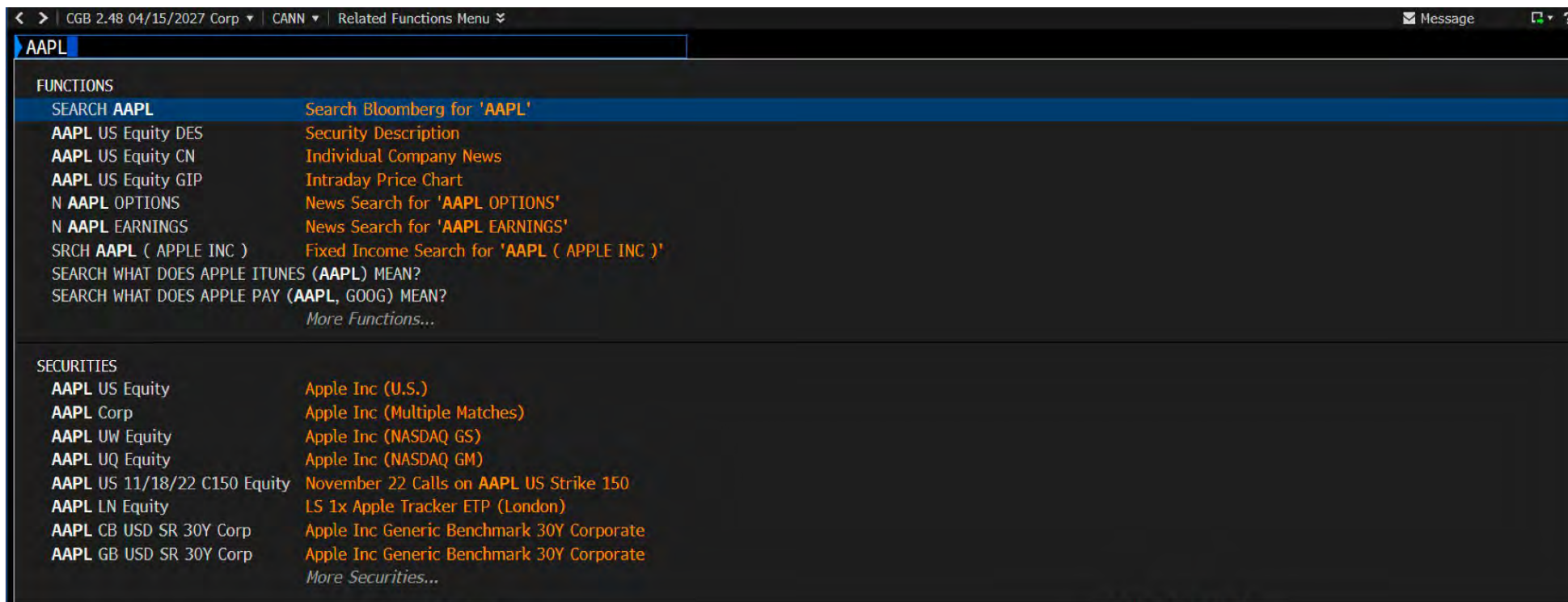
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Search @ Bloomberg



The screenshot shows a Bloomberg terminal window with the search results for 'AAPL'. The window title bar includes navigation arrows, 'CGB 2.48 04/15/2027 Corp', 'CANN', 'Related Functions Menu', and a 'Message' icon. The search input field contains 'AAPL'. The results are organized into two main sections: 'FUNCTIONS' and 'SECURITIES'. The 'FUNCTIONS' section lists various search and analysis tools, with 'SEARCH AAPL' highlighted. The 'SECURITIES' section lists different types of securities for Apple Inc., with 'AAPL US Equity' highlighted.

FUNCTIONS	
SEARCH AAPL	Search Bloomberg for ' AAPL '
AAPL US Equity DES	Security Description
AAPL US Equity CN	Individual Company News
AAPL US Equity GIP	Intraday Price Chart
N AAPL OPTIONS	News Search for ' AAPL OPTIONS'
N AAPL EARNINGS	News Search for ' AAPL EARNINGS'
SRCH AAPL (APPLE INC)	Fixed Income Search for ' AAPL (APPLE INC)'
SEARCH WHAT DOES APPLE ITUNES (AAPL) MEAN?	
SEARCH WHAT DOES APPLE PAY (AAPL , GOOG) MEAN?	
	<i>More Functions...</i>

SECURITIES	
AAPL US Equity	Apple Inc (U.S.)
AAPL Corp	Apple Inc (Multiple Matches)
AAPL UW Equity	Apple Inc (NASDAQ GS)
AAPL UQ Equity	Apple Inc (NASDAQ GM)
AAPL US 11/18/22 C150 Equity	November 22 Calls on AAPL US Strike 150
AAPL LN Equity	LS 1x Apple Tracker ETP (London)
AAPL CB USD SR 30Y Corp	Apple Inc Generic Benchmark 30Y Corporate
AAPL GB USD SR 30Y Corp	Apple Inc Generic Benchmark 30Y Corporate
	<i>More Securities...</i>

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Search @ Bloomberg

A05E

<Pg Dn> for More Results, <Back> to Return

aapl Page 1 Search Bloomberg: Results

Top Results Equities (77) Fixed Income (142) Companies (5) Index/Stats (500) More ▾

Apple Inc »

Ticker AAPL US Equity
Last Price/% Chg (USD) 148.33 / -1.96%
Price/Earnings 24.27

View Chart | GP »

BI Research Primer | BICO »
Company Description | DES »
Company Management | MGMT »

Functions (1)
News (5)
Research (5)
Reference (345)
Definitions (5)
FAQs (13)
Funds (128)
Intelligence (1)
Law
People
Data Fields
Commodities
Excel Library
Pricing
Muni Issuers
Currencies
Mtge Issuers

Load AAPL US Equity

Apple Inc (Multiple Matches) - AAPL +C101695 Corp Corporate Bonds
Issuer Ratings WR/AA+ Total Debt(USD) 110739.78
Avg Maturity 07/14/34

Apple Inc Generic Benchmark 10Y Corporate - AAPL CB USD SR 10Y Corp Corporate Bond
Price 91.25 1 Day Chg 4.471
Yield 4.470 Type FIXED

LS 1x Apple Tracker ETP (London) - AAPL LN Equity ETF
The LS 1x Apple Tracker ETP seek to track the Apple Tracker Investment Strategy, which is designed to provide 1:1 exposure to the ...
Price 497.20 Name LS 1X AAPL Type ETP NAV 5.98

Selected News Articles | More »

Apple and Amazon Underperform as Tech-Heavy Nasdaq 100 Sinks	BFW	16:52
Apple Music Support Seems To Be Finally Coming To Tesla Cars	BZG	15:22

Why EU Decided Tech Giants Can't Police Social Media: QuickTake Background
For all the promises from politicians to tackle online hate speech and misinformation, they continue to proliferate, polarizing societies and harming the vulnerable. Governments have been reluctant to act, fearing a broad crackdown will see them accused of ...

Apple Inc Generic Benchmark 10Y Corporate - AAPL GB USD SR 10Y Corp Corporate Bond
Price 91.25 1 Day Chg 4.471
Yield 4.470 Type FIXED

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Search @ Bloomberg

which german bonds will mature in the next 10 years? Page 1 Search Bloomberg: Results

Top Results Reference (2) FAQs (2) More ▾

Bonds | SRCH »

	R ↓	Issuer Name	Ticker	Coupon	Maturity Date	Currency	Amt Out
42)	📊	Sudzucker International Fin...	SZUGR	5.125	10/31/2027	EUR	400MM
43)	📊	Nidda Healthcare Holding G...	SAZGR	3.500	09/30/2024	EUR	479.2MM
44)	📊	Landesbank Baden-Wuertte...	LBBW	2.750	10/18/2024	EUR	1MMM
45)	📊	Talanx AG	TALANX	4.000	10/25/2029	EUR	500MM
46)	📊	thyssenkrupp AG	TKAGR	2.875	02/22/2024	EUR	1.5MMM
47)	📊	State of North Rhine-Westp...	NRW	3.000	01/27/2028	EUR	2.5MMM

Selected News Articles | More »

- Four Big Market Things to Know That Aren't the Fed: John Authers BBO 09/21
- ECB Needs a Formidable Anti-Fragmentation Tool: Marcus Ashworth BBO 07/08
- ECB Delay Presages Bigger Rate Rises Ahead: Marcus Ashworth BBO 06/09
- Fitch Revises Techem's Outlook to Stable, Affirms IDR at 'B' FII 04/21
- Fitch Assigns PCF GmbH 'B+' Final IDR; Outlook Stable FII 04/2021
- Fitch Assigns PCF GmbH First-Time 'B+(EXP)' IDR; Outlook Stable FII 04/2021

In DDIS, why do bonds maturing in other years appear in the securities... [FAQ](#)
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YAS - > Workflows > Analyzing Yield/Spread > Changing the Benchmark [Function Help](#)
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QA @ Bloomberg

which drones did russia buy from iran? Page 1 Search Bloomberg: Results

Top Results [FAQs \(1\)](#) [More ▾](#)

Shahed

been found after being shot down. What's the advantage of using the **Shahed** drones? As Russia runs down its stockpile of precision-guided missiles and struggles to buy or make replacements while under sanctions, Iran's drones offer an accurate, mid-range alternative.

What Are Iranian Drones Russia Is Using in Ukraine?: QuickTake
Published: 17/10/2022 | [Bloomberg News](#) | [NSN>>](#) Is this helpful?

Selected News Articles | [More »](#)

Al Jazeera: Analysis: What's behind Iran's alleged drone deal with Russia?	AJZ	10/31
Ukraine Latest: Putin Demands Safety Guarantee for Russian Ships	BN	10/31 <input type="button" value="📄"/>
Al Jazeera: Analysis: What's behind Iran's alleged drone deal with Russia?	AJZ	10/31
Ukraine Latest: Russia Says UK Involved in Naval Vessel Strike	BN	10/29 <input type="button" value="📄"/>
US Says Will Make It Harder for Iran to Sell Weapons to Russia	BFW	10/20
Ukraine Latest: Kyiv Energy Use Limited; New Threat From North	BN	10/20 <input type="button" value="📄"/>

Where can I find information on Russian repurchase agreements? [FAQ](#)
You can find information on Russian repurchase agreements for bonds and equities on the Moscow Exchange REPO Monitor (MICR) function. For more on using MICR: [MICR Help Page](#).

Today's Talk!

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Why Productionize QA?

- Make Bloomberg textual sources more easily discoverable
 - News; Financial research; Company filings; Earning call transcripts; Reference material & documentation
- Expressive search to uncover the wealth of knowledge in the Terminal
 - 2.7K+ journalists and analysts writing news and in-depth investment research
 - 2M news articles/day from 125K+ curated third-party news sources
- Testbed for Transformer-based LLMs at Bloomberg

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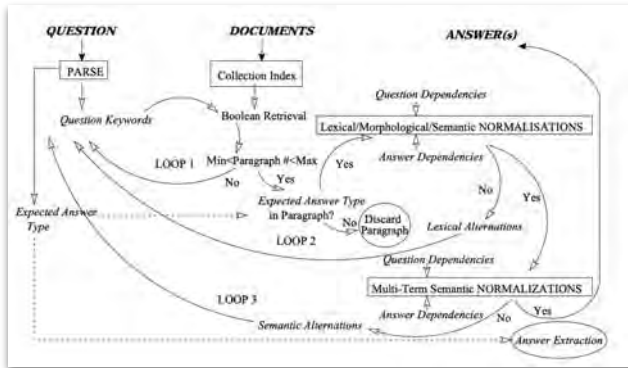
Why Productionize QA now?

2001

High Performance Question/Answering

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2011

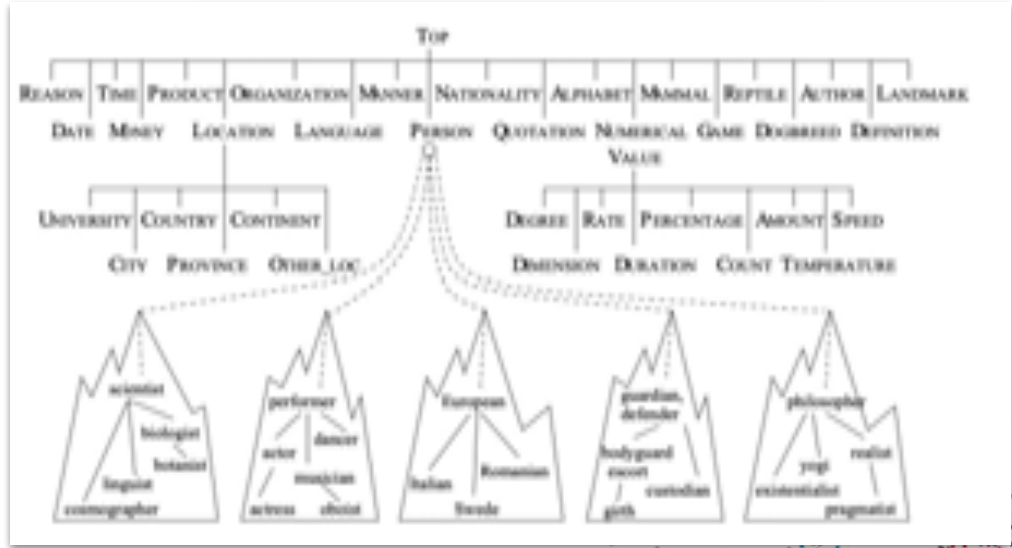
VOLUME 56, NUMBER 3/4, MAY/JUL. 2012

Journal of Research and Development

Including IBM Systems Journal

Bram Stoker	62%
Dracula	40%
Herman Melville	9%

This Is Watson



A Computer Called Watson

Overview: Transforming the World Through Technical Breakthroughs

The Team
In Their Words

No product, idea or achievement is possible without our most critical asset—the collective thought capital of hundreds of thousands of IBMers. Their expertise, technical skill, willingness to take risks, and overall dedication of IBM employees have led to countless transformative innovations throughout the years. It is the team members who contributed to this Icon of Progress.

Dr. David Ferrucci

David Ferrucci graduated from Manhattan College with a bachelor of science degree in biology, and received his PhD in computer science, specializing in knowledge representation and reasoning, from Rensselaer Polytechnic Institute in 1994. His background is in artificial intelligence, specifically knowledge representation and reasoning. Ferrucci leads the Semantic Analysis and Integration department at the T.J. Watson Research Center, and is the principal investigator for the DeepQA project. ... *Jeopardy!*

Algorithmic Team
The IBMers responsible for Watson's DeepQA architecture include: Benjamin Bonet, Jeff Beaulieu, Michael P. Bazzani, Massimo Carrara, James East, Harold Goodale, Ashish Kulkarni, Adam Kelly, Anthony Lewis, Michael McClosky, 2011 Microsoft Pushout Prize, Michael S. Fox, Peng Tang, Sheng Wang, University of Waterloo.

Strategy Team
The group that worked on Watson's strategy and business strategy during Jeopardy! includes: Jonathan Shewchuk, David Lewis, Ben Love, Aron Kuper, and Andy Demeter.

Systems Team
The team that designed the Watson system architecture includes: Peter Houghton, John Gensic, Yong Fan, Sheng Wang, Adam Kelly, Steve Lathin, and Marshall Fisher.

Speech Team
The IBMers who developed Watson's voice and speech recognition capabilities include: Andy Aronoff, Saul Horvath, Sheng Wang, John Gensic, Andrew Rosenberg, Roberto Skovran, and Marissa Matulis.

Annotation Team
The Jeopardy! team that developed the annotations for Watson's knowledge base includes: Mark Rothstein and Kerry Hightower.

China Research Lab Team
The group primarily based in Beijing, China, that has worked on Watson's Chinese capabilities includes: Yan Yan, Yan Yan, and Xiao-Ming Qiu.

Tokyo Research Lab Team
The group that helped develop the Japanese capabilities for Watson's Japanese capabilities includes: Masahito Yamada, Masahito Yamada, and Masahito Yamada.

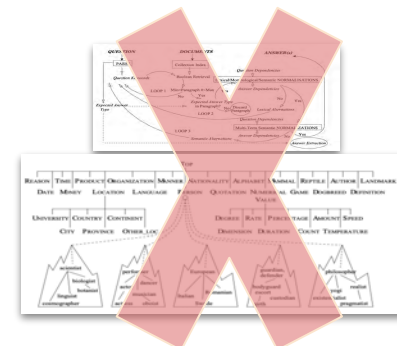
India Research Lab Team
The team responsible for providing the support for Watson's Indian capabilities includes: Devika Datta and Balaji Reddy.

Project Management Team
The team that managed the development of Watson's project includes: Steve Lathin, David Lewis, and David Lewis.

Application Team
The team responsible for providing the support for Watson's application capabilities includes: Adam Kelly, Steve Lathin, and Steve Lathin.

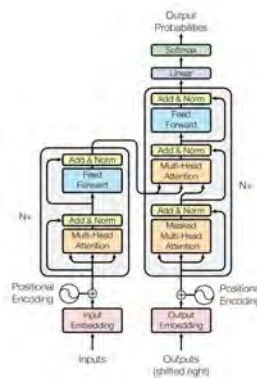
Why Productionize QA *now*?

QA =



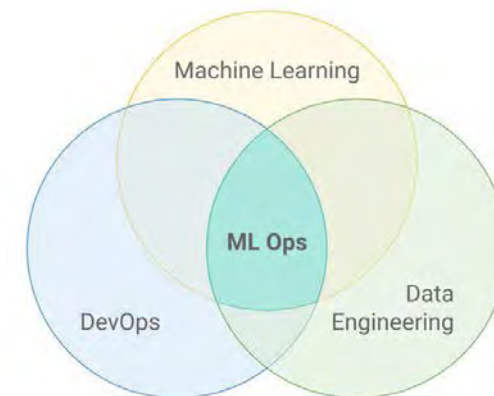
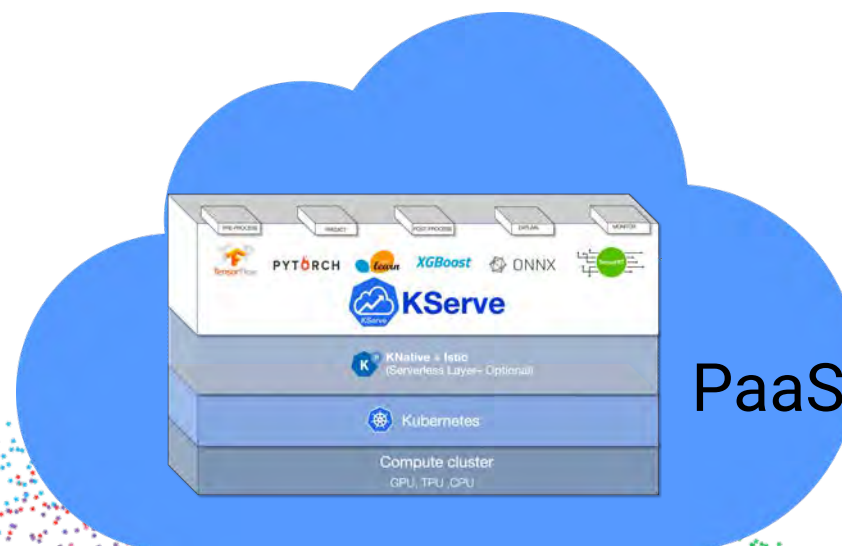
Effectiveness

Modeling +



Efficiency & Availability

Engineering & Infrastructure



Outline

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A Good Answer

which drones did russia buy from iran? Page 1 Search

Top Results FAQs (1) More ▾

Shahed

been found after being shot down. What's the advantage of using the **Shahed** drones? As Russia runs down its stockpile of precision-guided missiles and struggles to buy or make replacements while under sanctions, Iran's drones offer an accurate, mid-range alternative.

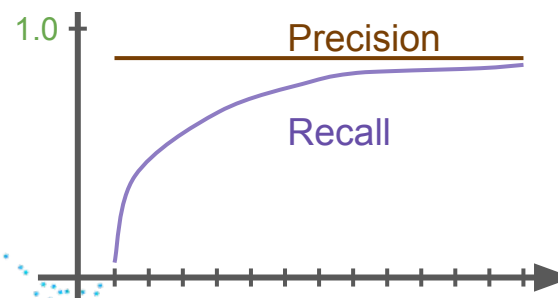
What Are Iranian Drones Russia Is Using in Ukraine?: QuickTake
Published: 17/10/2022 | [Bloomberg News](#) | [NSN](#)>>

Is this helpful?

Correct at the time presented & explainable

always high precision

recall can wait

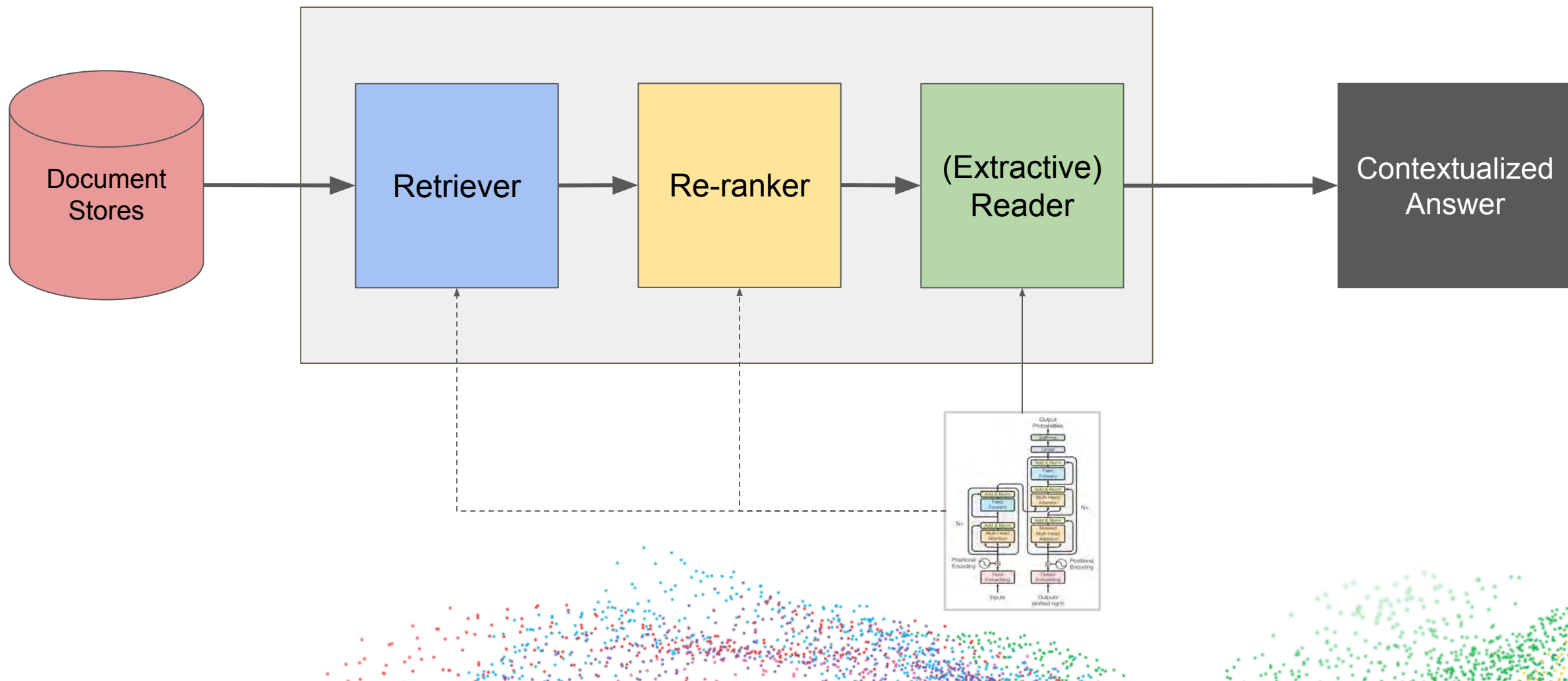


Iteration =
release

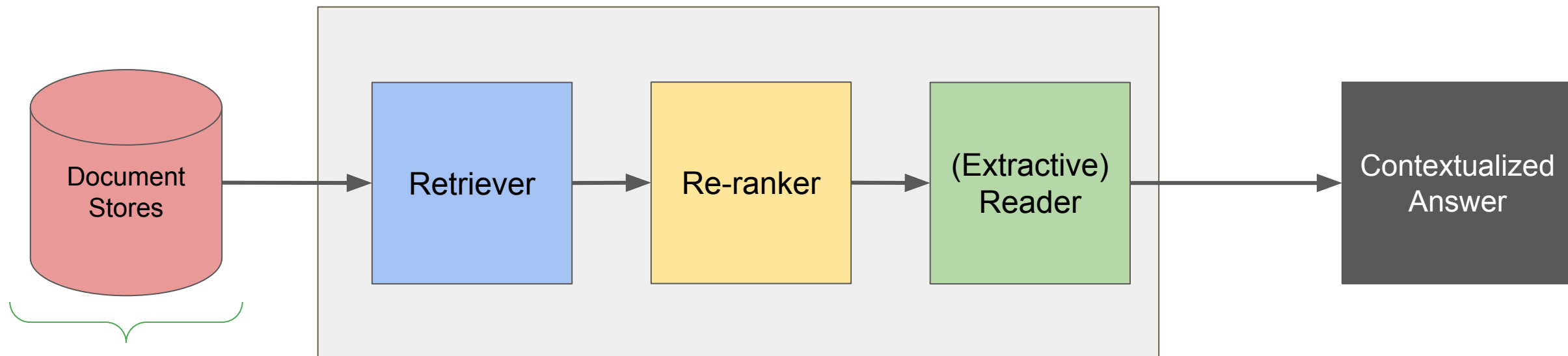
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Core QA pipeline



Answer Correctness: What Can Go Wrong?



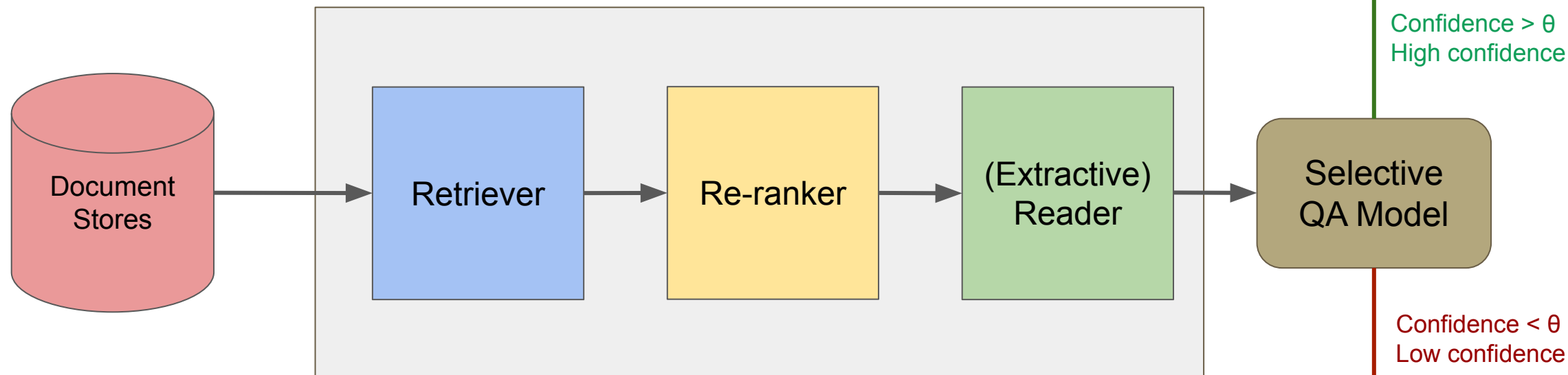
1

Corpus doesn't contain answer (OOD question or just a "limited" corpus)

2

Imperfect answering pipeline, that's always trying to answer

Selective Answering



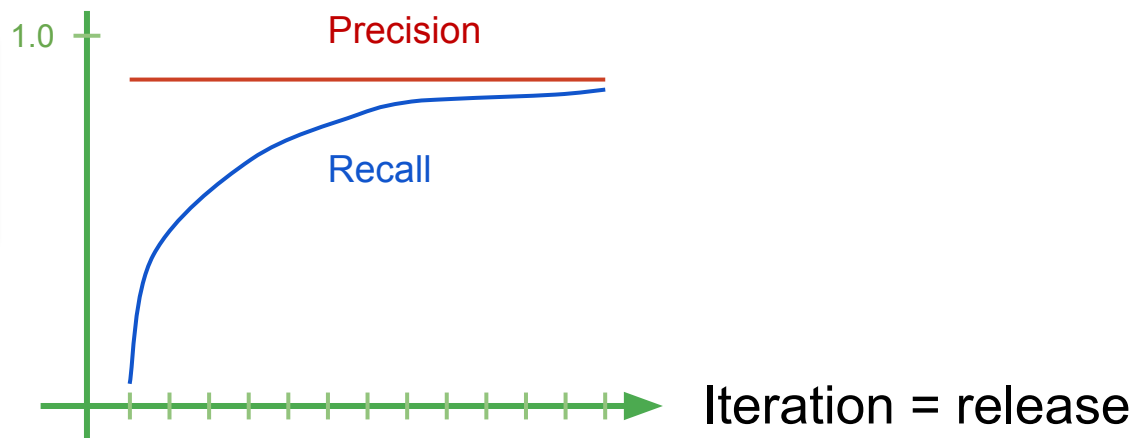
Journal of Machine Learning Research 11 (2010) 1605-1641 Submitted 10/09; Revised 4/10; Published 5/10

On the Foundations of Noise-free Selective Classification

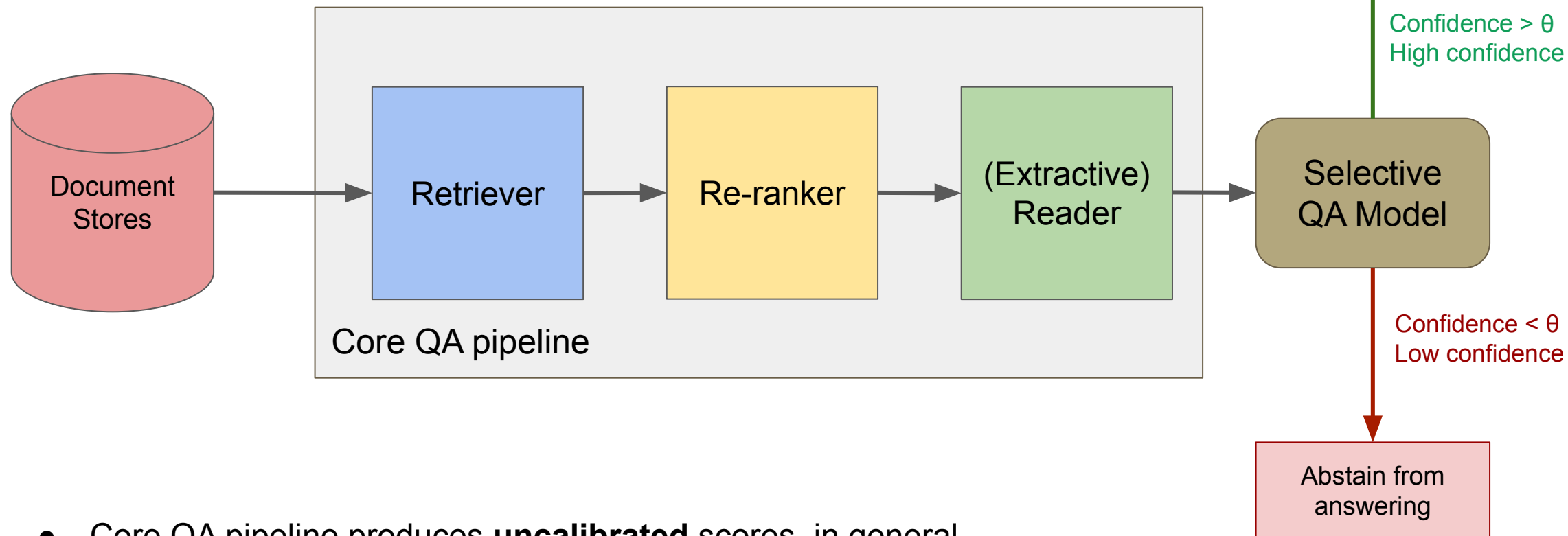
Ran El-Yaniv RANI@CS.TECHNION.AC.IL
Yair Wiener WYAIR@TX.TECHNION.AC.IL

Selective Question Answering under Domain Shift

Amita Kamath Robin Jia Percy Liang
Computer Science Department, Stanford University
{kamatha, robinjia, plieng}@cs.stanford.edu

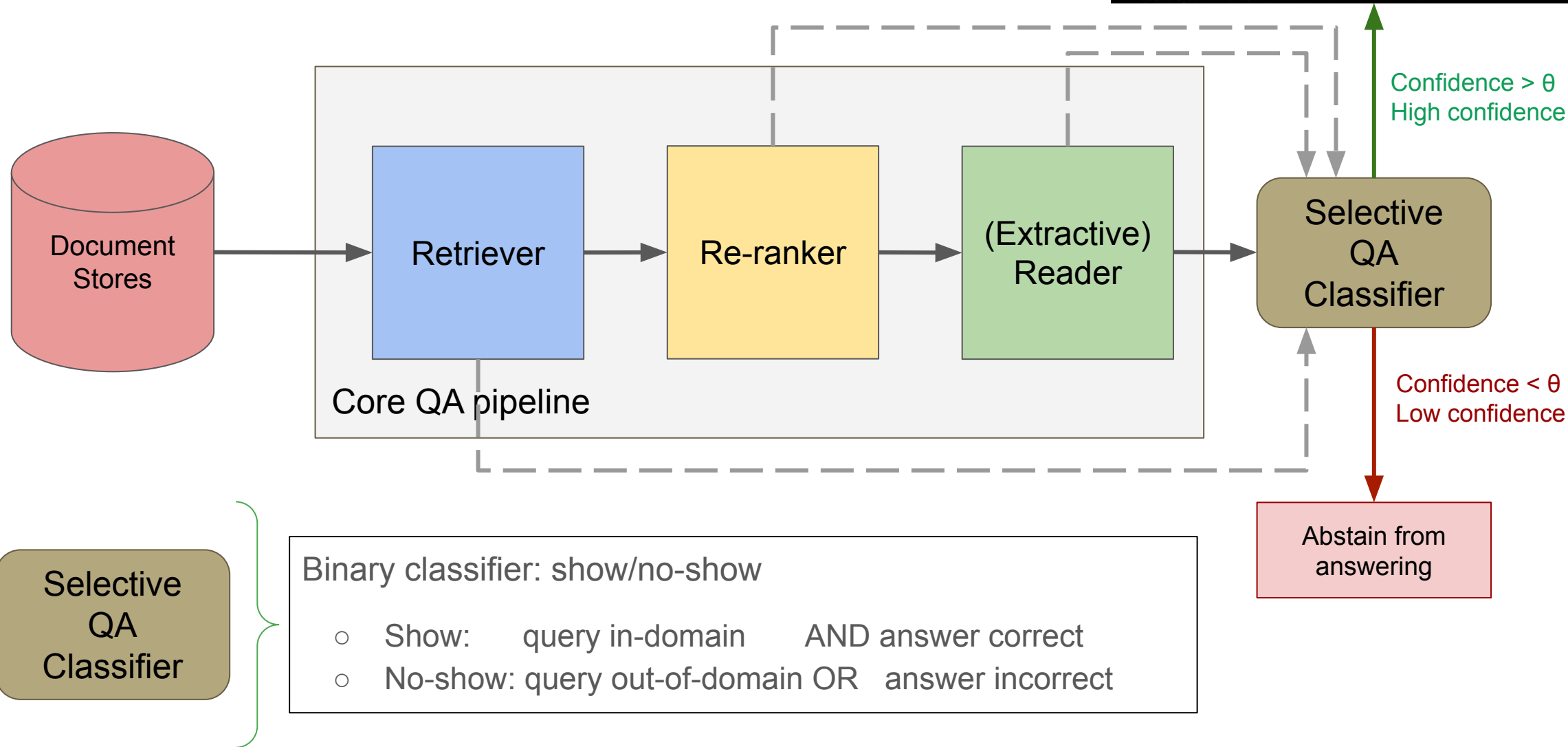


Selective Answering

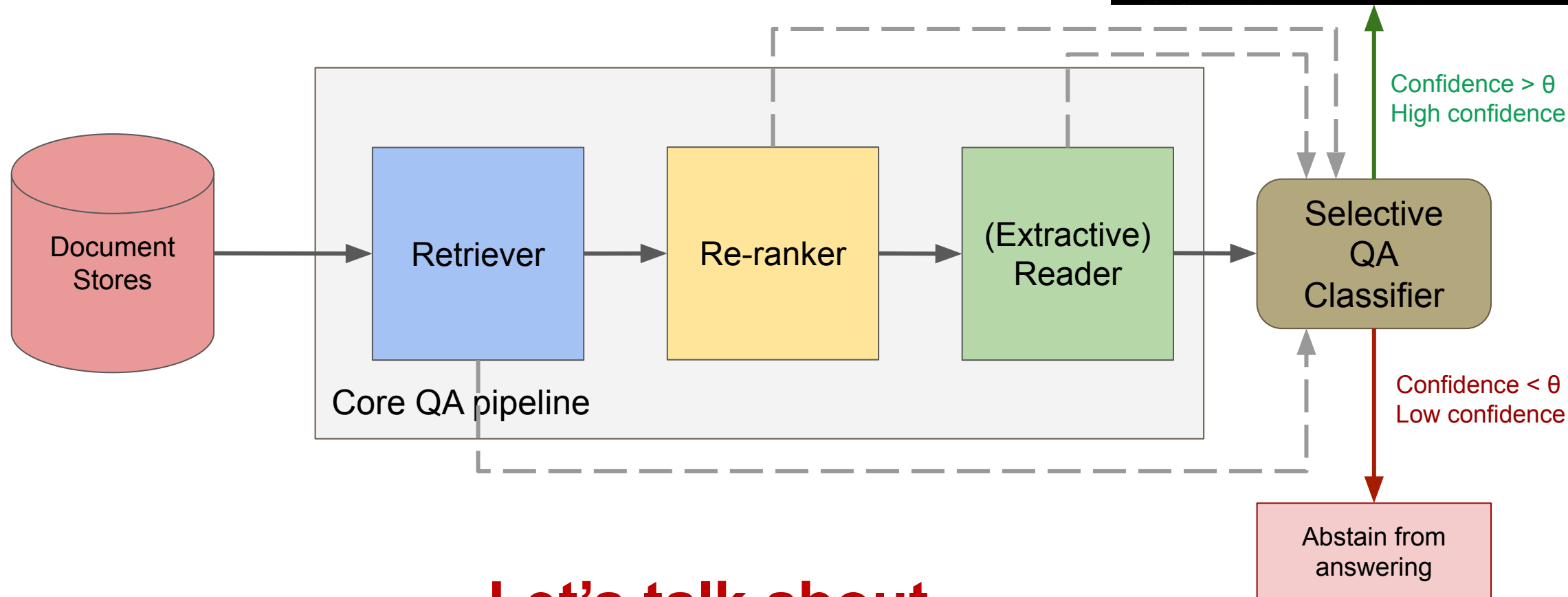


- Core QA pipeline produces **uncalibrated** scores, in general
- Iterate by experimenting with with **instantiations of pipeline components**
- **Inject features** not necessarily captured by the core pipeline

Selective Answering

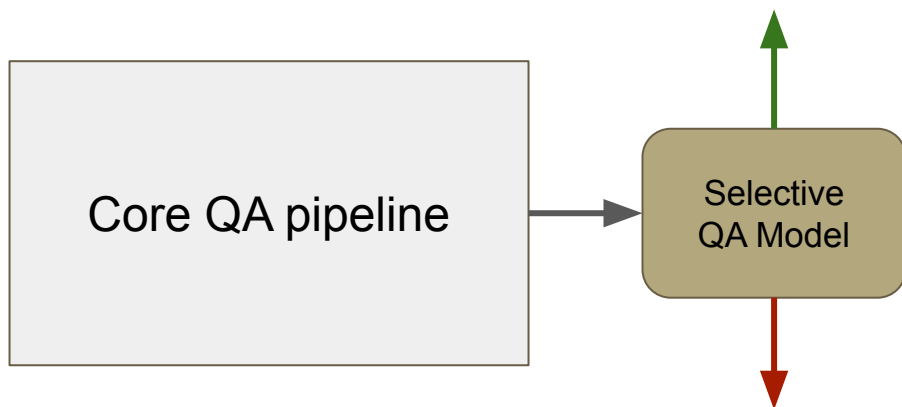


Selective Answering: Results



**Let's talk about
data & annotation first...**

Evaluation Data Needs - Setting



which german bonds will mature in the next 10 years? Page 1 Search

Top Results Reference (2) FAQs (2) More

Bonds	Issuer Name	Ticker	Coupon	Maturity Date	Currency	Am't Out.
47	Südzucker International Fin...	SZUGR	5.125	10/31/2027	EUR	400MM
48	Nidda Healthcare Holding G...	SAZGR	3.500	09/30/2024	EUR	479.2MM
49	Landesbank Baden-Wuertte...	LBBW	2.750	10/18/2024	EUR	100MM
49	Talanx AG	TALANX	4.000	10/25/2029	EUR	500MM
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49	State of North Rhine-Westp...	NRW	3.000	01/27/2028	EUR	2.500MM

Selected News Articles

- Four Big Market Things to Know That Aren't the Fed: John Authers BBO 09/21
- ECB Needs a Formidable Anti-Fragmentation Tool: Marcus Ashworth BBO 07/08
- ECB Delay Presages Bigger Rate Rises Ahead: Marcus Ashworth BBO 06/09
- Fitch Revises Techem's Outlook to Stable, Affirms IDR at 'B' FII 04/21
- Fitch Assigns PCF GmbH 'B+' Final IDR; outlook Stable FII 04/2021
- Fitch Assigns PCF GmbH First-Time 'b+'(EXP) IDR; outlook Stable FII 04/2021

In DDIS, why do bonds maturing in other years appear in the securities... FAQ

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YAS -> Workflows > Analyzing Yield/Spread > Changing the Benchmark Function Help

YAS launches with a default benchmark. You can change the benchmark to re-price the loaded security and recalculate spreads to a custom bond, swap, treasury curve, or to a local sovereign curve for emerging markets bonds... Steps: Select the...

YAS -> Reference > Calculations > Calculations by Security Type > Bon... Function Help

This section describes the calculations used in yield analysis for bonds in default. A bond is said to be in default when it fails to fulfill its contractual obligations, such as the delay or failure to make timely payments of interest or principal. Projected

QA system over a specific corpus deployed in an aggregated search setting

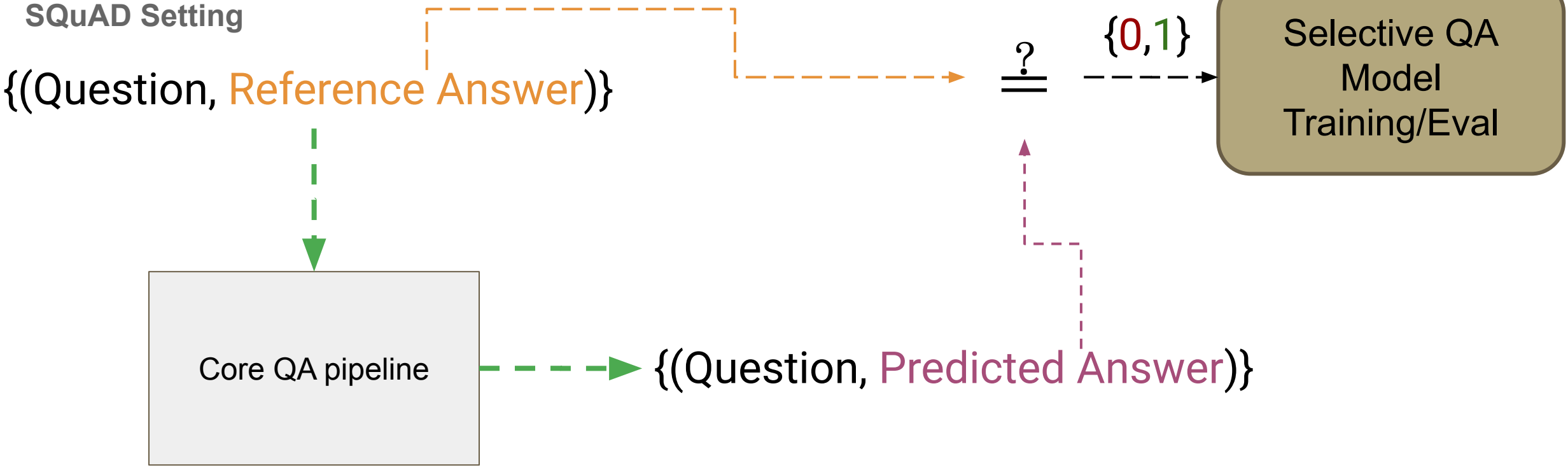
Need in-domain questions

Representative of what users will ask

QA pipeline can still go wrong on in-domain questions

OOD questions are the norm

Evaluation Data Needs - Setting



Evaluation Data Needs - Data Sources

In-domain ~~X~~ Cold start 

OOD

1

{(Question, Reference Answer)}

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Bonds	SRCH	Issuer Name	Ticker	Coupon	Maturity Date	Currency	Amt Out
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Evaluation Data Needs - Data Sources

In-domain ~~Cold start~~ 

OOD

{(Question, Reference Answer)}

In-domain

1

2

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YAS - > Workflows > Analyzing Yield/Spread > Changing the Benchmark Function Help
YAS launches with a default benchmark. You can change the benchmark to re-price the loaded security and recalculate spreads to a custom bond, swap, treasury curve, or to a local sovereign curve for emerging markets bonds.. Steps: Select the

YAS - > Reference > Calculations > Calculations by Security Type > Bon... Function Help
This section describes the calculations used in yield analysis for bonds in default. A bond is said to be in default when it fails to fulfill its contractual obligations, such as the delay or failure to make timely payments of interest or principal. Projected

Buildings Decarbonization Funding Lags Other Climate Tech: BNEF

Commercial buildings accounted for 11% of global emissions in 2019, making them a key target for decarbonization. However, the sector has not yet been met with much enthusiasm by the venture capital and private equity (VCPE) community.

NSN R3E3Q0T0AFB4 Published: 2021-12-01

Factoid:

11%

Factoid question:

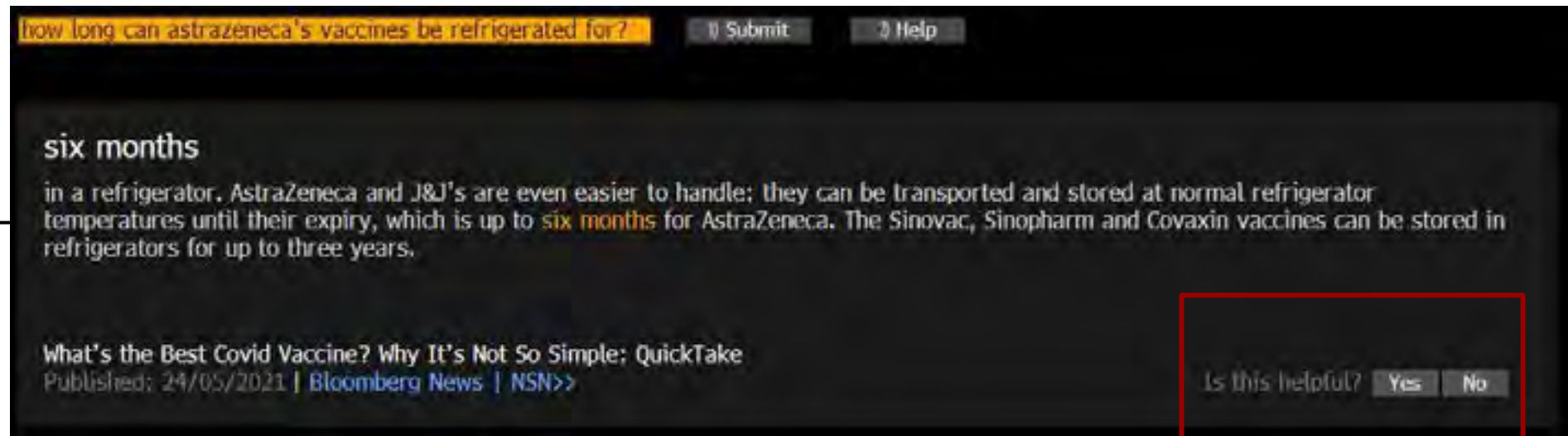
What share of global emissions comes form commercial buildings?

Submit Submit and Leave Cancel Task

Evaluation Data Needs - Data Sources

{(Question, Reference Answer)}

3



How long can astrazeneca's vaccines be refrigerated for?

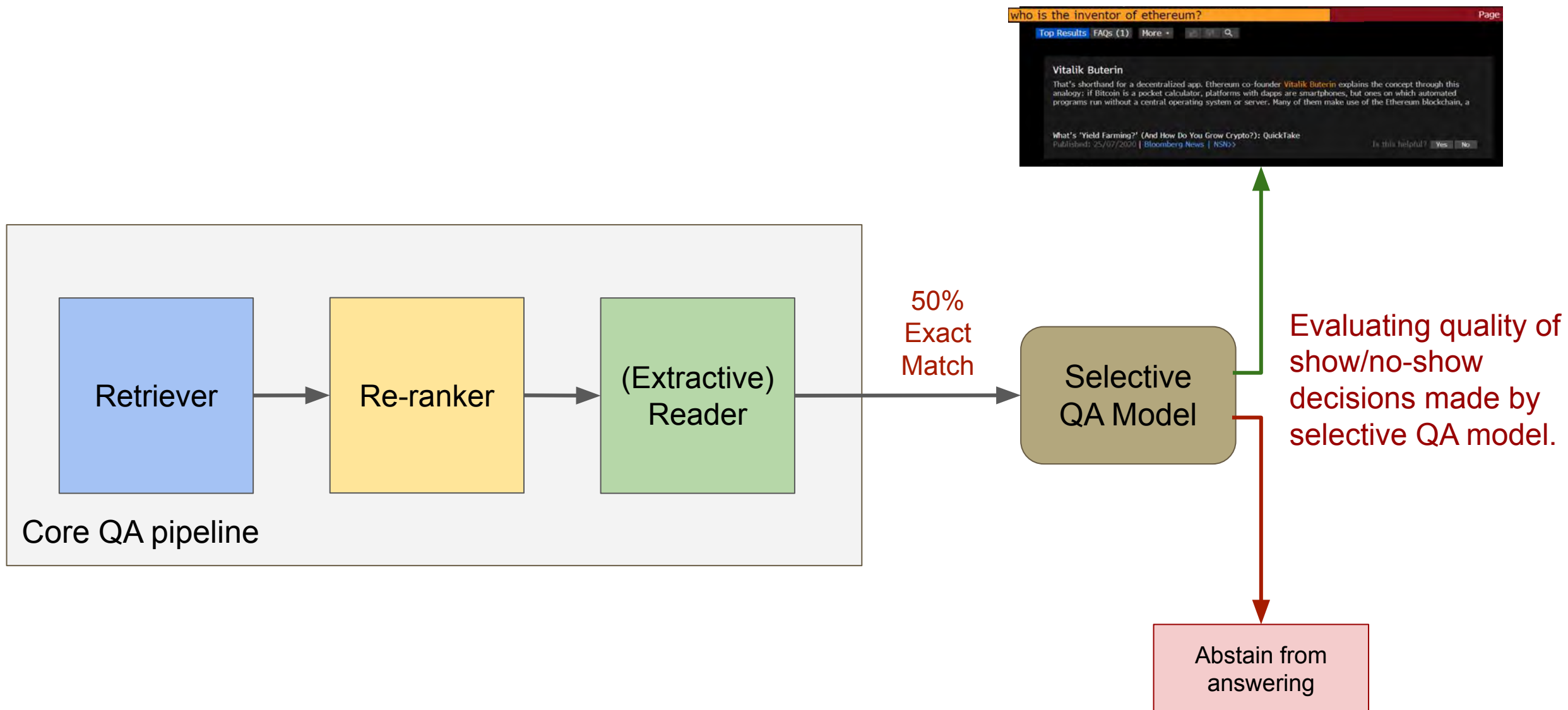
six months
in a refrigerator. AstraZeneca and J&J's are even easier to handle; they can be transported and stored at normal refrigerator temperatures until their expiry, which is up to **six months** for AstraZeneca. The Sinovac, Sinopharm and Covaxin vaccines can be stored in refrigerators for up to three years.

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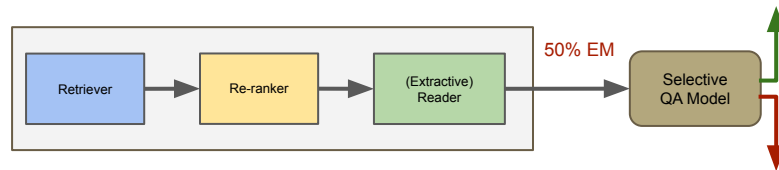
Is this helpful?

In-domain
(&OOD)

Evaluation Setting



Evaluation



Model	Dataset	Precision	Recall	Accuracy (TP+TN)
Iteration 1 - Lexical features (independent of pipeline)	Crowdsourced in-domain	0.89	0.70	0.74
	Logged OOD	N/A	N/A	0.98
	Naturally asked (not in training)	0.82	0.23	0.51

which german bonds will mature in the next 10 years? Page 1 Search

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G-20 Gave Billions in Fossil-Fuel Support Amid Green Push: BNEF

For all the talk about shifting to a low-carbon world, Group-of-20 nations once again gave hundreds of billions of dollars in support for fossil fuels last year. The countries provided almost \$600 billion in subsidies and other support to fossil fuels, down only slightly from 2019, according to BloombergNEF estimates based on provisional data. The figure is almost six times the \$100 billion per year that developed nations pledged to raise by 2020 to help developing countries transition to cleaner energy, which still hasn't been delivered. Governments, state-owned enterprises and public financial institutions continue to provide billions of dollars each year to support the production and consumption of fossil fuels, even as leaders struggle to reach an accord on cutting greenhouse gas emissions. Moreover, despite recent pronouncements, some countries still plan to build hundreds of gigawatts of new coal-fired power plants, locking in those emissions for decades to come. The backing is one of three areas that BNEF highlighted for governments to take toward the goals of the Paris Agreement: phasing out support for fossil fuels, especially coal; putting a price on carbon emissions; and making companies disclose the risks they face due to climate change. The slip in fossil-fuel backing from 2019 was driven by a 20% cut in subsidies to retail customers due to lower fuel and energy consumption during the Covid-19 pandemic, according to BNEF. Absent this drop, fossil-fuel support would have stayed level in 2020 due to continued and new subsidies. Still, the support is down from \$706 billion in 2015.

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Is there a factoid in the passage above about which a factoid question can be asked?

No.

Yes. Please provide the factoid and the corresponding question below.

If you answered Yes above, provide the factoid and the corresponding factoid question that it answers:

Factoid:

500 billion

Factoid question:

How much do G-20 countries subsidize fossil fuels?

Submit Cancel Done

how long can astrazeneca's vaccines be refrigerated for? Submit Help

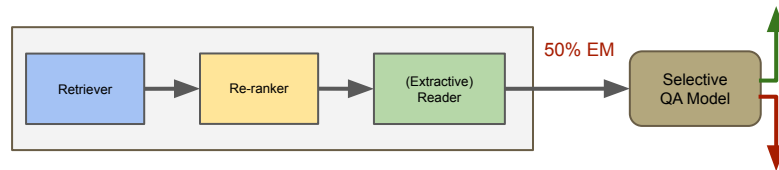
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Published: 24/05/2021 | Bloomberg News | NSN>>

Is this helpful? Yes No

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Iteration 2 - Features based on Reader embeddings	Crowdsourced in-domain	0.83	0.85	0.78
	Logged OOD	N/A	N/A	0.99
	Naturally asked (not in training)	0.83	0.54	0.66

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No.

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Factoid:

\$600 billion

Factoid question:

How much did G-20 countries subsidize fossil fuels?

Submit Cancel Error/Disk

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six months

in a refrigerator, AstraZeneca and J&J's are even easier to handle: they can be transported and stored at normal refrigerator temperatures until their expiry, which is up to six months for AstraZeneca. The Sinovac, Sinopharm and Covaxin vaccines can be stored in refrigerators for up to three years.

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Is this helpful? Yes No

Outline

- Context: Search @ Bloomberg
- Why QA now?
- Selective Question Answering
- **Takeaways and future work**

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Takeaways

- QA enabled by LLMs + PaaS + MLOps
- Selective QA enables early productionization and rapid iteration
- Most search settings are NOT Web-scale
 - a. Rely on crowdsourcing for data
 - b. Bootstrap a QA system
 - c. Use actual logged data

Ongoing & Future Work

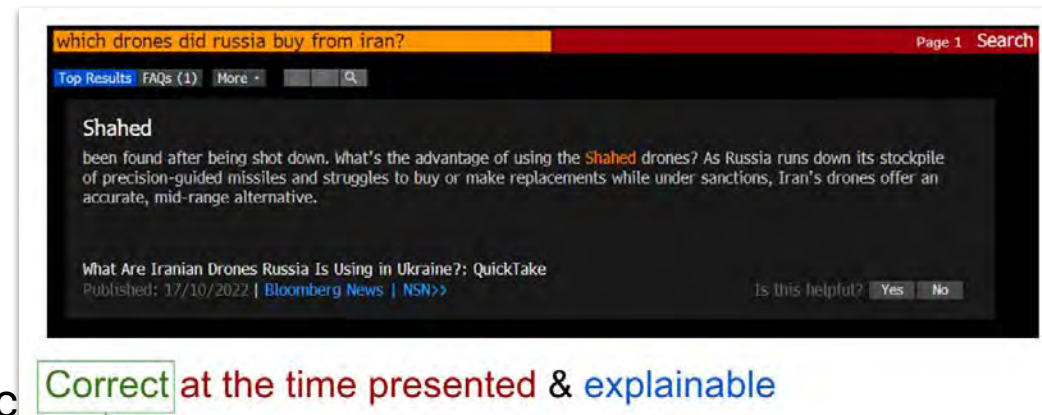
- Temporal dimension of QA

- Discovery for QA

How do you tell users that you do QA, and what you can/c

- Snippetting & explanations for QA

- Self-service QA (QAaaS)



REALTIME QA: What's the Answer Right Now?

Jungo Kasai^{♥*} Keisuke Sakaguchi^{♦*} Yoichi Takahashi[◇] Ronan Le Bras^{*} Akari Asai[♥]
Xinyan Yu[♥] Dragomir Radev[♥] Noah A. Smith^{♥*} Yejin Choi^{♥*} Kentaro Inui^{♦*}
[♥]Paul G. Allen School of CSE, University of Washington ^{*}Allen Institute for AI
[◇]Tohoku University [♥]Department of Computer Science, Yale University ^{*}RIKEN

Session: Applied - Language Models

CIKM '19, November 3-7, 2019, Beijing, China

Semantically Driven Auto-completion

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