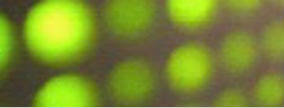


Automatic Natural Language Question Answering from Large Text Databases

Lance Ramshaw & Prem Natarajan
BBN Technologies
2009-10-05



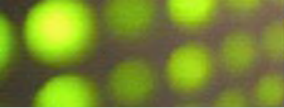
The Question Answering Challenge

- **“Find statements by Abu Abbas about hijacking”**
- **Google Query:**
 - *"Abu Abbas" statements hijacking*
- **Typical response:**
 - *Abu Abbas, a convicted Palestinian terrorist who masterminded the 1985 hijacking of the Italian cruise ship Achille Lauro on which a wheelchair-bound American was killed, was captured by U.S. Special Forces in the outskirts of Baghdad, U.S. Central Command said Tuesday.*
- **None of Google's first 50 responses displayed a relevant statement.**

Our System's Output

- **Find statements made by or attributed to Abu Abbas on hijacking**

- ✓ 1) *"He said at the time that the Achille Lauro hijacking was "part of the past" and a "mistake""*
- 2) *Abbas , whose exact age was not available but is believed somewhere between 55 and 62 years old , proved an exceptionally elusive quarry , slipping through the fingers of U.S. officials shortly after the hijacking .*
- ? 3) *"Having jumped on the peace camp bandwagon, he said on several occasions he wanted peace, although in his most recent statements to the media in October 2000, at the start of the Palestinian uprising, he pledged to resume attacks on Israel."*
- ✓ 4) *"Abbas repeatedly apologized for the slaying, saying his fighters had meant to attack Israel and only seized the ship after its crew discovered the terrorists' weapons."*
- 5) *Abbas to be released, saying his detention is illegal because of an immunity clause in the 1995 Oslo Peace Accords*



- **NLP Text Analysis (in BBN's SERIF system)**
 - Extraction Tasks
 - Linguistic Features
 - Machine Learning and Modeling Techniques
- **Question Answering**
 - Text Graph Similarity
 - System Description and Examples
- **Future Directions**

Extraction Tasks

Names & Other Mentions:

The founder of Pakistan's nuclear department Abdul Qadeer Khan has admitted he transferred the country's nuclear technology to Iran, Libya, and North Korea

Names:

Pakistan
Abdul Qadeer Khan
Iran
Libya
North Korea

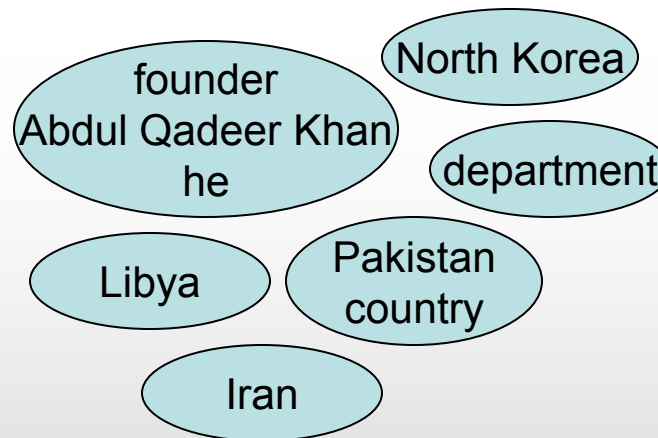
Other Mentions:

The founder of
Pakistan's nuclear
department

he

the country's nuclear
technology

Entities:



Relations & Events:

Relationship:

Organization-Location

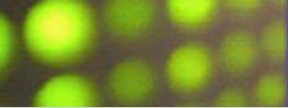
Argument-1: department

Argument-2: Pakistan

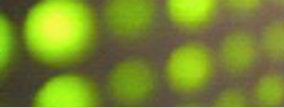
Event: Organization-Start

Argument-Founder: „founder’

Argument-Organization:
„department’

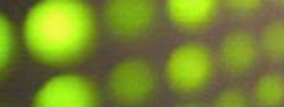


- **Seven target entity types (as defined in the ACE program)**
 - Person
 - Organization
 - GPE (GeoPolitical Entity)
 - Location
 - Facility
 - Vehicle
 - Weapon
- **Each entity mention has an extent and a head**
 - “the founder of Pakistan’s nuclear department”



- **Connections between two entities**
 - Can also have an optional time argument
- **18 specific categories**
 - Employment
 - Family
 - Located
 - ...
- **Examples:**
 - American president Barak Obama met with several governors on Friday.
 - Employment (“American”, “president”)
 - Mr. Obama returned to Washington today.
 - Located (“Obama”, “Washington”, “today”)

- **33 specific categories**
 - “Contact.Meet”
 - “Life.Marry”
 - “Conflict.Attack”
 -
- **Each event consists of a textual “trigger” and zero or more entity arguments**
 - American president Barak Obama **met** with several governors on Friday.
 - Contact.Meet (trigger: “met”, Agent: “Barak Obama”, Agent: “governors”, Time: “Friday”)
 - Mr. Obama **returned** to Washington today.
 - Movement.Transport (trigger: “returned”, Agent: “Mr. Obama”, Destination: “Washington”, Time: “today”)



LINGUISTIC FEATURES

Names

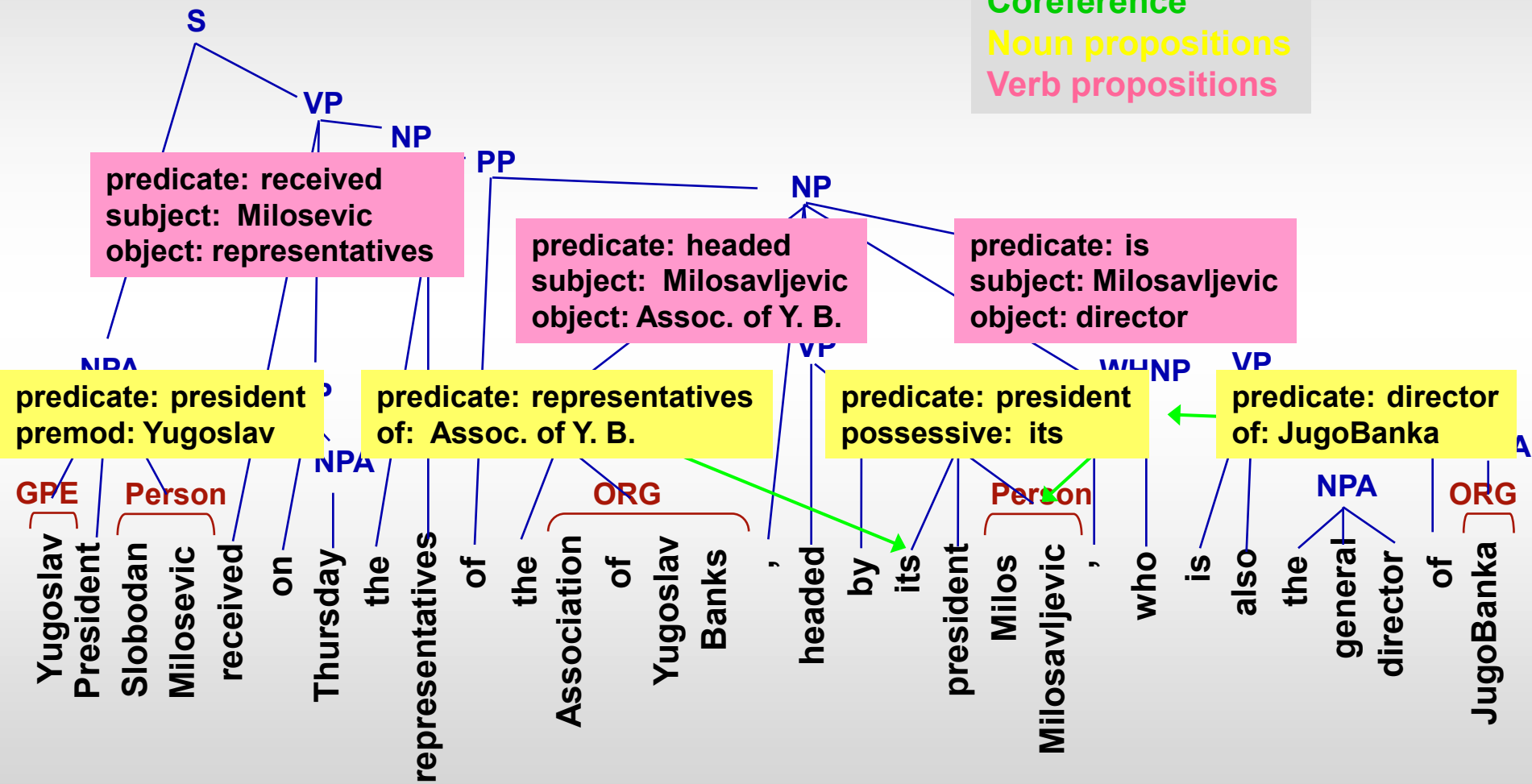
Syntactic Parses

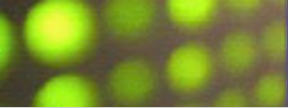
Coreference

Propositions

Levels of Linguistic Analysis

- Names
- Parse
- Coreference
- Noun propositions
- Verb propositions

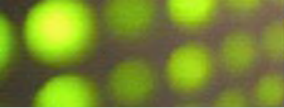




BBN Coreference

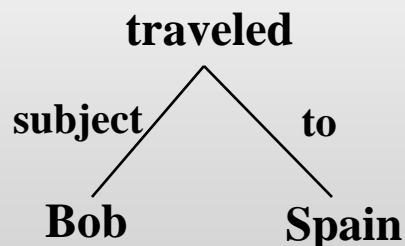
BBN
TECHNOLOGIES

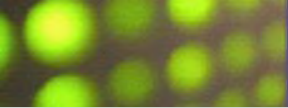
- **Goal: Cluster all mentions of people, organizations, etc., into real-world entities**
- **Process: For each mention in the document, decide whether to link it to a previously created entity or to create a new entity with this mention**
- **Coreference is essential for language understanding**
 - The sentence “They called him a dictator” is meaningless without coreference
 - “Iranian students called Ahmadinejad a dictator” contains real information



Propositions

- **Capture predicate argument structure**
 - Normalized from the parse
 - Identifies “logical” subject and object for passive verbs
 - “Cops arrested the thief” = “The thief was arrested by cops”
 - Identifies arguments of predicates (primarily verbs or nouns)
 - Resolves traces
 - In “she decided to take the job”, “she” is identified as the subject of both “decided” and “take”
 - Simple example: “Bob traveled to Spain”
 - Proposition: traveled<verb>(subject: X1, to: X2)





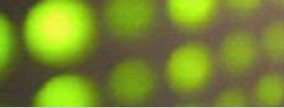
MACHINE LEARNING & MODELING TECHNIQUES

Feature-based Log Linear Models

Semi-Supervised Learning

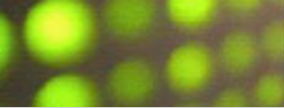
Cluster Features

Active Learning



Feature-Based Log Linear Models

- **Classifier models**
 - Trained using the averaged Perceptron method
- **Feature templates, applied to the training data, define the features for which the model learns weights**
 - Sample Name-Finding Features (PER.start, PER.cont, ...)
 - Current word and next word
 - “Motors” “announced” → ORG.cont
 - Current word, label of the previous word
 - “General”, <SentStart> → ORG.start
 - Sample Relation-Finding Features
 - Entity type of arguments and words between
 - ORG, PER, “s” → Employment
 - Entity type of arguments and head word of common ancestor
 - PER, ORG, “hired” → Employment



Semi-supervised Learning

- **Basic idea**
 - Raw, unannotated text contains vast amounts of data about language
- **Potential**
 - Provides an automatic way to smooth our models from word-based to back-off word-class features
 - Automatic adaptation to new data sources
- **Case Study: name extraction**

Automatic Word Clustering

- **Hypothesis:**
 - Words occurring in similar contexts refer to similar things
- **Criterion:**
 - Cluster words with similar distributions over their following words
 - Minimize average future entropy of a bigram class model (similar to Brown et al, 1990)

*Example Clusters from
100M words of WSJ*

First Names?
John
Consuelo
Jeffrey
Kenneth
Phillip
WILLIAM
Timothy
Terrence
Jerald
Harold
Frederic
Wendell

Occupations?
lawyer
newspaperman
stewardess
toxicologist
slang
babysitter
conspirator
womanizer
mailman
salesman
bookkeeper
troubleshooter

Active Learning

- **Goal: Use the human annotators efficiently**
 - Not reannotating instances that the model already knows
- **An initial keyword-based annotation phase**
 - User supplies a list of examples
 - System selects sentences containing those words for annotation
- **Repeated active learning phases**
 - System trains a model on all sentences annotated so far
 - This discriminative model combines word cluster features with the training examples.
 - System selects a new batch of sentences for annotation that contain instances that the model is maximally unsure about

Entities: (8)

- (E) Person
- (R) Organizatio
- (G) Geopolitica
- (X) Geographic
- (V) MonetaryV
- (D) Date
- (F) Constructio
- (T) Time-Quan

For the past year or two, the carpet division's operating profit margins have hovered around 5 %, high by industry standards, but disappointing compared with the 13 % to 19 % margins for two of Armstrong's chief businesses, flooring and building products. Analysts hailed the planned transaction as being beneficial to Armstrong and Shaw, the market leader in the U.S. carpet industry, with an estimated 17 % to 20 % share. Shaw, based in Dalton, Ga., has annual sales of about \$ 1.18 billion, and has economies of scale and lower raw-material costs that are expected to boost the profitability of Armstrong's brands, sold under the Armstrong and Evans-Black names. Yesterday, in composite trading on the New York Stock Exchange, Shaw's shares closed ex-dividend at \$ 26.125, up \$ 2.25. Armstrong's shares, also listed on the Big Board, closed at \$ 39.125, up 12.5 cents.

(Q) Clear

Move to Inbox

Move to Outbox

Example Sentence in Context, automatically tagged

Annotation Classes

Inbox: (44)

Shaw, based in Dalton, Ga., has annual sales of about \$1.18 billion. Then, as if to show that he could play fast as well, he offered COMMERCIAL PAPER placed directly by General Motors. The SEC will probably vote on the proposal early next year. Mr. Agnelli and the Aga Khan also have some business ties. For instance, Fiat earlier this year bought an 18 % stake in the chain of diners at my table simply lit more Gauloises and scoffed. Six years ago, Judge O'Kicki was voted president of the Ford is "in the driving seat at the moment," observed Bill In "The Cuckoo's Egg" (Doubleday, 326 pages, \$14.95). Mitsubishi Estate ended the day at 2680, up 150. Moody's Investors Service Inc. said it lowered the rating on the company. Years ago, he collaborated with the new music gurus Peter Dinklage. "The SEC has historically paid obeisance to the ideal of

Outbox: (6)

Total this session: (6)

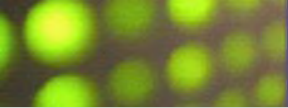
I was a last-minute (read interloping) attendee at a French dinner. That's because when Coke looks to the Pacific area, it sees Citicorp also said that the average rate rose to 8.0087 % at the end of the year. The Teachers Insurance and Annuity Association-College Retirement Fund "Deep Peace" also featured a slide show of lovely but preposterous photos. At the same time, they contend that a reduction of NATO forces

List of Sentences to Review

Command to Retrain Model and Select New Sentences via Active Learning

List of Completed Sentences

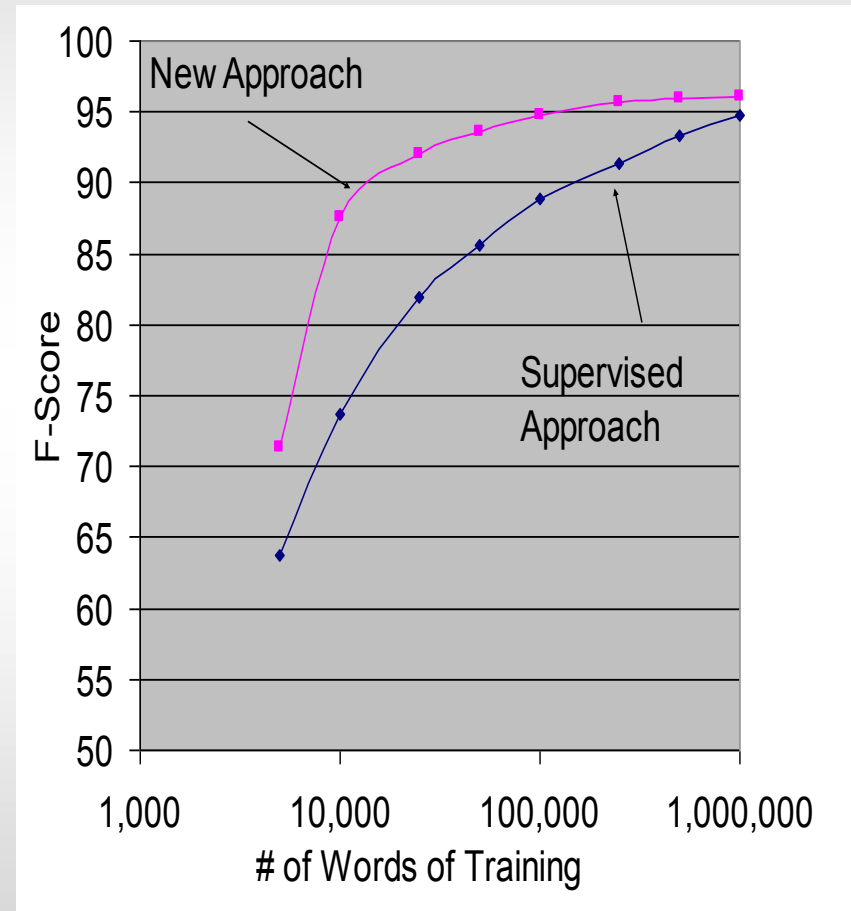
Train | Retrain model from file... | Exit



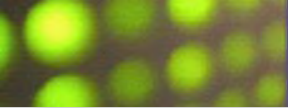
Benefit from Clusters and Active Learning

- **Combine**
 - Small supervised training with massive amounts of unsupervised training
 - Clustering of 100M words of WSJ
 - Active learning
 - To maximize impact of early training data
- **Effect**
 - 25% reduction in error compared to well-trained HMM
 - 1/8th the supervised training (~3 hours) to achieve F of 90

Name Extraction



Annotation rate: 5,000 words/hour.

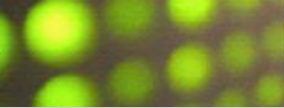


QUESTION ANSWERING

Distillation task within the DARPA GALE program

Distillation as Question Answering

- **The goal of Distillation is to provide accurate and non-redundant responses to user queries**
 - Using techniques that go far beyond keyword search
- **For each user query, Distillation must return specific, relevant, non-redundant snippets of text**
 - Rather than links to often-repetitive documents that must be manually searched for relevant information
- **For instance:**
 - Query: List facts about plots or attacks against US soldiers in Kuwait
 - System Responses:
 - Al-Qaeda-linked militants who over the past month fought four bloody gunbattles with Kuwaiti security forces had plotted to kidnap and execute US soldiers and Westerners, a newspaper reported Saturday [2005-02-05].
 - A US Marine was killed and another wounded in an attack by two Kuwaiti gunmen on Failaka island, east of the capital, in October 2002.



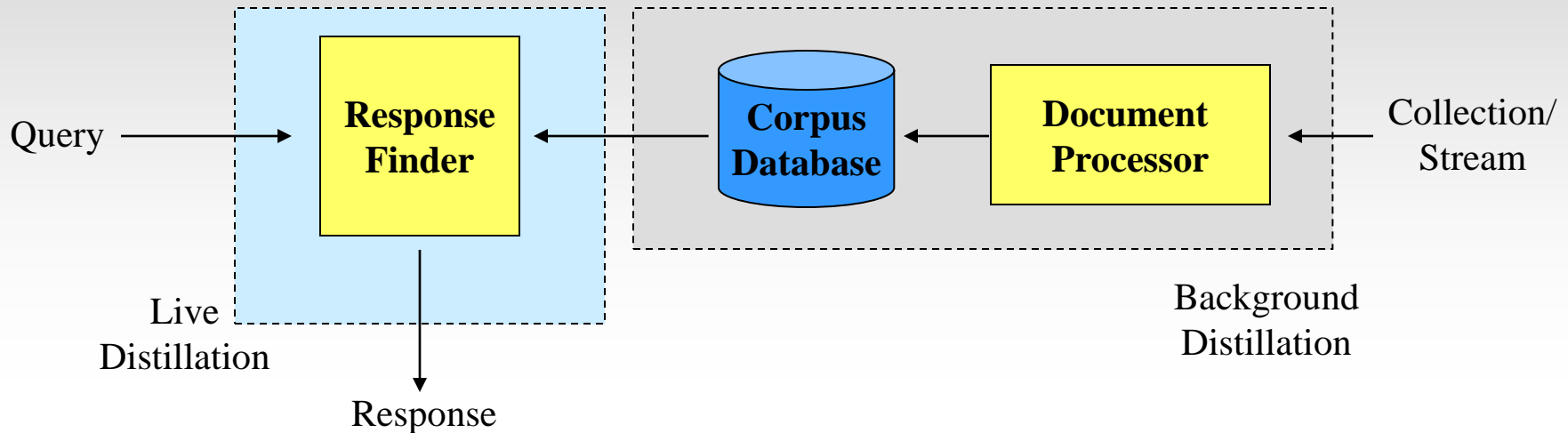
Distillation Approach

- **Automatically detect linguistic features in the question and in potential answer passages**
 - Linguistic features will help to identify relevant texts in each source language
 - Linguistic features are also the key to condensing the retrieved texts into a concise partial answer
- **Use trainable algorithms from the SERIF NLP system to do the linguistic analysis**

Distillation: Redundancy Removal

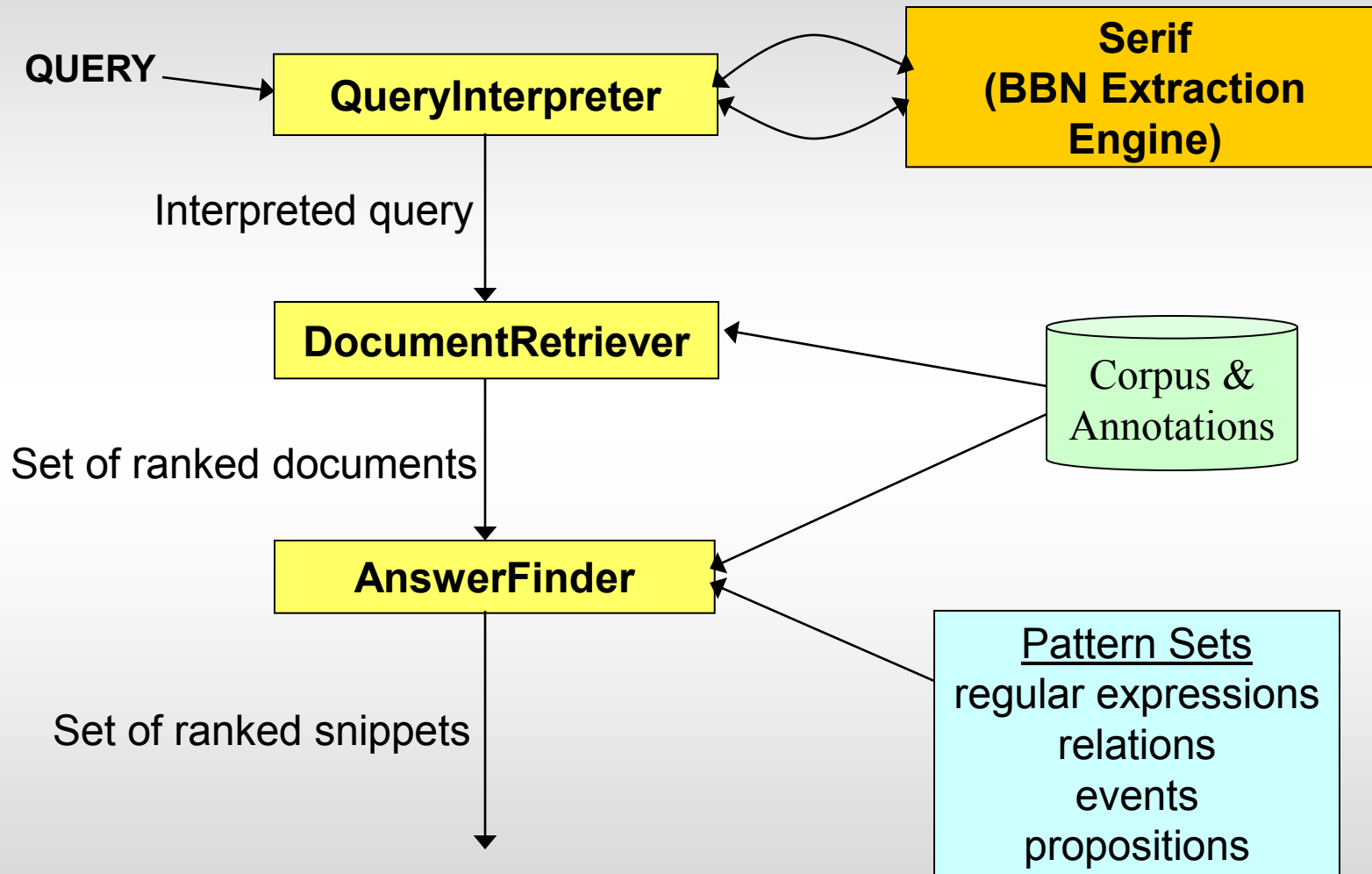
- **Redundant information must be identified and removed**
- **But redundant information is still potentially important to the end user**
 - A piece of information reported by 10 sources may be more reliable than a piece of information reported only once
 - So each piece of redundant information removed is reported as supporting evidence in the appropriate place
- **Example:**
 - Query: List facts about attacks against US soldiers in Kuwait
 - Response: A US Marine was killed and another wounded in an attack by two Kuwaiti gunmen on Failaka island, east of the capital, in October 2002. ([document 3621](#))
 - *Supporting evidence*: two Kuwaiti gunmen killed a US marine and wounded another during wargames on Failaka island, 20 kilometres (12 miles) east of the capital ([document 455](#))

Distillation System Architecture



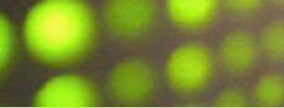
- **All corpus documents are preprocessed (by Serif) and stored in a database**
- **During live distillation, the Response Finder analyzes the user query and generates relevant response snippets from the corpus database**
- **Sophisticated linguistic analysis (done in preprocessing) is the key to providing results superior to keyword search**

Live Distillation Architecture



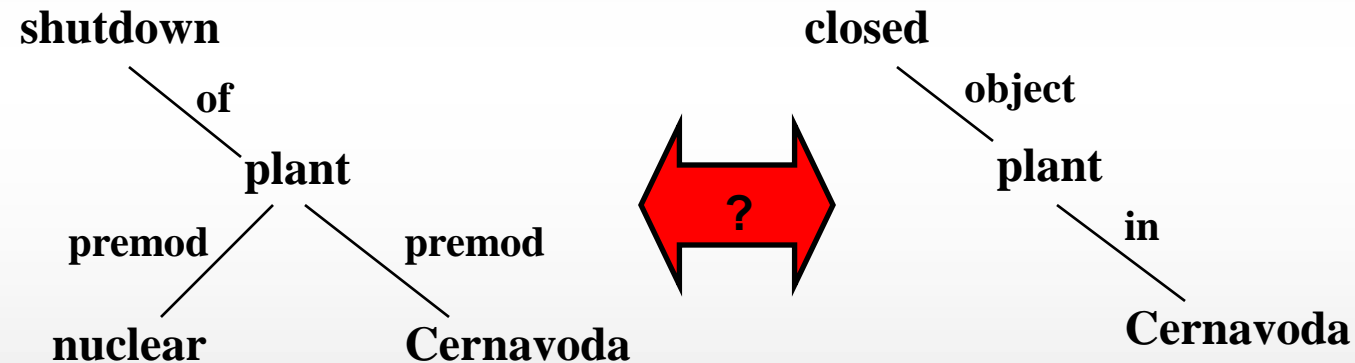
Interpreting the Query

- **Serif extraction engine identifies entities, relations, events, parses, and propositions for the query**
- **Example: List facts about [attacks against US soldiers in Kuwait]**
 - GPE name: US
 - GPE name: Kuwait
 - PERSON descriptor: soldiers
 - Employment Relation: “US”, “US soldiers in Kuwait”
 - Location Relation: “US soldiers in Kuwait”, “Kuwait”
 - Conflict.Attack event: “attacks”, Victim: “US soldiers in Kuwait”
 - Proposition: (noun: attacks, against: soldiers)
 - Proposition: (noun: soldiers, premod: US, in: Kuwait)
 - Parse: (not shown)



Matching the Query to Candidate Texts

- We represent the logical structure of both the query and the documents using “text graphs”, assembled from the propositions derived from the parse
 - Nodes are predicates or arguments; branches are “roles”

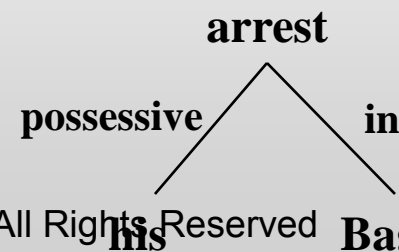


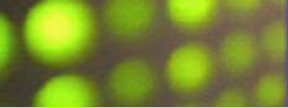
**The shutdown of the Cernavoda
nuclear plant**

**The plant in Cernavoda was
closed**

Text Graph Generation

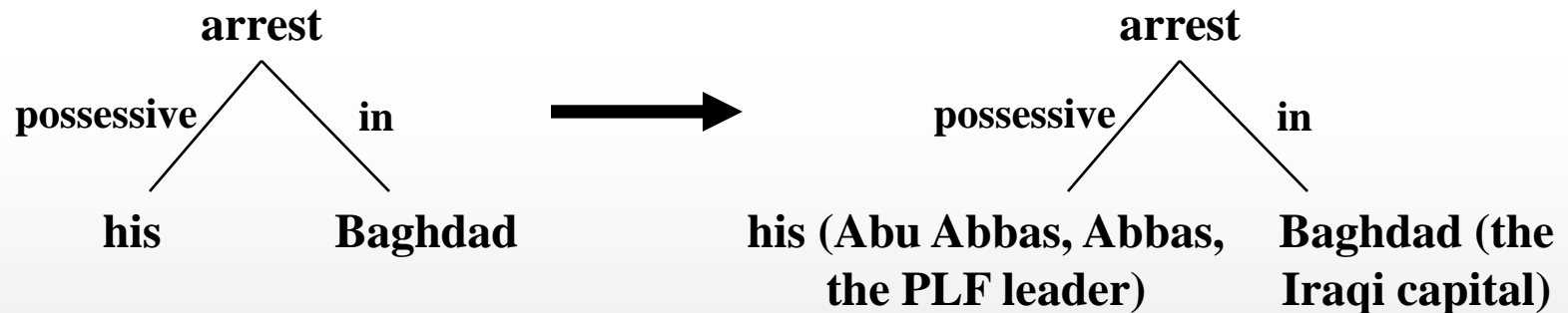
- **Syntactic parser generates parse tree for each sentence**
- **Proposition finder transforms parses into simple predicate-argument propositions**
 - Each proposition consists of a noun/verb predicate and zero or more arguments, each with a “role” label
 - Identifies logical subject and logical object as roles
 - Prepositional roles are not resolved/analyzed (role label remains “of”, “in”, “at”, etc.)
 - This process includes trace resolution
- **Connected propositions are combined into text graphs**
- **A set of text graphs is created for each sentence**
- **Example: “his arrest in Baghdad”**

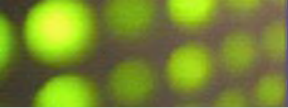




Text Graph Augmentation (1)

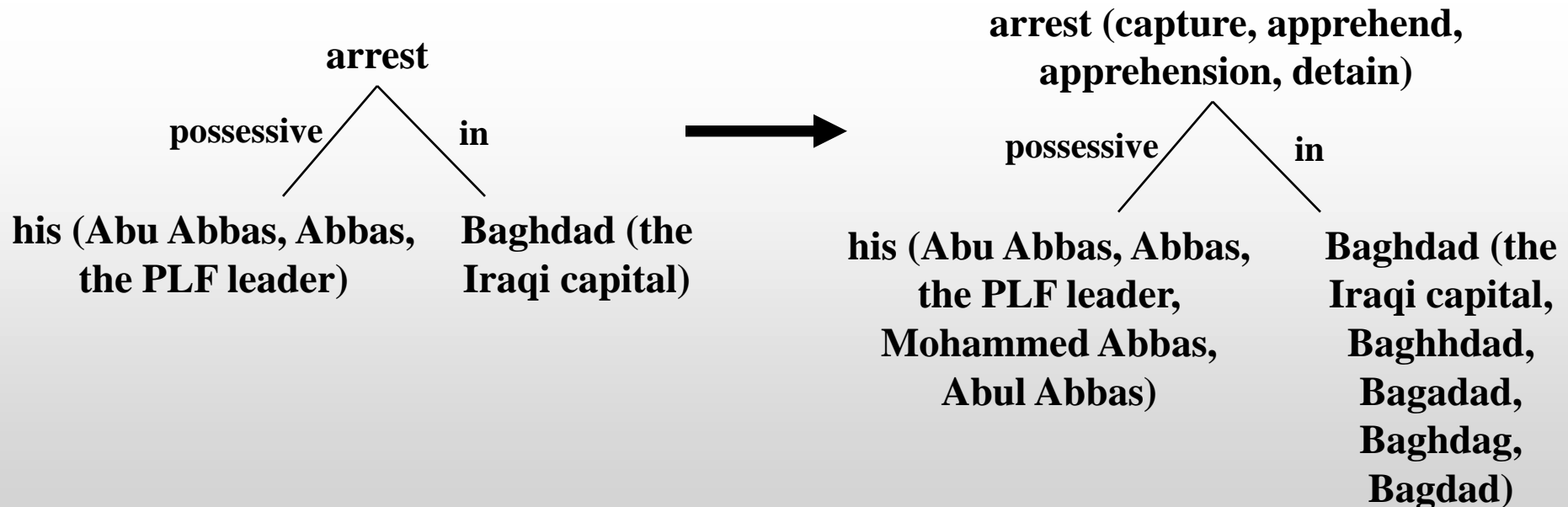
- **Automatically supplement text graphs with names or descriptors obtained through in-document coreference**
- **Example: “his arrest in Baghdad”**

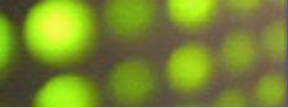




Text Graph Augmentation (2)

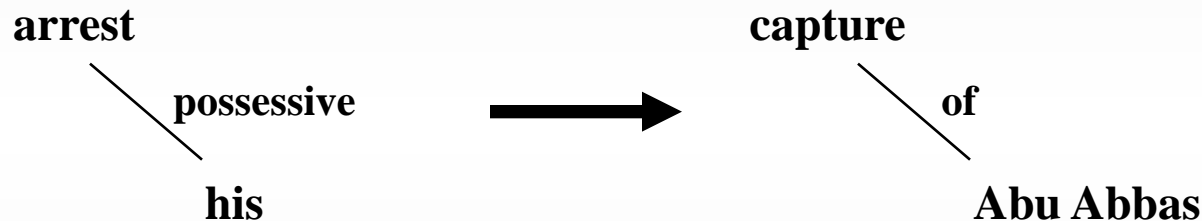
- **Automatically supplement all text graphs with synonyms**
 - WordNet
 - Nominalization table
 - BBN “equivalent name” algorithm
 - Misspellings, transliteration variants, aliases , acronyms



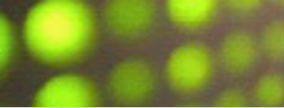


Text Graph Similarity Scoring

- **Two text graphs are similar if one can be transformed into the other at minimal cost**
- **Sample query argument: “the capture of Abu Abbas”**
 - Is “his arrest” similar to “the capture of Abu Abbas”?



- Substitution (synonym): arrest → capture
 - Substitution (label): possessive → of
 - Substitution (coreference): his → Abu Abbas
- **Match score for these two trees: ~75%**
 - Despite zero percent token overlap



Scoring: Cost Structure

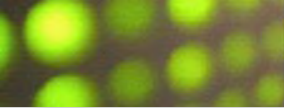
- **Different tree transformations have different costs**
- **The cost for replacing a word with its synonym is based on the estimated reliability of the synonym**
 - “United Nations” → “UN” is very reliable
 - “plant” → “works” is less reliable
- **Certain role substitutions are more costly than others**
 - Changing the role from “in” to “premodifier” is cheap
 - “the plant in Cernavoda” → “the Cernavoda plant”
 - Changing the role from “in” to “by” is expensive
 - “the attack in Iraq” → “the attack by Iraq”
- **The cost for omitting a word/phrase increases the closer the word/phrase is to the root of the text graph**
 - Because it causes a larger subtree to be omitted
 - In “the shutdown of the Cernavoda nuclear plant”, “nuclear” can be omitted more easily than “plant”

Scoring: Additions/Omissions

- **Matching of text graphs is actually non-symmetric**
 - Example: “the shutdown of the Cernavoda nuclear plant”
 - “The shutdown of the Cernavoda nuclear plant by the authorities” is perfectly relevant with respect to this query argument
 - “The shutdown of the plant” is not
 - When comparing query topic to candidate response, use only one direction of similarity
 - When comparing two candidate responses for redundancy, look at both
- **Names can only be omitted if they appear somewhere else nearby in the document (i.e. are still in focus)**
 - Eliminates matches to “the shutdown of the nuclear plant” when the document is about Chernobyl rather than Cernavoda

Scoring: Examples

- **QUERY: “The arrest of Abu Abbas in Iraq”**
 - The US arrest of Palestinian hardline leader Abu Abbas in Baghdad (0.872619)
 - The capture of Abu Abbas in Iraq (0.8)
 - Abbas' capture in Iraq by U.S. military forces (0.739286)
 - the exile Palestinian radical leader who was arrested near Baghdad in Iraq (0.733333)
 - Abu Abbas was arrested by US troops near the Iraqi capital of Baghdad. (0.686905)
 - US troops on Tuesday captured Abu Abbas (0.615476)



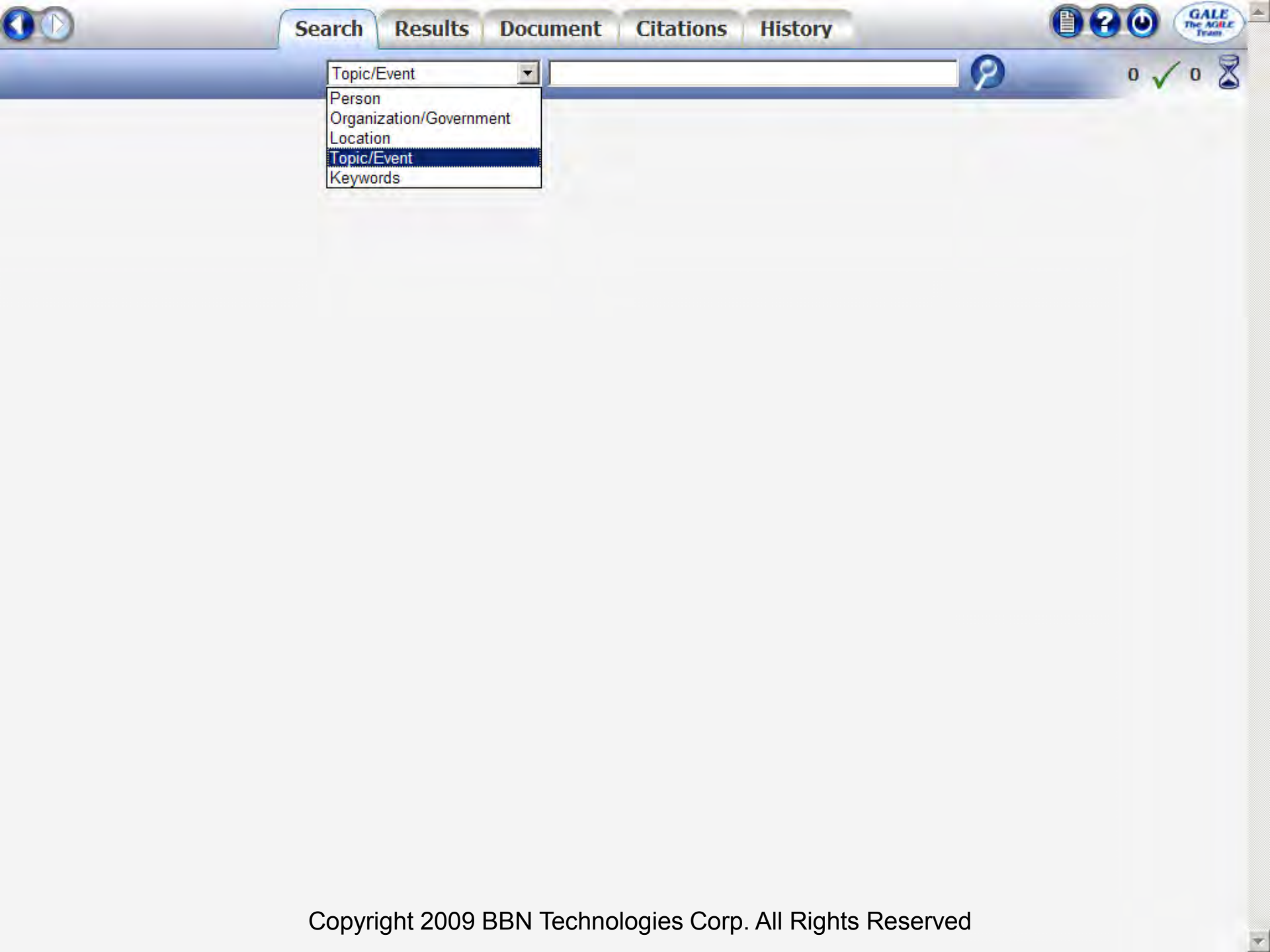
Notes on Text Graphs

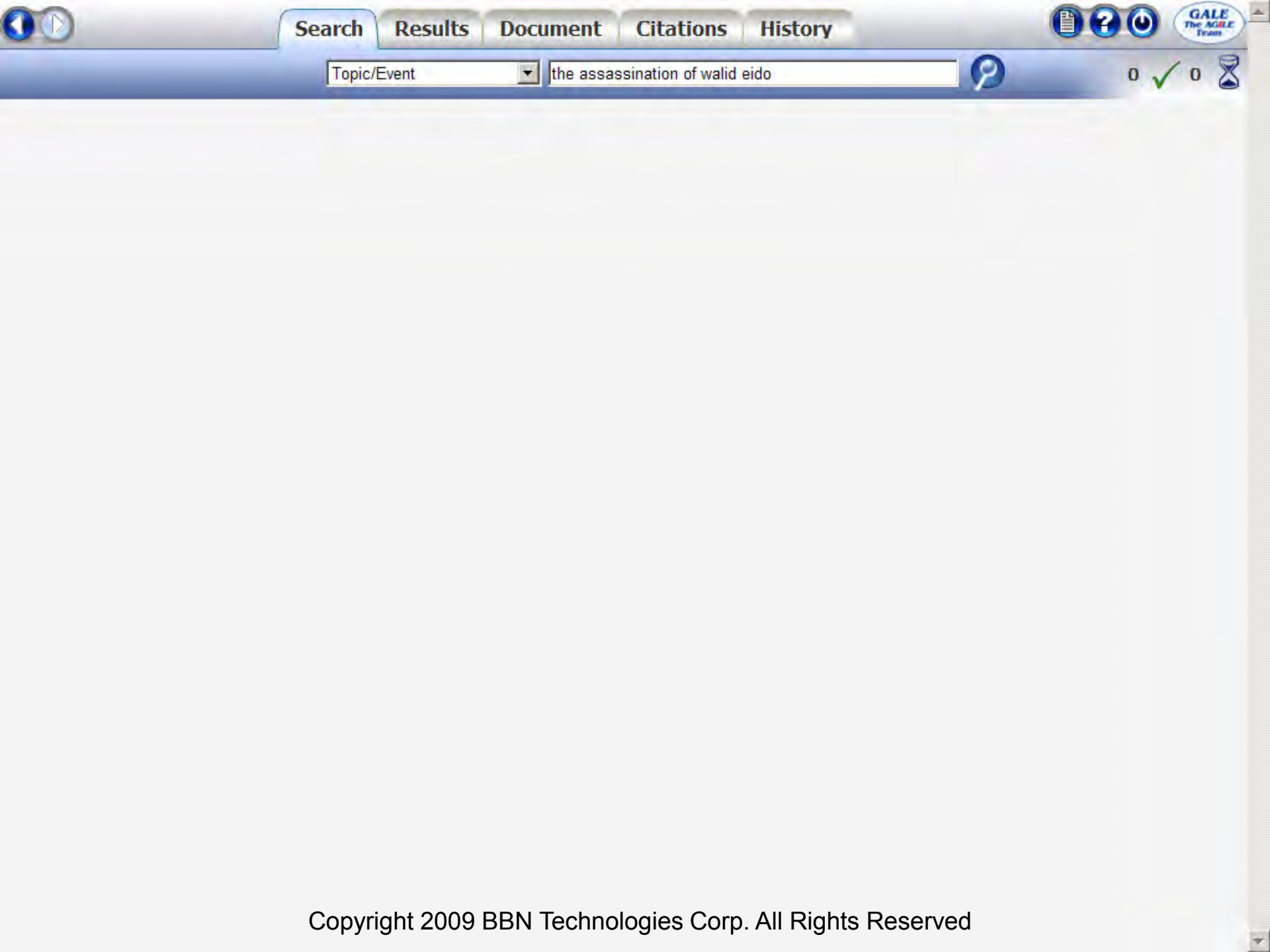
- **Text graphs represent shallow semantic structure**
 - Not a complete logical representation of the document
- **Strengths of text graph representation**
 - Shallow semantics allow us to do matching without tackling deeper challenges of logical form (e.g. quantifier scope)
 - Matching is relatively robust when dealing with poorly formed or unexpected language
 - Used successfully over blogs, STT output, MT output
 - Generation is fast
 - Full extraction processing runs at 320 words/second

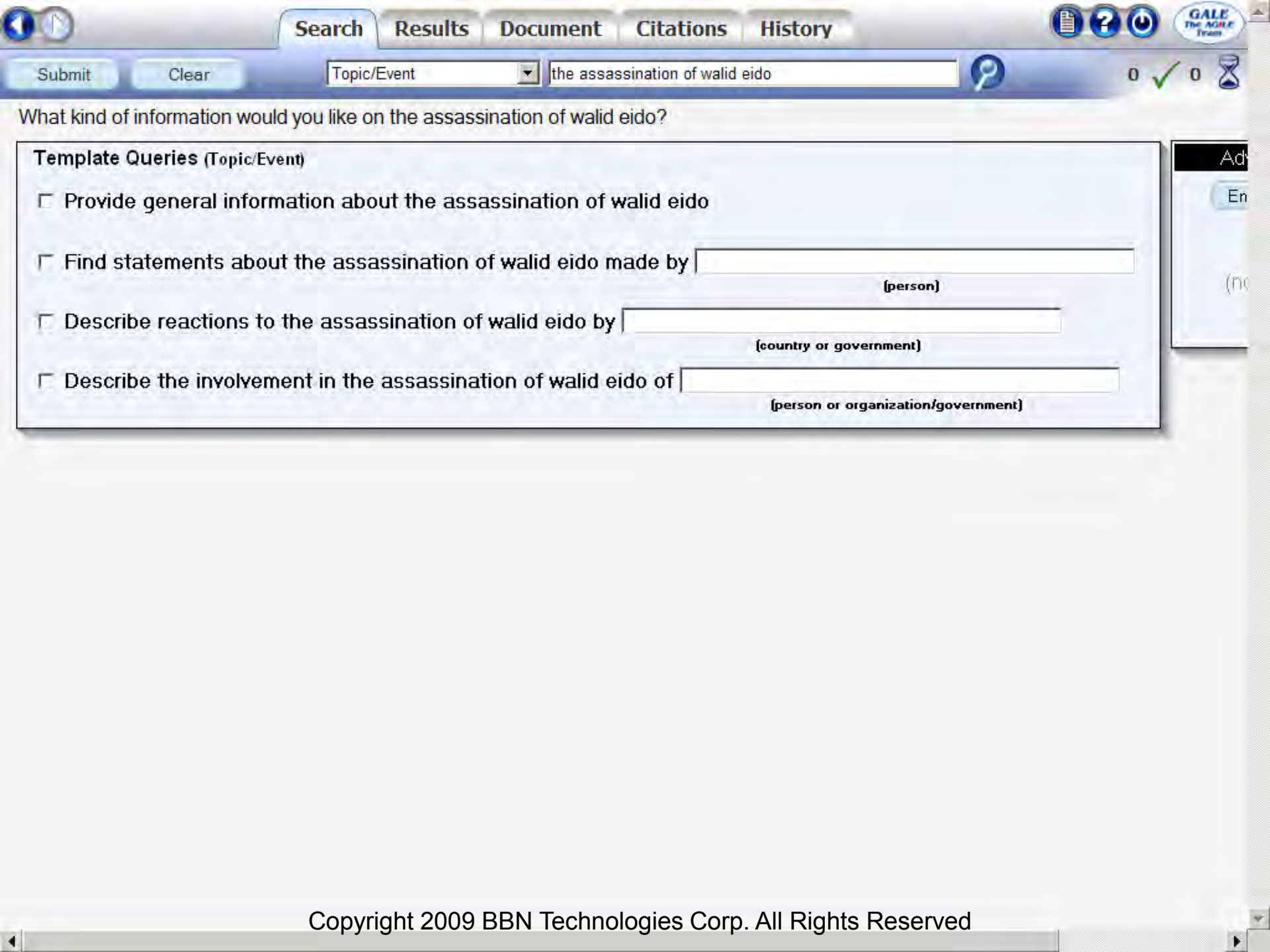
Distillation Evaluation

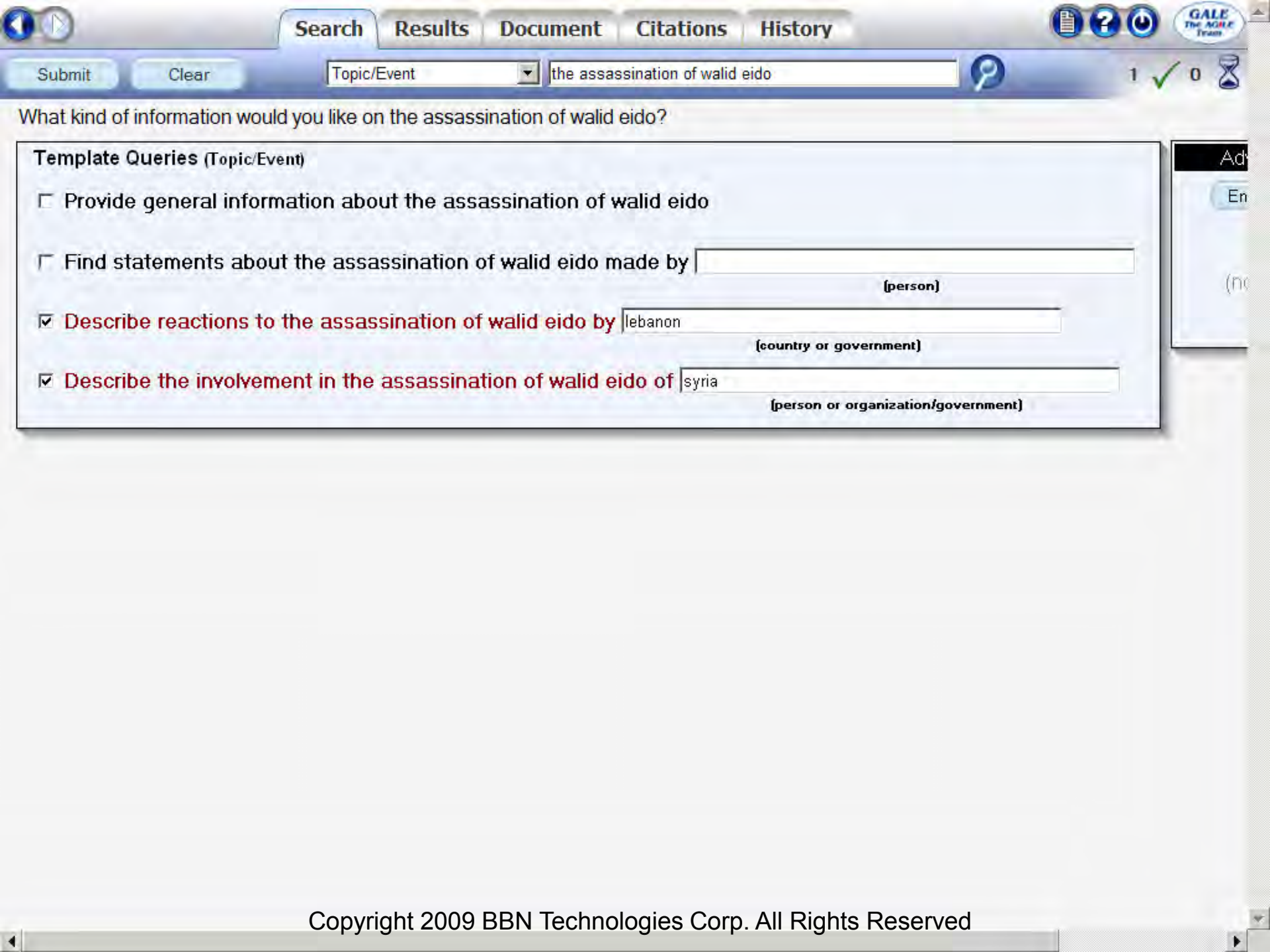
- **BBN (AGILE) was the top performing system when averaged across the 3 languages**

Language	# Questions	AGILE Scaled-F	Average System Scaled-F	Average Human Scaled-F
Arabic	17	19.9	14.5	25.8
Chinese	17	17.5	9.7	29.7
English	17	29.0	23.0	38.5









Submit

Clear

Topic/Event

the assassination of walid eido



1 ✓ 0 ⌚

What kind of information would you like on the assassination of walid eido?

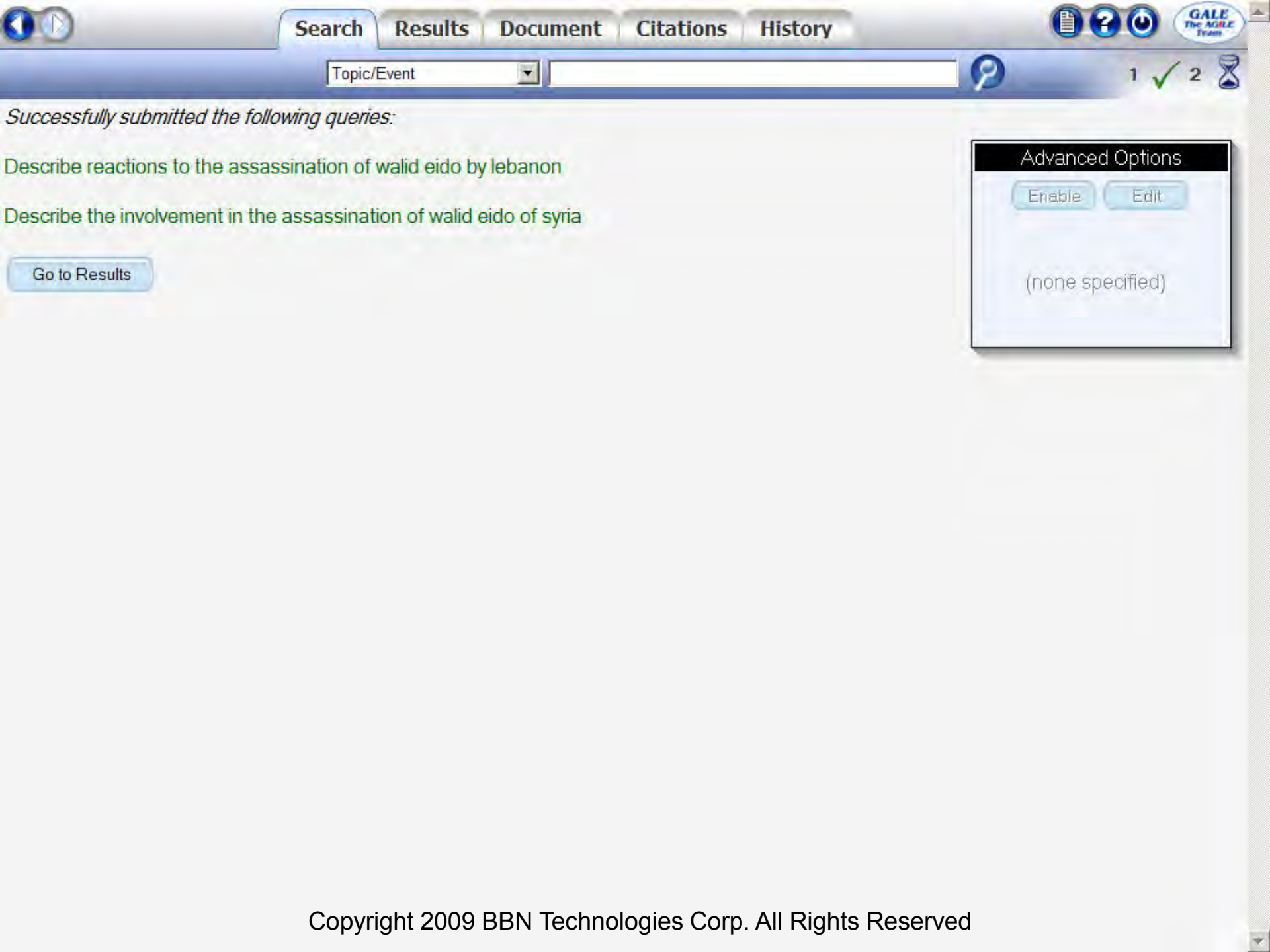
Template Queries (Topic/Event)

Provide general information about the assassination of walid eido

Find statements about the assassination of walid eido made by []
(person)

Describe reactions to the assassination of walid eido by [lebanon]
(country or government)

Describe the involvement in the assassination of walid eido of [syria]
(person or organization/government)



Search

Results

Document

Citations

History

Topic/Event

1 ✓ 2 ✓ ⌚

Successfully submitted the following queries:

Describe reactions to the assassination of walid eido by lebanon

Describe the involvement in the assassination of walid eido of syria

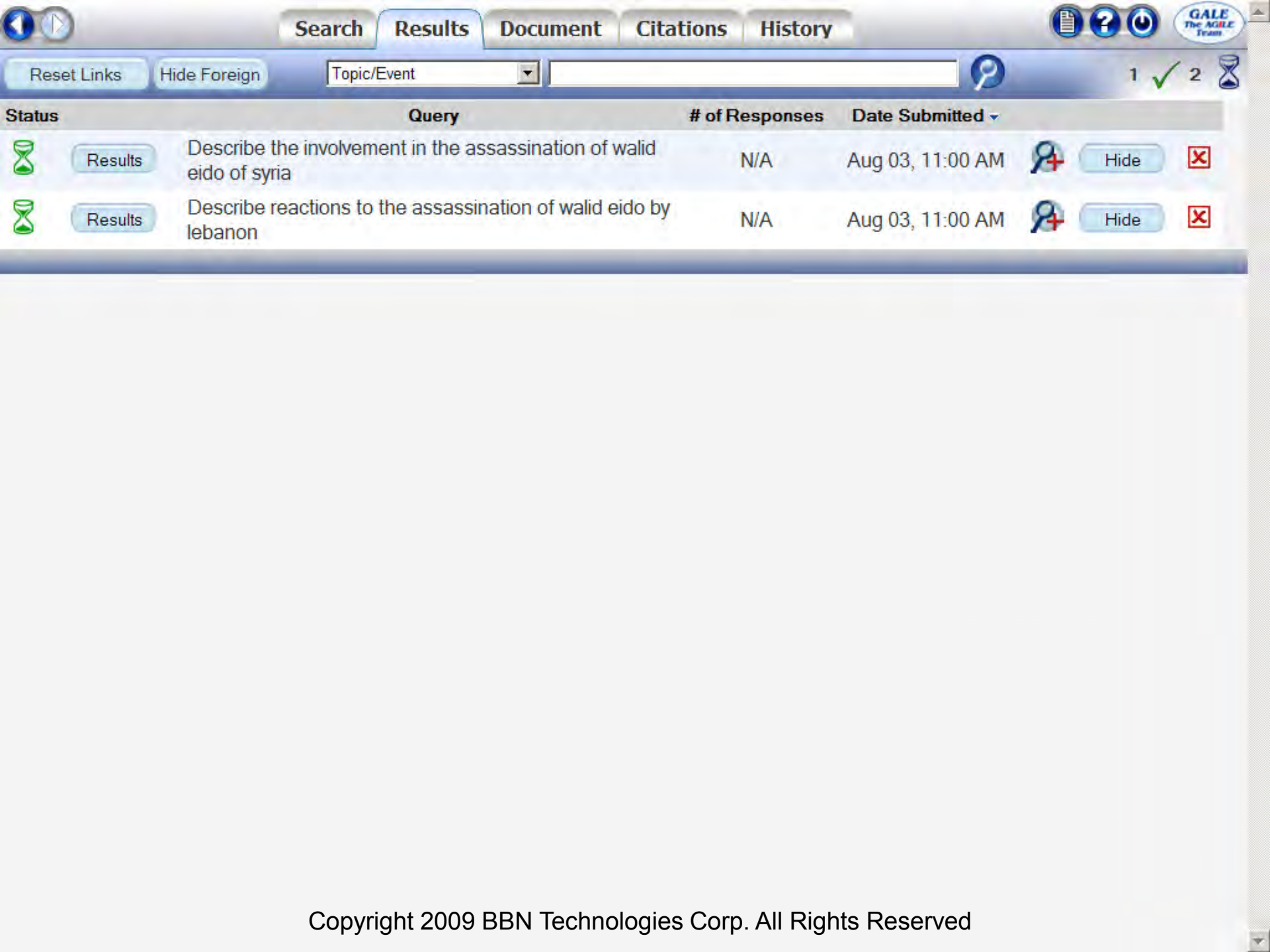
Go to Results

Advanced Options

Enable

Edit

(none specified)



Search

Results

Document

Citations

History



Reset Links

Hide Foreign

Topic/Event



1 ✓ 2 ⌚

Status	Query	# of Responses	Date Submitted
Results	Describe the involvement in the assassination of walid eido of syria	N/A	Aug 03, 11:00 AM
Results	Describe reactions to the assassination of walid eido by lebanon	N/A	Aug 03, 11:00 AM

Status	Query	# of Responses	Date Submitted
✓ Results	Describe the involvement in the assassination of walid eido of syria	23	Aug 03, 11:00 AM
✓ Results	Describe reactions to the assassination of walid eido by lebanon	20	Aug 03, 11:00 AM

Describe reactions to the assassination of walid eido by lebanon

Rank ▲	Additional	Response	Document ID	Date
1		He [Fouad Siniora] also called on the United Nations for security and technical assistance to help uncover the perpetrators of the crimes taking place in Lebanon and expanding the international investigation to include Eido's assassination.	eTAB306165	Jun 14, 2007 +Cite
2		Lebanon's Prime Minister Fouad Siniora asked on Wednesday [2007-06-20] for the special meeting, just hours after MP Walid Eido was murdered by a seafront bomb.	eTAO300517	Jun 17, 2007 +Cite
3		Lebanon is saying its final goodbye Thursday [2007-06-14] to anti-Syrian MP Walid Eido, 65, his son, and two of his bodyguards killed in a car bombing yesterday [2007-06-13].	eTAB306165	Jun 14, 2007 +Cite
4		Lebanese Prime Minister Fouad Siniora called for the crisis meeting to discuss Wednesday [2007-06-13]'s assassination of March 14 MP Walid Eido and other security issues.	eTAB305215	Jun 15, 2007 +Cite
5		He [Marouf Al Bakhit] expressed Jordan's condemnation of the heinous crime of assassination which killed MP Walid Eido recently.	eTAB295682	Jun 18, 2007 +Cite
6		Shocked by the assassination of 65-year-old MP Walid Eido Wednesday evening [2007-06-13TEV], Lebanese President Emile Lahoud called on his people to unify their ranks in the face of enemies targeting Lebanon's	eTAB314236	Jun 13, 2007 +Cite

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Navigation: Search Results Document Citations History

Buttons: Add Citation Hide Foreign

Search: Topic/Event

Counters: 0 ✓ 0

Source: Worldwide Open-source News (English/NewsWire)

Date: Jun 14, 2007

Document ID: eTAB306165

Views: Selected Response

The capital is shut down as the country observed a national day of mourning. Beirut's streets were full of crowds of mourners and an increased security presence despite most businesses and schools being closed.

The bodies, shrouded in a Lebanese flag, will be buried in a Beirut cemetery later today.

Lebanese Prime Minister Fouad Siniora called yesterday for an extraordinary meeting of Arab foreign ministers to take charge of its responsibilities towards Lebanon and the security of its citizens.

He also called on the United Nations for security and technical assistance to help uncover the perpetrators of the crimes taking place in Lebanon and expanding the international investigation to include Eido's assassination.

The March 14 Alliance called yesterday for elections to fill the two empty seats left behind by the two assassinated MPs Pierre Gemayel, who was killed last November, and Walid Eido.

The alliance said President Emille Lahoud was responsible for stalling these elections and was now considered a partner in these crimes.

Eido's assassination comes a few days after the international tribunal was established. The car bombing followed a series of five bombings that happened in less than a month.

[Description of Source: Kuwait KUNA (Internet Version WWW) in English Official news agency of the Kuwaiti Government]

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Source: Worldwide Open-source News (English/NewsWire)
Date: Jun 14, 2007
Document ID: eTAB306165

- Views: All Named Entities
- Person
 - Organization
 - GeoPoliticalEntity
 - Location
 - Facility
 - Weapon
 - Vehicle

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- Views: By Named Entity...
Person (4): Walid Eido, Fouad Siniora, MPs Pierre Gemayel, Emille Lahoud
Organization (3)
GeoPoliticalEntity (5)
Location (0)
Facility (0)
Weapon (0)
Vehicle (0)

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Date: Jun 14, 2007
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Views: Plain Text [dropdown]

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Citations from this document:

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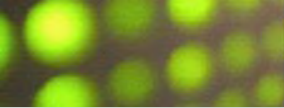
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- 17 The Lebanese government has called on the Council of Arab foreign ministers to convene an extraordinary, it also asked the international investigation committee into the assassination of former Prime Minister Rafik Al Hariri include its assassination Eido.
 ودعت الحكومة اللبنانية مجلس وزراء الخارجية العرب للانعقاد استثنائيا، كما طلبت من لجنة التحقيق الدولية في اغتيال رئيس الوزراء السابق رفيق الحريري أن تشمل بعملها اغتيال عيدو.
- 18 On the other hand, the Lebanese government responded to the assassination of deputy Walid Eido announcement of confrontation is a call for early parliamentary elections subsidiary to fill the seats of MPs Walid Eido, who was assassinated the day before yesterday [2007-06-16], Pierre Gemayel, who was assassinated in November [2007-11] (November [2007-11]).
 ومن جانبها، ردت الحكومة اللبنانية على عملية اغتيال النائب وليد عيدو باعلان قرار مواجهة يتمثل بالدعوة الى إجراء انتخابات نيابية فرعية لملء مقعدي النائبين وليد عيدو الذي اغتيل اول من امس وبيار الجميل الذي اغتيل في نوفمبر (تشرين الثاني) الماضي.
- 19 In another development, an official source confirmed yesterday [2007-06-15] that the Lebanese government will reconvene today [2007-06-16] to hold elections subsidiary parliamentary seats vacant after the assassination of two of the anti-Syrian majority are Walid Eido, Pierre.
 وفي تطور آخر أكد مصدر مسئول أمس أن الحكومة اللبنانية ستدعو اليوم الي إجراء انتخابات نيابية



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