Graphical AKR

- AKR (Abstract Knowledge Representation)
  - Developed at PARC
  - Sharp separation of conceptual, contextual, and other structures

- Graphical AKR
  - Socialize AKR with computer scientists
  - Comprises conceptual, contextual, and other graphs
    - Separate but linked and interacting graphs
  - Readily extendible to incorporate other sub-graphs of information
    - E.g. task models, frames, dialog states
  - Easy to ignore certain levels of information

- Grand vision
  - A semantic representation that bridges natural language inference and formal knowledge-based reasoning

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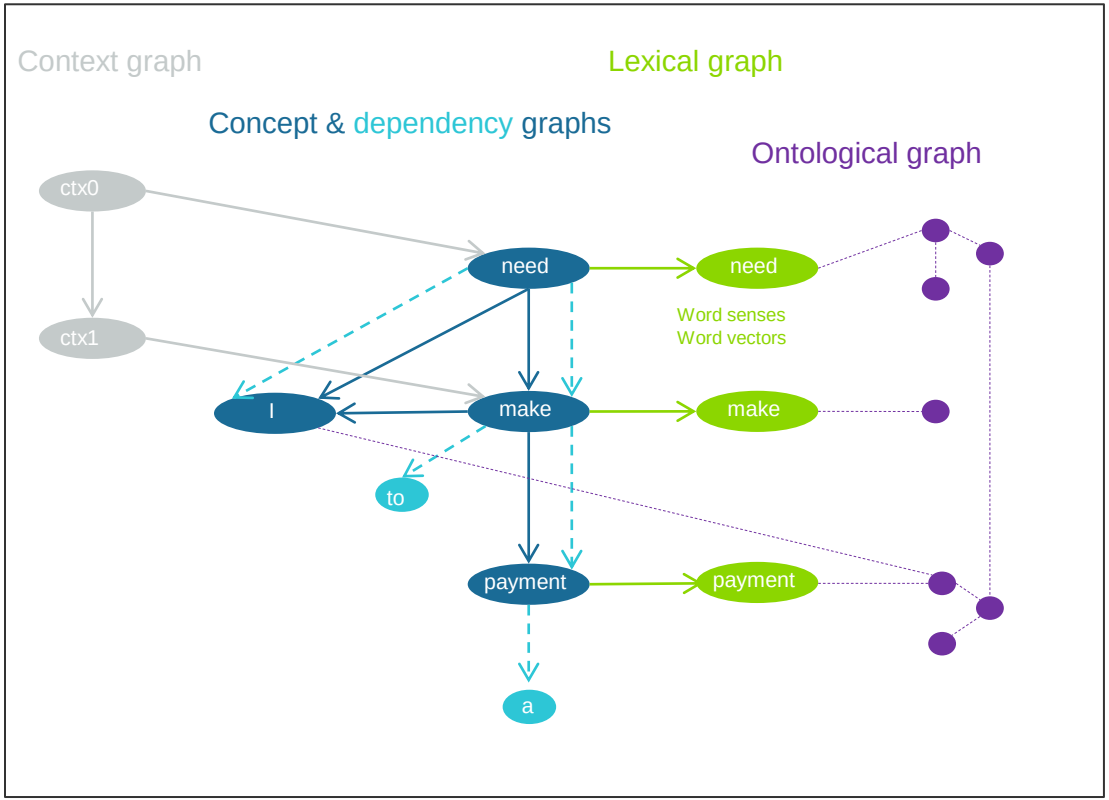
Example: *I need to make a payment*



- Concept Graph
  - Predicate-argument structure
- Context Graph
  - Scope & modality
- Lexical Graph
  - Word senses/vectors
- Property Graph
  - Determiners, tense
- Link Graph
  - Coreference

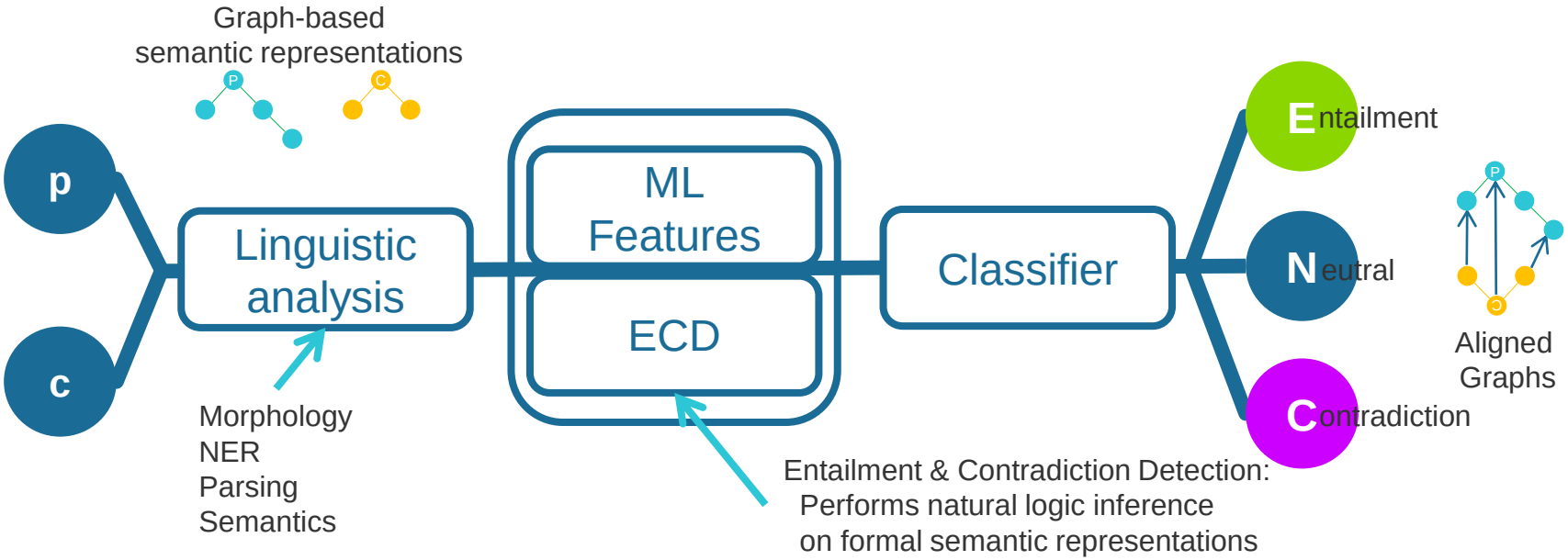
Basic Graph Semantics

Concept graph is a description logic restriction structure
- Graph carries no existential commitment
- Nodes denote concepts (not individuals)
- Arcs represent concept restrictions
- Property graph arcs (to determiners, tense) represent further restrictions

Context graph
- Imposes existential commitment by saying whether head concepts are instantiable
- Context structure induced by
  - Connectives (not, or, if)
  - Mood & modals
  - Clausal complements
  - Distributivity (aka quantifier scope)

Approach to NL Inference

- Uses deep linguistic structures
- Output is weighted classification **plus** structure alignment



Natural Logic Inference for ECD

- Determine specificity relations between words
  - then phrases
    - then sentences
- More specific implies less specific

⊏ more specific than

~ incompatible

Words

plane ⊏ *vehicle*
man ⊏ *person*
no ~ *a*

Phrases

flew a plane ⊏ *flew a vehicle*
jet plane ⊏ *plane*
every person ⊏ *every man*
no man ~ *a man*

Sentences

A man flew a plane ⊏ *A man flew a vehicle*
Every person flew a plane ⊏ *Every man flew a plane*
No man flew a plane ~ *A man flew a plane*

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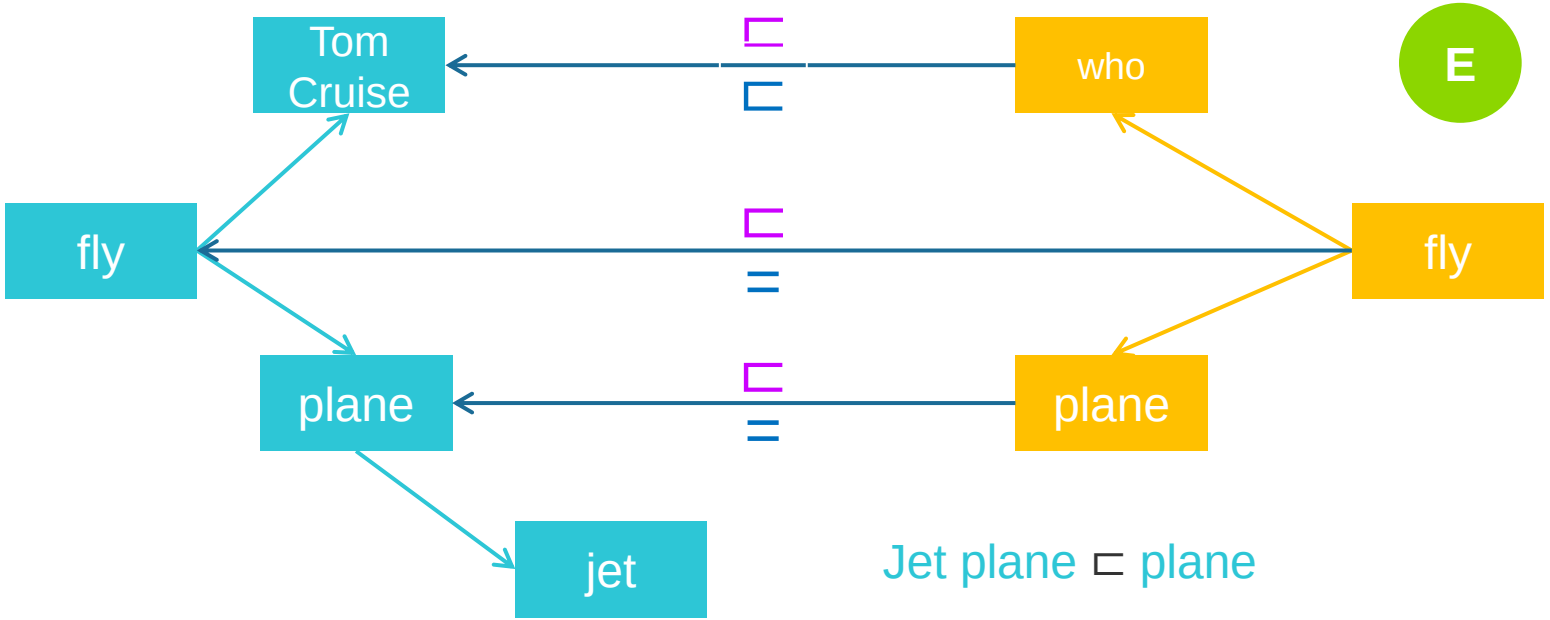
ECD Processing (for QA)

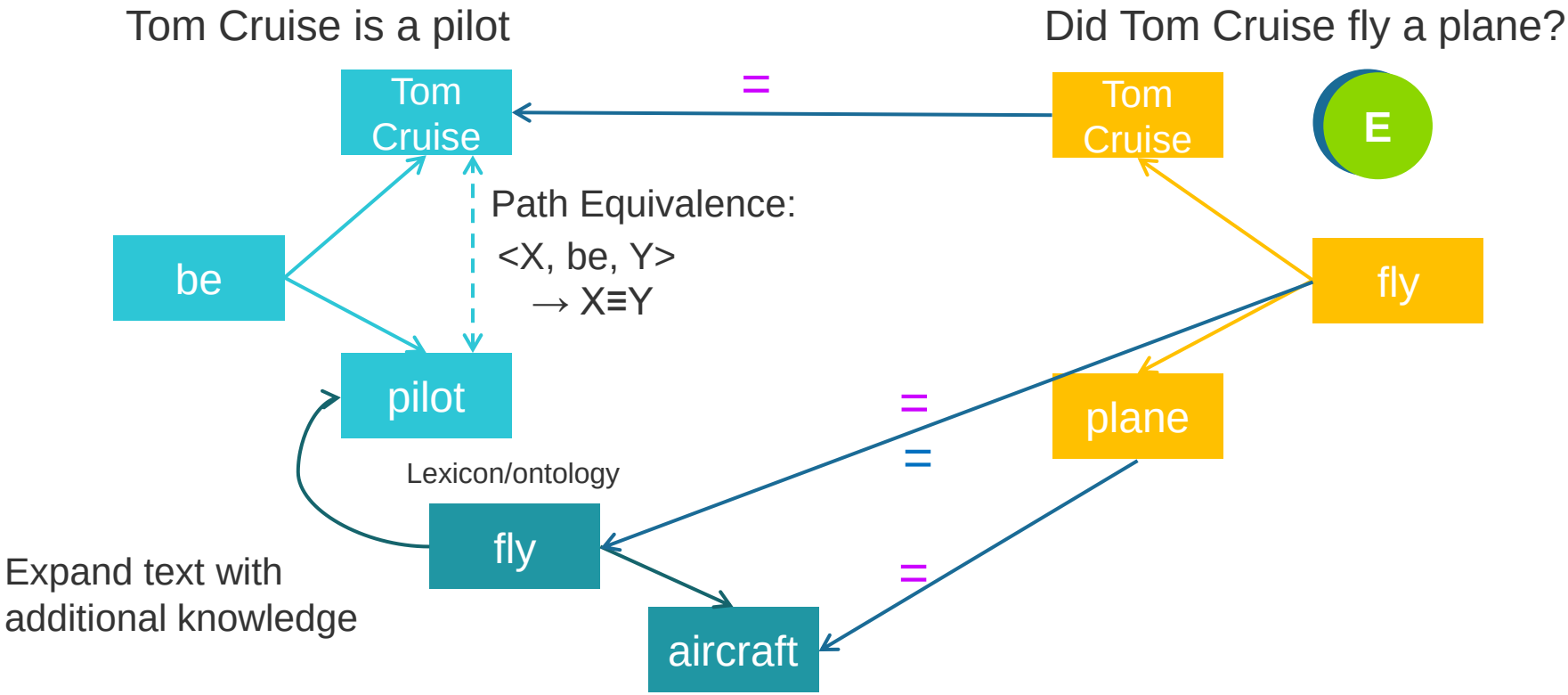
- Construct semantic graphs
- Initial term matches
- Revise specificity relations

Tom Cruise flew a jet plane

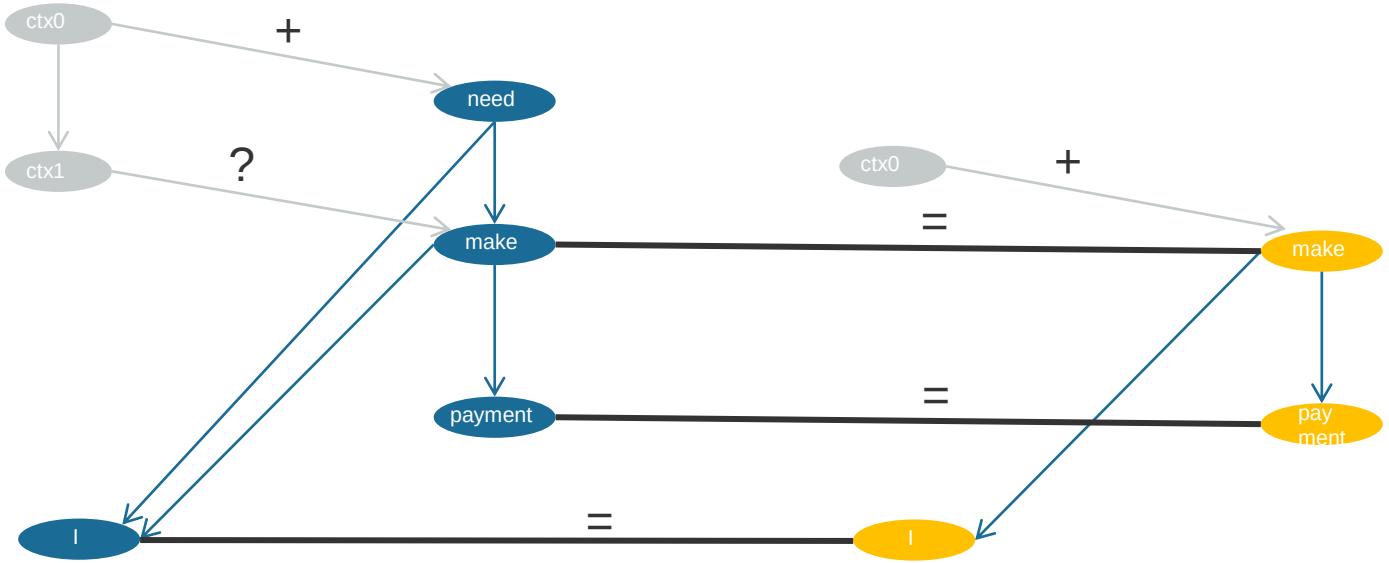
Who flew a plane?



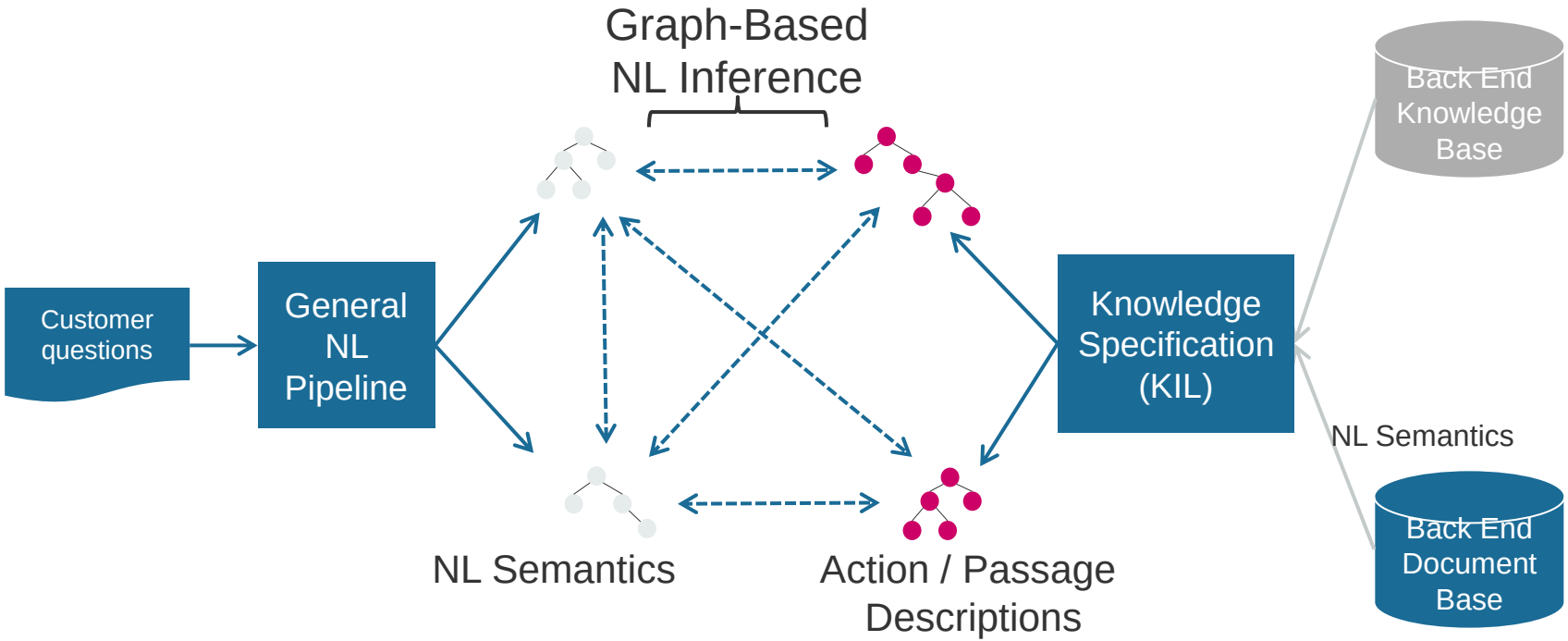
Adding more Knowledge



Contexts, Polarity, Instantiability



NL & KB Inference

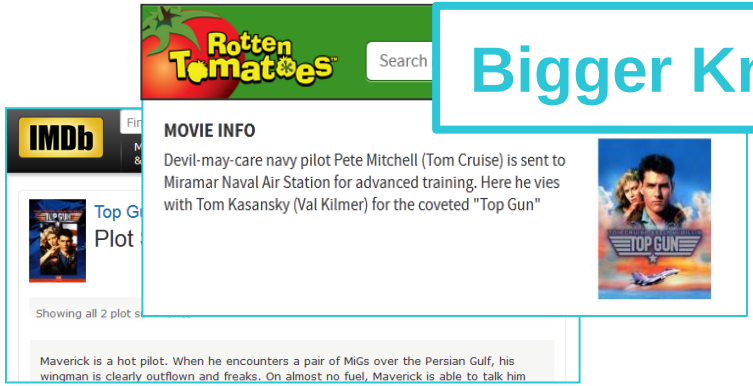


Mixing Canonical and Non-Canonical Data

Is anywhere showing that movie where Tom Cruise flies a plane?

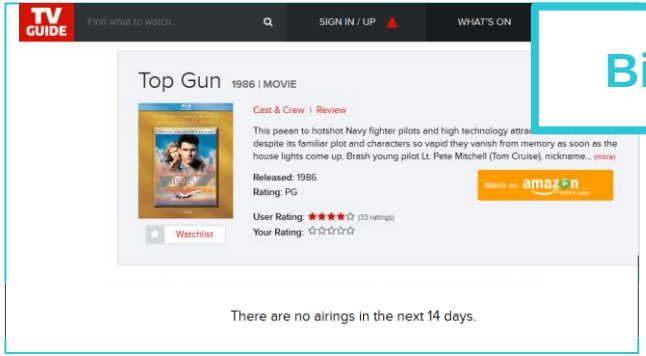
Which Movie?

TV / Movie Listings?



Bigger Knowledge

Information may not yet or ever be in a formal knowledge base



Big Knowledge

Scrape structured data, or ingest from content aggregator

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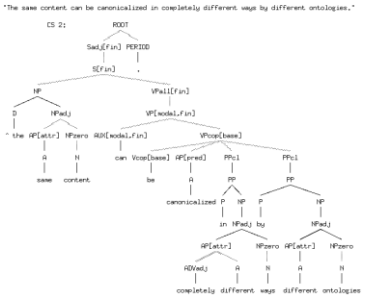
Language ≠ Unstructured Data

Two Dimensions of Structure

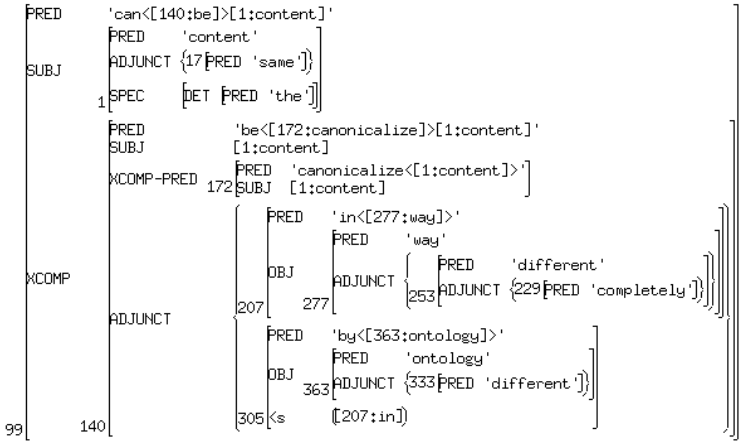
	Formal	Canonical
Ontology	Yes	Yes
NL	Yes	No

- Formal
  - Has a defined, computer readable notation
- Canonical
  - Unique representation for each content

Language as formal structure



"The same content can be canonicalized in completely different ways by different ontologies."



Latest RTE Bake-Off: SemEval 2014

Recognizing Textual Entailment

Topic of active academic research & bake-offs since 2004

Team	Accuracy
1. Illinois	84.5
2= Nuance NLIE	82.6*
6. Meaning Factory	81.6
….	
9. Nuance ECD	78.9*
…	
14. Stanford NLP	74.5
…	

First attempt

Achieved without acquisition of paraphrase relations or extensive world knowledge

**Nuance did not participate*

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Big Knowledge Inference

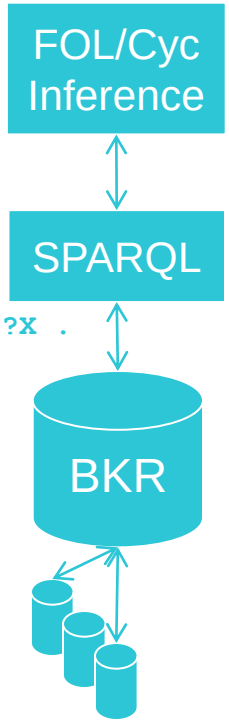
Finding answers in the Big Knowledge Repository

- Question is mapped into a SPARQL query
  - SPARQL: “SQL for triple stores”
  - First-order inference useful for mapping toSPARQL
- Triples retrieved from BKR
  - BKR accesses back-end databases, determined by semantic routing
- Term bindings returned to FOL inference

```
?X = bkr:F14
```

```
SELECT ?X
WHERE {
 bkr:TomCruise bkr:fly ?X .
 ?X isa bkr:Aircraft .
}
```

```
<bkr:TomCruise
 bkr:fly
 bkr:F14>
```



Back-end provider data

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Problem

Getting NL and big knowledge to talk to each other

- Inference and processing mechanisms can be very different
- Must share output representations
  - Use shared representations to interleave NL and BK inference
- Can structured output from NL inference be shared with BK?
  - Difficult if NLI output is a weighted classification of sentence pairs.

Solution: Term Bindings

- Although NLI and BKR inference is different, results are represented uniformly as **term bindings**

- SPARQL queries to knowledge repository return **term bindings**
  - `?X = bkr:TomCruise`

- Term matches between premise and conclusion in NLI are **term bindings**
  - $\texttt{Who}_c = \texttt{TomCruise}_p$

Discovering and refining intents

Discovery

- Start with automatic acquisition of intents from logs
  - Likely to be of lower quality than hand constructed intents

Refinement

- Use HAVA to refine initial intent definitions
  - Allows quick deployment with incomplete / poor intents
  - Combination of human assisted learning and manual review increases scope of VA over time
  - Possibility of using HAVA behind completely empty VAs

1. Evaluate against existing domain.
2. Move to new domains.

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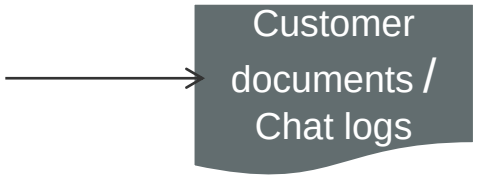
Intent classification

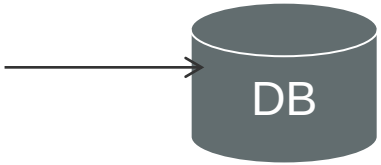
"Can I get a car insurance quote?"



"You can start the auto insurance quote process here."

General/Class-based

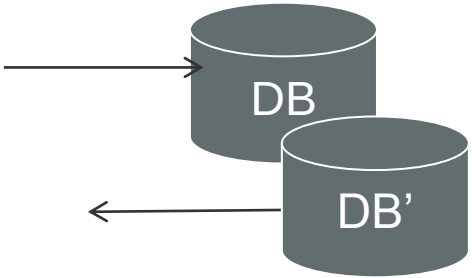
"How much is my next car insurance payment?"



"$736.00 is due on March 31, 2016."

Complex/Personalized

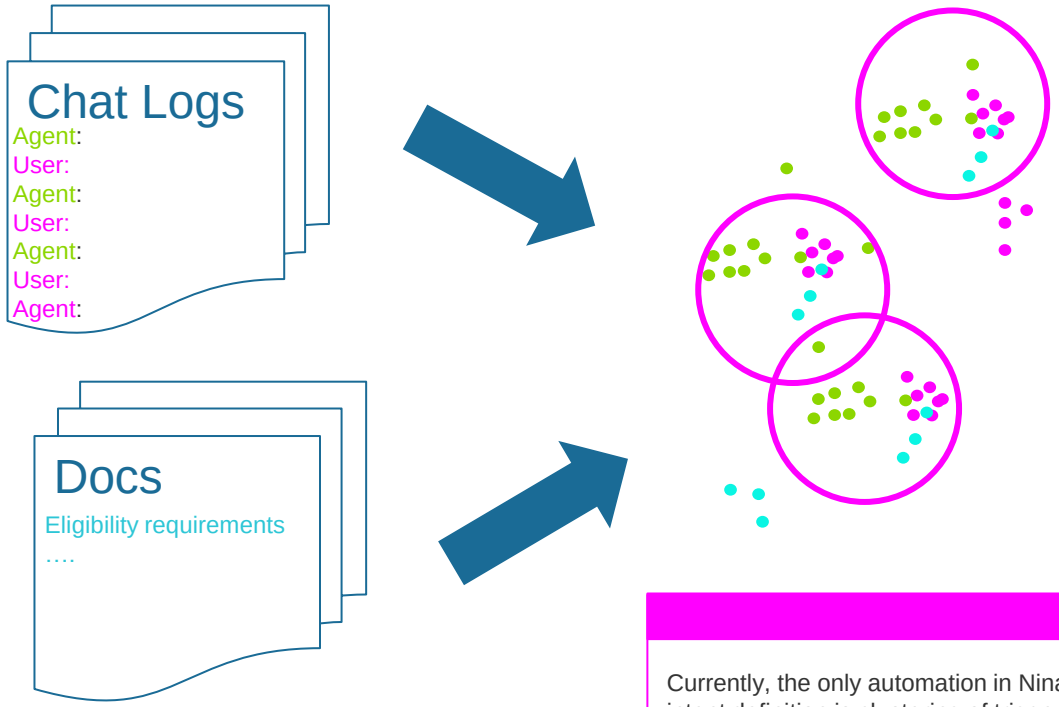
"Can I change to every 6 months?"



"Your payment has been changed to quarterly with monthly reminders."

Transactional

NiK Clustering: General & Class-based



NiK/NLI:
Joint clustering of questions, answers, passages

Currently, the only automation in Nina intent definition is clustering of trigger questions from chat logs in Nuance Experience Studio.

Standard NES string similarity
Search relevance / similarity
Natural language inference
Graph similarity
DNN/Seq2Seq

Clustering approaches

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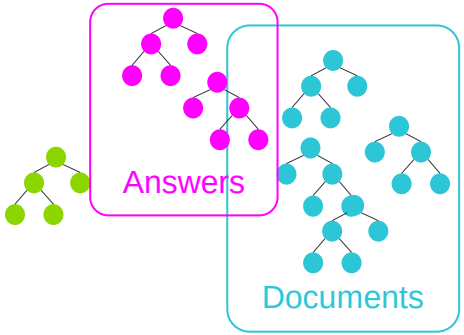
Nina Knowledge clustering

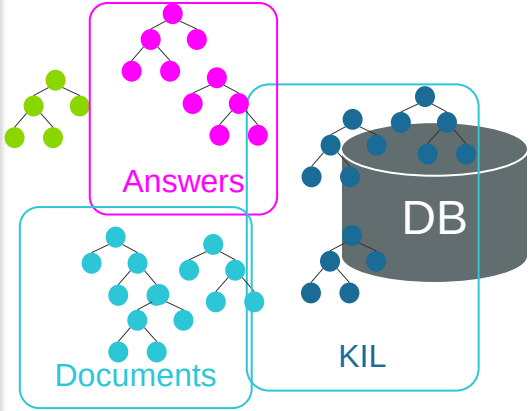
"Can I get a car insurance quote?"



"You can start the auto insurance quote process here."

General

"How much is my next car insurance payment?"



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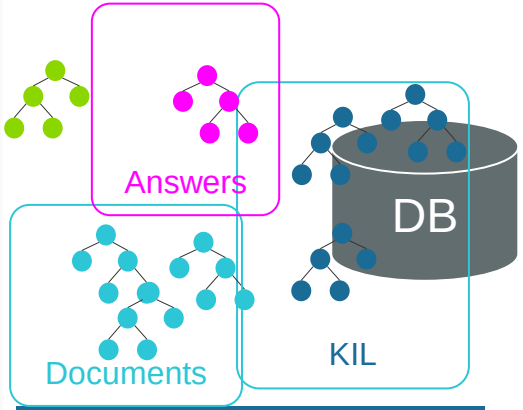

"Your payment has been changed to quarterly with monthly reminders."

Transactional