BIBFRAME DISCOVERY USING GENERATIVE AI

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1

OUTLINE

1. RDFS/OWL Foundations + BIBFRAME

2. Generative AI

- Retrieval-augmented generative (RAG) chat

3. New Semantic Web Agent

- Draws on BIBFRAME inference (Share-VDE APIs)
- Utilizes Wikidata as knowledge base
- Grounds responses in external data sources to limit hallucination

KNOWLEDGE REPRESENTATION AND REASONING

Knowledge Representation and Reasoning aims ".. to construct systems that contain **symbolic representations** with two important properties.

- First is that we (from the outside) can understand them as standing for propositions.

  Second is that the system is designed to behave the way that it does because of these symbolic representations.''

  (Brachman and Levesque 2004)

This approach, rooted in the **Knowledge Representation Hypothesis** (Smith 1982), assumes that effective AI systems require symbolic representations that ground their reasoning processes.

RDFS/OWL AND BIBFRAME

- Principles of knowledge representation underpin BIBFRAME

- (McCallum 2017).

```xml
<rdf:RDF xml:base="http://id.loc.gov/ontologies/bibframe/"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:bf="http://id.loc.gov/ontologies/bibframe/" xmlns:bflc="http://id.loc.gov/ontolog
  xmlns:owl="http://www.w3.org/2002/07/owl#" xmlns:skos="http://www.w3.org/2004/02/skos/c
  xmlns:dcterms="http://purl.org/dc/terms/" xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:cc="http://creativecommons.org/ns#">
<owl:Ontology rdf:about="">
  <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string">2.6.0</owl:ver
  <owl:versionIRI rdf:resource="http://id.loc.gov/ontologies/bibframe-2-6-0/"/>
  <owl:priorVersion rdf:resource="http://id.loc.gov/ontologies/bibframe-2-5-0/"/>
  <rdfs:label>BIBFRAME vocabulary</rdfs:label>
  <dcterms:issued rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime"
    >2025-07-23T12:00:00.000-05:00</dcterms:issued>
  <dcterms:modified rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime"
    >2025-07-23T18:12:22.350407175-04:00</dcterms:modified>
  <dcterms:description xml:lang="en">The Bibframe vocabulary consists of RDF classes an
    properties used for the description of items cataloged principally by libraries, bu
    be used to describe items cataloged by museums and archives. Classes include the th
    classes - Work, Instance, and Item - in addition to many more classes to support de
    Properties describe characteristics of the resource being described as well as rela
    among resources. For example: one Work might be a "translation of" another Work; an
    may be an "instance of" a particular Bibframe Work. Other properties describe attri
    Works and Instances. For example: the Bibframe property "subject" expresses an impo
    attribute of a Work (what the Work is about), and the property "extent" (e.g. numbe
    expresses an attribute of an Instance.</dcterms:description>
  <dcterms:creator rdfs:resource="http://id.loc.gov/vocabulary/organizations/dlc"/>
  <dcterms:publisher rdfs:resource="http://id.loc.gov/vocabulary/organizations/dlcmrc"/
  <dcterms:rights rdf:resource="https://creativecommons.org/publicdomain/zero/1.0/"/>
  <cc:license rdf:resource="https://creativecommons.org/publicdomain/zero/1.0/"/>
</owl:Ontology>
```

- The data in Share-VDE is comprised of BIBFRAME clusters.
  - Penn Libraries catalog is transformed, enriched and clustered into the BIBFRAME model.
- When we query the endpoints of the BIBFRAME APIs, we are asking for the inference of the Work and Instance relationships (BIBFRAME terminology).

5

GENERATIVE AI

- Based on (empirical) innovations in the transformer architecture

  - Generates text capabilities for calling tools.

  - Model Context Protocol, allows for Gen AI models to interface or plugin to tools like, for example the BIBFRAME data from Share.

  - Theoretic underpinnings of massively scaled transformers are absent.
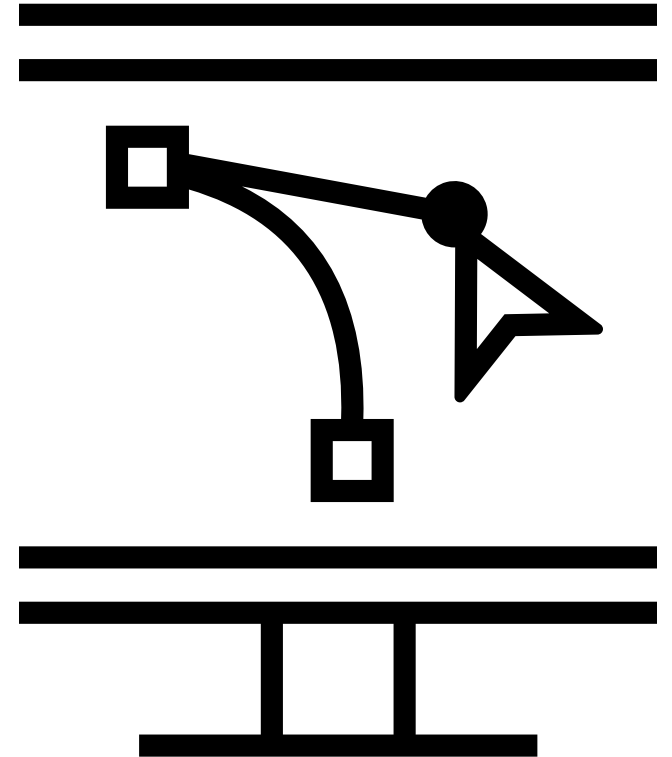
INTEGRATION STRATEGY OF SYMBOLIC AND GENERATIVE

- The integration employs strategies in prompt development and semantic retrieval that merge classic semantic web principles with Gen AI capabilities, providing users with contextually enriched exploration of library resources and linked data.
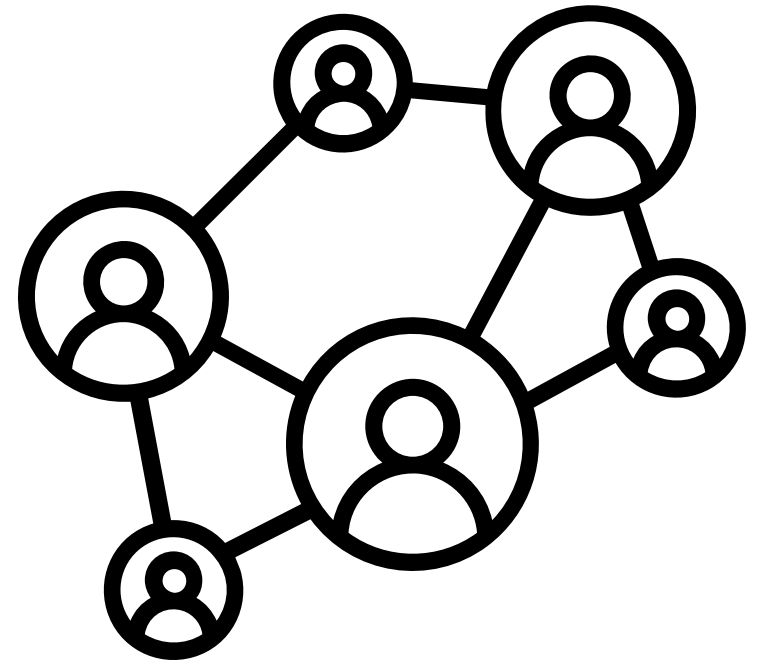
HIERARCHY FOR CHAT RESPONSE BASED ON BIBFRAME + SHARE-VDE API

Johann Sebastian Bach

Bach | J.S. Bach | J. S. Bach | J S Bach

German composer (1685–1750)

Selected Works ›

Ask AI about Johann Sebastian Bach ⌄

Works held by Penn Libraries:

- **Piano music, 4 hands. Selections**

- **Concertos. BWV 593. Organ**
  └─ 📁 2 publication(s) with Penn holdings:
  ├─ 📁 **Bach.**
  │ ├─ 🏳 Item
  │ └─ 🏳 Item
  └─ 📁 **Concertos and fugues /**
  ├─ 🏳 Item
  ├─ 🏳 Item
  ├─ 🏳 Item
  ├─ 🏳 Item
  └─ 🏳 Item

- **Präludium und Fuge. BWV 552. Organ**
  └─ 📁 6 publication(s) with Penn holdings:

Links ⌄

Wikidata page

New Chat

Niccolò Machiavelli

Nicolas Machiavel | Machiavel | Niccolò di Bernardo dei Machiavelli

Italian diplomat and political and military theorist (1469–1527)

Selected Works ›

Ask AI about Niccolò Machiavelli ⌄

AI ASSISTANT

I found 10 works by Niccolò Machiavelli in our knowledge base. 2 have confirmed Penn Libraries holdings.

Works held by Penn Libraries:

· **Istorie fiorentine**
  └─ 🗒 3 publication(s) with Penn holdings:
├─ 📁 **Histoire de Florence /**
│ └─ 🏷 Item
├─ 📁 **Historie di Nicolo Macchiauelli, cittadino, et secretario...**
│ ├─ 🏷 Item
│ ├─ 🏷 Item

Links ⌄

Wikidata page

Ask AI about Niccolò Machiavelli

- **Istorie fiorentine**
  - 3 publication(s) with Penn holdings:
  - **Histoire de Florence /**
    - Item
  - **Historie di Nicolo Macchiauelli, cittadino, et secretario...**
    - Item
    - Item
    - Item
    - Item
    - Item
    - Item
  - **The Florentine historie /**
    - Item
    - Item
    - Item
    - Item
    - Item
    - Item

New Chat

💡 **Suggested questions:**

Who influenced Niccolò Machiavelli's development?

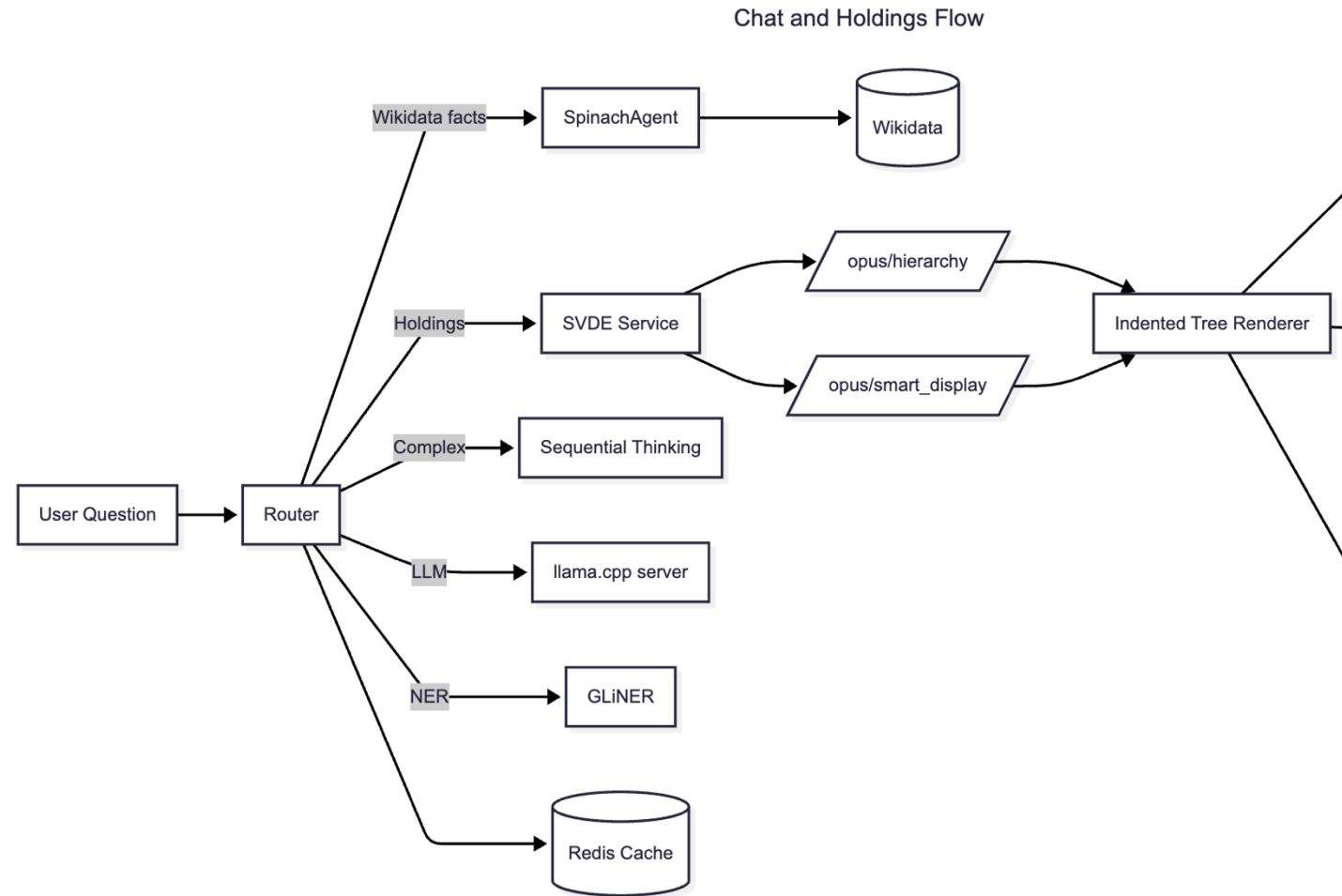Who were Niccolò Machiavelli's teachers or mentors?

Did Niccolò Machiavelli have notable students or protégés?

Links ⌄

Wikidata page

Chat and Holdings Flow

SYSTEM FLOW

STEERING PROMPTS

System role : a limited (constrained set) of librarian assistant skills from RUSA guidelines (ALA, 2023).

Domain primer: Linked Data, RUSA cues (ALA, 2023).

Task routing: intent and path.

Tool retrieval instructions: to call Share-VDE and Wikidata.

Query planning: SPARQL generation based on adapted SPINACH Agent code (Liu, et al. 2024).

Output formatting templates: indented trees.

Reasoning scaffolds using "sequential thinking" MCP: structured step prompts (internal).

Validation: SPARQL constraints, timeouts, URL checks.

Fallback: alternative paths, retries, graceful degradation.

Follow-up and next question: scope and deduplication.

PIPELINE (HIGH LEVEL)

1

Normalize + NER

- ModernGliner for semantic processing

2

Fast paths

- for basic facts (dates, labels) → Wikidata summary.

3

Classify intent

- Sequential Thinking classifier

ROUTING CATEGORIES

- Holdings search
  - **Use SVDE** for works/holdings:
    - **Try:** /opus/hierarchy → render indented tree
    - **Fallback:** /opus/smart_display → same renderer
    - **Final fallback:** opus→items from editions/mmsids
    - When endpoint chain is exhausted without responses: need to reply with an "unable to answer" or risk hallucination by relying on the model "world knowledge"
  - Penn-only filtering + Alma MMSID validation
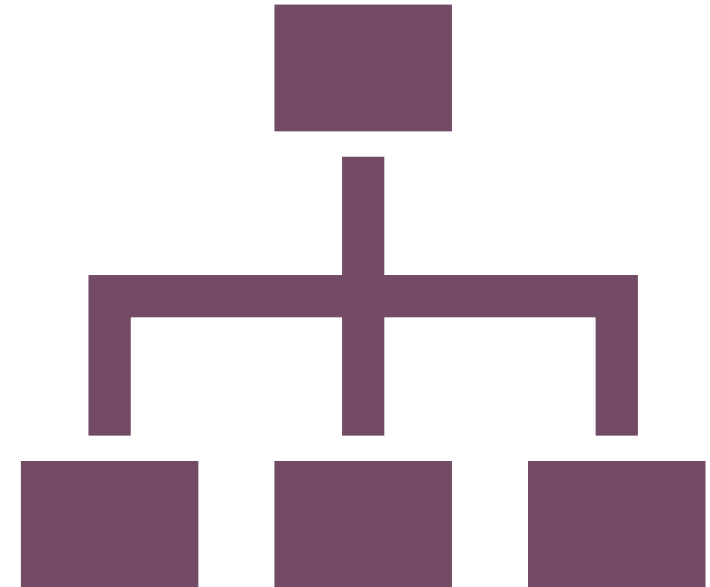
ROUTING CATEGORIES

- Factual lookups: summaries, properties via a port of the SPINACHAgent (Liu, et al. 2024)

- Plans SPARQL, executes multi-hop queries (relations, graph traversals).

- Post-processing
  - RUSA guidelines invite continued engagement and referral
  - RUSA usually has a closing to completely answer questions, but the GenAI is limited and does not completely answer questions, rather introduces resources and refer to library help.
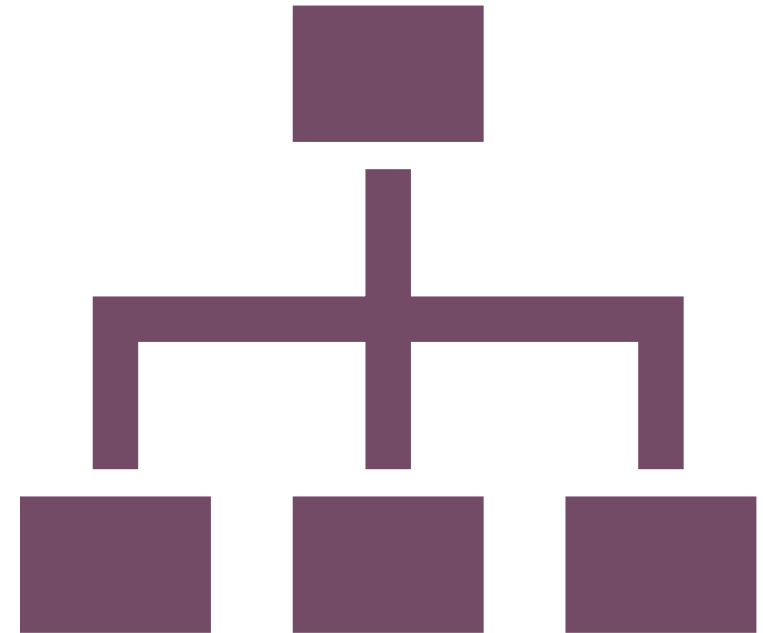
USER STUDY DESIGN

SOCIAL SIGNALING THEORY

- A formative evaluation is being planned to determine how the system design influences the credibility of social signals sent by the generative AI agent and the interaction costs to users engaging in bibliographic discovery tasks.
  - We want to design in credible signals and reduce costs of the receivers to understand those credible signals.

  - The conceptual framework of evaluation is grounded in Donath's social signaling framework, which addresses the fundamental challenge for semantic web agents: establishing credibility through costly signals that cannot be faked (Donath 2007).

SYSTEM CREDIBILITY SIGNALS

- The system establishes credibility through source integration and source attribution, which function as costly signals of credible information access that utilizes knowledge bases like Wikidata and library catalogs rather than relying only on the "world knowledge" of a large language model.
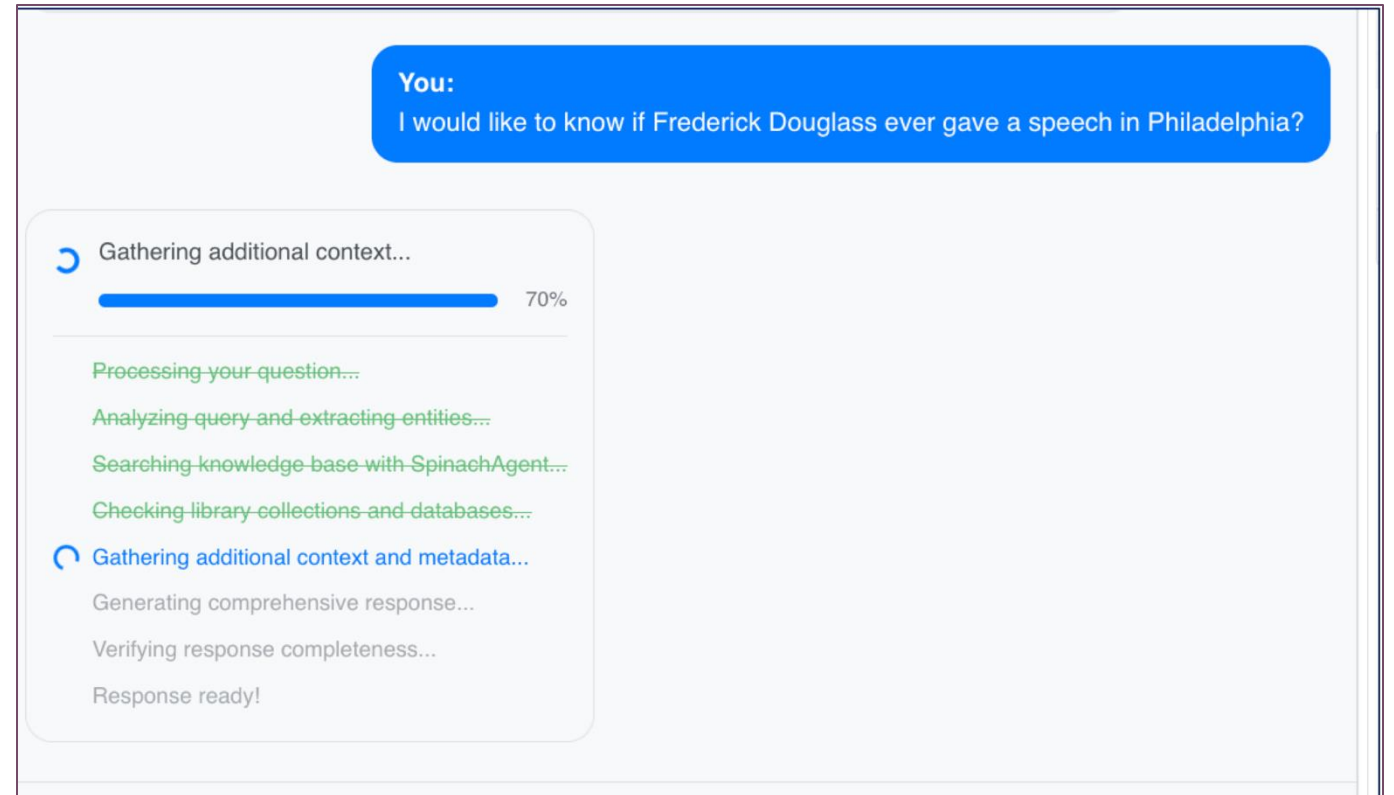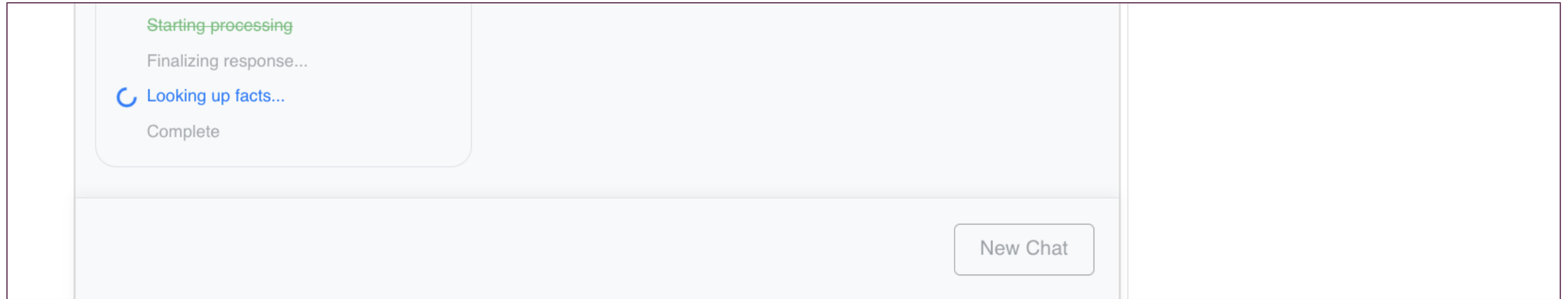
CREATING SIGNALS OF CREDIBILITY

- Because this represents a fundamental redeployment of semantic web agents, the data from users in this formative evaluation will drive potential improvements to the signaling architecture that bridges symbolic AI expressiveness with generative AI's natural language capabilities.

NEXT STEPS

Formative evaluation and revision

Integration to Blacklight system

- Demonstration of chat features available from the browser plugin (Firefox)
  - BIBFRAMinator

BIBFRAMinator
by Jim Hahn

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