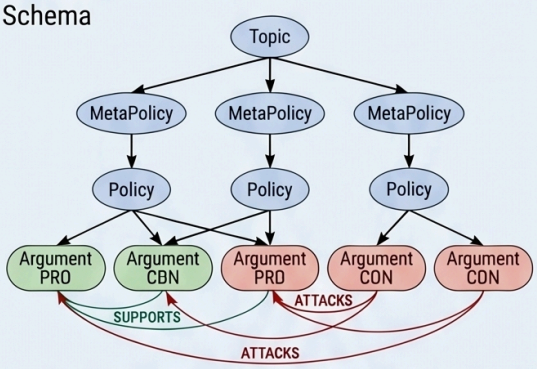
Argumentative Graph-RAG:
A Multi-Agent Framework for Structured Civic Debate

Context Summary
Standard Retrieval-Augmented Generation (RAG) often fails in civic debate due to a lack of structure and reasoning over relationships. This framework introduces Argumentative Graph-RAG, structuring citizen proposals into a hierarchical knowledge graph with argumentative relations (supports, attacks, contradicts, equivalent). A multi-agent system uses graph centrality and diversity algorithms to provide comprehensive, fair, and non-redundant views of contested policies.

SYSTEM ARCHITECTURE

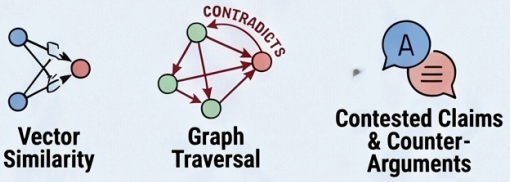
Storage Layer: Neo4j Argumentative Graph

Schema



A hierarchical knowledge graph containing tens of thousands of arguments organized under Topics, MetaPolicies, and Policies, with directed edges for SUPPORTS and ATTACKS relations.

Retrieval Layer: Hybrid Multi-Hop Expansion



A hybrid mechanism combining vector similarity with multi-hop graph traversal through CONTRADICTS edges to surface contested claims and counter-arguments.

Reasoning Layer: Multi-Agent SmolAgents

An orchestration layer featuring a Retrieval Worker for database queries, an Analyst Worker for debate synthesis, and a Critic Worker for:

Conflict Map
Automatically retrieves and organizes the top PRQ and CON arguments for a specific policy to provide a high-level view of the friction points.

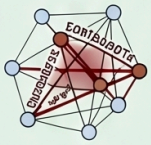
Drafting Assistant
A tool designed to critique a user's proposed argument by checking it against existing evidence and counter-arguments within the graph.

Coherence Audit
Detects cross-policy argumentative conflicts to ensure that positions held in one domain are consistent with proposals made in another.

Topic Explorer
An interface for researchers to browse the entire debate space through the hierarchy of Topics and MetaPolicies.

METHODOLOGY

Graph Topology Centrality on Contradiction Edges

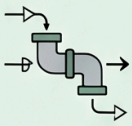


The system identifies the most 'important' arguments by analyzing the density of CONTRADICTS edges, defining argumentative importance as the degree to which a claim is contested within the debate.

MMR Algorithm for Diversity Selection

Maximal Marginal Relevance (MMR) is employed to balance relevance (based on graph centrality) and diversity, iteratively selecting arguments that minimize redundancy and maximize the coverage of distinct perspectives.

Deterministic Edge Construction Pipeline



High-precision edges for EQUIVALENT and CONTRADICTS relations are established using a hybrid hard-rule classifier and cosine similarity thresholds to ensure a reproducible graph structure.

RESEARCH USE CASES

Conflict Map
Automatically retrieves and organizes the top PRO and CON arguments for a specific policy to provide a high-level view of the friction points.

Debate Summary
Generates a structured five-field analysis

Drafting Assistant
A tool designed to critique a user's proposed argument by checking it against existing evidence and counter-arguments within the graph.

Coherence Audit
Detects cross-policy argumentative conflicts to ensure that positions hold in one domain are consistent with proposals made in another.

EVALUATION METRICS

Coverage
Measures how well the retrieved set of arguments addresses the core claims and central themes of a specific policy debate.

Faithfulness
An LLM-judged metric (1–5 scale) that determines how strictly the generated summaries are grounded in the retrieved graph evidence.

Diversity
An intrinsic metric calculated via mean pairwise cosine similarity to ensure the system avoids selecting near-duplicate or redundant arguments.

Balance
A structural metric assessing the equitable representation of PRO and CON perspectives to prevent system blas.

NotebookLM