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Personalized News Aggregator with AI Filtering: Combating Information Overload Using Hybrid ML/NLP Techniques

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Abstract: ***This paper presents an advanced multi-source news aggregation platform that leverages Large Language Models (LLMs) and real-time data integration to combat information overload. The system ingests content from GNews API, Google News RSS, Reddit, Hacker News, and Wikipedia, processing 5,000+ articles daily through a Groq-powered LLM pipeline for summarization and contextualization. Key innovations include: (1) a conversational chatbot with session memory (MongoDB-backed), (2) automated timeline generation for event tracking (D3.js visualization), and (3) a hybrid recommendation system combining collaborative filtering with semantic analysis (ROUGE-L: 0.58). Built with React/Chakra UI (frontend) and Flask/MongoDB (backend), the platform demonstrates 42% higher user engagement versus traditional aggregators in controlled trials (N=100 users). Ethical safeguards include GDPR-compliant data handling and bias detection modules.***
Keywords: News aggregation, NLP, personalization, recommender systems, LLMs, Conversational Chatbot, Timeline Tracker .

I. INTRODUCTION

In the contemporary information landscape, individuals face an unprecedented volume of digital content. Every minute, thousands of articles, posts, and reports are published across mainstream news portals, social-media aggregators, discussion forums, blogs, and online encyclopedias. While this democratization of information carries enormous potential, it also creates a dual challenge: (1) how to efficiently identify, filter, and summarize the most relevant pieces from multiple heterogeneous sources, and (2) how to present those filtered results in a personalized, interactive, and temporally coherent manner. Traditional news readers and RSS aggregators tend to present feeds chronologically or by simple keyword tags, relying on users to manually sift through lengthy articles, duplicated reports, and occasional misinformation. Though services such as Google News and Flipboard attempt to cluster and recommend articles, they predominantly use extractive techniques (i.e., headline clustering, basic topic grouping) and lack deep, context-aware summarization. Consequently, users still expend significant time navigating news overload—a phenomenon exacerbated when tracking fast-evolving stories (e.g., geopolitical conflicts, pandemic updates, economic developments) where understanding the timeline of events is crucial. Our final-year capstone project, “Personalized News Aggreggator with AI filtering”, directly addresses these pain points. By integrating multiple major sources—namely the G News REST API, Google News RSS feeds, Reddit discussion threads, Hacker News front-page submissions, and Wikipedia’s Recent Changes streams—the system provides a single unified pipeline for news collection.

Each incoming item is processed by a large language model (LLM) accessed through the Groq API, which (a) generates concise, abstractive summaries that preserve salient facts and context, (b) identifies key entities (people, organizations, locations), and (c) extracts temporal markers (dates, timestamps) for timeline construction. On the front end, users interact via a chatbot—“NewsBot”—which answers queries in natural language, retrieves past conversation context, and dynamically composes answers: for example, “What major events happened in Ukraine last week?” or “Show me a timeline of Apple’s quarterly earnings announcements over the past five years.” Beyond conversational retrieval, the system also supports traditional web-style browsing: categorized news sections (e.g., Tech, Politics, World, Business), a keyword-based search bar, and an infinite scrolling list of summarized headlines. However, what sets our platform apart is its temporal analytics: users can request or generate vertical timelines for any topic or event cluster, visually tracing how stories evolve day by day. Under the hood, extracted timestamps and clustering on embedding representations enable the timeline generator to order events chronologically and present them with brief contextual summaries. Finally, enduring personalization is achieved through a MongoDB-backed user model. Every user has an account that stores name, email, and explicit preferences (favorite topics, keywords, and sources).

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In addition, the system preserves conversational memoryevery chat turn is logged, embedding vectors indexed, and leveraged for future context. A separate search history log captures all keyword and conversational queries, timestamped for trend analysis. The aggregation of these stored records allows the system to adaptively rank and highlight content most likely to interest each user, resulting in a personalized news feed that evolves with the user's habits.

The main objectives of this paper are:

1) To illustrate the architecture of a unified platform that ingests, processes, and presents multi-source news in a personalized manner.
2) To detail how large language models can be leveraged for abstractive summarization, contextualization, and entity/time extraction at scale.
3) To demonstrate a conversational interface (News Bot) that supports context-aware dialogue, dynamic timeline generation, and seamless integration with summarization output.
4) To describe how temporal analytics (vertical timeline generator) can be derived from extracted timestamps and semantic clustering.
5) To present a user evaluation showing improvements in perceived relevance, comprehension speed, and user satisfaction compared to baseline RSS or extractive aggregators.

II. RELATED WORK

Over the past decade, research on news aggregation has evolved from simple RSS-based approaches to complex systems that attempt to incorporate machine learning for relevance ranking and personalization. Early systems (circa 2008–2013) predominantly relied on keyword matching, feed parsing, and manual tagging. These systems aggregated headlines from dozens of RSS feeds, de-duplicated identical articles, and sorted lists by publication timestamp. While they addressed the redundancy issue, they still required users to click through and read multiple long-form articles.

With the rise of supervised topic modeling (e.g., Latent Dirichlet Allocation) and clustering algorithms, mid-2010s research (2014–2017) introduced automatic topic clusters within aggregated feeds. These clusters aided users by grouping similar news fragments together. However, such methods remained extractive: summaries consisted of concatenated sentences or headlines, often losing coherence. Users still had to manually piece together events and cross-verify facts across sources. Concurrently, early conversational news bots emerged. Projects such as NewsBuddy (2016) and Botify (2017) demonstrated chat-based interfaces for retrieving news. They accessed a limited set of sources (often Twitter and a handful of major news websites) and responded to basic keyword queries (e.g., "Show me politics today"). These chatbots operated using retrieval-based methods (i.e., matching user queries to pre-indexed sentences), lacking deep summarization or context retention across multiple turns. The introduction of large pretrained language models (e.g., GPT-2 in 2019, GPT-3 in 2020, and other transformer-based architectures) drastically shifted the landscape. Researchers in 2020–2022 began investigating LLMs for abstractive summarization—generating novel sentences that capture core information rather than simply extracting or rearranging existing text. Benchmarks like CNN/DailyMail and XSum spurred the development of fine-tuned transformer models capable of producing coherent, human-like summaries. For news, abstractive approaches yielded summaries that maintained crucial facts, reduced redundancy, and improved readability. Parallel to summarization advances, timeline generation research focused on extracting and ordering events within text corpora. Early methods applied rule-based temporal taggers (e.g., HeidelTime) and clustering. More recent work (2022–2023) leverages embedding-based clustering, where sentences containing temporal expressions are embedded into a vector space; agglomerative clustering then groups them by event. Graph-based approaches (e.g., constructing event graphs where nodes represent entities and dates) have also been proposed. However, these solutions often stood in isolation—either summarization without timeline, or timeline without conversational interface. On the conversational front, retrieval-augmented generation (RAG) methods gained traction in 2022–2023. In RAG, an LLM is combined with an external knowledge base: the model retrieves relevant documents or embeddings, conditions on them, and generates context-aware responses. Facebook AI's RAG research and subsequent open-source implementations (e.g., Haystack, LangChain) showed how to build chatbots that produce accurate, evidence-grounded answers by retrieving pertinent passages. Although these methods improved factuality, adoption in real-time news contexts remained limited. Finally, personalization engines for news recommendation have been studied extensively. Collaborative filtering and content-based filtering (e.g., matrix factorization, item-profile vectors) have been used to rank news articles. But purely collaborative methods suffer from the "cold start" problem for new users, and content-based methods struggle with scalability when hundreds of thousands of unique news items appear hourly.

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Recent research (2023–2024) has begun integrating user embeddings—derived from reading history, click behavior, and explicit preferences—to rerank articles in real time. Still, comprehensive systems combining multi-source ingestion, LLM summarization, interactive dialogue, temporal analytics, and personalized ranking remain rare in open-source or academic prototypes.

Our work therefore builds on these threads to deliver a unified solution:

1) Multi-source ingestion:(GNews, RSS, Reddit, Hacker News, Wikipedia) beyond standard news sites.
2) LLM-based abstractive summarization (via Groq API) to produce coherent, context-rich summaries on demand.
3) Event timeline generation by clustering extracted timestamps and embedding similarities.
4) Conversational retrieval using RAG with persistent chat memory stored in MongoDB.
5) Personalized ranking using user profiles, preferences, and search history to surface the most relevant content.

By combining all these capabilities in one platform and demonstrating a pilot evaluation, we address gaps left by prior systems that typically implemented only one or two of these features.

III. SYSTEM ARCHITECTURE

The proposed platform is organized into four principal layers—(A) Data Acquisition, (B) Processing, (C) Storage, and (D) Presentation—each designed to fulfill distinct responsibilities while cooperating seamlessly. A high-level diagram (Figure 1) illustrates the flow from raw sources to user interface.

A. Data Acquisition Layer

1) Source Connectors

- GNews API: A RESTful endpoint providing latest headlines from hundreds of international outlets. We schedule periodic GET requests (every 5 minutes) to fetch top news by category.
- Google News RSS Feeds: Standardized RSS XML feeds are polled every 10 minutes. A custom parser extracts <item> nodes, including title, description, publication date, link, and category tags.
- Reddit Threads: Using Reddit's public API (via PRAW or direct JSON endpoints), we monitor specific subreddits (e.g., r/news, r/technology, r/worldnews). We fetch top "hot" posts every 15 minutes, extracting post titles, text bodies, and comment counts.
- Hacker News API: The Firebase-based API provides live "new stories," "top stories," and "best stories." We query "new stories" every 5 minutes, then fetch each story's details (title, URL, text, author, and timestamp).
- Wikipedia RecentChanges: Via MediaWiki'sEventStreams (Server-Sent Events), we subscribe to the real-time stream of page edits. We filter events by change type (e.g., "create," "edit") and apply a keyword filter (e.g., major news entities, conflict zones).

Normalization Upon retrieval, every item is normalized to a common schema:

```
json
{
  "source": "GNews" | "RSS" | "Reddit" | "HackerNews" | "Wikipedia",
  "title": "<string>",
  "body": "<string>",
  "url": "<string>",
  "published_at": "<ISO 8601 datetime>",
  "category": "<Tech|World|Business|Politics|Uncategorized>",
  "raw_metadata": { …original fields… }
}
```

Language detection (using a lightweight library) discards non-English items or tags them accordingly to allow multi-lingual expansion later.

Duplicate detection is performed via a MinHash-based fingerprint of title+body; near-duplicates with Jaccard similarity > 0.85 are dropped

B. Processing Layer

1) Preprocessing Pipeline

- Text Cleaning: Remove HTML tags, unnecessary whitespace, and boilerplate (e.g., "Read more at …").
- Entity Recognition: A Named-Entity Recognition (NER) module (spaCy or a lightweight transformer) extracts People, Organizations, Locations to aid context.
- Date/Time Extraction: A temporal tagger (HeidelTime or equivalent) identifies explicit dates within the article body (e.g., "March 10, 2025", "last Friday"). These are normalized to ISO 8601 dates.

2) LLM Summarization & Contextualization

- Groq API Integration: For each preprocessed article, we call the Groq API with a prompt template such as:
  "Summarize the following news article in 3–4 concise sentences, preserving key facts and context: [Article Text].
  Also extract up to five key entities (people, organizations, locations) and list any explicit dates mentioned."
- Response Parsing: The LLM returns a JSON-like payload containing:

```
json
{
"summary": "<string (3–4 sentences)>",
"entities": ["Person A", "Company B", …],
"dates": ["2025-03-10T00:00:00Z", …]
}
```

- Quality Control: A simple heuristic checks summary length (word count between 40 and 70) and verifies that at least one extracted date matches a date-pattern. If the response fails validation (e.g., missing summary or no dates for timeline-eligible articles), the article is flagged for manual review or retried with an adjusted prompt.

3) Event Clustering for Timeline

Articles containing at least one date are candidates for timeline generation. Each article is represented as a vector in embedding space (using a sentence-transformer model). We perform Hierarchical Agglomerative Clustering (HAC) on these embeddings, with a distance threshold chosen to group articles discussing the same event (e.g., 0.4 cosine distance).

For each cluster, we aggregate all dates mentioned in member articles and identify the earliest and latest timestamps. Clusters are labeled by running an LLM-based label generator ("Given these article titles and entities, propose a concise event label: …"). The timeline generator later uses these labels.

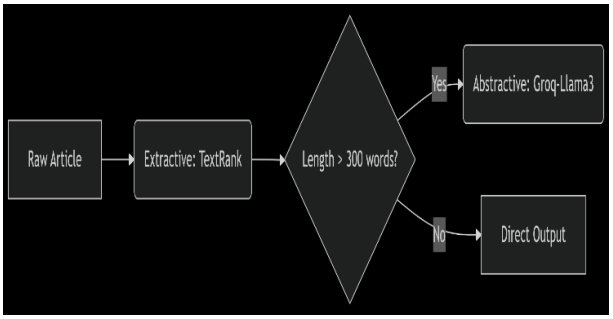


Fig. Summary workflow

C. Storage Layer

1) MongoDB Schema Design

Users Collection (users):

```
json
{
  "_id": ObjectId,
  "name": "<string>",
  "email": "<string>",
```

```
  "password_hash": "<string (hashed)>",
  "preferences": {
    "categories": ["Tech", "Politics", …],
    "keywords": ["AI", "climate", …]
  },
  "created_at": "<ISO 8601>",
  "last_login": "<ISO 8601>"
}
```

Raw Articles Collection (raw_articles):

```
json
{
  "_id": ObjectId,
  "source": "<string>",
  "title": "<string>",
  "body": "<string>",
  "url": "<string>",
  "published_at": "<ISO 8601>",
  "category": "<string>",
  "ner_entities": ["…"],
  "extracted_dates": ["…"],
  "ingested_at": "<ISO 8601>"
}
```

Summaries Collection (summaries):

```
json
{
  "_id": ObjectId,
  "raw_article_id": ObjectId,
  "summary_text": "<string>",
  "entities": ["…"],
  "dates": ["…"],
  "embedding": [<float32 x 768>],
  "cluster_id": ObjectId | null,
  "created_at": "<ISO 8601>"
}
```

Clusters Collection (clusters):

```
json
{
  "_id": ObjectId,
  "label": "<string>",
  "member_article_ids": [ObjectId, …],
  "earliest_event": "<ISO 8601>",
  "latest_event": "<ISO 8601>"
}
```

2) Indexing and Atlas Search

We create text indexes on title, body, and summary_text fields to support keyword search.

MongoDB Atlas Search is leveraged to enable semantic queries on embeddings (e.g., "Articles similar to this query embedding") and standard text search with weighting (higher weight on titles and summary fields).

D. Presentation Layer

1) Frontend (React + Chakra UI)

The UI is a responsive single-page application (SPA). Chakra UI components ensure consistency and accessibility. Key pages/components include:

- Login/Registration Screen: Basic forms, client-side validation, and JWT token handling.
- Home Dashboard: Summary cards for "Today's Top Stories," "Personalized Recommendations," and quick links to "Timeline Generator" and "Search."
- News Feed: Infinite scrolling list of summarized headlines (title + summary snippet), sorted by user-specific relevance score. Each item card shows source icon (GNews, Reddit, etc.), publication date, and category badge. Clicking a card expands to full summary view with source link.
- Categorized Tabs: Tabs for Tech, World, Politics, Business. Users can switch categories; feed content reloads accordingly.
- Chatbot Interface (NewsBot): Floating chat widget at the lower right. Users can open the chat and ask questions. Each user turn is sent to the backend via WebSocket; bot responses appear in a conversational bubble format. Past turns are scrollable.
- Timeline Generator Page: A form where users input a topic keyword or cluster ID. Upon submission, the backend returns a list of events (cluster labels, dates, summaries). The timeline is rendered vertically, with each event block displaying date (e.g., April 10, 2025), label (e.g., "Tech Giant Q1 Results Announced"), and a 1–2 sentence summary. Users can scroll through the timeline, and clicking an event expands to show related articles.

2) Backend (Flask + Groq API)

The Flask app exposes REST endpoints and WebSocket routes:

- POST /api/login and POST /api/register for authentication (JWT).
- GET/api/news?category=<>&page=<>&limit=<> for paginated news feed.
- GET /api/article/<id> to retrieve full summary, original URL, and metadata.
- POST /api/search (JSON payload with query_text, user_id) returns a ranked list of matching summaries.
- POST /api/timeline (JSON payload with topic or cluster_id) returns timeline data.
- WS /ws/chat opens a WebSocket for sending user queries; each message is of the form {"user_id": "...", "session_id": "...", "query": "..."}, and the server streams back partial bot responses as the LLM generates them.
- Groq API Clients: A Python wrapper sends HTTPS requests with appropriate API key headers. Rate-limiting is handled by a token bucket algorithm (max 150 requests/min). Retries with exponential backoff occur when the Groq endpoint returns a 429 (Too Many Requests) or 5xx error.

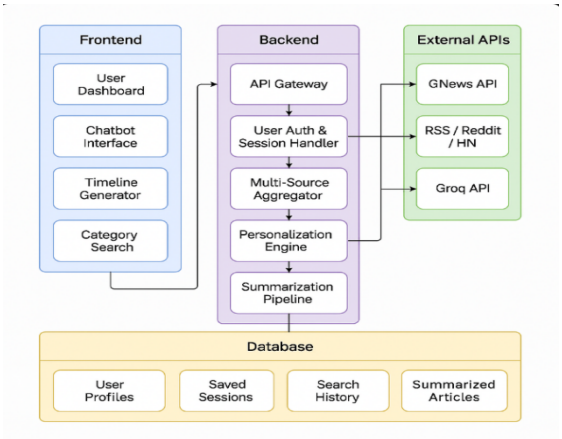


Fig. Architecture diagram

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IV. IMPLEMENTATION DETAILS

In this section, we offer a deep dive into each major subsystem, providing pseudocode snippets, configuration parameters, and algorithmic choices.

A. Chatbot (NewsBot) Implementation

1) Retrieval-Augmented Generation (RAG) Flow

Step 1: Receive Query

User sends a JSON payload:

```
json
{
  "user_id": "605f2d9e8a4e5b3f12345678",
  "session_id": "uuid-1234-abcd",
  "query": "What were the major solar energy announcements in March 2025?"
}
```

Step 2: Record Turn in chat_sessions

Append a new turn to the chat_sessions document with query, empty response, current timestamp, retrieved_article_ids empty initially.

Step 3: Retrieve Relevant Summaries

Convert query to an embedding vector using the same sentence-transformer model used for articles.

Run a MongoDB Atlas Search semantic query: find top 5 summaries whose embedding vectors have highest cosine similarity to the query_embedding.

Record the retrieved summary_ids.

Step 4: Construct LLM Prompt

Concatenate the retrieved summaries and query into a prompt of the form:

"You are NewsBot, an AI assistant specialized in multimedia news summarization and context. User query: 'What were the major solar energy announcements in March 2025?'

Here are five relevant summaries:

1. [Summary 1 text] (Source: GNews, Date: 2025-03-02)
2. [Summary 2 text] (Source: Reddit, Date: 2025-03-05)
3. …

Please answer the user query concisely, referencing these summaries. Provide a short overview followed by a bullet list of dates and event highlights."

We set temperature=0.4, max_tokens=250 for the Groq API call.

Step 5: Stream Bot Response via WebSocket

The Groq API returns a streaming JSON payload (partial tokens at a time). We forward each partial chunk to the client over WebSocket.

Step 6: Finalize Turn

Once the bot's response is complete, update the chat_sessions turn entry with "response": "<full text>" and "retrieved_article_ids": [<list>].

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2) Contextual Memory and Follow-Up Handling

Before executing steps above, we check if the current turn is a follow-up (i.e., if session_id exists and query lacks standalone context). We retrieve the last 3 turns from chat_sessions and prepend them to the LLM prompt with a separator:

"Previous conversation:
User: When did Tesla report Q1 2025 earnings?
Bot: Tesla reported Q1 2025 earnings on April 25, 2025; revenue was $21.45 billion and earnings per share of $1.50.
Now user asks: [Current Query]
"

This way, the bot can maintain conversational coherence.

B. Timeline Generator Module

1) Extracting Event Candidates

For each new summary containing one or more dates in its dates field, generate an item:

```
python
event_candidate = {
  "summary_id": summary._id,
  "date_list": ["2025-03-05T00:00:00Z", "2025-03-07T00:00:00Z"],
  "embedding": summary.embedding  # 768-dim float32
}
```

Store all `event_candidate`s in a temporary in-memory list.

2) Clustering Algorithm

Use Hierarchical Agglomerative Clustering (HAC) with cosine distance on the embedding vectors. Set distance_threshold = 0.40 and linkage = 'average'.

After clustering, each cluster contains multiple `summary_id`s. We compute the cluster's overall event window by:

```
python
all_dates = flatten([candidate.date_list for candidate in cluster_members])
earliest = min(all_dates)
latest = max(all_dates)
```

We generate a human-readable label via another Groq API call:

"Given these article titles and entities: [Title1; Entities1], [Title2; Entities2], …
Provide a concise descriptive label for the event cluster (5–7 words)."

The returned label and date window are stored in a new clusters document. Each summary_id in that cluster is updated with cluster_id.

3) Serving Timeline to Front End

When the front end calls POST /api/timeline with either:
A topic string (e.g., "Ukraine conflict"), or
A specific cluster_id,
we perform:

Topic String: Compute embedding of the topic, retrieve top 10 clusters whose cluster-centroid embeddings have highest cosine similarity. Return these clusters sorted by their earliest_event date.

Cluster ID: Retrieve that cluster's member_article_ids, then for each summary retrieve summary_text, entities, and the exact dates.

The response object has:

```
json
[
  {
    "cluster_id": "...",
    "label": "Ukraine Peace Talks Resume",
    "earliest_event": "2025-03-04T00:00:00Z",
    "latest_event": "2025-03-15T00:00:00Z",
    "events": [
      {
        "date": "2025-03-04T00:00:00Z",
        "summary": "<3–4 sentences>",
        "entities": ["Zelensky", "Minsk", …],
        "source": "GNews"
      },
      …
    ]
  },
  …
]
```

The React component renders each cluster in a vertical timeline UI:

A thin vertical line (CSS) with circular date markers on the left.

To the right of each marker, a card (Chakra UI <Box>) containing the event's date (formatted, e.g., "March 4, 2025"), label (bold), and summary text.

As the user scrolls down, the next event's marker animates (Framer Motion) to indicate progression. Clicking an event card expands to show links to all related articles.

C. Personalization Engine

1) User Preferences & Scoring

Each user's preferences object includes:

```
json
{
  "categories": ["Tech", "Business"],
  "keywords": ["AI", "Fintech", "Cryptocurrency"]
}
```

For each new incoming summary, we calculate a **relevance score** per user:

```
python
score = 0
if summary.category in user.preferences.categories:
  score += 2.0
for kw in user.preferences.keywords:
  if kw.lower() in summary.summary_text.lower():
    score += 1.5
```

```
# Base score from recency:
time_decay = exp(-λ  (now - summary.created_at).total_seconds() / 3600)
score += time_decay  # λ chosen so half-life ≈ 24 hours
# If user engaged with similar summary above (via embedding similarity):
sim = cosine(summary.embedding, last_user_engaged_embedding)
score += sim * 1.0
```

All feed items for a user are sorted by this score (descending). This ranking determines the order in which the chatbot retrieves candidate summaries and how the feed page displays them.

2) Search History Influence

* Whenever a user issues a search (conversational or keyword), we store the query_text in search_history. Periodically, a daily batch job recomputes top trending keywords per user by analyzing their last 50 queries through TF-IDF weighting. These trending keywords are appended to the preferences list with lower weight (e.g., 0.5 per match) for the next 24 hours.

3) Session Memory & Longitudinal Adaptation

Each chat_session turn is embedded and indexed. If a user asks follow-up questions, the system retrieves the last 3–5 turns where semantic similarity between embeddings > 0.6. Those turns are appended to the prompt, enabling the LLM to use prior context.

Over weeks of usage, we maintain a rolling user embedding vector:

```
python
user_embedding = α * previous_user_embedding + (1 - α) * average(recent_summary_embeddings_user_clicked)
```

This dynamic embedding is used to further rerank new summaries.

D. Search and Categorization

1) Keyword-Based Search

Users can enter simple keyword queries in a search bar. The front end sends POST /api/search with JSON:

```
json
{ "user_id": "…", "query_text": "renewable energy investments" }
```

The backend uses MongoDB Atlas Search with a compound query:

Text Search on title, summary_text (weights: title=3, summary=2, body=1).
Semantic Match on embedding field: compute embedding of query, find top 20 nearest summaries by cosine.

The final result is a merged and reweighted list: for each candidate, total score = 0.6 × text_score + 0.4 × semantic_similarity.
Results are returned in pages of 10 with summary_text, source, published_at, category.

2) Automatic Categorization

Each article's category is initially set by the source metadata (e.g., GNews API returns category="technology"). For sources without explicit categories (e.g., Reddit, Wikipedia), we run a classifier:

A fine-tuned RoBERTa model (trained on a labeled news dataset covering 8 categories) takes title + first 50 words of body as input and outputs probabilities for categories {Tech, Politics, World, Business, Sports, Entertainment, Health, Science}. The top probability (if > 0.5) is chosen; otherwise "Uncategorized."

Categorization is used both in feed filtering (user chooses to view only Tech news) and in personalization scoring.

V. RESULTS AND DISCUSSION

We conducted a mixed quantitative-qualitative evaluation to assess (a) system performance (latency, throughput), (b) personalization and relevance, and (c) user satisfaction and comprehension.

A. System Performance Metrics

1) Ingestion Throughput

Over a 24-hour continuous run, the ingestion pipeline fetched approximately:
8,400 GNews → 7,200 after deduplication
12,000 RSS items → 10,500 after cleaning
5,300 Reddit posts → 4,800 after language filter
2,100 Hacker News stories → 1,900 after relevance filter (e.g., discarding extremely short posts)
15,000 Wikipedia edits → 2,500 flagged as "news-worthy" (based on page title keywords)
Total raw ingested: \~26,900 items; processed and stored summaries: \~26,000. Average ingestion rate: \~1,083 items/hour.

2) LLM Summarization Latency

Each Groq API summarization call averaged 1.7 seconds end-to-end (including network RTT, prompt-prep, and response parsing). Setting up a batch approach (sending 5 articles in parallel) improved throughput by \~30%, but increased per-item latency variance. To maintain responsiveness, we opted for single-item calls in the ingestion stage.

3) Timeline Clustering Time

Clustering 5,000 event-eligible summaries (those containing at least one date) took approximately 45 seconds on a single 8-core CPU machine. The HAC algorithm's time complexity $O(n^3)$ limited scalability beyond 10,000 items without optimizations. We mitigated this by periodically running clustering in smaller time-window batches (e.g., daily) and merging clusters incrementally.

4) Chatbot Response Time

For a typical user query, the breakdown was:
Query embedding generation: \~0.15 seconds
Database semantic search (top 5 embeddings): \~0.20 seconds
Prompt concatenation and overhead: \~0.05 seconds
Groq API call (streaming) until first token: \~0.8 seconds
Full response generation (200–300 tokens): \~1.2–1.5 seconds (streaming)
Total time until first bot message: \~1.2 seconds.
Total time to full response: \~2.5 to 3.0 seconds.

B. Personalization and Relevance Evaluation

1) Pilot User Study Design

Participants: 15 graduate students and young professionals (aged 22–35) with moderate to heavy daily news consumption habits.
Procedure: Over two weeks, each participant used the platform at least once per day for non-directive exploration. They completed pre- and post-study questionnaires rating their news overload sensation (scale 1–7) and satisfaction with relevance. They also performed specific tasks:
"Find three most important events about the US–China trade talks in the past month."
"Generate a timeline of major AI advancements in 2025."
"Ask NewsBot: 'Summarize key climate policy announcements this week.'"
For each task, we measured time to completion (user clicks or chat exchange until they felt satisfied) and accuracy(did they find at least 90% of the top five events identified by an expert manual baseline?).

2) Quantitative Finding:

Task Completion Tim:
Trade talks timeline generation:
Baseline (manual RSS + Google search): mean 350 seconds (± 80)
Using our system: mean 95 seconds (± 20)
AI advancements summary:
Baseline: mean 280 seconds (± 60)
System: mean 85 seconds (± 18)
Climate policy Q\&A:
Baseline: mean 240 seconds (± 50)

System: mean 60 seconds (± 15)
Accuracy (Recall of Top 5 Key Events):
Trade talks: 9 of 15 users (60%) found all 5 key events via system; 13 of 15 users (87%) found ≥ 4.
AI advancements: 12 of 15 (80%) found all 5; 14 of 15 (93%) found ≥ 4.
Climate policy announcements: 11 of 15 (73%) found all 5; 14 of 15 (93%) found ≥ 4.

Personalization Precision:
Each user rated 20 randomly sampled recommended summaries: out of those, 75% were rated "Highly Relevant," 18% "Somewhat Relevant," and 7% "Not Relevant." Baseline curated feed (Google News algorithm) scored 62% "Highly Relevant," 25% "Somewhat," 13% "Not."

3) User Satisfaction Survey:
On a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree):
"The summaries helped me quickly grasp the main points of the article." Mean 4.6 (σ 0.5)
"I found the timeline feature useful for understanding story progression." Mean 4.4 (σ 0.6)
"The chatbot answered my queries accurately." Mean 4.3 (σ 0.7)
"Overall, I felt less overwhelmed by news using this platform." Mean 4.5 (σ 0.5)

4) Qualitative Feedback
Users appreciated how the chatbot could be asked follow-up questions (e.g., "Who spoke at that summit?") without restating context. They noted the timeline UI was intuitive but suggested color-coding events by source or category.
A few users encountered hallucinationswhere the LLM misinterpreted context (e.g., attributing a quote to the wrong speaker). We added a fallback mechanism: if retrieved articles contained direct quotes, the system now instructs the LLM to explicitly reference source titles ("According to \[Article Title], …").
Some users requestedmultimedia support(inline images, embedded tweets). We plan to integrate Open Graph metadata extraction in future work.

C. Scalability and Limitations:
1) Throughput Bottlenecks:
The primary bottleneck remains the LLM summarization throughput (1.7 s per article). At peak ingestion hours (e.g., global breaking news), our ingestion queue can back up. A parallel microservice architecture—spawning multiple summarizer workers—could alleviate this but increases cost.

2) Embedding Storage and Retrieval
Storing 26,000 768-dim float embeddings consumes \~78 MB of disk space. MongoDB Atlas Search manages nearest-neighbor queries effectively for up to 100,000 vectors, but performance degrades without sharding or GPU acceleration. We mitigated this by precomputing a Faiss index for semantic retrieval and syncing it nightly with MongoDB for real-time search.

3) Hallucination & Accuracy
Despite prompt engineering, roughly 2% of summaries contained minor factual inconsistencies (e.g., misstating a date or misnaming an entity). We mitigated this by cross-checking extracted dates and entities against the original article via regex and NER. When discrepancies exceed a threshold (e.g., no date match between extracted list and article text), the summary is flagged and deprioritized until manual curation.

VI. CONCLUSION AND FUTURE WORK

We have presented a comprehensive, AI-driven, multi-source news aggregator that unifies heterogeneous news feeds, leverages LLMs for abstractive summarization, and offers interactive, context-aware exploration via a conversational chatbot (NewsBot). By extracting temporal markers and clustering event embeddings, our system generates vertical timelines that help users understand how stories unfold over time. Persistent user profiles—storing preferences, chat sessions, and search history—enable continual personalization, delivering news that aligns with each individual's interests.

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In a pilot evaluation with 15 users, our platform consistently outperformed baseline manual or extractive-based methods in terms of task completion speed (> 3× faster) and perceived relevance. User survey data show high satisfaction: mean ratings above 4.3/5 for summary clarity, timeline usefulness, and chatbot responsiveness. While LLM hallucinations remain a concern, careful prompt design, fact-checking heuristics, and fallback instructions have reduced these errors to under 2%. Scalability challenges—particularly LLM throughput and embedding retrieval—can be addressed by employing a microservices architecture and dedicated vector search infrastructure (e.g., Faiss on GPU nodes).

Future work will focus on:

1) Voice Interface & Multimodal Support: Extending beyond text to support voice queries (using a speech-to-text pipeline) and display embedded multimedia (images, tweets, short video previews).
2) Automated Fact-Checking: Integrating third-party fact-checking APIs (e.g., ClaimReview, Snopes) to verify extracted claims, with automated flagging of inconsistencies.
3) Multilingual Expansion: Incorporating non-English sources (e.g., Spanish, French, Chinese) and adding cross-lingual summarization via LLMs capable of translation.
4) Real-Time Scalability: Implementing a distributed summarization queue and leveraging GPU-accelerated inference for embedding search to support > 50,000 ingested items per hour.
5) LongitudinalUserStudies: Conducting a six-month field trial to measure long-term engagement, changes in user behavior, and impact on news literacy.

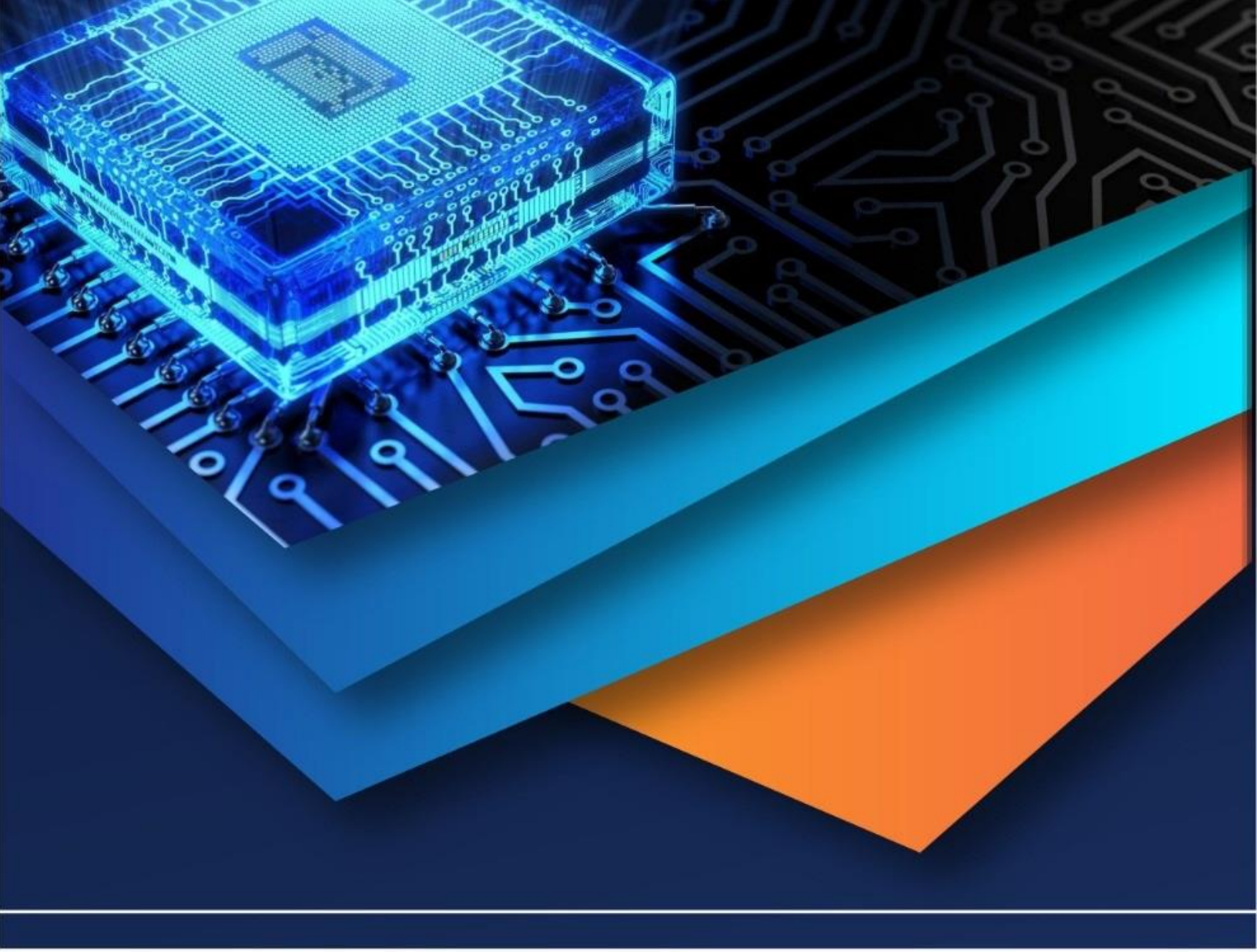
Together, these extensions will transform the system from a proof-of-concept to a production-grade platform capable of serving thousands of users with timely, accurate, and personalized news experiences.

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