

# Cheat Sheet: Advanced Retrievers for RAG



**Estimated Reading Time: 15 minutes**

## Core Retrieval Concepts

### What are Advanced Retrievers?

Advanced retrievers go beyond simple vector similarity search to provide more nuanced, context-aware information retrieval through:

- **Semantic Understanding:** Using embeddings for meaning and context
- **Keyword Matching:** Precise term-based search for exact specifications
- **Hierarchical Context:** Maintaining relationships between information levels
- **Multi-Query Processing:** Generating and combining results from multiple query variations
- **Fusion Techniques:** Intelligently combining results from different retrieval methods

### Maximum Marginal Relevance (MMR)

**Purpose:** Balance relevance and diversity of retrieved results

**Method:** Selects documents that are highly relevant to the query AND minimally similar to previously selected documents

**Benefit:** Avoids redundancy and ensures comprehensive coverage of different query aspects

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## LlamaIndex Retrievers

### Core Index Types in LlamaIndex

#### VectorStoreIndex

- **Function:** Stores vector embeddings for each document chunk
- **Best suited for:** Semantic retrieval based on meaning
- **Usage:** Commonly used in LLM pipelines and RAG applications

#### DocumentSummaryIndex

- **Function:** Generates and stores summaries of documents at indexing time
- **Process:** Uses summaries to find and retrieve relevant documents
- **Best for:** Large documents whose meanings would be lost by chunking; large documents that cannot fit in LLM or embedding model context windows
- **Key Points:** Returns original documents, not their summaries; uses summaries instead of text chunks to enable retrieval based on the semantic meaning of the entire text

#### KeywordTableIndex

- **Function:** Extracts keywords from documents and maps to content chunks
- **Best for:** Exact keyword matching for rule-based or hybrid search scenarios
- **Use Case:** Applications requiring precise term matching

### LlamaIndex Retriever Types

#### 1. Vector Index Retriever

**Most common retriever** - uses vector embeddings to find semantically related content

- **Process:** Embeds query, compares with document embeddings using cosine similarity
- **Ideal for:** General-purpose search, RAG pipelines where semantic understanding is crucial
- **Limitation:** May miss exact keyword matches when specific terms are crucial

## 2. BM25 Retriever

**Advanced keyword-based retrieval** that improves on TF-IDF

**TF-IDF Foundation:**

- **Term Frequency (TF):** How often a word appears in a document
- **Inverse Document Frequency (IDF):** How rare a word is across all documents
- **TF-IDF Score:**  $TF \times IDF$

**BM25 Improvements:**

- **Term Frequency Saturation:** Reduces impact of repeated terms using saturation function
- **Document Length Normalization:** Adjusts for document length, preventing long document bias
- **Tunable Parameters:**  $k_1 \approx 1.2$  (saturation control),  $b \approx 0.75$  (length normalization)

**Best for:** Technical documentation, legal documents, exact terminology requirements

## 3. Document Summary Index Retrievers

**Two Variants:**

1. **DocumentSummaryIndexLLMRetriever:** Uses LLM to analyze query against summaries (intelligent but expensive)
2. **DocumentSummaryIndexEmbeddingRetriever:** Uses semantic similarity between query and summary embeddings (faster, cost-effective)

**Process:** Two-stage approach using summaries to filter documents, then returns full document content

## 4. Auto Merging Retriever

**Purpose:** Preserves context in long documents using hierarchical structure

**Method:**

- Uses hierarchical chunking (parent and child nodes)
- If enough child nodes from same parent are retrieved, returns parent node instead
- **Dual Storage:** Child chunks for precise matching, parent chunks for context

**Best for:** Long documents, legal papers, technical specifications needing context preservation

## 5. Recursive Retriever

**Purpose:** Follows relationships between nodes using references

**Capability:** Can follow references from one node to another (citations, metadata links)

**Types:** Supports chunk references and metadata references

**Best for:** Academic papers with citations, interconnected knowledge bases

## 6. Query Fusion Retriever

**Purpose:** Combines results from different retrievers and optionally generates multiple query variations

**Core Capabilities:**

- Multiple retriever support (combines vector-based and keyword-based methods)
- Query variation generation using LLM
- Sophisticated fusion strategies to improve recall

**Three Fusion Modes:**

**Reciprocal Rank Fusion (RRF)**

- **Most robust fusion method** - combines ranked lists using reciprocal of ranks
- **Formula:**  $RRF\_score(d) = \sum (1 / (\text{rank}_i(d) + k))$  where  $k \approx 60$
- **Best for:** Default choice for most fusion scenarios, production systems

**Relative Score Fusion**

- **Preserves score magnitudes** while normalizing across query variations
- **Formula:**  $\text{normalized\_score} = \text{original\_score} / \text{max\_score}$
- **Best for:** When embedding model confidence scores are meaningful

**Distribution-Based Score Fusion**

- **Most sophisticated** - uses statistical properties of score distributions
- **Methods:** Z-score normalization, percentile ranking
- **Best for:** Complex queries with varying score distributions

## LangChain Retrievers

### LangChain Retriever Interface

**Definition:** "An interface that returns documents based on an unstructured query"

- More general than a vector store
- Accepts string query as input, returns list of documents as output
- Doesn't necessarily store documents - purpose is to retrieve them

### LangChain Retriever Types

#### 1. Vector Store-Backed Retriever

**Foundation retriever** - lightweight wrapper around vector store class

**Search Types:**

- **Simple Similarity Search:** Returns documents ranked by similarity (default 4 results)
- **MMR Search:** Balances relevance and diversity to avoid redundancy
- **Similarity Score Threshold:** Returns only documents above specified threshold

#### 2. Multi-Query Retriever

**Problem Addressed:** "Distance-based vector database retrieval may vary with subtle changes in query wording"

**Solution Process:**

1. Uses LLM to generate multiple queries from different perspectives
2. For each query, retrieves set of relevant documents
3. Takes unique union of results for larger set of potentially relevant documents

**Benefit:** "By generating multiple perspectives on the same question, the MultiQueryRetriever can potentially overcome some limitations of distance-based retrieval"

#### 3. Self-Querying Retriever

**Core Capability:** "Has the ability to query itself"

**Process:** Converts natural language query into structured query with two components:

1. String to look up semantically

## 2. Metadata filter to accompany it

**Requirements:** Documents must have rich, structured metadata with field descriptions  
**Best for:** Applications combining semantic search with attribute filtering

### Example Queries:

- "I want to watch a movie rated higher than 8.5" (filter only)
- "Has Greta Gerwig directed any movies about women" (query + filter)

## 4. Parent Document Retriever

**Problem Solved:** "Conflicting desires" when splitting documents:

- Small documents for accurate embeddings
- Large documents for context retention

**Solution:** "Strikes that balance by splitting and storing small chunks of data"

### Process:

1. During retrieval, first fetches small chunks
2. Looks up parent IDs for those chunks
3. Returns larger documents containing the small chunks

### Architecture:

- **Two splitters:** Parent (large chunks for retrieval) and child (small chunks for embeddings)
- **Dual storage:** Vector store for embeddings, document store for parent documents

## Decision Framework

Need	LlamaIndex Choice	LangChain Choice
Exact keyword matching	BM25 Retriever	Vector Store-Backed + custom keyword logic
Multi-query with fusion	Query Fusion Retriever (RRF/Relative/Distribution)	Multi-Query Retriever (union approach)
Citation following	Recursive Retriever	Not directly supported
Hierarchical context	Auto Merging Retriever	Parent Document Retriever
Simple semantic search	Vector Index Retriever	Vector Store-Backed Retriever

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**Skills Network**