



Achieving intelligent enterprise search with **Practical AI**



Whether you realize it or not, search applications are changing our daily lives. And thanks to AI, these applications are getting smarter all the time.

Traditional search is no longer enough. After all, people don't just want results, they want answers. This is now possible with intelligent search applications powered by maturing AI technologies like natural language processing (NLP), machine learning, computer vision and knowledge graphs.

Intelligent enterprise search delivers smarter answers more efficiently. Think about the various apps on your smartphone. It may not be obvious, but behind the scenes there's a search engine powering each app so that it can seamlessly deliver what the user needs:

Voice search – we don't just type phrases into search bars anymore, we talk to search engines or digital assistants. We ask specific questions and expect to get relevant answers.

Rideshare – instead of hailing a cab, we tap on an app and the rideshare service finds and identifies us in their customer database. We enter a destination and sophisticated search algorithms help match us to a nearby driver and provide a real-time ETA.

Smart navigation – where's the nearest gas station or the closest restaurant? Using our phone, we can find out the answer in a few seconds. And it doesn't stop there. What's the best route there? Are there any traffic delays? Search answers those questions too.

Intelligent search applications like these are transforming our day-to-day lives. And as users become more and more used to these smart apps, they've come to expect the same experience in the enterprise. In this report, we identify the building blocks for this capability and show how organizations can move forward on their journeys to smart enterprise search...that keeps on getting smarter.



Training datasets: quality and quantity both essential

So how does an enterprise make search applications smarter? For starters, you need high-quality data, and lots of it. Combined with an understanding of user requirements in specific use cases, this is the key to training the AI technologies that power search.

It's the secret behind the latest generation of cognitive – or more intelligent – search. Search engines like Google and Bing run datasets through neural networks so AI can learn how to classify and understand content and user-query intent.

What's so revolutionary is that this can also be done for enterprise search. And training data is the key enabler behind AI's understanding of user intent and enterprise content.

Understanding the users:

AI models like those used by Google, Microsoft Search, or Amazon Kendra can learn from user signals and behavioral data such as their search queries, the pages they visited, the videos they watched, their chat logs with virtual support agents and so on.

Taking this user behavioral data and feeding it into machine learning algorithms will help the search engine better understand the user's intent and what is relevant to him/her. In addition, existing data about the user, such as job location, title, department, and documents they author are all relevant signals that can be incorporated to further train the search engine.

As more training signals are provided, the search engine can continuously improve, automatically learning how different data sources or pieces of information are relevant to each specific user. For example, in a search for "impact of tobacco regulations," a marketer will likely be searching for business and legal impacts while a medical researcher may be

looking at public health impacts. An intelligent search engine would be able to provide personalized results to each user based on its understanding of the user type and intent. The more high-quality user data is available to understand the intent of a group of users, or better an individual user, the better AI algorithms can learn and enable the search engine to deliver the most relevant results to each group.

Understanding the content:

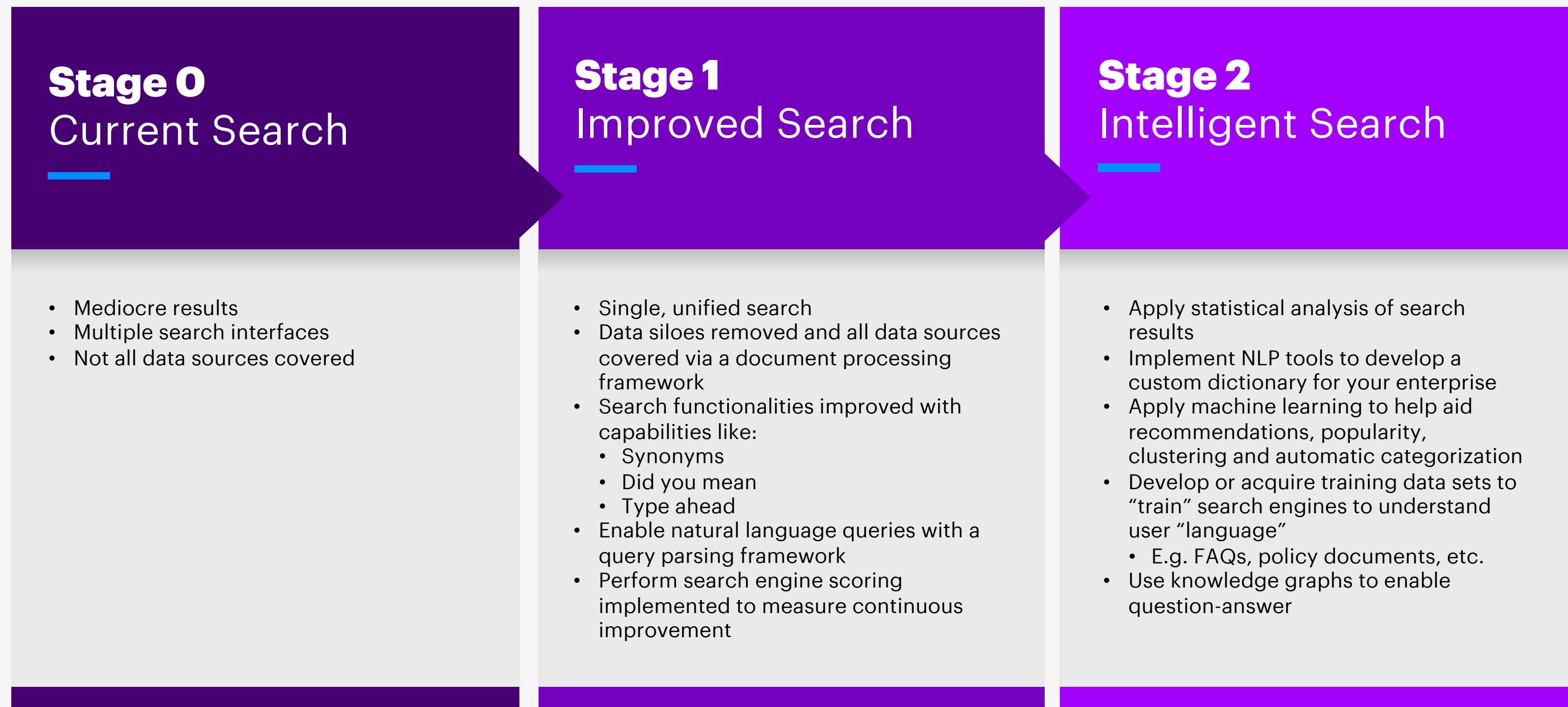
Organizations all have massive amounts of internal data, text documents, presentations, PDFs, images, emails, messages and more. Unlike internet content that is specifically labeled by humans to increase searchability, enterprise content lacks the standard labeling and classification required for good search. AI techniques like natural language processing (NLP) and machine learning (ML) can help automate the extraction, tagging and classification of concepts and entities within massive amounts of enterprise content.

For example, NLP can extract features from text documents like people, companies, places and products, with that data being fed into ML algorithms that can steadily learn the language specific to a company or industry (acronyms, products, processes etc). Because each individual word rarely makes sense without context, training data, such as business-specific dictionaries, make it possible for AI to learn and understand the content of documents.

As well as leveraging training data, enterprises will deliver better answers and user experiences for their people if they go through an evaluation process that helps them to understand their current search performance and identify what needs to be done to achieve intelligent search. During the planning phase, the general maturity model below can be used as a guideline to develop goals and implementation strategy.

Have a plan: achieving intelligent enterprise search

Simple search is no longer enough. Enterprises should be aiming for intelligent search – the most advanced of the three stages in our search maturity model:



Most enterprises fall into **Stage 0** where, even with the best search engines, search results are generally mediocre, resulting in a poor user experience.

With an improved architecture in **Stage 1**, data sources are brought together and a single index allows enterprise users to look at data across all structured and unstructured sources. Expert tuning techniques and functionalities like synonyms, “did you mean?,” and type-ahead help achieve the original Google-like experience. These types of modifications or improvements can also produce a correlated increase in conversion rates; gradual improvements can also be measured with the implementation of search engine scoring techniques pioneered by Accenture, among others.

To reach the highest maturity stage, **Stage 2 - ‘intelligent search,’** enterprises need to commit to leverage advanced statistical analysis and practical AI technologies to better understand user intent and the content being searched. This is what is required to deliver the AI-driven, conversational search experience users will come to expect:

- Query and click-through logs can be mined, and statistical analysis can be used to continuously measure and improve search relevancy.
- NLP tools can be used to develop a custom dictionary for your enterprise, which helps the search application better understand the language presented in search queries as well as the documents being searched.
- Machine learning and NLP models can be used to automatically extract and classify relevant information (and even full answers) from the content being searched. This is an alternative to a strictly rules-based approach, making extraction and classification more scalable and efficient for large volumes of content.
- The initial “training” of these models will require an appropriate (and often large) subset of the total searchable content. Developing these datasets represents a unique challenge in the implementation process.
- Finally, information extracted from the universe of searchable content can be used to populate knowledge graph databases, which may deliver better performance and results in extremely large-scale implementations.

As their enterprise search applications mature, we’re seeing enterprises combining search engines with AI technologies in this way to answer highly complex questions faster and more accurately. So, what does an intelligent search application look like? In the following sections, we’ll explore various applications and what to consider when building one.

Stage 0
Current Search

Stage 1
Improved Search

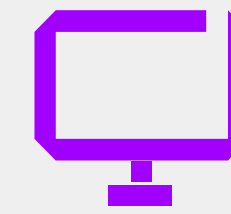
Stage 2
Intelligent Search

Search in action: examples of intelligent enterprise search applications

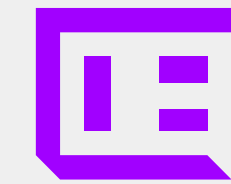
Search is needed anywhere there are large and complex datasets or systems.

For example, most corporate intranets, websites and applications are large and complex, with multiple nested hierarchical menus, each with numerous features, options and destinations. Companies are now replacing this complexity with a single search box which fetches content and answers questions. This single search box eliminates the complexity, putting everything the user might want just one search away.

Here are a few examples of search applications that can be applied across the enterprise, along with examples of content and what might be searched for:



Corporate portal/intranet



Data catalog



Procurement



Knowledge management



**Business insights/
Business analytics**

Corporate portal/ intranet

Examples of content:

- Corporate destinations (timecards, expenses, payroll, IT, CRM etc.)
- Policies and procedures, FAQs, support, ethics, forms
- Organizations, people, office locations
- Products, parts, projects, customers
- HR benefits

Search queries should answer the kinds of questions that employees actually have, such as “Who is John Doe?”, “How do I fill out my timecard?” and “How much of Widget X did we sell last year?”

Data Catalog

Examples of content:

- Data-lake/data-warehouse data sources
- Business system APIs, MasterData etc.

Search queries should help find the datasets that need to be analyzed. Queries like “Maryland franchises” or “Financial customers with over \$1m in sales” should be able to identify the best tables with the specified data, as well as subsetting that content.

Procurement

Examples of content:

- Purchasing plans/forms/procedures/categories
- Approved suppliers, approval paths and forms
- Invoice and order status

Search queries should allow users to find products or services that they want to buy. Buying a single notepad requires an entirely different process from buying 10,000 notepads. These purchasing complexities must be understood and properly handled by the search system.

Knowledge Management

Examples of content:

- Proposals/pitch books, RFPs, RFIs, contracts, legal documents
- Internal and external research, sales and marketing
- Documentation, guides, training

Search queries should enable users to access the right knowledge and insights within the vast store of enterprise content. Beyond serving relevant documents containing that knowledge, search can also leverage automated information extraction to deliver precise answers to user queries, without the user having to go through search results to find the answer.

Business insights/ Business analytics

Examples of content:

- Reports, charts, graphs
- Corporate KPIs, year-on-year comparisons

Search queries should answer questions on how an organization is performing. When needed, search should be able to provide subsets and filtered views based on time, location, product etc.

Accuracy is critical in all these applications. Without it, enterprises run the risk of feeding users with non-actionable or even misleading insights. It's more important than ever for enterprises to make sure they're adding structure to their unstructured data – like the examples of content types above – to enable better search and analytics over the best and most appropriate content available.

While each organization will have unique use cases and requirements for its search applications, there are common key criteria that should be considered in any search implementation strategy.

Building an intelligent enterprise search application: key considerations

Once you start defining an implementation strategy for your search applications, maximize your ROI by considering these key elements:

Search engine

When selecting the core search engine on which your search application will be built, consider the following questions:

- Is the search engine open source or proprietary?
- What are the total licensing costs?
- What skillsets will be needed to implement the search engine?
- How well does the search engine integrate with machine learning methods? Are these methods fixed or can they be customized and tuned to your needs?

Open source search engines (e.g. Solr and Elasticsearch) have the advantage of being license-free and provide a greater degree of flexibility for customized features. However, while they may bring potential cost savings, you will need to factor in the skills and resources needed for setup, customization, and maintenance.

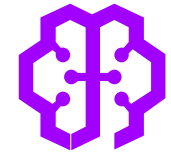
Commercial engines, on the other hand, may have more built-in systems for configuration, setup and maintenance as well as machine learning (ML). But their ML methods may be out of date and/or unsuited to your specific search needs.

Content sources

Understand which content sources are important, which ones can be excluded, when ingestion will be easy, and when it will require special attention. It's also critical to understand the technical requirements for searching your content sources. Different stakeholders come with different business systems and different content sets. It's why knowing your users' needs and what content you have will help you provide them with the best, most relevant search experience.

Consider the following factors to determine the complexity and potential costs involved in scaling your search application:

- Number of data sources
- Number of data records
- Number of updates
- Types of content – digital-born content, scanned PDFs etc.
- Different languages across enterprise content
- Is the content source well curated? If so, policies and procedures, documentation, safety guidelines etc may be candidates for deep NLP, such as neural network sentence understanding
- Is the content source high-volume? If so, these may be candidates for shallow NLP, such as large-scale clustering and classification
- Does the content contain a lot of tables and forms? If so, you may need special “document understanding” systems to extract semantic meaning from this content based on presentational clues like text size and position, lines, boxes, fonts etc.



Integration with AI technologies

During content processing and search application implementation, there are opportunities to leverage AI technologies – NLP, machine learning, knowledge graphs etc. – to enhance the search application’s performance. Technical leadership should evaluate AI technology offerings and understand how to translate their capabilities into business benefits.

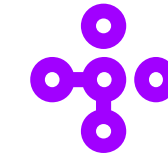
A successful integration of search and AI takes time, investment, domain-specific knowledge and technical expertise. But with practical strategy and expert implementation, organizations can unlock hidden value with intelligent enterprise search applications.

When processing content, AI technologies are used to:

- Generate an internal understanding of the text so that the machine can find things which have “similar meanings”
- Extract references to business objects, such as people, parts, vendors, customers, products etc.
- Extract relationships between referenced items
- Classify content by industry, purpose, lifecycle phase, business function etc.

When processing user requests, AI technologies are used to:

- Understand the intent of the user’s request
- Extract and identify references to business objects in the query (e.g. people, parts, products, customers, vendors, measurements etc.)
- Identify which content sources are best able to fulfill the request
- Formulate the proper request to the back-end business system to answer the user’s query
- Provide feedback on the interpretation of the user’s request so it can be corrected by the user if needed



NLP middleware

There is a wide diversity of NLP methods to extract entities and recognize intent:

- Pattern-based methods (Regex, BNF, Dictionary, N-of-M, Statistical)
- Traditional ML methods (Bag of Words, N-Grams, Linear, Skip-grams, GenSim, Spacy, LSI)
- Neural networks (Word2Vec, Universal Sentence Encoder, BERT, ELMo, XLNet, SQUAD)
- Cloud-based methods (Google NLP, Amazon Comprehend, Microsoft LUIS)

Every day, new NLP algorithms are being created and previous “award-winning” benchmarks are being surpassed. The only way to handle such rapid ongoing change and diversity is to adopt an NLP-middleware framework. Rather than custom-integrating a few select algorithms, an NLP-middleware framework will allow you to easily plug in any new NLP algorithms as they are created and then quickly embed them into an existing system.

Specifically, an NLP-middleware framework will support:

- Managing a library of NLP algorithms
- Applying any number of algorithms to the same text at the same time. This
 - represents and resolves ambiguity which is often produced when multiple algorithms are applied to the same text
 - allows “order independence” which does not impose ordering restrictions on algorithms (or automatically orders the algorithms for optimal execution)
- Managing the configuration and resource data (e.g. patterns, dictionaries, ML models) required by the algorithms
- “Plugging in” new algorithms
- Allowing for both Python and Java algorithms
- Managing the mapping of algorithms to semantic tags, which enables multiple algorithms to be applied to the same tag
- Having built-in algorithms for common items (email addresses, locations, URLs, phone numbers etc.)

A growing range of search engines support intelligent enterprise search

Rising demand for AI-powered search applications is being fueled by the growing range of search engines that support NLP and AI technologies.

Many open-source or commercial search engines can support intelligent search implementations. Some powerful, flexible, and scalable search platforms currently leveraged by enterprises include but are not limited to:

- **Elasticsearch** – allows for both sparse vector (with plug-in) and dense vector methods; vectors are produced by neural networks and other ML techniques
- **Solr** – pluggable to support vectors produced by neural networks and other ML techniques
- **Coveo** – built-in NLP methods
- **IBM Watson Discovery** – built-in natural language question-answer (NLQA) capabilities
- **Lucidworks** – plug-ins enable third-party crowdsourced learning models for ranking and classification
- **Mindbreeze** – hybrid AI approach with bootstrapped learning models and real-time feedback to schemas and vocabularies
- **Sinequa** – deep integration with many taxonomies
- **Google Cloud Search** – built-in NLP methods for common language
- **Azure search and Microsoft search** – can be integrated with Microsoft cognitive frameworks
- **Amazon Kendra** – built-in question-answering capabilities

With this growing ecosystem of search, NLP, and ML technologies, enterprises have increasing flexibility to select appropriate approaches and toolsets for their specific search use cases.











Building an intelligent enterprise search application: key considerations

Different business functions in your organization will have different requirements. An end-to-end intelligent search architecture for large amounts of enterprise content will be required to handle a wide range of enterprise user intents for a multitude of business stakeholders.

Whether you use an out-of-the-box commercial search solution, or create a customized solution, you'll need to apply a multitude of methods for understanding user intent and answering user questions to a wide range of business APIs and business data systems.

As an example, your enterprise search application may be required to:

-  Reserve a conference room from a reservation system
-  Access payroll to determine the number of paid vacation hours an employee has remaining
-  Access HR to identify the user's enrolled benefits
-  Access the timecard system to find total time charged to a code
-  Access the business intelligence/business analytics system to determine sales volume for products or regions
-  Access the customer database to find account representatives for customers or contact information for vendors
-  Find answers to questions in an ethics manual
-  Find answers to questions in a set of policy and procedure manuals

In all these cases, you will be required to integrate with a wide variety of back-end business systems, and your intelligent search solution must be able to handle this variety gracefully.

Reference architecture

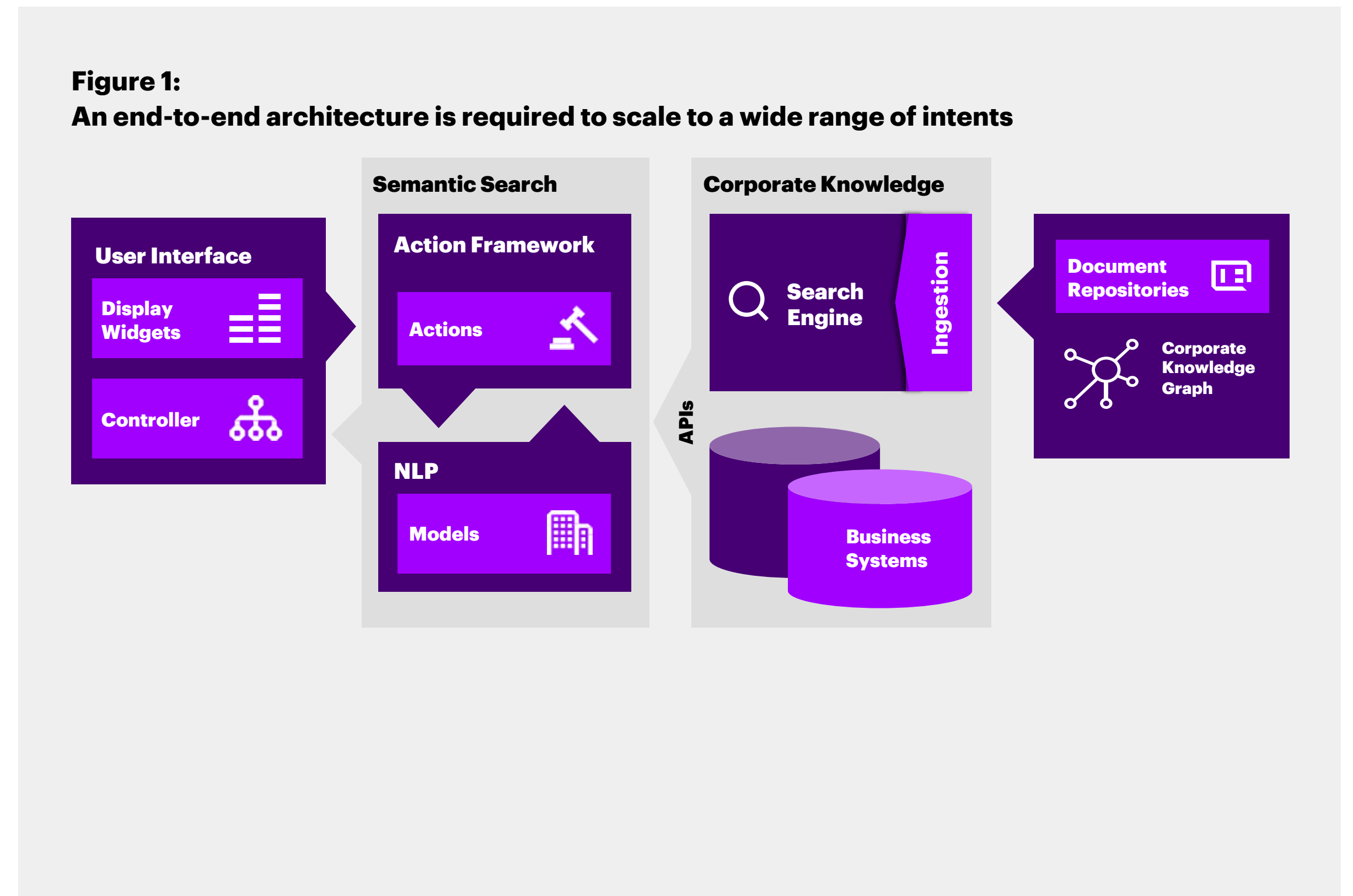
Figure 1 shows a reference architecture for such a system. Key components include:

Knowledge graph: This brings together data fragments from multiple data sources (e.g. employee resumés, project documents, client reports etc.) and creates meaningful connections between them. This network is the “enterprise knowledge graph,” from which the QA system can instantaneously pull a snapshot of connected information and deliver relevant insight when the user asks a question. The knowledge graph will be ever-growing as new data points and insightful relationships are added indefinitely.

NLP framework: A framework that allows multiple business stakeholders to create domain-specific language models that will not only process but also understand natural language queries and relevant business content to produce an actionable request.

Action framework: Translates the clarified requests produced by the NLP framework into specific searches and calls to business system APIs. The action framework will be triggered by request intents, which will identify exactly what action (or actions) should be executed. Action data will be pulled from the entities (e.g. people, parts, customers, locations, IDs etc.) identified in the request. This is translated into either a search of the knowledge graph, a search over business system indexed content, or an API request to any of a multitude of back-end business systems.

User interface: An end-user search interface that can be customized to business requirements and is capable of delivering answers to natural language queries with an intuitive and easily-understood UI presentation.



Reference architecture with Accenture assets

Accenture leverages this robust ecosystem and our own technology assets to orchestrate the different components of search applications – making them easily maintainable and scalable. Figure 2 is an example of an architecture integrating common technologies and Accenture’s own assets.

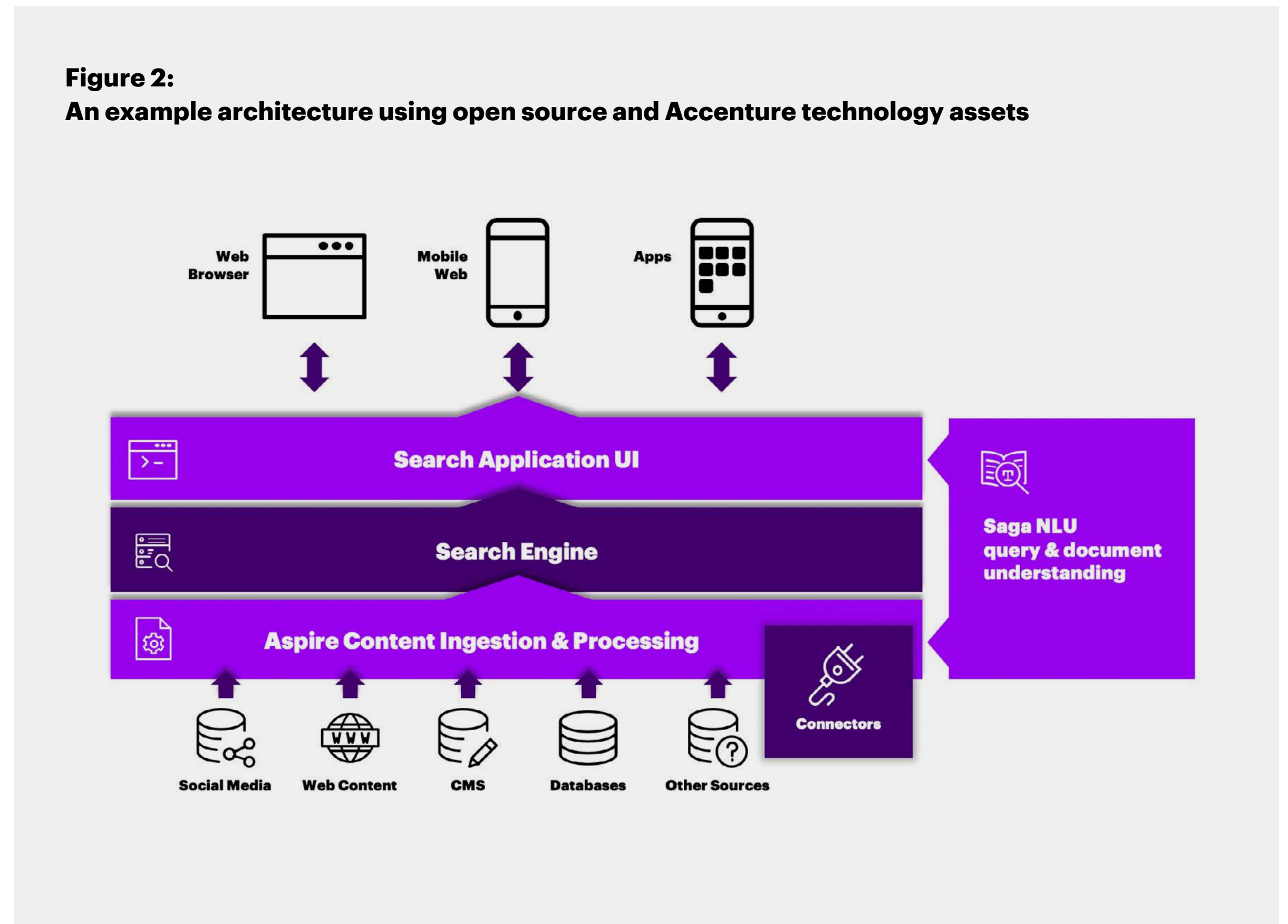
Aspire Content Processing Framework: A proven framework for acquiring and enriching unstructured data, providing relevant, rich context for search, analytics, and NLP applications.

Content Connectors: Securely connect to more than 40 unstructured and structured content sources.

Search Engine: Leveraging open source search engines like Elasticsearch and Solr or commercial search engines like SharePoint Search, Google Cloud Search, Amazon Kendra, Coveo, and others.

Saga Natural Language Understanding (NLU) Framework: An innovative NLU-middleware framework, Saga helps create and maintain scalable enterprise language models for user interaction and document understanding. In addition, “Saga for Semantic Search” contains an action framework for managing execution of search engine requests and API calls to back-end business systems in response to NLP requests to return live action data.

Enterprise Search UI: A search-engine-agnostic end-user search interface with full source code, customizable for specific requirements. The Accenture Search UI has built-in widgets for semantic search responses and is seamlessly integrated with the Saga action framework.



Get ready for smarter search

The building blocks for smarter enterprise search are all in place, with unprecedented opportunities for organizations to create new search experiences that match users' growing expectations. We've shown how AI technologies are maturing rapidly and getting smarter with training data and algorithms. They are now enabling search engines to unlock tremendous new insights from the vast resources of enterprise data. And this is just the start.

With a well-implemented AI-powered search solution in place, organizations can gain maximum leverage from their enterprise data. As well as supporting more accurate and more timely decision-making, this will significantly reduce employees' time spent searching for the right answers – boosting the quality of user experience and driving new productivity.

As organizations seek to increase the ROI of their enterprise search, the search maturity model provides practical guidelines for evaluating current performance and planning the next enhancement. During your organization's journey toward an intelligent search application, it's essential to ensure that your IT staff and/or implementation partners have the bandwidth and expertise required to conduct a thorough assessment. The goal? Aligning enabling technologies with your highest-priority business needs.

Whether you're still in the initial phase of evaluating various technologies or have already identified a technology stack, we can help – from evaluating and selecting the best-fit solution to implementing, optimizing, and managing the application.

Looking for support and want to leverage Accenture's expertise? [Contact us](#) to discuss your goals and start defining a strategy and implementation roadmap for your intelligent search application.

About Search & Content Analytics

Search & Content Analytics, formerly Search Technologies, is part of Accenture Applied Intelligence. We live in a data-driven world. But not everyone is making the most of their data. 80 percent of all data is unstructured – imagine the hidden insights trapped within unstructured enterprise content such as voice, images and emails. At Search & Content Analytics, our mission is to help enterprises unlock the full value within their unstructured and structured data. We combine innovative technologies such as machine learning and natural language processing with search and big data analytics to transform the way people work. Whether it's improving intranet and website search, monitoring internal communications to detect insider threats, helping recruiters match jobs to résumés, analyzing oil wellhead reports, or exploring molecular data, we bring comprehensive search and analytics services to clients across industries. Clients include organizations in e-commerce, media, healthcare, financial services, recruiting, manufacturing, and the government sector. What knowledge and insights are trapped in your data? Let us help you find better answers.

Learn more about our capabilities and client work at www.accenture.com/sca

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