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AGENT-BASED APPROACH TO IMPLEMENTING ARTIFICIAL INTELLIGENCE (AI) IN SERVICE-ORIENTED ARCHITECTURE (SOA)

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Abstract. Artificial Intelligence (AI) is becoming a general-purpose technology and is gaining a universal character for engineering, science, and society that today is only inherent in mathematics and computer technology. The agent-based approach to implementing artificial intelligence (AI) within the service-oriented architecture of an application is a fascinating and highly synergistic concept. Combining these paradigms leads to robust, scalable, and intelligent systems well suited for dynamic and distributed environments. This paper presents the results of a comparative analysis of three possible approaches to integrating AI into business processes, namely, connecting AI agents to service-oriented architecture (SOA), connecting AI agents to software (SaaS), and building AI as a service (AIaaS). The paper provides some insights into the potential benefits, challenges, examples, and considerations when adopting each of these approaches.

Keywords: AI (Artificial intelligence), agentic AI, AI-agent, SOA (Service oriented architecture), SaaS (Software-as-a-Service), RAG (Retrieval-Augmented Generation), large language models (LLM), single-agent and multi-agent systems, AI agent development platforms, AI agent integration with SaaS, AI agents and SOA.

AGENTIC AI

As artificial intelligence becomes an increasingly integral part of how we live and work, it's important to understand the differences between agent-based AI and generative AI [1; 2; 5; 10; 11; 12; 18].

Generative AI is a type of AI that focuses on creating new content, such as text, images, music, or even video. It works by learning from large amounts of data to understand patterns, styles, or structures, and then generating original content based on what it has learned. For example, generative AI such as *ChatGPT* can generate unique text answers to questions, while image generation models such as *DALL-E* can create images from text descriptions. In essence, generative AI is like a digital artist or writer, creating creative works based on what it has learned.

Agentic AI, on the other hand, is a step forward. Unlike generative AI, it can take initiative, set goals, and learn from its own experience (Fig. 1). It is proactive, able to adjust its actions over time, and can handle more complex tasks that

require constant problem solving and decision making. This transition from reactive to proactive AI opens up new possibilities for technology in many fields, allowing machines to operate with near-human understanding and creating a seismic technological shift. Machines now understand us better than ever before. They can learn, predict, intuit, and reason. They can take on uncertain tasks, manage complex processes, and make subtle decisions that only a year or two ago could only be made by humans. Imagine a robot that operates without a human controller, determining what to do next based on its environment, or a self-driving car that strives to get you to your destination safely, with every action, from steering to braking, serving that goal.

In short, at its core, agent-based AI is a type of AI that prioritizes autonomy. Agents have true autonomy, making decisions and taking actions independently with minimal human supervision. The level of autonomy is determined by the number of iterations an AI agent can go through to reach a conclusion, as well as the number of tools at its disposal.

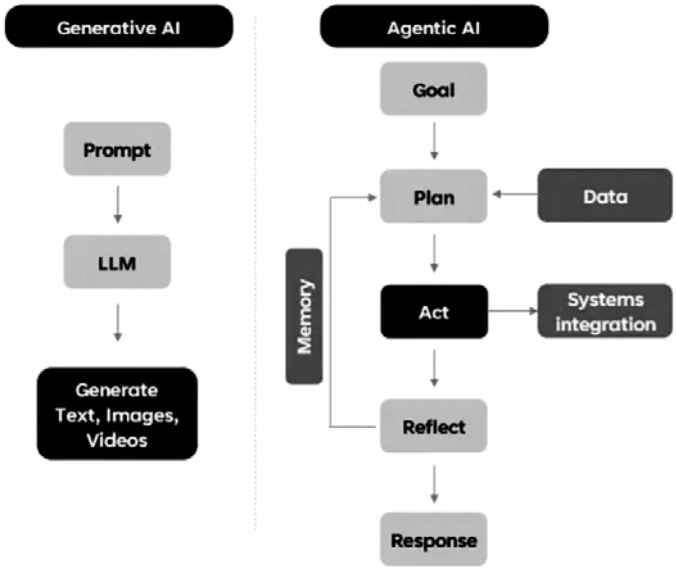

Fig. 1. Difference between Generative AI and Agentic AI [5]

An AI agent is an interactive computer program with pre-defined goals that can perform a variety of tasks on behalf of a user or another program. AI agents have the potential to understand and learn from their environment, make decisions, act, and even continuously improve with minimal human intervention. This is achieved by integrating several key components that allow it to interact with data, interpret its environment, choose appropriate responses, and communicate meaningfully with users. In addition, AI agents can benefit from human feedback, which enhances their adaptability and performance.

In particular, AI agents are used to automate the process of developing web applications without coding. They can analyze user needs, generate code, test applications, and even deploy them. This makes application development faster and more cost-effective. However, the use of AI agents requires the availability of LLMs (large language models such as *GPT-4, Claude, Gemini*, etc.), which can be expensive because LLMs require a lot of resources:

- Significant computational resources for training and operation.
- Huge amounts of data for training.

- Highly qualified machine learning and artificial intelligence specialists to develop and maintain LLMs.
- Significant energy for training and running LLMs.

But there are alternatives and ways to reduce costs:

- Cloud providers such as *Google Cloud, Amazon Web Services,* and *Microsoft Azure* offer access to LLMs on a pay-as-you-go basis.
- For some tasks, smaller SLMs can be used that require fewer computing resources (*Microsoft phi-4, DistilBERT, TinyBERT, Albert*).
- There are open-source LLMs that can be used for free (*Llama 2* and *OPT* from Meta, *GPT-Neo, GPT-J, GPT-3* from EleutherAI). However, they may be inferior in quality to commercial models.

The choice depends on the specific needs of your project. If you need maximum performance and functionality, commercial LLMs may be a better option. If efficiency, speed and resource savings are important, smaller SLMs or open source LLMs may be a better choice. In general, open source LLMs and small SLMs play an important role in the development and dissemination of artificial intelligence technologies, making them more accessible, efficient and versatile.

It should be noted that the boundaries between generative and agent-based AI are not always clear. Many modern AI systems include elements of both, creating hybrid models that can generate content and make autonomous decisions.

AI AGENTS WITH RETRIEVAL-AUGMENTED GENERATION (RAG)

To make an agent contextually relevant, it is connected to an external knowledge base or data source that supports its responses with accurate, domain-specific information. A common approach to such integration is the Retrieval-Augmented Generation (RAG) pattern, which combines external data retrieval with generative capabilities. In addition to basic understanding, the agent is equipped with a toolkit - specialized skills and abilities that allow it to autonomously perform actions, initiate workflows, or solve tasks according to set goals. An orchestrator coordinates all these components and ties the agent's functionality together. The orchestrator processes user input, manages internal operations, and delivers consistent results either directly to the user or to other agents in multi-agent interaction systems.

LLMs are trained on static data sets, which can lead to outdated information. RAG allows agents to access up-to-date information from dynamic sources such as web pages and news feeds (Fig. 2). RAG allows agents to tailor responses to

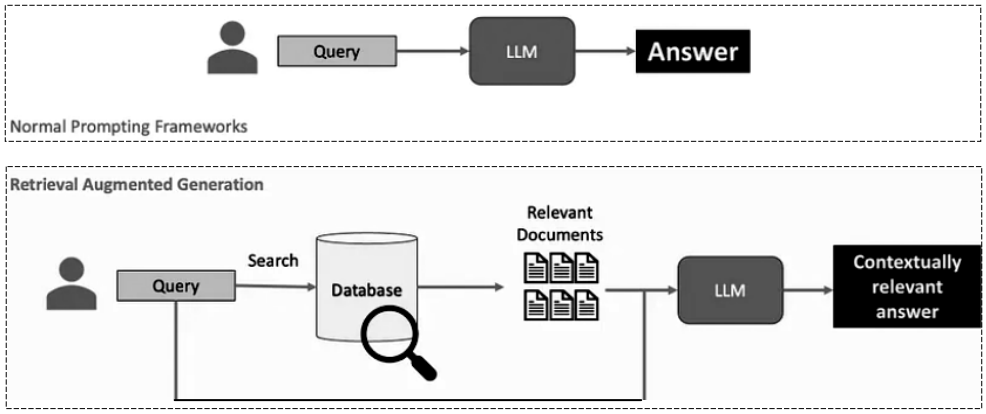

Fig. 2. Comparing standard LLM calls with RAG [9]

the specific context and needs of the user by retrieving relevant information from personalized sources such as search history or user profiles. RAG also enables agents to provide explanations and sources of information, increasing transparency and trust in their responses. RAG works in AI agents as follows [7–9]:

- *Request:* The user asks a question or makes a request to the AI agent.
- *Retrieval:* The agent uses information from the request to search for relevant documents or data in external sources.
- *Extraction:* The agent extracts the most important information from the sources found.
- *Generation:* The agent uses an LLM to generate a response, using the extracted information as context.

Overall, RAG is an important tool for creating more intelligent, accurate and useful AI agents that can effectively interact with the real world and meet user needs. However, an alternative and more modern approach has recently emerged — Table-Augmented Generation (TAG). While RAG has proven effective in integrating AI with external data retrieval systems, TAG offers a paradigm shift by allowing large language models (LLMs) to interact directly with structured databases. Table-Augmented Generation (TAG) provides a more direct and structured approach, allowing LLMs to query databases using SQL or other database-specific query languages [7].

TYPES OF AI AGENTS AND TOOLS FOR CREATING THEM

The following four rules define the functionality of an AI agent: autonomy, perception, decision making and adaptability [3; 6].

- *Autonomy:* This rule means that the AI agent must function independently to perform tasks without constant user intervention.
- *Perception*: The AI agent can interpret data from the environment, obtained through sensors, cameras or other sources.
- *Decision-making*: This involves the AI agent's ability to choose appropriate actions to achieve its goals.
- *Adaptability:* Adaptability is the ability of an AI agent to learn from new information or experience and improve its responses over time.

These principles are the foundation for the design of AI agents and are widely accepted in the AI community to describe the core capabilities that enable intelligent, agent-like behaviour.

Table 1 below provides examples of different types of AI agents. Each type reflects the functionality, adaptability, and level of autonomy of the agent, as well as the specific ways in which AI agents interact with the environment, make decisions, and process information [13; 14; 15; 17].

Since the end of 2024, there has been a significant shift from single-agent AI solutions to multi-agent systems [16; 18].

- *Single-agent systems:* These are focused artificial intelligence models geared towards specific tasks, such as smart chatbots. While effective in isolated scenarios, they have limitations in managing complex, interconnected workflows. Single-agent systems typically require human involvement to provide ongoing feedback.

- *Multi-agent systems:* These involve a network of AI agents that collaborate to solve problems or achieve goals that require diverse knowledge. Imagine a team collaborating, communicating internally, critiquing each other, and improving each other's results to solve a given task, as opposed to a single agent receiving feedback only from the human interacting with it.

Table 1. Types of AI Agents

№	Agent Type	Description	Examples
1	Simple Reflex Agent	These agents act solely based on the current state of the environment, without considering the history or planning for the future. They follow a set of predefined rules (condition-action rules), e.g., "if sensor detects X, then perform Y"	Thermostats, basic robots, or systems like spam filters that react to input based on simple criteria
2	Model-Based Reflex Agent	These agents maintain a model of the world that helps them keep track of the state of the environment. They use the model to make better decisions by considering both the current state and the history of interactions	Robotic vacuum cleaners (like Roombas) that map their environment to navigate efficiently
3	Goal-Based Agent	These agents not only track the state of the environment but also act to achieve specific goals. They use planning and search algorithms to determine the best course of action to achieve their objectives	Autonomous vehicles deciding the optimal route to a destination
4	Utility-Based Agent	These agents evaluate different states or actions based on a utility function, which measures how desirable a state is. They aim to maximize the utility (or "happiness") by choosing actions that lead to the best possible outcome	AI in recommendation systems (e.g., Netflix or Spotify), where the goal is to maximize user satisfaction
5	Learning Agent	These agents improve their performance over time by learning from data or experiences. They can adapt to new tasks or environments without explicit programming	Chatbots (like ChatGPT), recommendation systems, autonomous vehicles, and game-playing AIs (like AlphaGo)
6	Collaborative Agent	Works with other agents or humans	Coordinating the work of multiple robots
7	Mobile Agent	Moves between networks to perform tasks	Network management scenario
8	Multi-Agent System	Involves multiple agents working together or competing to solve complex problems that cannot be handled by a single agent. Agents in a MAS can communicate, negotiate, and collaborate to achieve shared or individual goals	Traffic management systems, distributed supply chain systems, and swarm robotics
9	Belief-Desire-Intention (BDI) Agent	Balances between beliefs, desires, and intentions	Autonomous bots for customer service
10	Interface Agent	Helps users by learning preferences	Personalized email sorting
11	Reactive Agent	Reacts quickly without internal models	Real-time game characters
12	Hybrid Agents	These agents combine multiple types of agent architectures (e.g., reflex and goal-based) to leverage the strengths of each	Autonomous drones that use reflex actions for obstacle avoidance and goal-based planning for navigation

AI Agent Development Platforms [16; 19; 20] are specialized tools that streamline the process of building, training, and deploying AI agents. These platforms aim to abstract away much of the complexity involved in AI development, allowing developers and even non-developers to create AI agents more efficiently. They simplify AI Agent Development by:

- *Rapid Prototyping*: Developers can quickly build prototypes without deep dives into complex algorithms or infrastructure setup.
- *Reduced Technical Debt:* By using standardized platforms, there's less custom code to maintain, reducing long-term technical debt.
- *Access to Cutting-edge Technology*: Platforms often incorporate the latest AI advancements, making them available to users without the need for extensive research or development.
- *Focus on Business Logic:* Developers can focus more on defining the business logic of the AI agent rather than the underlying technology.

Some such platforms are listed in Table 2 although there are many other platforms (*H2O.ai, DataRobot, DOMO, etc.)*.

T a b l e 2 . Examples of applications of Agent-Based AI in SOA

№	**Platform name**	**Description of features**
1	Google Vertex AI Agent Builder	This platform integrates Google's foundation models, search functionalities, and conversational AI technologies into a unified development environment. Utilising Vertex AI Agent Builder, developers are empowered to construct AI agents through a no-code interface or by employing more sophisticated frameworks
2	Microsoft Azure Autonomous Systems Platform	A plethora of instruments and facilities are available for the development of artificial intelligence agents, encompassing Azure Bot Service, Azure Cognitive Services and Azure Machine Learning
3	Amazon SageMaker Agents	AWS offers a variety of services for developing AI agents, such as Amazon Lex, Amazon Polly, and Amazon Rekognition
4	Hugging Face Transformers	An open-source platform that provides free access to a large number of pre-trained AI models and tools for developing AI agents
5	Microsoft AutoGen	Microsoft's multi-agent conversational platform is designed to facilitate the development of Large Language Model (LLM) workflows, with the objective of enabling the utilisation of diverse applications across multiple industry sectors. In addition, AutoGen provides "AutoGen Studio," a tool that facilitates the creation of multi-agent systems without the requirement for extensive coding
6	LangChain	This is an open-source platform for AI agents that features a low-code drag-and-drop interface. It is available for download at no cost on GitHub, but a paid OpenAI API key is required for operation
7	AgentGPT	A web platform for deploying AI agents directly from your web browser using GPT 3.5. Supports tasks such as AI image creation, Google search, and code writing
8	Salesforce Einstein Agent Builder	A platform for deploying AI agents from Salesforce, designed to automate complex tasks. Includes Agent Builder for creating AI agents with natural language instructions
9	Godmode	Web solution for AI agents powered by OpenAI and Microsoft. Supports the creation of multiple AI agents simultaneously using GPT-3.5 and GPT-4 based on user-defined goals
10	OpenAI Agents	With GPT-4o, o1, and subsequent versions, developers can create increasingly complex agents and deploy them in their applications or on the ChatGPT platform

Continued Table 2

11	Fetch.ai	This provides cryptographic and blockchain capabilities to AI agents, thus allowing various types of agents (i.e. reflex agents, goal agents and utility agents) to access blockchain features such as crypto wallets and on-chain interaction
12	LlamaIndex	A popular framework for developing AI agents, which provides tools for working with large language models, such as GPT-3
13	CrewAI	CrewAI is an open-source framework in Python designed to support the development and management of multi-agent artificial intelligence systems. The enhancement of these AI systems is achieved by the allocation of specific roles, the enablement of autonomous decision-making, and the facilitation of communication between agents. This collaborative approach enables the effective resolution of complex problems, surpassing the capabilities of individual agents operating in isolation
14	PhiData	PhiData provides a comprehensive framework for the creation of complex agents that possess enhanced memory and knowledge management capabilities, utilising GPT-4 technology. This platform is particularly well-suited for applications that necessitate profound contextual understanding and long-term learning capabilities. Potential use cases include long-term projects, knowledge-intensive tasks and personalised user interaction
15	Atomic Agents	Atomic Agent is a versatile, open-source framework created by BrainBlend AI designed for developing multi-agent systems and AI applications. It emphasizes modularity and atomicity, allowing developers to construct complex AI solutions by combining simple, interchangeable components. By breaking down AI systems into smaller, self-contained, reusable components, Atomic Agents promises a future where AI development is both modular and predictable

Key Benefits of AI Agent Development Platforms are:

Abstraction of Complexity:

- *No-Code/Low-Code Interfaces*: Platforms like Microsoft Azure AI, and Google Cloud AI offer drag-and-drop interfaces or visual programming tools, reducing the need for extensive coding.
- *Pre-built Components:* Many platforms provide pre-built AI models, templates, or modules for common tasks like NLP, image recognition, etc., which can be easily integrated.

Integration and Deployment:

- *Seamless Integration:* These platforms often come with built-in tools for integrating AI agents with other systems or services, using APIs or direct connectors.
- *Deployment Automation:* They handle the deployment process, including scaling, which can be particularly useful for cloud-based solutions.

Data Management:

- *Data Pipelines*: Platforms like DataRobot or H2O.ai offer tools to manage data flows, from ingestion to preprocessing, making it easier to feed data into AI models.
- *Model Training:* Automated or semi-automated model training features, which can optimize hyperparameters and select the best model architecture.

User-Friendly Interfaces:

- *Dashboarding:* Visual dashboards for monitoring model performance, data quality, and agent interactions.
- *Collaboration:* Features for team collaboration, version control, and sharing of AI assets.

Scalability and Performance:

- *Cloud Resources:* Leveraging cloud infrastructure for scalability, which is crucial for AI applications that might require significant computational resources.

Security and Compliance:

- *Built-in Security Measures:* Many platforms include security protocols to protect data and models.
- *Compliance*: Some platforms help in adhering to industry standards and regulations, which is vital for deploying AI in regulated sectors.

In conclusion, AI agent development platforms significantly lower the entry barrier for building AI applications. They democratize AI technology by making it accessible to a broader audience, including those without deep technical expertise in AI. However, for highly specialized or performance-critical applications, a more custom approach might still be required. Many platforms operate on a subscription or usage-based model, which can be costly for large-scale or long-term projects. There's also a risk of becoming dependent on the platform's ecosystem, which might complicate migration or integration with other systems.

CONNECTING AI AGENTS TO SOA

The agent-based approach to implementing artificial intelligence (AI) within a service-oriented architecture (SOA) is a fascinating and highly synergistic concept. Remind, that SOA is an architectural style where software components are designed as independent, reusable services that communicate with each other over a network. The combination of agent-based AI and SOA brings together the best of both worlds—autonomous decision-making from agents and the modular, distributed nature of SOA [20; 21].

Potential Benefits of Connecting AI Agents to SOA:

- **Enhanced Intelligence in Services:** AI agents can bring intelligence and autonomy to SOA by enabling services to dynamically adapt, learn, and make intelligent decisions based on real-time data.
- **Improved Automation:** AI agents can automate complex tasks and workflows within an SOA, leading to increased efficiency and reduced human intervention.
- **Personalized Experiences:** AI agents can analyze user data and preferences to personalize the delivery of services within an SOA, creating more tailored and engaging experiences.
- **Dynamic Optimization:** AI agents can continuously monitor and optimize the performance of services within an SOA, ensuring optimal resource utilization and responsiveness.
- **Dynamic and Adaptive Systems:** Agents can adapt to changes in the environment or user demands in real-time. When embedded in SOA, this adaptability allows services to be reconfigured dynamically based on the context, improving system responsiveness and robustness.
- **Decentralization**: SOA is inherently decentralized, and the agent-based approach aligns well with this philosophy. Each agent can act independently while still interacting with other services, reducing bottlenecks and single points of failure.

- **Scalability and Modularity:** SOA is designed for modularity, and adding intelligent agents to individual services allows for a scalable way to introduce AI capabilities. New agents can be introduced or updated without disrupting the entire system.
- **Interoperability:** Agents can act as intermediaries or orchestrators between services in SOA, enabling better integration of heterogeneous systems or legacy services.
- **Enhanced Decision-Making:** Agents bring reasoning and decision-making capabilities to SOA, enabling services to not just respond to requests but also predict, optimize, and proactively act to improve outcomes.
- **Support for Complex, Multi-Agent Systems**: In cases where multiple agents are deployed (e.g., for supply chain management or IoT systems), SOA provides a framework for communication and collaboration among agents, ensuring interoperability and coordination.

Connecting AI agents to a Service-Oriented Architecture (SOA) involves **several technologies and methodologies** to ensure seamless integration, interoperability, and effective communication between AI components and other services. Here's a breakdown of the key technologies and approaches:

API Integration

- *RESTful APIs:* AI agents can expose their functionalities through RESTful services, allowing them to be consumed by other services within the SOA. This method is stateless, making it scalable and easy to integrate.
- *GraphQL:* For more flexible data fetching, GraphQL can be used where clients can request exactly what data they need from the AI agent, reducing over-fetching and under-fetching.

Messaging Systems

- *Message Brokers (e.g., RabbitMQ, Apache Kafka):* These facilitate asynchronous communication. AI agents can publish results or receive tasks through messages, which is particularly useful for handling high volumes of data or when real-time processing isn't necessary.
- *Event-Driven Architecture (EDA):* AI agents can react to events triggered by other services, allowing for dynamic, responsive systems where AI capabilities are invoked based on specific business events.

Microservices Architecture

- *Containerization (Docker, Kubernetes):* AI services can be containerized, making them portable and scalable. This approach fits well with microservices where each AI function might be its own microservice.
- *Service Mesh (e.g., Istio):* Enhances how services communicate, manage, and secure inter-service communication, which is crucial when integrating AI agents that might need specific network policies or security measures.

Data Handling and Integration

- *Data APIs:* For AI agents that require or produce data, data APIs can be used to integrate with data services or databases within the SOA.
- *Data Streaming Technologies:* Tools like Apache Kafka or AWS Kinesis can be used for real-time data streaming to and from AI agents, ensuring they have the latest data for processing.

Orchestration and Workflow Management

- *Workflow Engines (e.g., Camunda, Apache Airflow):* These can orchestrate complex workflows where AI agents are just one part of a larger process, ensuring that AI tasks are executed in the right sequence and context.

- *Serverless Computing:* Using platforms like AWS Lambda or Azure Functions, AI tasks can be executed in response to events without managing the underlying infrastructure.

Security and Governance

- *OAuth, JWT (JSON Web Tokens):* For secure communication and authentication between services.
- *API Gateways:* To manage access to AI services, ensuring that only authorized services can interact with AI agents.

Monitoring and Management

- *Service Monitoring Tools (e.g., Prometheus, Grafana):* To monitor the health, performance, and usage of AI services within the SOA.
- *Centralized Logging:* Tools like ELK stack (Elasticsearch, Logstash, Kibana) for logging and analyzing interactions and performance of AI agents.

AI-Specific Technologies

- *Model Serving Platforms (e.g., TensorFlow Serving, Seldon Core*)**:** These platforms allow for the deployment of machine learning models as services, making it easier to integrate AI models into SOA.
- *Feature Stores:* Centralized repositories for managing and serving features used by machine learning models, ensuring consistency and reducing data duplication.

Integration Patterns

- *Proxy Pattern:* AI agents can act as proxies or facades, simplifying the interface for other services.
- *Adapter Pattern:* Used to convert the interface of an AI agent into another interface clients expect, improving reusability.

The technology for connecting AI agents to SOA involves a blend of modern software architecture practices, cloud technologies, and AI-specific tools. The goal is to create a flexible, scalable, and maintainable system where AI capabilities are seamlessly integrated into business processes, enhancing overall system intelligence without disrupting existing services. This integration requires careful planning, especially around data flows, security, and performance, to ensure that the AI components work harmoniously within the broader service ecosystem.

While the agent-based AI approach within SOA is powerful, there are ***some challenges*** and factors you need to consider:

- ***Complexity*****:** Introducing agents into SOA can increase system complexity, especially when managing interactions between autonomous agents and services.
- ***Communication Overhead*****:** Agents and services need to communicate frequently, which can introduce latency or bottlenecks in distributed systems if not carefully designed.
- ***Security*****:** Autonomous agents might make unauthorized decisions or interact with malicious services. Ensuring secure communication and decision-making is critical.
- ***Standardization*****:** SOA relies on standard protocols (e.g., SOAP, REST), while agents may require additional protocols for negotiation, collaboration, or reasoning. Aligning these standards can be challenging.
- ***Scalability of Decision-Making*****:** As the number of agents and services grows, ensuring that agents can make decisions in a timely manner without overwhelming the system is essential.

- ***Interoperability of AI Models*:** Agents might use different AI models, which could lead to compatibility issues. A common framework or ontology may be needed for agents to collaborate effectively.
- ***Monitoring and Debugging*:** Debugging agent behaviors in a distributed SOA environment can be complex, especially when agents are making autonomous decisions based on incomplete or uncertain information.

It should be emphasized that this approach differs significantly from previous developments, where a software agent-based service-oriented integration architecture for collaborative intelligent systems was proposed. A unique feature of mentioned approach was that the order planning process was organized online through negotiations between agent-based web services. Of course, the software agents used were not present AI agents [22].

Agent-based AI within a Service-Oriented Architecture (SOA) is a powerful combination. Examples of applications of Agent-Based AI in SOA are presented in Table 3.

Table 3. Examples of applications of Agent-Based AI in SOA

№	Sectors	Use cases	Agents' role
1	Resource Management and Optimization	Smart Grids	AI agents represent energy producers (solar panels, wind turbines), consumers (homes, businesses), and storage units. They interact and negotiate in real-time to balance energy supply and demand, optimize grid stability, and reduce costs
		Supply Chain Logistics:	Agents model suppliers, manufacturers, distributors, and customers. They autonomously manage inventory, predict disruptions, and optimize delivery routes to improve efficiency and responsiveness
2	Personalized Customer Service	E-commerce	AI agents act as virtual shopping assistants, learning customer preferences and providing personalized product recommendations, deals, and support, enhancing the shopping experience
		Financial Services	Agents offer personalized financial advice, analyze market trends, and manage investment portfolios based on individual client goals and risk tolerance
3	Complex System Modeling and Simulation	Healthcare	Agents simulate patients, doctors, hospitals, and other healthcare providers to model disease spread, evaluate treatment strategies, and optimize healthcare resource allocation
		Traffic Management	Agents represent vehicles, pedestrians, and traffic signals. They interact to optimize traffic flow, reduce congestion, and improve road safety
4	Autonomous Systems	Robotics	Agents control robots in manufacturing, warehouse automation, and exploration. They can adapt to changing environments, collaborate with other robots, and learn from experience
		Self-Driving Cars	Agents perceive the environment, make driving decisions, and coordinate with other vehicles to ensure safe and efficient navigation

Examples of Real-World Applications:

- **IBM Watson:** Used in healthcare to provide personalized cancer treatment recommendations.
- **Amazon Alexa:** Employs AI agents for natural language understanding and task automation.

- **Tesla Autopilot:** Utilizes agent-based AI for autonomous driving features.

Agent-based AI in SOA is transforming how we design and build intelligent systems. By combining the strengths of both approaches, we can create more flexible, scalable, and responsive solutions to complex real-world problems.

CONNECTING AI AGENTS TO SAAS

Applying an AI agent to a Software as a Service (SaaS) platform can indeed be highly beneficial, offering numerous advantages that can enhance the value proposition of the SaaS product. It is important to recall the definition of SaaS, which is a software delivery service in which a provider hosts a software service and makes it available to customers over the Internet. Customers can access the software through a web browser, eliminating the need to purchase, install and maintain software on their own servers. The SaaS provider assumes responsibility for a wide range of tasks, including maintaining servers and databases, providing updates and implementing security measures. There are a number of platforms for creating sophisticated web applications without writing code [23]:

- Customer Relationship Management (CRM): Salesforce, HubSpot, Zoho Creator.
- Enterprise Resource Planning (ERP): SAP, Oracle NetSuite.
- Project Management: Trello, Asana, Webflow.
- Document Collaboration: Google Workspace, Microsoft 365.
- E-commerce Platforms: Shopify, Magento, Airtable.
- Marketing Automation: Mailchimp, Marketo, Bubble.
- Human Resources: BambooHR, Workday.

Key Characteristics of SaaS Platforms:

- *Cloud-Based Delivery:* SaaS applications are hosted on servers in the cloud, accessible via web browsers or lightweight client applications. This eliminates the need for users to install software on their local machines.
- *Subscription-Based Pricing:* Users typically pay for SaaS on a subscription basis, which can be monthly, annually, or based on usage. This model contrasts with traditional software where you buy a license outright.
- *Multi-Tenancy:* The software is designed to serve multiple customers (tenants) from a single instance of the application. Each customer's data is isolated and secure, but the codebase and infrastructure are shared.
- *Scalability:* SaaS platforms are built to scale easily, allowing them to accommodate growth in users, data, or functionality without significant additional setup or cost.
- *Automatic Updates:* Updates, including new features, security patches, and bug fixes, are automatically rolled out to all users, ensuring everyone has the latest version without manual updates.
- *Data Management:* The provider manages data storage, backup, and recovery, which includes handling data security and compliance with relevant regulations.
- *Accessibility:* Users can access the software from any device with an internet connection, often requiring only a web browser, which enhances mobility and remote work capabilities.

Benefits of SaaS Platforms:

- *Cost Efficiency*: Reduces the need for capital expenditure on hardware and software licenses.

- *Ease of Use:* Generally easier to deploy and use compared to on-premises software.
- *Flexibility:* Allows for flexible scaling of resources according to business needs.
- *Innovation:* SaaS providers often update their services with new features, keeping the software current with market trends.

Challenges:

- *Dependency on Internet:* Requires a reliable internet connection for access.
- *Data Security:* Concerns about data privacy and security since data is stored on external servers.
- *Customization*: Some SaaS solutions might not offer the level of customization that on-premises software can provide.
- *Vendor Lock-in:* Potential for dependency on the SaaS provider, making it difficult to switch.

Key Benefits and Potential of AI-SaaS Integration:

- **Enhanced Automation:** AI agents automate routine business processes in SaaS applications, minimizing human intervention and can automate routine tasks, customer inquiries, or even complex processes like data analysis, freeing up human resources for more strategic tasks.
- **Improved Customer Experience:** AI agents use SaaS platforms to deliver fast and personalized services to customers and to tailor the user interface, content, and recommendations based on user behavior and preferences, making the service more intuitive and engaging.
- **Data Analytics and Insights:** AI agents analyze data within SaaS applications to deliver actionable insights and to automate routine tasks, customer inquiries, or even complex processes like data analysis, freeing up human resources for more strategic tasks.
- **Collaboration Efficiency:** AI optimizes collaboration processes within SaaS applications and optimize the use of computational resources, ensuring the SaaS platform scales efficiently with demand.
- **Cost and Time Savings:** AI-SaaS integration reduces operational costs by minimizing the need for manual labour and saves time**.**
- **Security and Compliance:** AI agents enhance data security and compliance within SaaS applications by identifying unusual patterns that might indicate a security breach or unauthorized access.
- **Innovation and Competitive Edge:** AI agents can be used to develop new features or enhance existing ones, providing a competitive edge by offering capabilities that are difficult for competitors to replicate quickly.

Market Differentiation: A SaaS with integrated AI can differentiate itself in a crowded market by offering smart, proactive services.

- ***Customer Engagement*:** Chatbots and Virtual Assistants can provide 24/7 customer support, handle FAQs, and guide users through the platform, improving customer satisfaction and engagement.

AI agents integrated with SaaS (Software as a Service) applications offer a wide range of opportunities for businesses, including process optimization, customer satisfaction, cost savings, and strategic decision support. When integrating AI into a SaaS platform, the AI functionalities are often provided as part of the service, enhancing the platform's capabilities (Table 4).

Table 4. Examples of applications of Agent-Based AI in SaaS

№	Sectors	Use cases	Agents' role
1	Personalized User Experience	Learning Platforms	AI agents act as virtual tutors, adapting to individual learning styles, recommending relevant content, and providing personalized feedback to optimize learning outcomes
		Content Streaming Service	Agents analyze user preferences and viewing history to suggest personalized recommendations, discover new content, and create custom playlists
2	Intelligent Automation	CRM Systems	AI agents automate repetitive tasks like data entry, lead qualification, and customer segmentation, freeing up human agents to focus on more strategic activities
		Project Management Software	Agents can monitor project progress, identify potential risks, and automatically assign tasks to team members based on their skills and availability
3	Proactive Customer Support	Help Desk Software	AI agents provide instant answers to common questions, troubleshoot issues, and escalate complex problems to human agents, improving response times and customer satisfaction
		Chatbots	Agents engage in natural language conversations with customers, providing support, answering questions, and guiding them through processes
4	Data Analysis and Insights	Marketing Automation Platforms	Agents analyze customer data to identify patterns, predict behavior, and personalize marketing campaigns for better engagement and conversion rates
		Business Intelligence Tools	Agents can sift through large datasets, identify trends, and generate reports to provide valuable insights for decision-making
5	Enhanced Security	Cybersecurity Platforms	AI agents monitor network traffic, detect anomalies, and respond to security threats in real-time, protecting sensitive data and systems
		Identity and Access Management	Agents can analyze user behavior, identify suspicious activities, and prevent unauthorized access to critical resources
6	Automated Task Management	AgentForce	AgentForce is Salesforce's innovative AI agent designed to deliver speed, efficiency, and personalized solutions in areas like customer service, sales, and marketing. Its core strength lies in placing artificial intelligence at the heart of business processes, helping companies become smarter and more competitive

Examples in Action:

- **Salesforce Einstein:** Uses AI agents to provide sales predictions, automate tasks, and personalize customer interactions.
- **HubSpot:** Leverages AI for content optimization, lead scoring, and chatbot interactions.
- **Grammarly:** Employs AI agents to provide grammar and writing suggestions.

By incorporating agent-based AI into SaaS applications, businesses can unlock new levels of efficiency, personalization, and intelligence, ultimately delivering greater value to their customers. In summary, a SaaS platform delivers software applications over the internet, managed by third-party providers, offering users a convenient, scalable, and often cost-effective way to access software. The integration of AI into these platforms leverages cloud computing's scalability and data processing capabilities to provide advanced, data-driven features that can significantly enhance the functionality and user experience of the software.

BUILDING AI AS A SERVICE (AIAAS)

With AIaaS, businesses of all sizes can access natural language processing (NLP), machine learning (ML) algorithms, predictive analytics, and more to automate tasks, analyze data, or improve business strategies and customer experience. They can use and benefit from these AI tools, even without a large team of developers or a huge budget, making it a lower-risk way to integrate AI into their business. As a cloud computing service, AIaaS is flexible and can easily scale as its needs grow without updating your hardware or infrastructure [24; 25].

Advantages:

- *Cost-effectiveness:* Businesses can access AI capabilities without the need for significant upfront investment in hardware and software.
- *Scalability and Flexibility*: AIaaS solutions can be easily scaled up or down to meet changing business needs.
- *Faster Deployment:* Pre-built AI agents can be quickly integrated into existing systems and workflows.
- *Access to Expertise:* AIaaS providers offer expertise and support to help businesses effectively leverage AI technology.
- *Business Model Innovation:* AIaaS can open new revenue streams by offering AI capabilities as a subscription or pay-per-use model, potentially attracting a broader customer base.
- *Scalability:* Easier to scale AI services as they are managed centrally by the service provider, who can optimize resources across multiple clients.
- *Focus on Core Business:* Allows companies to focus on their core competencies while outsourcing AI development and maintenance.

Challenges:

- *Dependency:* Clients become dependent on the service provider for AI capabilities, which could pose risks if the provider faces issues or if there are changes in service terms.
- *Customization:* Generic AI services might not fully meet the specific needs of every business, potentially requiring additional customization which could negate some cost benefits.
- *Data Privacy and Security*: Outsourcing AI means sensitive data might be processed outside the organization, raising concerns about data privacy and compliance with regulations like GDPR or CCPA.
- *Market Saturation:* The AIaaS market could become saturated, leading to price wars and reduced profitability.

The “AI Agent as a Service” model involves selecting of an AI agent type and tools for AI agent Development [25; 27]. The type of AI agent which is building depends on the complexity of the task and the environment in which it will operate. From simple reflex agents to learning agents and multi-agent systems, each type has strengths and applications. Similarly, the tools and frameworks which are choosing will depend on project requirements, such as scalability, ease of use, and the specific domain (e.g., robotics, gaming, or conversational AI). By combining the right type of agent with suitable tools, it is possible to create powerful AI systems tailored to your needs. Some existing use cases where this model has been implemented: are summarizing in Table 5.

Table 5. Examples of use cases for which AIaaS was developed

№	Sectors	AIaaS	Agents' role
1	Specialized AI Assistants	Customer Service Agents	Companies like Ada and Intercom offer AI-powered chatbots that can be integrated into websites and apps to handle customer inquiries, provide support, and even process transactions
		Sales and Marketing Agents	Tools like Drift and Conversica provide AI agents that can qualify leads, schedule appointments, and nurture prospects through personalized email campaigns
		HR and Recruiting Agents	Services like Ideal and Pymetrics use AI agents to screen resumes, conduct initial interviews, and match candidates with the best-fit jobs
2	AI-Powered Automation Platforms	UiPath and Automation Anywhere	These platforms offer AI agents that can automate repetitive tasks, such as data entry, invoice processing, and report generation, across various business applications
		Zapier and IFTTT	These services use AI agents to connect different apps and automate workflows, such as sending notifications, creating tasks, and updating spreadsheets
3	Healthcare Data Analysis	Google Cloud Healthcare API with AI capabilities	This AI agent allows healthcare providers to analyze patient data for better treatment outcomes, operational efficiency, and compliance with healthcare regulations without needing to develop AI models in-house
4	Content Generation and Editing	Grammarly for Business	This AI agent not only checks for grammar and spelling but also provides suggestions for clarity, tone, and engagement, ensuring high-quality content production at scale
5	Personalized Learning	Knewton's Alta for adaptive learning	This AI agent personalizes the learning experience for each student, adapting content and difficulty based on individual performance, thereby improving learning outcomes
6	Energy Sector Optimization	Siemens' MindSphere	This AI agent helps in scheduling maintenance efficiently, reducing energy costs, and extending the lifespan of infrastructure
7	Real-time Traffic Management	INRIX Traffic AI	This AI agent helps in reducing traffic jams, improving emergency response times, and enhancing overall city mobility

These examples demonstrate how "AI Agent as a Service" can be applied across various industries to provide specialized AI functionalities without the need for clients to invest heavily in AI infrastructure or expertise. This model allows businesses to leverage cutting-edge AI technologies for specific tasks, enhancing their operations, customer service, and decision-making processes.

COMPARISON OF DIFFERENT WAYS OF AI AGENTS' USAGE

There are three basic approaches: connecting AI agents to SOA, connecting AI agents to SaaS and building a new business model "AI as a Service". Which is better?

Key Differences:

- **SOA:** Emphasizes modularity, reusability, and interoperability across different systems and applications within an organization. It's ideal for complex enterprise-level solutions where integration and flexibility are crucial.
- **SaaS:** Focuses on enhancing specific applications with AI capabilities to improve user experience, automate tasks, and provide intelligent insights. It's often delivered as part of a cloud-based software subscription.

- **AIaaS:** Provides access to pre-built AI agents or tools for specific tasks, such as natural language processing, image recognition, or data analysis. It allows businesses to leverage AI without the need for extensive development or infrastructure.

The choice depends on the organization's strategic goals, existing technological landscape, risk tolerance, and market positioning [26] The detailed analysis of important factors, including features of integration, scalability, customization, maintenance, deployment and cost, are summarized in Table 6.

Table 6. Comparison of different ways of AI agents' usage

Feature	Agent-Based AI in SOA	Agent-Based AI in SOA	AI Agents as a Service
Architecture	Decentralized, service-oriented	Centralized, application-specific	Typically centralized, API-driven
Integration Method	AI agents are integrated as services within an existing or new SOA framework	AI agents are integrated into or alongside SaaS applications, often through APIs or as plugins	AI capabilities are offered as standalone services, accessible via APIs, which can be integrated into any platform or application
Deployment	On-premise or cloud	Cloud-based	Cloud-based
Focus	Complex system integration, enterprise-level solutions	Specific application functionality, user experience	Specialized AI tasks, pre-built agents
Customization	High	Moderate	Limited, but increasing with API options
Scalability	Highly scalable through adding/removing agents	Agent-Based AI in SaaS	Highly scalable, managed by the provider
Data Handling	Full control over data flow and processing	Less control over data, what simplifies data management	Users have control over what data they send to the AI service, but the data processing happens on the provider's infrastructure
Maintenance	Can be complex due to the need to maintain both AI services and the underlying SOA infrastructure	Lower maintenance burden on the user side as SaaS providers handle much of the backend maintenance	Low for users, as the service provider manages the AI infrastructure and updates
Cost	Higher upfront investment	Subscription-based, predictable costs	Pay-as-you-go, variable costs
Examples	Smart grids, supply chain optimization, healthcare systems	Personalized learning platforms, CRM systems, help desk soft	Chatbots, virtual assistants, automation tools

Choosing the Right Approach:

The best approach depends on your specific needs and goals:

- ***SOA:*** Best for large organizations with complex systems and integration requirements.
- ***SaaS:*** Suitable for businesses seeking AI-powered features within specific applications.
- ***AIaaS***: Ideal for those wanting to quickly integrate AI capabilities into their existing systems or build custom AI solutions without heavy investment.

Comparison Summary:

- *Integration Complexity*: **SOA > SaaS > AIaaS (AIaaS** being the simplest for external integration).

- *Control Over Data and Infrastructure:* **SOA > SaaS > AIaaS** (SOA offers the most control).
- *Scalability and Flexibility:* **AIaaS > SaaS > SOA** (AIaaS and SaaS excel in cloud-native environments).

Ultimately, these approaches are not mutually exclusive. They can be combined and integrated to create comprehensive AI solutions that address a wide range of business challenges.

CONCLUSIONS

Businesses are increasingly leveraging AI to enhance their operations and customer experiences. There are three primary ways to integrate AI:

AI with SOA: This involves incorporating AI agents into existing Service-Oriented Architectures (SOA). SOAs are built on interconnected services, and adding AI can automate tasks, analyze data within these services, and improve overall system efficiency. This approach is useful for businesses with established SOAs looking to enhance functionality.

AI with SaaS: This integrates AI agents into Software as a Service application. This can personalize user experiences, automate tasks within the application, and provide valuable insights from user data. This approach is beneficial for businesses utilizing SaaS solutions and wanting to improve their capabilities.

AI as a Service: This is a business model where AI capabilities are offered as a standalone service. Companies can access sophisticated AI tools without investing heavily in infrastructure or expertise. This is ideal for businesses wanting to experiment with AI or needing specific AI functions without building them from scratch.

Each approach has its own merits and the best choice depends on a business's specific needs, existing infrastructure, and AI goals. However, all three approaches have the potential to help businesses improve their operations and gain a competitive advantage. Careful attention to design, communication, security, and scalability is required to fully realize the benefits of these approaches.

AI agents powered by advanced generative AI (GenAI) technologies will be the most disruptive force in technology in 2025 [29]. These autonomous systems, capable of performing complex tasks with minimal human intervention, are poised to revolutionize industries, rethink workflows, and increase productivity. Using the results of recent research, including Deloitte's 2025 Forecast Report [30], we can predict the emergence, application, and future of AI agents in most industries. Retrieval-augmented generation (RAG) extends the ability of AI agents to work with unstructured data. Such agents can quickly find the information they need and generate accurate answers, making them invaluable for knowledge management and improving the efficiency of managing interdependent workflows. AI agent architectures are becoming more modular, allowing for greater customization and scalability. This evolution ensures that organizations can deploy solutions tailored to their specific needs without significant AI agent overhauls.

The surge in popularity of AI agents in late 2024 mirrors how ChatGPT and other LLMs transformed the AI market in 2022. Now, vendors and developers are massively shifting from creating cutting-edge LLMs and AI chatbots to developing AI agents and exploring ways to implement them. Recently, a new approach to language modelling (called Large Concept Models or LCMs) has been announced that operates at a higher semantic level, dealing with concepts that often correspond to a sentence in text or an equivalent speech utterance [31].

It is predicted that starting in 2025, organizations that embrace this transformation will thrive, while those that cling to traditional SOA and SaaS paradigms will struggle to remain relevant. Ethical considerations are at the forefront of AI agent development. In 2025, the focus will be on explainability so that users can understand and trust the decisions made by AI agents.

REFERENCES

1. *SOAIS. Agentic AI: The Future of Autonomous, Action-Driven Automation.* Available: https://soais.com/agentic-ai-the-future-of-autonomous-action-driven-automation/
2. Lorena Nessi, *What are AI Agents: How To Create a Based AI Agent*. Available: https://www.ccn.com/education/crypto/ai-agents-how-to-create-based-ai-agent/
3. Olesia, *AI Agents: Types, Functions, Advantages & Challenges - Exploring the World of Autonomous Intelligence*. Available: https://lablab.ai/blog/the-best-ai-agents-in-2023
4. *Atomicwork. 12 AI agent frameworks for businesses to consider in 2025.* Available: https://www.atomicwork.com/itsm/best-ai-agent-frameworks
5. Haricharaun Jayakumar, *Agent AI and Generative AI: understanding the difference*. Available: https://www.solix.com/uk/blog/agentic-ai-and-generative-ai-understanding-the-difference
6. Ilias Ism, *10 Real-World AI Agent Examples in 2024*. Available: https://www.chatbase.co/blog/ai-agent-examples
7. G. Sreedevi, *From RAG to TAG: Leveraging the Power of Table-Augmented Generation (TAG): A Leap Beyond Retrieval-Augmented Generation (RAG)*. Available: https://www.linkedin.com/pulse/from-rag-tag-leveraging-power-table-augmented-leap-beyond-gogusetty-nh8hf/
8. Hiren Dhaduk, *6 Types of AI Agents: Exploring the Future of Intelligent Machines*. Available: https://www.simform.com/blog/types-of-ai-agents/
9. Avishek Biswas, *The Ultimate Guide to RAGs — Each Component Dissected*. Available: https://towardsdatascience.com/the-ultimate-guide-to-rags-each-component-dissected-3cd51c4c0212
10. Emrecan Dogan, *What are AI agents, and how do they work?* Available: https://www.glean.com/blog/ai-agents-how-they-work
11. *Kanerika Inc. AI Agent Examples: The Future of Business and Technology*. Available: https://www.linkedin.com/pulse/ai-agent-examples-future-business-technology-kanerika-tdbcc/
12. *Agents in Artificial Intelligence.* Available: https://www.javatpoint.com/agents-in-ai
13. *Fuzen. AI Agents Examples and Types.* Available: https://fuzen.io/ai-agents-examples-and-types/
14. Samanyou Garg, *7 Types of AI Agents to Streamline Your Workflow in 2025*. Available: https://writesonic.com/blog/types-of-ai-agents
15. *Intelligent Agent Examples: Transforming Industries with AI.* Available: https://salescloser.ai/intelligent-agent-examples-transforming-industries-with-ai/
16. Sarfraz Nawaz, *Top 24 Use Cases of AI Agents in Business*. Available: https://www.ampcome.com/post/24-use-cases-of-ai-agents-in-business
17. Safa Bouguezzi, *Artificial Intelligence Agents Explained*. Available: https://www.baeldung. com/cs/artificial-intelligence-agents
18. *The 4 biggest AI stories of 2024*. Available: https://www.oksim.ua/2024/12/26/4-najbilshi-istori%D1%97-pro-shtuchnij-intelekt-za-2024-rik/
19. *OpenAI will launch an AI agent*. Available: https://babel.ua/news/112657-openai-zapustit-shi-agenta-vin-vikoristovuvatime-komp-yuter-vid-imeni-lyudini
20. Madhu Kumar, *Paradigms and Transformations in Software Development*. Available: https://dev.to/aws-heroes/the-future-of-ai-agent-driven-paradigms-and-transformations-in-software-development-55l
21. Jonghong Jeon, *SOA, Agentic AI, AI as a Service, and Future Autonomous AI*. Available: https://medium.com/@favorable_eminence_oyster_546/soa-agentic-ai-ai-as-a-service-and-future-autonomous-ai-132fdd1765fc

22. M. Alessandrini, W.M. Lippe, and W. Nuesser, “Intelligent Service System: An Agent-Based Approach for integrating Artifical Intelligence Components in SOA Landscapes,” *2008 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology, Sydney, NSW, Australia, 2008*, pp. 496–499. doi: 10.1109/WIIAT.2008.139
23. *KOFANA. Digital. How Do AI Agents Integrate with SaaS Applications?* Available: https://www.kofana.com/en/trends/reports-and-blog/how-do-ai-agents-integrate-with-saas-applications
24. *DOMO. Guide to AI as a Service (AIaaS): Benefits, Types, Companies.* Available: https://www.domo.com/glossary/ai-as-a-service
25. *How To Build LangChain Custom Agents (Tools).* YouTube. 2024. Retrieved August 4, 2023.
26. Oleksandra, *A Brief Guide on AI Agents: Benefits and Use Cases*. Available: https://www.codica.com/blog/brief-guide-on-ai-agents/
27. G. Sreedevi, *Building Multi-Agent LLM Systems with PydanticAI Framework: A Step-by-Step Guide To Create AI Agents With Ease*. Available: https://www.linkedin.com/pulse/building-multi-agent-llm-systems-pydanticai-framework-gogusetty-w4b5f/
28. Ori Ziv, *How AI Agents Will Disrupt SaaS in 2025*. Available: https://medium.com/@oriziv4/how-ai-agents-will-disrupt-saas-in-2025-7567d793ca68
29. *Deloitte Global’s 2025 Predictions Report: Generative AI: Paving the Way for a transformative future in Technology, Media, and Telecommunication*. Available: https://www. deloitte.com/global/en/about/press-room/deloitte-globals-2025-predictions-report.html
30. Edwin Lisowski, *A List of AI Agents Set to Dominate in 2025*. Available: https://medium.com/@elisowski/a-list-of-ai-agents-set-to-dominate-in-2025-028f975c5b99
31. Mehul Gupta, *Meta Large Concept Models (LCM): End of LLMs?* Available: https://medium.com/data-science-in-your-pocket/meta-large-concept-models-lcm-end-of-llms-68cb0c5cd5cf

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INFORMATION ON THE ARTICLE

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АГЕНТНИЙ ПІДХІД ДО ВПРОВАДЖЕННЯ ШТУЧНОГО ІНТЕЛЕКТУ (AI) В МЕЖАХ СЕРВІС-ОРІЄНТОВАНОЇ АРХІТЕКТУРИ (SOA) / А.І. Петренко

Анотація. Штучний інтелект (ШІ) стає технологією загального призначення і набуває універсального характеру для техніки, науки і суспільства, який сьогодні притаманний лише математиці та комп’ютерним технологіям. Агентний підхід до реалізації ШІ в межах сервіс-орієнтованої архітектури додатків є захопливою і дуже синергетичною концепцією. Поєднання цих парадигм призводить до створення надійних, масштабованих та інтелектуальних систем, які добре підходять для динамічних і розподілених середовищ. Подано результати порівняльного аналізу трьох можливих підходів до інтеграції ШІ в бізнес-процеси, а саме: підключення агентів ШІ до сервіс-орієнтованої архітектури (SOA), підключення агентів ШІ до програмного забезпечення (SaaS) та побудова ШІ як послуги (AIaaS). Розглянуто потенційні переваги, виклики, приклади та міркування із застосуванням кожного з цих підходів.

Ключові слова: AI (Artificial Intelligence), агентний AI, AI-agent, SOA (Service oriented architecture), SaaS (Software-as-a-Service), RAG (Retrieval-Augmented Generation), великі мовні моделі (LLM), одноагентні і багатоагентні системи, платформи розроблення AI агентів, інтеграція агентів AI з SaaS, агенти AI і SOA.