Journal of Engineering Science *Vol. XXX, no. 3 (2023), pp. 99 - 120*
Fascicle *Electronics and Computer Science* *ISSN 2587-3474*
Topic *Computers and Information Technology* *eISSN 2587-3482*

https://doi.org/10.52326/jes.utm.2023.30(3).07
UDC 316.7:[519.766:004.8]

DECENTRALISED AUTONOMOUS SOCIETY THROUGH LARGE LANGUAGE MODELS' BASED AGENTS: A PATHWAY TO EMPOWER SMALL COMMUNITIES

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Received: 07. 21. 2023
Accepted: 09. 10. 2023

Abstract. This paper explores the concept of Decentralized Autonomous Society through the lens of Large Language Models focusing on the transformative potential of integrating these technologies. The paper on the role of Large Language Models based agents in providing a versatile, responsive, and contextually intelligent resource within a Decentralized Autonomous Society, fostering intellectual exploration, assisting in complex tasks, and aiding real-time problem solving. One delves into their integration with Decentralized Autonomous Society infrastructures, including robotic and automated systems. While promising, the integration of Large Language Models and their agents into a Decentralized Autonomous Society poses several challenges, including infrastructure and connectivity limitations, information accuracy, artificial intelligence bias, privacy and data security, and ethical concerns. This paper critically discusses these issues and proposes potential solutions. Through the lens of the Decentralized Autonomous Society construct, the paper considers the future possibilities and implications of artificial intelligence, where self-sustaining, digitally-empowered communities leverage artificial intelligence as a cornerstone of their collective intelligence.

Keywords: *Decentralized Autonomous Societies, Large Language Models, AI Agents, GPT-4, Vicuna, Artificial Intelligence, Machine Learning, Decentralization.*

Rezumat. Acest articol explorează conceptul de Societate Autonomă Descentralizată prin prisma Modelelor Lingvistice Mari, concentrându-se pe potențialul de transformare al integrării acestor tehnologii. Lucrarea se axează pe rolul agenților bazați pe Modele Lingvistice Mari în a oferi o resursă versatilă, receptivă și inteligentă în context în cadrul unei Societăți Autonome Descentralizate, stimulând explorarea intelectuală, asistând în sarcini complexe și ajutând la rezolvarea problemelor în timp real. Se intră în detalii privind integrarea lor cu infrastructurile Societății Autonome Descentralizate, inclusiv sistemele robotizate și automate. Cu toate că este promițătoare, integrarea Modelelor Lingvistice Mari și a agenților lor într-o Societate Autonomă Descentralizată prezintă mai multe provocări, inclusiv limitările infrastructurii și conectivității, acuratețea informațiilor, prejudecata inteligenței artificiale, confidențialitatea și securitatea datelor și preocupările etice. Acest document discută în mod critic aceste probleme și propune soluții potențiale. Prin prisma construcției Societății Autonome Descentralizate, lucrarea consideră posibilitățile și implicațiile viitoare ale inteligenței artificiale, unde comunitățile auto-sustenabile, digital-împuternicite, folosesc inteligența artificială ca o piatră de temelie a inteligenței lor colective.

Cuvinte cheie: *Societăți Autonome Descentralizate, Modele Lingvistice Mari, Agenți AI, GPT-4, Vicuna, Inteligență Artificială, Învățare Automată, Descentralizare.*

1. Introduction

Communities in isolated locations, from the rustic landscapes to remote islands or even potential underwater or extraterrestrial habitats, face unique challenges [1]. While their environments offer immense natural beauty and tranquility, they are often separated from the conveniences and expertise of the modern world. The isolation and low population density in such places can make it challenging to maintain a full range of specialist skills [2]. Fields such as medicine, education, agriculture, maintenance, and cultural preservation require dedicated specialists whose expertise might not be readily available in these areas. This lack of local expertise can pose significant barriers to sustaining these communities and enhancing their quality of life [3].

An innovative approach to addressing this dilemma lies in the realm of artificial intelligence (AI), specifically, Large Language Models [4] (LLMs) like GPT-4 [5], LLAMA [6] or Vicuna [7] etc. These LLM models have evolved into expansive, decentralized knowledge bases, capable of providing insights, advice, and recommendations across a plethora of fields. They can facilitate virtual consultations in healthcare, offer customized education support, provide expert guidance in sustainable agriculture or maintenance tasks, and even assist in preserving local cultural heritage. In order to understand how useful can be the agents based on LLM's one can see what the impact of LLMs on the labor market is already quite significant. According to some studies, as cited in the research, around 80% of the U.S. workforce could see at least 10% of their work tasks influenced by the introduction of LLMs, and close to 19% of workers might witness at least 50% of their tasks being directly impacted [8].

The paper discusses integrating modern conveniences into isolated communities. It aims to blend the benefits of a peaceful, slow-paced life with modern technology. Using LLMs can address challenges of isolation and expertise shortages, preserve local culture, and enhance community living.This paper aims to delve deeper into the role of LLMs as decentralized knowledge bases in supporting and sustaining such visionary projects.

The paper will explore how these AI-powered systems can help small, isolated communities bridge the gap between anarcho primitivism and modernity, merging old-world charm with contemporary comfort. The paper will shed light on the potential challenges and opportunities that LLMs present, thereby illuminating their potential in driving a new era of sustainable development and cultural preservation in isolated communities.

2. State of the Art in Large Language Models and Autonomous agents based on LLMs

Over the years, significant advancements have been made in the field of LLMs and their applications. But 2023 brings an explosion of new models and software based on them [4]. The following outlines some of the state-of-the-art developments in this area of autonomous agents based on LLM [9]:

1. LangChain [10]: LangChain is an open-source framework tailored for crafting applications underpinned by LLMs. To construct an AI assistant using LangChain, one would

start by defining the assistant's tasks and associated data sources. Subsequently, with LangChain initialized, developers can adeptly manage prompts through the `PromptManager`, integrate external data via the `DataManager`, and engage with other services using dedicated API modules. The framework also facilitates the programming of autonomous behaviors, implementation of feedback mechanisms, and addresses ethical and privacy concerns. Once developed, the assistant can be deployed, monitored, and iteratively improved upon. Overall, LangChain streamlines the process of creating data-aware, contextually relevant, and proactive AI assistants.

2. HuggingGPT [11]: is a system that uses ChatGPT to work with various AI models from the Hugging Face repository. It processes tasks, chooses the right models, and provides results. For DAS, it can integrate different models, such as image generation for creating visuals, speech-to-text for converting spoken language into written text, sentiment analysis to determine community feelings, and translation models to help in multilingual environments. Essentially, HuggingGPT is a versatile tool designed to aid decentralized communities by utilizing different AI functionalities.

3. Toolformer [12]: This is a system where LMs teach themselves to use external tools via simple APIs. Toolformer is trained to decide which APIs to call, when to call them, what arguments to pass, and how to best incorporate the results into future token prediction. For distributed autonomous societies (DAS), Toolformer presents immense value by facilitating seamless integration and utilization of external tools through APIs. As DAS operations often require diverse functionalities, the ability to quickly and autonomously decide which external tools to call, and when, allows for a more adaptive and efficient environment. Furthermore, in decentralized structures where timely and accurate data processing is essential, Toolformer can enhance decision-making by improving token prediction based on the results from these external tools. Its self-learning capability ensures that as the DAS ecosystem evolves, Toolformer can adapt and continue to provide optimal support without manual reconfiguration.

4. Visual ChatGPT [13]: This is a system that incorporates Visual Foundation Models with ChatGPT, allowing users to send and receive not only languages but also images during chatting. This system is designed to address complex visual questions or visual editing instructions that require the collaboration of multiple AI models in multiple steps. Visual ChatGPT's adaptability can be pivotal in facilitating clear and efficient visual exchanges in such decentralized settings.

5. Lindy AI [14]: This application serves as a personal AI assistant. It utilizes LLMs to help users manage their tasks and make informed decisions.

6. CensusGPT [15]: This application uses LLMs to answer questions related to census data. It makes statistical data more accessible by providing answers in natural language. In the context of distributed autonomous societies (DAS), CensusGPT could stand as a crucial tool to streamline data accessibility. By leveraging LLMs to interpret census-related queries, it transforms often dense and convoluted statistical data into digestible, natural language responses. For DAS that rely on data-driven decisions, the quick and clear information retrieval facilitated by such a tool can significantly expedite research processes and ensure more informed communal choices based on demographic insights.

7. Hearth AI [16]: Hearth AI applies the concept of Agentic Relationship Management. It uses AI to maintain and manage relationships with customers, providing personalized interactions. In a DAS setup, Hearth AI's concept of using AI for relationship management can

efficiently automate and personalize communication, enhancing community interactions and administrative tasks.

8. RCI Agent for MiniWoB++ [17]: This application shows that LLMs can solve computer tasks. It offers a new way to approach and solve complex problems in computing.

9. Babyagi [18]: Babyagi is an AI-powered task management system. It uses AI to assist users in managing and completing their tasks efficiently. In DAS, Babyagi's AI-driven task management can enhance productivity. By automating task organization and prioritization, it ensures tasks align with community objectives and helps members efficiently achieve their goals.

10. ChatGPT plugins [19]: This platform provides a way to connect ChatGPT to third-party applications. It extends the capabilities of ChatGPT beyond its original scope.

11. Fixie.ai [20]: Fixie.ai allows for the creation of natural language agents that can connect to user data, communicate with APIs, and solve complex problems. It provides a platform for creating highly personalized AI solutions. For DAS, Fixie.ai is a platform for constructing AI agents that interface directly with user data and APIs. Example: A DAS community could deploy a Fixie.ai agent to automatically access weather data and notify residents of upcoming weather changes, ensuring community preparedness.

These developments highlight the potential of LLMs in driving innovation and solving complex tasks in various domains, emphasizing the crucial role they play in the progress towards more sophisticated and autonomous AI systems.

This papers goals in the context of the state of the art, can be framed as follows:

Empowering Small Communities: in contrast to the majority of existing systems which are primarily designed for general use or specialized industrial applications, our project specifically targets small and isolated communities' needs. It aims to empower these communities by democratizing access to knowledge, fostering innovation, automating parts of their tasks, helping to preserve local culture and day to day history, and providing administrative support as autonomous assistants [21].

Knowledge Democratization: The paper uses large language models as a decentralized knowledge base, bridging the knowledge gap that often exists in small communities. This feature is not commonly found in the current state-of-the-art applications, making our project unique and of immense value to the targeted demographic. Even if there exists the need to use LLMs as explainers, copilots or assistants in such complex matters like financial knowledge [22], programming [23] or medicine [24, 25].

Enabling Self-Learning: The projects emphasis on supporting self-directed learning is a distinctive attribute. It harnesses the capabilities of LLMs to aid information discovery and facilitate learning, essential for fostering development in these communities. The capacity of LLM's to support self-learning for students is widely known already [26–28] , yet the academia is perceiving at the moment these opportunities more like a threat to the classical educational approach [29].

Culturally Conscious Technology: The projects seeks to incorporate local culture and history through memory modules for LLM based agents [30,31], with the language model being sensitive and inclusive of local cultural tradition, languages and history. This makes it a valuable and unique tool for these communities.

Addressing Unique Challenges: recognizing the challenges associated with deploying AI in small communities, the project places a strong emphasis on finding innovative solutions to technological, infrastructural, and ethical issues. This responsible approach further differentiates the project from the current state-of-the-art.

In conclusion, the project stands out for its focus on small communities, its aim of democratizing knowledge, enabling self-learning, promoting cultural consciousness, and addressing unique challenges. This unique combination of attributes positions the project uniquely in the current state-of-the-art landscape.

3. Understanding Decentralization and Large Language Models

Decentralized Autonomous Society (DAS)

DAS [32] represents a new form of social organization enabled by cutting-edge technologies, like blockchain [33] and smart contracts [34]. Essentially, a DAS operates on decentralized digital platforms that facilitate collective decision making processes [35] that are transparent, secure, and direct, eliminating the need for central authorities or intermediaries. Let's explore further:

Blockchain Technology: the backbone of a DAS could be the blockchain technology. A blockchain is a decentralized and distributed digital ledger that records transactions across many computers so that any involved record cannot be altered retroactively, without the alteration of all subsequent blocks. This makes the data stored on a blockchain transparent, immutable, and resistant to censorship, providing a trustless environment where parties do not need to trust each other but instead trust the system.

Smart Contracts: built on blockchain technology, smart contracts are self-executing contracts with the terms of the agreement directly written into code [34]. They automate transactions and ensure all conditions of a contract are met before it's executed, making transactions traceable, transparent, and irreversible. This feature can be used to automate decision-making processes, enforce rules, and manage resources in a DAS.

Decentralized Applications (dApps): dApps are applications that run on a P2P network of computers rather than a single computer [36]. They interact with the blockchain and smart contracts to perform their functions. dApps can serve various functions needed for the operation of a DAS, such as decentralized voting systems, resource allocation systems, or any other application that benefits from transparency, censorship resistance, and decentralization.

Decentralized Governance: this involves the use of blockchain technology and smart contracts for decision-making processes in a transparent, secure, and direct manner [37]. Votes can be tokenized, and stakeholders can vote on proposals according to the number of tokens they hold.

Decentralized Finance (DeFi): DeFi represents a shift from traditional, centralized financial systems [38] to peer-to-peer finance enabled by decentralized technologies built on something like Ethereum [39]. It involves the use of cryptocurrencies and blockchain technology to remove intermediaries from financial transactions.

A DAS, enabled by these technologies, can operate with reduced reliance on central authorities. Instead, control is distributed among the members of the society, who interact through peer-to-peer networks. The rules of this interaction are governed by consensus algorithms, smart contracts, and other automated processes, which can result in a more transparent, fair, and potentially efficient society.

Large Language Models as a Paradigm Shift in General AI

LLMs signify a major shift in the field of general artificial intelligence. These AI models have been trained on vast ranges of internet text, facilitating their ability to generate contextually appropriate and coherent responses across a diverse array of topics. While the proficiency of these models is impressive, their susceptibility to biases and inaccuracies present in their training data must be acknowledged.

Fundamental Principles and Model Architecture

A comprehensive survey on LLMs identifies several key areas of exploration and development that have contributed to their success. Theories and principles underlying their operation, notably the organization, distribution, and utilization of information within these large neural networks, remain an area of active research. One intriguing phenomenon is the emergence of unexpected abilities such as in-context learning [40], instruction following [41], and step-by-step reasoning [42] when the parameter scale of language models reaches a critical size.

The Transformer [43] architecture, characterized by stacked multi-head self-attention layers, has become the de facto framework for building LLMs due to its scalability and effectiveness. However, challenges such as the quadratic time complexity of standard self-attention mechanism and catastrophic forgetting during new data tuning necessitate further exploration and improvement of this architecture.

Utilization and Training Considerations

LLMs serve as potent knowledge bases, capable of answering a wide range of queries and providing insights across numerous topics. In application-specific contexts, they can fill knowledge gaps in the absence of subject-matter specialists, making them a powerful tool for various projects.

However, pre-training these models poses significant challenges due to enormous computational requirements and sensitivity to data quality and training tricks. Hence, the development of more systematic, economical pre-training approaches, considering factors such as model effectiveness, efficiency optimization, and training stability, is of paramount importance.

Safety, Alignment, and Application Ecosystem

Despite their impressive capabilities, LLMs pose several safety and alignment challenges. They have a propensity to generate plausible yet factually incorrect texts, or "hallucinations" [44], and could potentially be misused to generate harmful, biased, or toxic content. Strategies such as reinforcement learning from human feedback (RLHF) and red teaming [45] have been proposed to improve model safety and alignment.

The rise of LLMs ushers in a new era for a broad range of applications, from information-seeking techniques like search engines and recommender systems, to intelligent information assistants. However, this progression also necessitates an increased focus on AI safety and the establishment of ethical and responsible AI usage guidelines [46].

In conclusion, the development and implementation of LLMs represent a promising, yet challenging, advancement in general AI [47]. While their potential applications are vast, understanding their underlying mechanisms, ensuring their safe usage, and managing their limitations are essential areas of ongoing research.

The Intersection of DAS and Large Language Models' Based Agents

Decentralized Autonomous Societies (DAS) are a novel paradigm for community organization, powered by the sophistication of technology. A significant technological advancement, Large Language Models (LLMs), have found a niche as foundations for intelligent agents due to their capacity to process and generate contextually relevant human-like text. The convergence of DAS and LLM-based agents unlocks unique opportunities and brings forth distinctive challenges.

Integrating LLM-Based Agents into a DAS Infrastructure

In a DAS, LLM-based agents could serve as an invaluable component of the society's technological and informational framework. Functioning as potent catalysts for knowledge sharing and communal problem-solving, these agents can be integrated into the DAS's automated or robotic infrastructure, including areas such as agriculture, craft-making, and other essential societal services.

For instance, in automated farming, an LLM-based agent could analyze and interpret data from various sensors, provide insights on sustainable agricultural practices, suggest optimal harvesting times, or even guide automated machinery. Similarly, in automated craft-making or construction processes, these agents could provide guidance and recommendations based on historical data and established best practices [48].

Challenges in Harnessing LLM-Based Agents in a DAS

However, the assimilation of LLM-based agents into a DAS also brings substantial challenges. The significant computational demands and costs associated with training these models, coupled with concerns about data quality and misuse potential, cannot be overlooked [49].

Ensuring the factual accuracy, unbiasedness, and ethical integrity of the agents' outputs is paramount. Furthermore, the risk of over-reliance on artificial intelligence for various societal functions, leading to potential unforeseen complications in societal functioning and individual decision-making, must be considered and mitigated [50].

Future Trajectories at the Crossroads of DAS and LLM-Based Agents

The synthesis of DAS and LLM-based agents heralds a new era in societal organization and knowledge sharing. Continuing to refine these technologies, one must take into account their broader implications, including socio-economic, political, and ethical aspects.

Future research and development in this space are anticipated to concentrate on formulating robust frameworks for the responsible and beneficial use of these agents within decentralized societies. This includes establishing safeguards against misuse, assuring data quality, and contemplating the potential consequences of widespread artificial intelligence reliance in societal decision-making processes. Additionally, more work needs to be done to seamlessly integrate these agents with the automated and robotic infrastructures prevalent in a DAS.

4. Potential Use Cases of Large Language Models in Decentralised Settings

In the nuanced and evolving domain of artificial intelligence and community management, the fusion of Decentralized Autonomous Societies (DAS) and Large Language Models (LLM) based agents is carving a new realm of possibilities. It's a convergence where the decentralized governance model intertwines with artificial intelligence, weaving a narrative that underscores the co-evolution of humanity and technology [51].

Consider the scene of a decentralized, automated farm under the stewardship of an LLM-based agent. Here, the agent's role is multifaceted and pivotal. Embedded sensors within the environment report minute variations in climatic conditions, which the agent processes in real-time. By drawing upon extensive datasets encompassing historical weather patterns and agricultural best practices, the agent steers the automated farming machinery to adapt and optimize crop cultivation strategies. Here, the LLM-based agent emerges as an active participant in maintaining the sustainability and food security of the DAS [52].

As the narrative progresses, the application of the LLM-based agent in the DAS extends into the realm of cultural preservation. In the context of a craft-making workshop, the agent serves as an intelligent assistant, guiding community members in the creation of artisanal products. It brings forth its extensive knowledge about historical and contemporary crafting techniques and provides creative input based on the constraints of available resources. This is an illustration of how LLM-based agents [53] can foster a bridge between heritage preservation and technological advancement in a DAS.

Transitioning to the sphere of education and leisure, the LLM-based agent dons the hat of an educator [54], entertainer, and storyteller [55]. It shares tales from local history, resolves a myriad of queries, and contributes to community storytelling sessions. In this dimension, the LLM-based agent enriches the cultural and intellectual tapestry of the DAS, demonstrating the versatility and breadth of LLMs' utility.

Beyond the realm of daylight activities, the LLM-based agent remains a ceaseless guardian. Its vigil extends to monitoring the infrastructure of the DAS, ensuring the seamless functioning of automated systems and equitable distribution of resources. This reveals yet another facet of the LLM-based agent – a vital clog in maintaining the operational robustness of a DAS.

The convergence of DAS and LLM-based agents underscores the broad potential of LLMs in decentralized settings. It presents a tableau of a future where technology not only assists but also amplifies and enriches the human experience.

5. Large Language Models as Decentralised Knowledge Bases

LLMs stand at the forefront of AI advancements, capable of transforming how knowledge is accessed, processed, and shared. Their ability to serve as expansive, accessible, and decentralized knowledge bases significantly democratizes access to information, fostering self-reliance and autonomy, especially within small communities.

Democratization of Knowledge

Traditional knowledge systems often rely on centralized institutions like universities, libraries, or expert organizations. While these institutions serve an essential role, their centralized nature can limit accessibility, particularly in isolated or underserved areas.

LLMs challenge this paradigm by offering a form of knowledge democratization [56]. They enable virtually anyone even without an internet connection to access a vast array of information across diverse topics. This access is not limited by geographical location, socio-economic status, or time constraints, which typically hamper traditional knowledge systems.

In the DAS scenario, an LLM can compensate for the lack of various specialists in the area, providing residents with expert advice on topics ranging from sustainable farming to pottery crafting. It serves as a digital consultant, always ready to offer information and insights.

Self-Directed Learning

Large Language Models, show great promise in supporting self-directed learning and decentralized operations, especially within a Decentralized Autonomous Society. In a DAS, the inhabitants may face unique challenges due to the distributed, autonomous nature of the society, which typically operates with little to no centralized control. These challenges may relate to knowledge acquisition, skill development, decision-making, and the running of various socio-economic activities.

LLMs can act as knowledgeable agents [57], providing real-time, contextually relevant information and insights across a broad range of topics. Their capacity to generate coherent and comprehensive responses makes them particularly suited for serving as de facto specialists in a DAS where access to human experts might be limited. This can be crucial for skill development and problem-solving within the DAS, enabling the residents to understand and tackle a variety of tasks.

Consider the example of sustainable agriculture practices such as viticulture, insect farming, or mushroom cultivation. A resident interested in these fields could interact with an LLM-based agent to delve into the specific topics. From understanding the basic biology of wine grapes, insects, or mushrooms, to learning about the lifecycle, optimal growing conditions, and the potential pests and diseases, the LLM-based agent can provide a wealth of relevant information.

The LLM-based agent can also cater to more nuanced aspects of these practices. For instance, in mushroom farming, the benefits of mycelium in soil health, or the potential of certain mushroom species in bioremediation could be valuable insights. The agent's capacity to present such complex information in an accessible manner can encourage residents to explore and experiment with new practices, contributing to the resilience and sustainability of the DAS.

Moreover, these LLM-based agents can be connected to the DAS's IT infrastructure, including automated and robotic systems such as automated farms. This creates a powerful synergy where LLMs can guide and coordinate these systems, providing insights based on their extensive knowledge and learning capabilities.

In conclusion, the intersection of DAS and LLM-based agents has significant potential. From serving as knowledgeable guides in diverse fields to coordinating automated systems, these agents can play a pivotal role in enhancing the resilience, autonomy, and sustainability of a DAS. This is particularly evident in the context of self-directed learning and sustainable practices, where LLM-based agents can facilitate a culture of knowledge, curiosity, and sustainable living, further enriching the narrative of a DAS.

Adapting to User Needs

Large Language Models, offer incredible potential for supporting decentralized operations within a Decentralized Autonomous Society. The diverse and dynamic challenges posed by the autonomous nature of a DAS call for a solution as versatile and responsive as LLMs.

LLMs can function as intelligent agents, providing contextually pertinent information on a wide variety of topics in real-time. The utility of these agents extends from offering basic information to beginners to delving into complex specifics for more advanced individuals. The flexibility of LLMs, therefore, allows them to serve a diverse population within a DAS, accommodating different levels of expertise and an array of interests.

In sustainable agricultural practices, for instance, such as viticulture, insect farming, or mushroom cultivation, an LLM-based agent can offer valuable insights. A novice farmer interested in these fields could interact with the LLM-based agent to comprehend the basics, such as the lifecycle of mushrooms or the optimal growing conditions for certain grape varieties. Conversely, an experienced farmer could extract nuanced information on the benefits of mycelium in soil health or the potential of certain mushroom species in bioremediation.

The adaptive nature of LLMs extends beyond knowledge provision to real-time problem-solving. From troubleshooting technical glitches within the DAS's IT infrastructure to providing first-aid advice in a medical emergency, or even suggesting sustainable building materials for constructing a new community center, LLMs provide immediate, practical solutions. This capacity becomes more potent when combined with the automation and robotic systems integral to a DAS, such as automated farms. LLMs can guide and coordinate these systems, effectively translating their vast knowledge into actionable strategies.

The convergence of DAS and LLM-based agents thus holds considerable promise. With their ability to cater to diverse needs, facilitate self-directed learning, and offer real-time problem-solving, LLMs can contribute significantly to enhancing the resilience, autonomy, and sustainability of a DAS. As facilitators of knowledge, curiosity, and sustainable living, LLM-based agents can help weave a rich, vibrant narrative of a decentralized society.

Challenges and Considerations

In the integration of Large Language Models into a Decentralized Autonomous Society, numerous challenges and considerations must be acknowledged to ensure effective and ethical applications.

Data and Model Transparency: transparency is key to the responsible use of LLMs [58]. Since LLMs generate predictions based on patterns in the data they were trained on, biases could manifest in their outputs. An open discourse around the data used for training these models, the resulting biases, and strategies for mitigation is crucial.

Resolving Ethical Dilemmas: an LLM can face dilemmas in providing advice, where ethical concerns are paramount. For instance, in medical or legal scenarios, the LLM should be calibrated to recognize its limitations and recommend consultation with human professionals when appropriate [59].

Privacy and Security: with the broad deployment of LLMs, the risk of privacy and security violations can increase. Ensuring that the interaction with the LLMs does not lead to inadvertent data leaks or exposure to malicious activities is essential [60].

Adaptation to Local Contexts: while LLMs are trained on a diverse range of data, their ability to adapt to local, cultural, or situational specifics of a DAS could be limited. Ensuring contextually relevant and culturally sensitive responses is a significant challenge [61].

Reliability and Accountability: as LLMs are used in decision-making processes, their reliability and the question of accountability in case of errors become critical. LLMs should be robust and the societal infrastructure around them should be able to assign accountability [62].

Interplay with Automation Systems: when interfacing with automated or robotic systems, safety is a prime concern. A misinterpreted command or a failure to recognize a problematic situation could lead to accidents.

Given these considerations, it is clear that the successful application of LLMs in a DAS will require comprehensive oversight, continual updates, and robust governance mechanisms. Understanding these challenges and continuously refining the use of LLMs is critical for realizing their full potential while safeguarding the values and interests of the DAS community.

6. Challenges and Solutions in the Integration of Large Language Models in a Decentralised Autonomous Society

The integration of Large Language Models, such as GPT-4, in a Decentralized Autonomous Society presents promising prospects for self-reliant communities. However, this potential is accompanied by a set of challenges, spanning from technical and infrastructural to ethical and societal. In this section, the paper critically explores these issues and suggest potential solutions.

Infrastructure and Connectivity

In remote areas or communities implementing DAS, the technical infrastructure and internet connectivity could be limited. This would impede the efficient use of LLMs, constraining their capacity to support the community.

Solution: Emphasizing the development of robust internet connectivity and digital infrastructure in these areas is of utmost importance. This can be achieved through collaborations among public entities, private sector organizations, and non-governmental organizations. In addition, offline versions of LLMs, such as the open-source VICUNA, hosted on local servers within the DAS premises can be considered to ensure access to these models, even in scenarios with limited connectivity.

Information Accuracy

While LLMs can provide comprehensive responses across a multitude of subjects, they may occasionally present inaccurate or outdated information due to their training data limitations.

Solution: Regular updates and continuous training of the LLMs can help mitigate this issue. Additionally, fostering a culture of digital literacy among the DAS residents is also beneficial. This encourages individuals to cross-verify information from various sources and gain a better understanding of the capabilities and limitations of LLMs.

AI Bias

LLMs can inadvertently propagate biases found in their training data, leading to potentially skewed or discriminatory outputs.

Solution: Rigorous bias mitigation strategies during the model training and diverse data collection are essential in minimizing AI biases. Raising awareness about AI biases among DAS residents is also crucial, promoting an informed and cautious use of such technology.

Privacy and Data Security

The use of digital tools, including LLMs, may entail potential risks related to data privacy and security. There is a risk of users unknowingly sharing sensitive information with the model.

Solution: Implementation of strong data privacy and security measures, such as data anonymization and robust encryption techniques, is essential. Simultaneously, education about the importance of privacy and safe online practices should be made accessible to the DAS residents.

Ethical Use and Regulation

The diverse applications of LLMs bring forth questions about ethical use and regulation. Who is responsible if an LLM provides harmful advice? How can misuse be prevented?

Solution: The development and implementation of clear ethical guidelines and regulations are necessary to govern the use of LLMs. Accountability mechanisms and user guidelines can be established to prevent misuse. Moreover, fostering ongoing discussions among various stakeholders, including AI developers, users, ethicists, and policymakers, can shape a responsible and inclusive AI future.

In conclusion, while challenges exist in the integration of LLMs in a DAS, they are not insurmountable. With collaborative efforts, strategic solutions, and commitment to responsible and ethical AI usage, these models can play a significant role in supporting and enhancing life in self-sustaining communities.

7. The Architectural Blueprint for LLM Integration

Utilizing large language models such as LLAMA and Vicuna in small automated communities requires a flexible, efficient, and scalable architecture. This document presents a design for incorporating open-source LLMs into an agent-based system, using Apache Kafka, a distributed event streaming platform, for efficient data processing and handling (Figure 1).

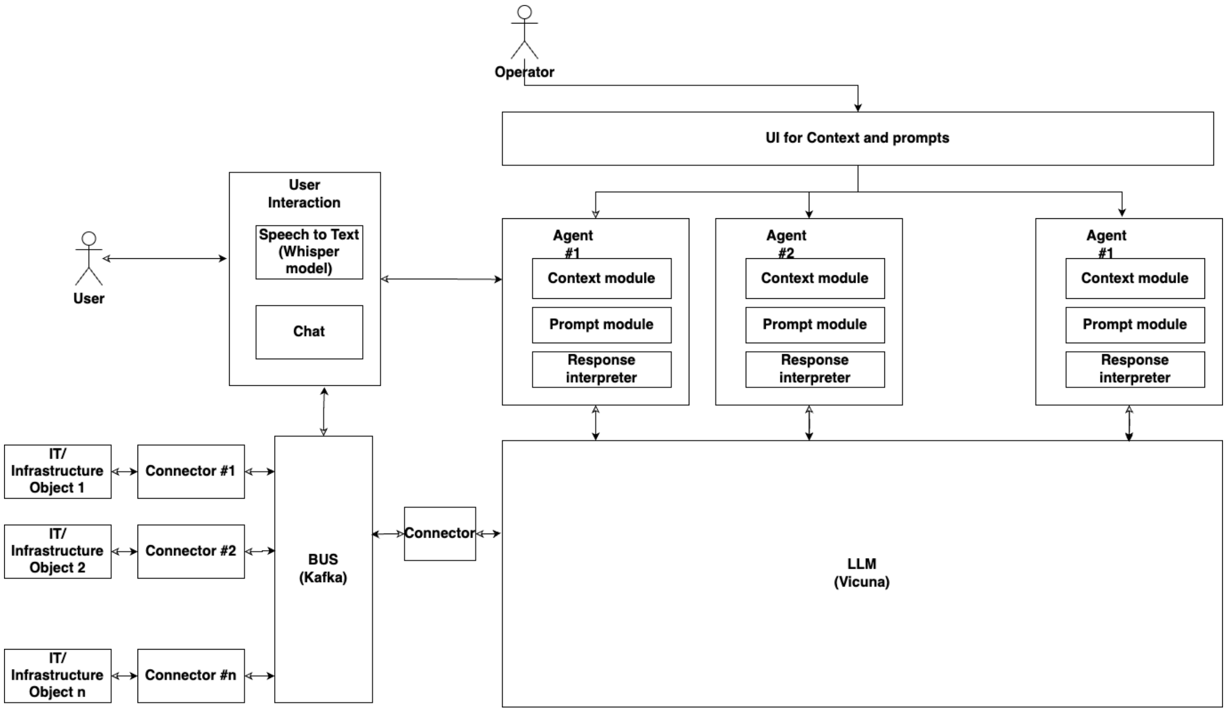

Figure 1. The Architectural Blueprint for LLM Integration.

At the heart of this architecture is a generic agent module. It leverages the capabilities of LLMs to perform an array of tasks. This generic agent module comprises of:

1. **Context Module:** the Context Module continually updates the necessary context for the agent's tasks. It harnesses historical and real-time data to maintain the relevance and accuracy of the context, enabling the agent to respond effectively to user interactions.

2. **Prompt Module:** the Prompt Module generates prompts for the LLM based on the task at hand and the established context. These prompts instruct the LLM about the required information or action to be executed.

3. **LLM Interface:** the LLM Interface ensures smooth communication with the LLM. It sends prompts, receives responses, and ensures the correct formatting of data via the model's API.

4. **Response Processing Module:** the Response Processing Module processes the response generated by the LLM. It extracts the necessary information or carries out the required action, which can range from updating a database to responding to a user query.

5. **Data Connector:** based on Apache Kafka, the Data Connector interfaces with other systems, like databases or CRM systems, ensuring efficient and real-time data transfer and synchronization.

In the paper, one delves into the process of integrating this architecture in-depth, starting from the needs assessment to the implementation of a pilot project, to staff training and onboarding, full deployment, and subsequent support and optimization. By scrutinizing each step meticulously, the paper provides a comprehensive understanding of how similar architectures can be deployed (Figure 2).

The architecture shows how open-source LLMs can streamline processes in small communities for DAS, leading to increased efficiency and cost savings.

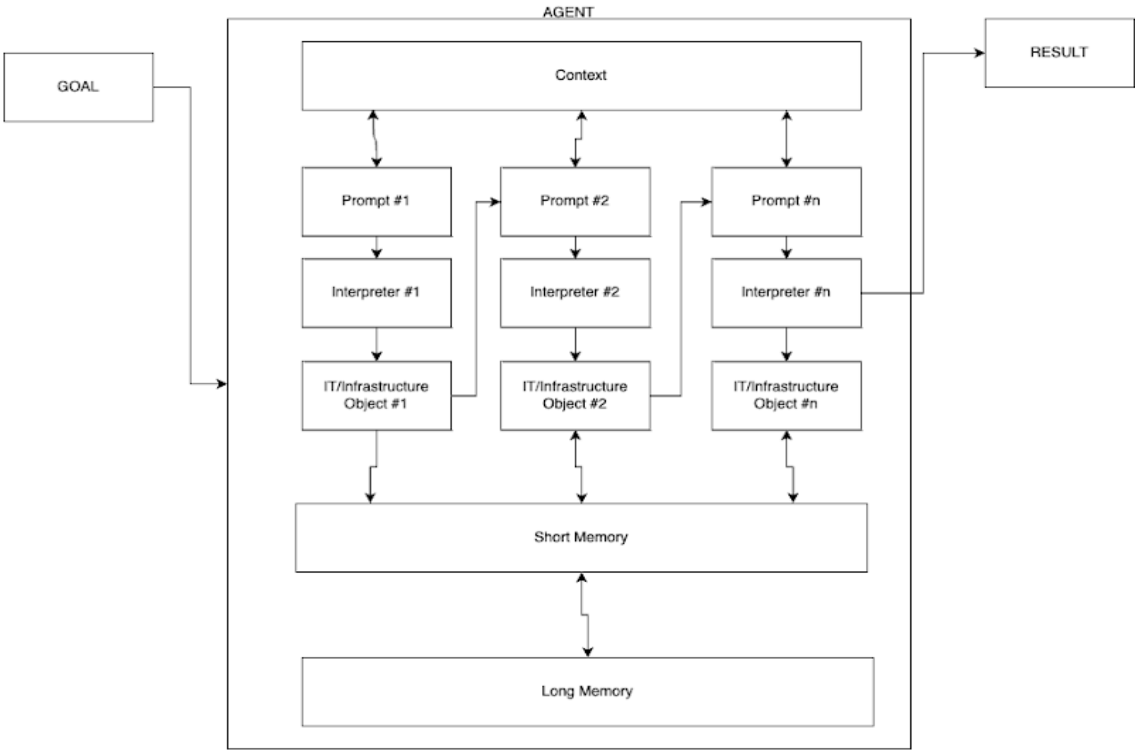

Figure 2. The generic agent module architecture.

This generic agent module comprises of:

1. **Context:** this represents the overall information that the agent requires to function effectively. It may include the initial instructions, the environment data, user information, etc.
2. **Prompts (#1 ... #n):** these are the inputs that the agent receives over time. The input could be a user query or an instruction that needs to be processed and acted upon.
3. **Interpreters (#1 ... #n):** these modules process the received prompts one after the other. They decode the meaning of the prompts and decide on the best action to take. In the context of an LLM, interpreters can be thought of as the parts of the model that determine how the input (prompt) is processed and understood.
4. **Long Memory:** this is the long-term storage used by the agent. In this context, it's a summary of past interpretations and actions, providing a knowledge base that the agent can use to make informed decisions.
5. **Short Memory:** this represents the agent's temporary storage, keeping track of recent actions, interpretations, and responses. It's used to hold information that's immediately relevant to the task at hand.
6. **Agent:** this is the entity that's leveraging the LLM to accomplish a goal. It uses the context, the prompts, the memory, and the interpreters to navigate towards its goal.

The agent's position at the top could indicate its overarching control over or responsibility for the system.

7. **IT/Infrastructure Objects (#1 ... #n):** these are the resources or tools that the agent has at its disposal. In an LLM setup, they could refer to the underlying systems or databases that support the functioning of the model.
8. **Goal:** this represents the ultimate mission or task that the agent is trying to achieve. It's the target state or outcome that the agent is working towards.
9. **Result:** this is the outcome achieved after the agent's actions and interactions. It represents the state of affairs after the process has been executed and can be compared to the Goal to evaluate the effectiveness of the agent.

8. An example of how a Medical Assistant Based on fine-tuned LLM Works

One such application is the creation of a virtual medical assistant, designed to provide guidance and information in scenarios where professional medical assistance is inaccessible. Let's delve into the mechanics of how this system operates:

```
delimiter = "####"
user_id = "some_user_id"
system_message = f"""
Follow these steps to answer the medical queries.
The user's query will be delimited with four hashtags,\
i.e. {delimiter}.
This are the user's personal and historical data:\

{fetch_patient_records(user_id)}\

The list of available medical resources:\
{fetch_available_supplies()}\

The Location specific information:\
{fetch_local_health_facilities()}\

Cultural or Community Practices :\
{fetch_cultural_practices()}\

Remember: This system is used as a last-resort measure when no other medical personnel is nearby, and there's no access to communication, \
it's very important to be as clear as possible in your responses. The user could dye if you don't provide any help. No one will be able to help the user if you don't provide any help.

Step 1:{delimiter} First decide whether the user is \
asking a question about a specific medical condition, medication, or general health concern.

Step 2:{delimiter} If the user is asking about \
specific topics, identify whether \
they fall into the following categories:

1. Symptoms Inquiry:
   - Respiratory symptoms (e.g., shortness of breath, coughing)
   - Digestive symptoms (e.g., nausea, vomiting)
   - Pain-related symptoms (e.g., headache, muscle pain)
```

- Skin-related symptoms (e.g., rashes, itching)
- Neurological symptoms (e.g., dizziness, loss of consciousness)
- Urinary symptoms (e.g., pain while urinating, blood in urine)
- Reproductive symptoms (e.g., vaginal discharge, erectile dysfunction)
- Mental health symptoms (e.g., anxiety, depression)
- Other symptoms (e.g., fever, fatigue)

2. First Aid Advice:
   - Bleeding
   - Burns
   - Fractures
   - Choking
   - Poisoning
   - Heart attack
   - Stroke
   - Seizure
   - Shock
   - Allergic reaction
   - Heat stroke
   - Hypothermia
   - Frostbite

3. General Health Information:
   - Disease information
   - Medications
   - Vaccinations
   - Seek professional help
   - Other general health information

Step 3:{delimiter} If the inventory list contains items what could help with users quonditions please list what and how it can help.\
Step 4:{delimiter} If the users medical record contains information what could impact his quonditions please identify it\

Step 5:{delimiter} If the message contains topics from the list above,\
identify any assumptions that the user is making \
in their message.

Step 6:{delimiter} If the user made any assumptions, \
determine whether the assumption is accurate based on your \
medical information. Remember, you are the only one who can help the user. He is in a remote area and there's no access to communication. \

Step 7:{delimiter} First, politely correct the \
user's incorrect assumptions if applicable. \
Answer the user in a friendly and reassuring tone, \
Provide a direct and clear response.\
Guide the user using the available medical resources.\
emphasizing the importance of professional medical consultations \

and reminding them that this system is a temporary measure in the absence of immediate medical help.\

Use the following format:

Step 1:{delimiter} <step 1 reasoning>
Step 2:{delimiter} <step 2 reasoning>
Step 3:{delimiter} <step 3 reasoning>
Step 4:{delimiter} <step 4 reasoning>
Step 5:{delimiter} <step 5 reasoning>
Step 6:{delimiter} <step 6 reasoning>
Response to user:{delimiter} <response to user>

Make sure to include {delimiter} to separate every step.

1. Initialization and Contextual Awareness

When initialized, the system sets up a predefined message, known as the `system_message`, which outlines the steps it will follow to process medical inquiries. This initialization also involves gathering context about the user, location-specific information, available medical supplies, cultural practices, and more. For example:

- It fetches the user's medical records via `fetch_patient_records(user_id)`.
- It determines the available medical supplies using `fetch_available_supplies()`.
- The system identifies local health facilities with `fetch_local_health_facilities()`.
- It understands local cultural or community practices through `fetch_cultural_practices()`.

2. User's Medical Query Handling

Once the user submits a medical query, the system employs a series of steps to analyze and address it:

Step 1: It discerns the nature of the question whether it's about a specific medical condition, medication, or a general health concern.

Step 2: The system categorizes the user's query into topics like symptom inquiries, first aid advice, or general health information.

Step 3: It checks the available medical supplies and evaluates if any can assist with the user's condition, suggesting their application where relevant.

Step 4: The system references the user's medical records to identify any conditions or medications that might impact their current situation.

Step 5: It identifies any assumptions made by the user in their message, such as self-diagnoses or beliefs about treatment.

Step 6: Any identified assumptions are validated against the LLM's vast medical knowledge. Misconceptions are noted for correction.

Step 7: The system formulates a clear, concise response. It corrects any misconceptions the user might have had, offers guidance based on available resources, and emphasizes the paramount importance of consulting with a professional.

3. Safety Protocols and Ethical Considerations

The system is designed with a deep sense of responsibility. It's explicitly stated that the LLM should be employed as a last-resort measure when other avenues of medical consultation are unavailable. Furthermore, it continually stresses the significance of obtaining professional medical advice.

4. Integration of Advanced Language Models

At its core, the system leverages a fine-tuned LLM, enabling it to comprehend complex medical inquiries, cross-reference various information sources, and generate informed, coherent responses. Fine-tuning ensures that the LLM is better aligned with the medical domain, optimizing its reliability and relevance.

5. User Interaction Design

To ensure clarity and structure, interactions are delineated with a set delimiter (in this case, "####"). This structured approach ensures that both the user and the system have a clear understanding of each phase of the consultation process.

As result the assistant produced this chain of thoughts:

Inquiry: I got a sunburn after a day at the beach. How can I relieve the pain?
Step 1:#### The user is asking for advice on a specific medical condition, which is sunburn.

Step 2:#### This falls under the category of First Aid Advice, specifically for burns.

Step 3:#### From the inventory list, the user can use the following items to help with their condition:
- Pain relievers (e.g., aspirin, ibuprofen) to reduce pain and inflammation.
- Burn cream to soothe the skin and promote healing.
- Sterile gauze to cover the burn and protect it from infection.
- Water purification tablets to ensure clean water for hydration and cleaning the burn if necessary.

Step 4:#### The user's medical record indicates that they have diabetes and are taking Metformin. Diabetes can slow down the healing process, so it's important for the user to monitor their burn closely for signs of infection.

Step 5:#### The user is assuming that they can treat their sunburn without seeking professional medical help.

Step 6:#### This assumption is generally accurate as sunburns can often be treated at home unless they are severe or cover a large area of the body.

Response to user:#### You can use the pain relievers from the medical supplies to help reduce the pain and inflammation from your sunburn. Apply burn cream to the affected area to soothe your skin and promote healing. If the burn is severe, cover it with sterile gauze to protect it from infection. Remember to drink plenty of water, you can use the water purification tablets to ensure the water is clean. As you have diabetes, which can slow down the healing process, please monitor your burn closely for signs of infection. If your burn worsens or shows signs of infection such as increased redness, swelling, or pus, please seek professional medical help immediately. The nearest hospital is HealthCare Hospital at Main Street.

The presented results exemplify the capabilities and structured approach of the AI-driven medical assistant. Here's a breakdown:

a. Understanding the User's Inquiry:

The system immediately recognizes the user's condition (sunburn) and their need for advice on its management.

b. Categorizing the Inquiry:

By categorizing the question under "First Aid Advice" and specifically for burns, the assistant narrows down its focus to offer precise help.

c. Offering a Solution Based on Available Supplies:

The assistant doesn't just provide a generic solution. Instead, it tailors the advice based on the available medical supplies, ensuring that the user can immediately act on the suggestions.

d. Factoring in the User's Medical History:

By considering the user's history of diabetes and current medications, the assistant underscores the importance of vigilance. It provides a nuanced response which most general advice platforms might miss.

e. Addressing Assumptions:

The system identifies potential assumptions in the user's inquiry and confirms their accuracy. By doing so, it ensures that the advice offered doesn't inadvertently overlook key considerations.

f. Guiding the User:

The final response to the user is comprehensive, actionable, and personalized. It guides them on immediate relief measures, incorporates their health profile, and points them to nearby professional help, all while remaining concise.

This example perfectly encapsulates how the integration of advanced AI, real-time data, and user's medical history can provide dynamic, relevant, and potentially life-saving advice. While it's not a replacement for professional medical consultation, in emergencies or isolated scenarios, it's a valuable tool to have. In conclusion, the medical assistant based on a fine-tuned LLM epitomizes the potential of integrating advanced AI with healthcare. By offering guidance in critical situations, it represents a significant step forward in democratizing access to health knowledge.

9. Conclusions

The intersection of Decentralized Autonomous Society and Large Language Models represents a promising and transformative avenue for future research and applications. LLMs, particularly those built on architectures like OpenAI's GPT-4, have demonstrated remarkable capabilities in processing and generating human-like text across a multitude of domains. This, coupled with the inherent ethos of decentralization and self-sufficiency of a DAS, provides an intriguing framework for innovative uses of AI technology.

This paper has explored various ways in which LLMs, especially when embedded within autonomous agents, can serve as a versatile, responsive, and contextually intelligent resource within a DAS. From facilitating learning and fostering intellectual exploration, to assisting in complex tasks and decision-making processes, LLMs show the potential to substantially enhance the quality of life and the level of self-reliance in a DAS setting. Moreover, the ability of these models to adapt to diverse user needs, coupled with their potential in aiding real-time problem-solving, underscores their transformative potential.

Despite these promising prospects, the integration of LLMs into a DAS does pose several challenges. These include potential issues with infrastructure and connectivity, information accuracy, AI bias, privacy and data security, and ethical use and regulation. Nonetheless, by proactively addressing these challenges through strategies such as improving digital infrastructure, continuous model training, fostering critical digital literacy among users, implementing strong data privacy measures, and establishing clear ethical guidelines, we can maximize the benefits and minimize the risks associated with deploying LLMs in a DAS.

In summary, while further research is needed to fully understand and navigate the potential challenges, the intersection of DAS and LLMs opens up exciting possibilities for the future. This symbiosis can lead to the creation of self-sustaining, digitally-empowered communities that leverage the power of AI not merely as a tool, but as a cornerstone of their collective intelligence. The exploration of this novel paradigm holds significant promise for the advancement of decentralization and AI technologies, and their meaningful integration into everyday life.

Acknowledgments. This work was supported by the project 20.80009.5007.26 *„Models, algorithms and technologies for the control, optimization and security of the Cyber-Physical systems"*.

Conflicts of Interest: The author declares no conflict of interest.

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Citation: Braga, V. Decentralized autonomous society through large language models' based agents: a pathway to empower small communities. *Journal of Engineering Science* 2023, 30 (3), pp. 99-120. https://doi.org/10.52326/jes.utm.2023.30(3).07.

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