TCSN Newsletter – Issue Thirteen – June 2024
Social Networks Technical Committee
Editor: Prof. Claudio Marche

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CHAIR'S MESSAGE

When social media dominates the traffic over the Internet and mobile communication networks, there are further insights and engineering that could be developed based on understanding social networks in depth. Such interplay between technological networks and social networks has so many different aspects to inspire IEEE Communications Society members toward the further frontier of communication technology and benefits of human society. Under such background, Technical Committee on Social Networks (TCSN) is established in 2016, after incubation as a sub-committee in Emerging Technology. We believe that the TCSN newsletters allow us a more fluent exchange of vision, ideas, and technological opportunities, in addition to the website and social media platforms. We greatly appreciate all the members who have contributed to this issue of the newsletter. Last, but not least, we wish TCSN newsletters serve as an effective means for this exciting multi-disciplinary knowledge on social networks to blend humanity and technology in an even better way. Most important, please welcome you to actively participate or initiate more volunteer services to TCSN and IEEE Communications Society.

Best wishes,

Damla Turgut, Chair, TCSN, 2022-2023

UPCOMING CONFERENCES & CFP FOR SOCIAL NETWORKS TRACK

IEEE Globecom 2024: 8-12 December, Cape Town, South Africa
IEEE ICC 2025: 8-14 June, Montreal, Canada

Social networks have become prevalent forms of communication and interaction on the Internet and contribute to an increase in network traffic. As a result, social networks have attracted significant research interests in many related areas. Social networks have traditionally been studied outside of the technological domains; however, the focus is now changing towards networking challenges such as cloud, privacy, data analytics, and so on while still keeping the social perspective such as focusing on improving quality of life. The interplay between social networks and technological networks such as mobile networks and mobile computing is becoming still strong and many areas are still to be exploited.

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IS SOCIAL MEDIA ALLY OR ADVERSARY IN CHALLENGING PEOPLE'S TRUST IN SCIENCE?

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In this age of misinformation and increasing skepticism and doubt which extends even to fundamental principles and truths, even science seems to face serious challenges and has to struggle against significant concerns. In what sometimes might even look like a counter process to the European Enlightment[1], the number of cases where public challenges reports and recommendations of experts, ignoring the scientific process and favoring views and arguments that directly address emotion, is growing.

So, the inevitable questions which are raised are what do people trust, who do they trust and how is trust in science built? These are three critical questions that the EU HORIZON-funded VERITY project (https://verityproject.eu) raises and tries to address. VERITY aims to develop a protocol of recommendations aimed at providing guidelines and methods for traditional and non-traditional "*Stewards of trust*" to enhance trust in science and facilitate science-society collaboration and co-creation. The core aim of VERITY is to re-shape the "*Ecosystem of Trust in Science*", a conceptual space where social trust in science is formed, shaped, negotiated and influenced. It encompasses the complex interactions, dynamics and factors that contribute to building, negotiating, enhancing or diminishing trust in science. The actors in this ecosystem aim to enhance public trust in scientific research and promote a more inclusive and accountable scientific enterprise.

VERITY project applied a combined methodology to examine the factors that influence people's trust in science which included citizen and expert focus groups, vignette studies, a systematic literature review, a study of previous projects with similar objectives and social network analysis. This article focuses on the findings from social network analysis that provide answers to questions about people's trust in science through social media.

As users' "*digital voice*" on social media can be recorded and formally made available to researchers by the social network platform, it can be analyzed for various purposes, and in the project's case, to determine the level of trust in science and discover potential factors influencing user's opinion on scientific issues. The analysis for the purposes of VERITY project was based on the case study of the

[1] The European intellectual movement of the late 17th and 18th centuries emphasizing reason and individualism rather than tradition.

vaccination against COVID-19 and specifically on open access data set from the X (at the time Twitter) social network, providing important findings addressing the factors that influenced people's views and opinions. The data set consists of tweets related to COVID-19 vaccination between January 21 and January 23 while further information such as the date of the message, the number of likes and reshares and the URL of external sources was collected as long as the free API of the platform was available. The methodologies used such as the evaluation of external sources, social network analysis, analysis of message characteristics, analysis of messages based on the number of likes and reshares as well as the use of machine learning, produced conclusions to better understand the phenomenon of misinformation on social networks in relation to science.

The conclusions of the analysis performed are presented in brief, while the reader is directed to the D1.4 Network Analysis Report[2] for a more elaborate presentation and analysis.

Source credibility

As far as the credibility of sources is concerned, their evaluation can be done through journalistic organisations (such as Media bias / Fact Check[3] and PolitiFact[4]) which analyse the validity of the posted news and thus news sources can be evaluated according to how often they publish fake news. The analysis of the data set based on the Iffy+ index[5] which contains a list of untrustworthy websites checked using Media Bias/Fact Check checker showed that a significant number of sources circulated within social networks were unreliable. To understand the extent of the spread of fake news, the research showed that on average one in four posts containing an external source came from an unreliable source.

User behavioral patterns

But how do users behave in social networks when spreading fake news? Social network analysis algorithms have shown that users who trust fake news appear in more closed and isolated subnetworks very often mentioning words related to conspiracy theories, creating an echo chamber effect where users encounter information or opinions that reflect and reinforce their own. On the other hand, users who share news from sources that are considered trustworthy seem to form wider networks and are more likely to engage with news from multiple sources.

Of particular interest is the comparative examination of the terms used within trustworthy and untrustworthy posts. The analysis of word frequency shows very frequent use of words related to conspiracy theories in untrusted sources, while posts containing trusted sources often mention terms related to vaccination. The importance of this analysis is based on the fact that it reveals a high frequency of individuals and websites particularly in the untrusted sources, which reveals who are the most influential to the audience.

[2] https://zenodo.org/records/10902300

[3] https://mediabiasfactcheck.com/

[4] https://www.politifact.com/

[5] https://iffy.news/iffy-plus/

Time is of essence (or not)?

Another question that arises is whether time is an important factor in the spread of fake news. This is a very important question and analysis from this perspective leads to useful conclusions. In particular, the analysis of messages in relation to the number of likes and reshares over time showed that at the beginning of the vaccination period, the messages that were most liked were those containing false news. However, when examining the later time period of the vaccination period, messages with credible sources ultimately appeared to have more influence, which shows how necessary a public information campaign is at the beginning of critical periods. Studying the content of the messages, it was concluded that the reference to politicians was very frequent and especially in the unreliable messages, which is confirmed by the literature review conducted that puts the political factor among the main factors that seem to affect trust in science.

Fake news die hard

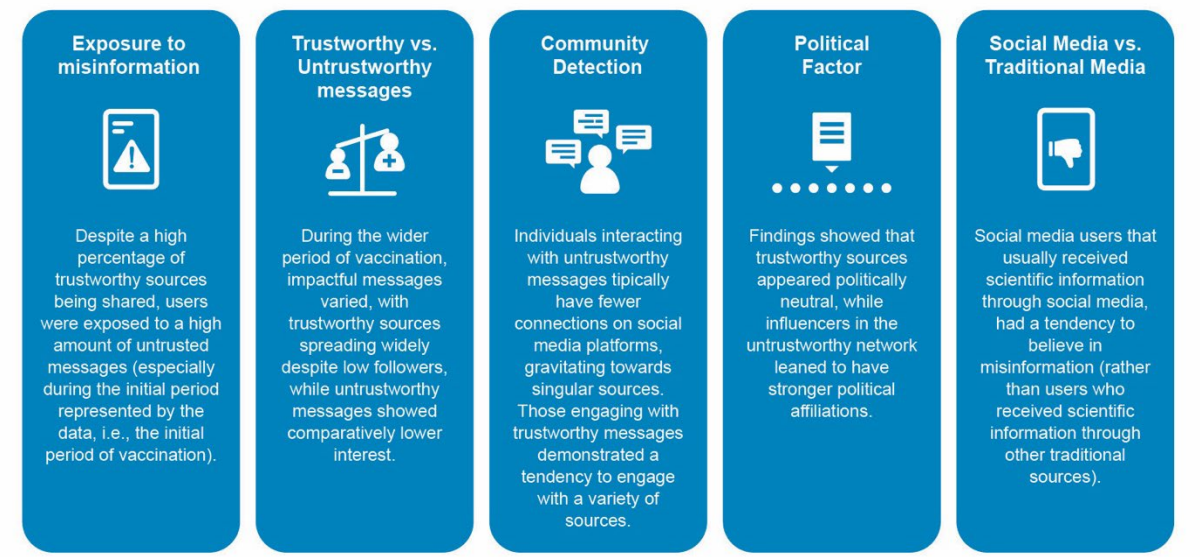
A time-based analysis of the data set was also conducted to clarify the public's sentiment on the specific topic over time and whether the text of the messages had subjective or objective stance. The results showed that on average and during the whole period of the data set there was a relatively positive attitude of users on social networks towards COVID-19 vaccination, and also the majority of messages by 75% had an objective attitude. This type of analysis is appropriate for detecting spikes in the data set which means messages that were highly influential with a very negative or a very positive sentiment expression identifying the exact time as well. Thus, the algorithm identified an impactful message of fake news that caused negative feeling about the death of a man some hours after vaccination. It is noteworthy that while the news still existed on social networks, the news from the website had been deleted.

What is “fertile ground” for fake news?

The above technical analysis was enriched with findings from the Eurobarometer 516 survey in relation to social networks and trust in science. Significant findings show the use of social networks for scientific information much more in some countries such as Cyprus, Greece and Lithuania and much less for other countries such as Austria, Denmark and Finland, while the EU average is 29%. An important finding of this analysis is that social media users are much more likely to believe in conspiracy theories than users who choose traditional ways of getting science and technology information such as TV and newspapers.

Let’s sum up!

In summary, the above findings are visualized in the following infographic mentioning 5 important pillars.



In conclusion, the analysis of data from social networks yields significant results in relation to the public's trust in science and raises issues for informing users to evaluate the information that is circulated within them.

VERITY project findings, in addition to the results of the other research work can be used as a starting point towards building a protocol of recommendations and developing a strategy for helping people (re)trust in science. At a time where the sheer volume of information sometimes is more confusing than helpful to the citizens, the need to support the very foundations over which our modern societies have been built (science and adoption/trust in scientific methodology), is imperative. After all, in the words of Galileo Galilei: "*By denying scientific principles, one may maintain any paradox.*"

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SOCIAL NETWORKING IN METAVERSE

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Metaverse is expected to revolutionize the existing social networking features, applied to different contexts, from Social Internet of Things to Vehicular Social Networks, as well Online Social Networks. Metaverse is mainly used to refer to the expected future iterations of the Internet. This concept can also be referred to as Web 3.0. The advent of the Metaverse concept has further expedited the evolution of haptic, tactile Internet, and multimedia applications, thanks to the use of Virtual Reality (VR), Augmented Reality (AR) and Extended Reality (XR) services. As a result, fully immersive sensing will most likely define the next generation of wireless networks, providing novel and immersive user experience. Generally speaking, VR is an artificial environment created digitally, where users will be able to experience the amplified interactive experience brought by means of special multi-sensory equipment such as immersive helmets, VR devices and omnidirectional treadmills through visual, auditory, tactile and other senses.

In Metaverse we will find a copy of each wireless network in the physical world, such as Internet of Things, Internet of Vehicles, Internet of Drones, and so on. The physical world will be connected to its different Digital Networks, still maintaining the same features, as well as existing social relationships. In such environment, also social networks will be revolutionized by immersive media, where communicating to the own clique will occur in a 3D environment, providing a more immersive experience. Also, Metaverse can provide opportunities for social interaction to people who may face barriers in the real world, such as those with physical disabilities or those who live in isolated areas. This increased accessibility can help to create more diverse and inclusive social networks within virtual environments. Metaverse is expected to provide users with tools to create their own content, such as buildings, avatars, and even entire environments. This user- generated content can provide opportunities for creative expression and can also help to shape the social dynamics of the virtual world.

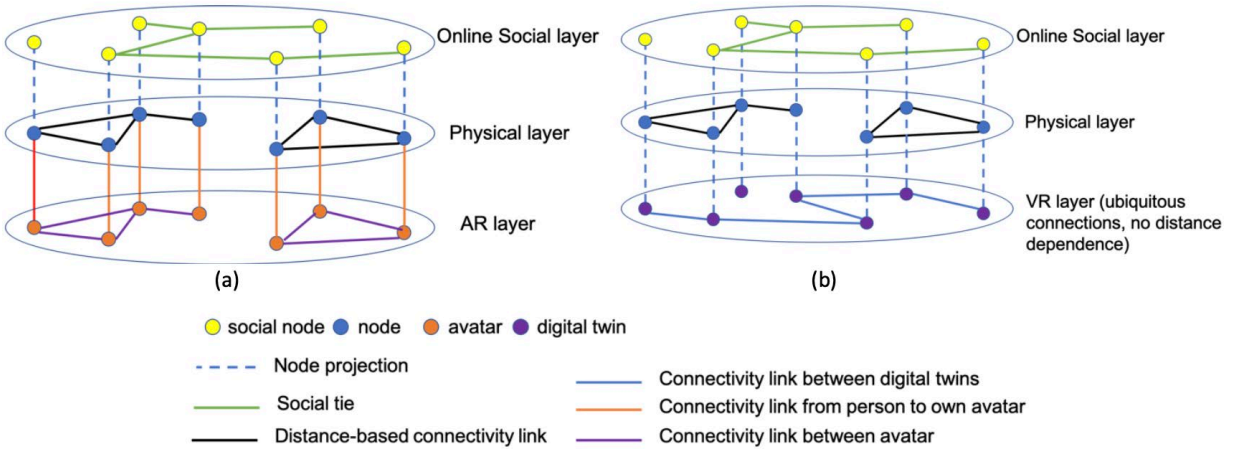

Figure 1 - Overlapping Network Layers From Physical To The Online Social Layer, And The Metaverse In The Form Of (A) Augmented Reality, And (B) Virtual Reality Layer.

In social VR environments, each user materializes and is visible as an avatar. According to this vision, users can meet, socialize and interact without restrictions in an embodied form as 3D holograms or avatars in physical or virtual spaces. Cross-platform and cross-technology meetings and interactions, where some users are in VR and others in AR environments, are the next frontier. Common principles of the Metaverse include software interconnection and user teleportation between worlds. In Metaverse, virtual social networks will allow interactions between digital twins and avatars, as well as between users and avatars. As compared to physical social networks, social interactions will be more easy to build as there will be a plethora of nodes, not only digital twins but also avatar and virtual users. Social networks in virtual worlds are often built around shared experiences, such as playing games, attending virtual events, or exploring new environments. These shared experiences can help to build social connections and foster a sense of community among users. Furthermore, in Metaverse, users have the option to remain anonymous, allowing them to explore different identities and social dynamics without the constraints of their real-world persona. This anonymity can provide opportunities for experimentation and self-discovery, but it can also create challenges around trust and accountability.

As compared to traditional social networking in real world, that is, all those social features applied to the Internet of Social Things frameworks and other similar architectures (i.e., Social Internet of Vehicles / Drones / Robotic Things, etc.), social networking in Metaverse will not rely on physical distance, as it is not a barrier to social interaction, allowing people to connect with others from around the world. Indeed, social networks in the real world are often based on physical proximity, meaning that people tend to connect with others who are nearby, while in Metaverse social ties can be built faster and easier since there is not distance constraint and nodes can interact in different ways. The virtual identities will integrate social and cyber spaces and establish online social relationships. It is expected that OSNs would strive for an extremely interconnected Metaverse in the future.

Starting from physical real world, Metaverse can be built and developed, in case of AR and VR. From physical layer, where nodes are connected mainly based on proximity links, the Metaverse is built through the AR/VR layer. As shown in Figure 1 (a), in case of AR, each node has its own avatar and proximity links are maintained, thus allowing social ties mainly among avatars. Interactions from nodes to avatars are

also allowed. On the other side, in Figure 1 (b) the Metaverse is built from the VR layer, where nodes in the physical world have the own digital twin. Social ties and interactions are no more distance-dependent, as occurring in the VR layer, but ubiquitous connections are allowed. However, in the VR layer the entities are mainly digital twins of the nodes in the physical layer and no proximity constraint is applied. Notice that in Figure 1 the Online Social layer is also drawn. It considers all the traditional social media where social ties are built between users, following an ubiquitous connectivity. Overall, while social networking in Metaverse shares some similarities with traditional social networks (i.e., Online Social Networks), they also offer unique opportunities and challenges that are shaped by the specific features and dynamics of virtual environments.

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REBUILDING TRUST IN ONLINE SOCIAL NETWORKS

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Nowadays, we are almost living our whole lives on online social networks (OSNs) to find new friends, watch movies, buy food, read news, etc. According to the United Nations Worldometer, the current population is around 8 billion; 5.17 billion among them are using OSNs. This simply means that around 60% of the world population are living online generating around 120 zettabytes of data in the form of text, images, and videos. These numbers reveal the importance and the great impact of these OSNs on our lives.

However, these OSNs are vulnerable to fake news (false information). In fact, a study in 2018 published in Science, three professors from the Massachusetts Institute of Technology (MIT) demonstrated that fake news spreads "farther, faster, deeper, and more broadly than the truth". Using Twitter (actually X), the researchers studied all real and fake news that was verified on the network by six fact-checking organizations between 2006 and 2017. They found that fake news was 70% more likely to be retweeted than real news and that it reached the top 1,500 people six times faster. This could be very harmful to societies at the economic and social levels. Especially when generated by Artificial Intelligence (AI), this fake information fakes become seven more dangerous; and is widely adopted by politicians, crime organizations, etc. In fact, generative AI has now the ability to generate real-like data in the form of text, images, videos; and using several deep learning algorithms like Generative Adversial Networks (GANs); Large Language Models (LLMs); etc. As a general consequence to this fact, we are losing trust in the information being shared in OSNs.

In order to regain trust, existing approaches in the scientific literature could classified into two categories. The first approach adopts machine-learning algorithms to classify the information (as well as its source) as trustful or not. However, this approach is reaching its limits due to the "realism" of fake data generated by AI. For example, nowadays, it is very hard even for experts to say whether a scientific paper was written by ChatGPT or a by a renewed scientist. The second category builds a subnetwork of the OSNs composed of trusted nodes that "will take in charge" the verification and validation of the data exchanged over the whole network. This trusted subnetwork is build using Blockchain technology.

For this, we are proposing a twostep approach for rebuilding trust in OSNs. In the first step, each node computes values of trusts of its neighbors. For this, we consider for each node its egocentric network of diameter L; that is, its neighbors that are L hops away from the source node. Figure 1 illustrates this principle. In practice, we choose =6 at maximum due to the "Six Degrees of Separation" theory that states

Target node = « A »

- Neighbors at 1-hop = {B, C, J, H}
- Neighbors at 2-hops = {I, G, F}
- Neighbors at 3-hops = {E}

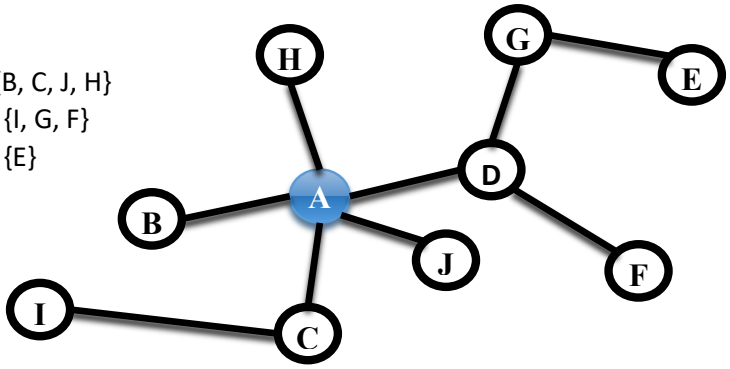

Figure 1 – A Sample Egocentric Network Centered Around Node A of Size L=3 hops

that any person on the planet can be connected to any other person on the planet through a chain of acquaintances that has no more than five intermediaries. In order, for a source node to compute a trust value in one of its L-hops neighbors, it can send him a set of transactions to execute; and use the number of satisfied transactions and the number of not-satisfied ones to derive a local trust value. Thereafter, these local trust values are exchanged through a diffuse process in the network; and thereby global trusted values are derived using an aggregation operator. Here, we can use the following operators: average to have an average view; or the minimum if we want to be very safe. In the second step of our approach, we cluster nodes; and for each cluster, we elect a leader using leader election algorithms. The used criteria for leader election would be the global trust value. Hence, the most trusted node will lead each cluster. These cluster leaders will be responsible for adding blocks to the networks; and thereby for data exchange and validation. For this, they will use the TC-PBFT (Trusted Cluster-based Practical Byzantine Fault Tolerance) protocol which a modified version of the standard PBFT -- see Figure 2.

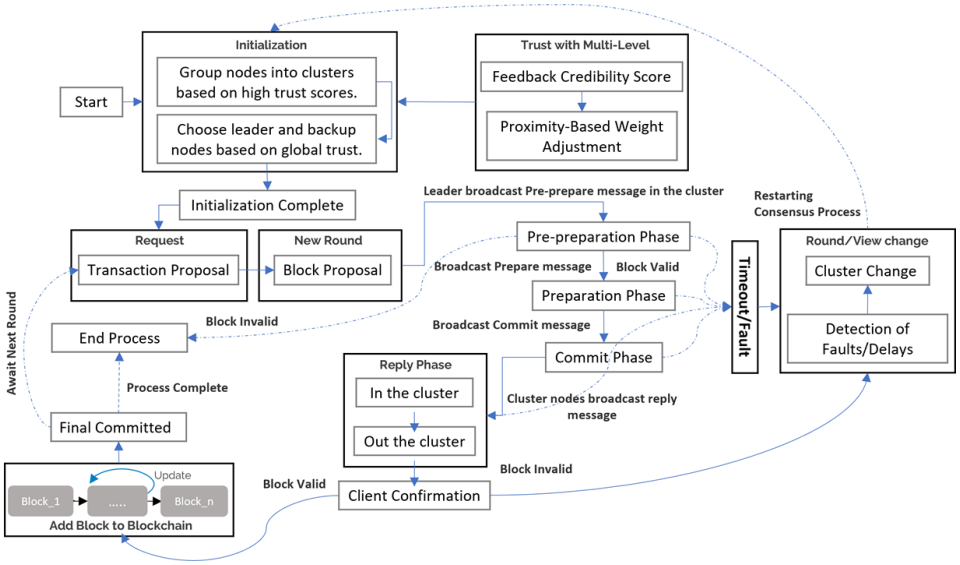

Figure 2 - The Tc-Pbft Protocol

To conclude, OSNs are losing in trust due to the emergence of fake data. This phenomenon is harpened by the emergence of Generative AI, which make the detection of fake data a very hard task for machine learning algorithms. The adoption of Blockchain technology coupled with distributed consensus algorithms seems to be a very promising direction to regain trust in OSNs.

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IEEE COMMUNICATIONS SOCIETY

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HUMAN-AI HYBRID SOCIAL NETWORKS: THE CONVERGENCE OF AI MULTI-AGENTS AND HUMAN SOCIAL NETWORKS

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Rapid developments in the field of artificial intelligence have revolutionize many domains that are part of our everyday life, and, at the moment, social networks are a huge part of these fast transformations. Human-AI hybrid Social Networks are a remarkable evolution, in which AI agents and human users are interacting and contributing to the network's operations. The fusion of AI multi-agents with human social networks is very natural evolution, linked both in data and the technologies of AI and social media, as well as multi-agent systems, and is perhaps setting the sprouting seeds for an interconnected future in which AI agents will no longer be merely a bots, but actual active participants in the human/AI hybrid social networks. These AI agents will form with their own thoughts, personalities, and arguably their own unique representation not unlike URIs. This will further entail interacting with human users in a useful and personalized way for interaction, recommendation, and generation of content. Such symbiotic will increase the socialization experience into more vibrantly and person-specific.

For digital companions, AI agents will quickly learn from and adapt the user behaviours, preferences, and needs. Such agents will communicate with users to provide emotional support, information, and entertainment. The AI agent may also support a person in managing their social media presence by providing content, responding to messages, and even starting discussions pertaining to the interests of a user or what they have previously engaged with on such platforms. The other area where AI agents will play a key role is in the creation and curation of content, which will be appealing to specific audiences through the mining of large datasets. For example, an AI artist can produce digital art related to current events, and an AI writer may write individualized tales or blog posts. Even more, the agents are in a position to curate content from multiple sources, and present the user with a feed tailored to their interests and preferences.

Social connectivity between users will be given a boost by the integration of AI agents on social networks. The AI agents might act as intermediaries to introduce users with similar interests to respective others, mediate group activities, and catalyse community formation. This feature of extended connectedness would help users to build valid relationships and networks all over the globe, transcending borders and cultures. Each AI agent will have a distinctive representation, like a URI, ensuring different identities on the social network. This identifier will enclose the personality, role, and relation of the agent with human users, enabling transparent interaction over different platforms and services. Uniqueness in these representations will also bring about trust and accountability since it will be easier for users to tell and prove the identity and authenticity of AI agents.

The confluence of linked data, AI, social networks, and multi-agents is an evolutionary process, natural and unavoidable. The linked data has the potential to set the scene for any meaningful and relevant interaction that the AI agents aim at. The social networks are the very medium of such interaction, enabling engagement and connectivity. It is hence able to coordinate and collaborate with many AI agents,

providing the system with greater functionalities and intelligence. The critical point of this convergence is linked data, which has a richly associated information web. Artificial intelligence agents can use this richness to improve their understanding of the user's preferences, behaviours, and contexts hence deliver more accurate and personalized interaction that makes social networking very engaging and meaningful.

Over time, with AI being more sophisticated, this help from AI-driven mechanisms will in turn further determine the trends and will dynamically evolve behaviour in accordance with keeping the network up to the mark with user interests. This will create dynamism for constant evolution and an innovative, user engagement-driven point of growth for social networks. The multi-agent systems to be in place will grant smooth coordination and collaboration of AI agents on social networks. The systems will allow sharing among agents, learning from each other for the common goal, therefore improving the general intelligence and efficiency of the network, making it a richer, more dynamic experience for the user.

Conclusion

Hybrid human-AI social networks are the next development in social media, in which both AI agents and human users coexist, interacting with one another in a semantically rich manner. The crucial convergence of AI technologies with human social networks will probably be in huge part simply thanks to technological advances in linked data, AI, social media, and multi-agent systems. The advent of AI agents as part and parcel of social networks continues to bring a more personalized interaction, creativeness, connectivity, and general network experience to life for the user. The frontier has to be guaranteed with trust and authenticity in the special representation of the AI agents, linked data, and multi-agent systems in specialization, innovation, and growth continuation.

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