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An Overview of Emerging Trends in Networking and Social Networking

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Abstract: *This paper presents a brief review of modern networking technologies and social networking systems, focusing on their fundamental concepts, applications and limitations. Advanced networking paradigms enable efficient, scalable, and flexible communication to meet the growing demands of contemporary digital environments.*

Keywords: Networking, Software Defined Networking, Information-Centric Networking, Wireless Networks, Social Networking, Green Networking

Introduction

The rapid evolution of communication technologies has fundamentally transformed the way information is created, shared, and consumed across digital environments. Traditional host-centric and infrastructure-dependent networking models are increasingly unable to meet the demands of modern applications characterized by mobility, scalability, data-centric communication and social interaction. As a result, new networking paradigms and social networking systems have emerged to support flexible, intelligent, and user-driven communication.

Recent advances in software-defined networking (SDN), information-centric networking (ICN), wireless ad hoc networking, and low-power wide-area networks (LPWANs) have redefined network architecture by introducing programmability, decentralization, and energy efficiency. These technologies enable dynamic resource management, seamless connectivity and efficient data dissemination in heterogeneous environments such as cloud computing, Internet of Things (IoT), disaster recovery systems and smart infrastructures.

Parallel to these technical developments, social networking systems have become a dominant mode of interaction in personal, educational and organizational contexts. Social networking platforms facilitate collaboration, knowledge sharing, professional visibility, and community building by leveraging Web 2.0 technologies and user-generated content. Research shows that social networks play a critical role in education, enterprise collaboration, knowledge management, and organizational innovation, while also introducing challenges related to privacy, security and governance.

The convergence of networking technologies and social networking applications highlights the need for an integrated understanding of how modern networks support human interaction, data exchange, and intelligent services. This research paper builds upon existing studies to examine key networking and social networking concepts, their functional characteristics, and their relevance to contemporary

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communication systems. By synthesizing insights from multiple research works, this paper aims to provide a structured foundation for analyzing advanced networking models and social networking applications.

Definitions

Networking: Networking refers to the process of interconnecting computing devices, systems, or entities to enable communication, data exchange, and resource sharing. Modern networking extends beyond physical connectivity to include logical architectures, programmable control, and data-centric communication models.

Software Defined Networking (SDN): Software Defined Networking (SDN) is a networking paradigm that separates the control plane from the data plane, enabling centralized network management, programmability, and dynamic configuration through software-based controllers.

Information-Centric Networking (ICN): Information-Centric Networking (ICN) is a network architecture that focuses on named data objects rather than host locations, allowing content to be retrieved based on identity rather than physical address. ICN enhances caching, mobility support, and data security.

Wireless Ad Hoc Network: A Wireless Ad Hoc Network is a decentralized, infrastructure-less network in which nodes self-organize and communicate via multi-hop wireless links. Each node functions as both a host and a router, enabling rapid deployment in dynamic environments.

Low-Power Wide-Area Network (LPWAN): LPWAN is a class of wireless communication technologies designed for long-range, low-data-rate, and energy-efficient communication, primarily supporting IoT applications such as smart metering, environmental monitoring, and industrial sensing.

Social Networking: Social Networking refers to the use of digital platforms that enable individuals or groups to create profiles, establish connections, communicate and share content. These platforms support relationship maintenance, collaboration, and information exchange.

Social Networking Services (SNS): Social Networking Services (SNS) are web-based or mobile applications that provide functionalities such as identity management, contact management, network awareness, communication, and content sharing to support social interaction.

Enterprise Social Networking: Enterprise Social Networking involves the use of internal social platforms within organizations to support knowledge sharing, professional networking, collaboration and innovation among employees.

Public Key Infrastructure (PKI): It is a framework of policies, technologies, hardware, software and procedures used to create, manage, distribute, use, store and revoke digital certificates and public–private key pairs. PKI enables secure communication, authentication, data integrity and confidentiality over untrusted networks such as the Internet

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Social Networking in Education: Social Networking in Education refers to the application of social networking platforms and tools to enhance teaching, learning, collaboration and student engagement in formal and informal educational environments.

Motivation for Social Networking: Motivation for Social Networking describes the psychological and social factors that drive users to participate in social networks, including relationship maintenance, career advancement, knowledge sharing, self-expression, and community building.

Role of Networking and Social Networking

In1996 Green [13] focused on the emerging concept of green optical networking, addressing the growing concern over energy consumption in high-capacity optical communication networks. With the rapid expansion of Internet traffic, cloud services and data centers, optical networks though more energy-efficient than electronic networks became significant contributors to overall ICT power usage. A major contribution of the study was its comprehensive breakdown of energy consumption components in optical networks, including transmitters, receivers, optical amplifiers, switches and network control systems. The paper surveyed techniques and architectural approaches aimed at improving energy efficiency while maintaining high performance and reliability. The study highlighted the role of optical network architectures in enabling energy efficiency and discussed transparent and translucent optical networks, elastic optical networks and reconfigurable optical add-drop multiplexers (ROADMs) as key enablers for green networking. The integration of control-plane intelligence, such as GMPLS and software-defined control was shown to be crucial for adaptive and energy-aware operation. An important strength of the paper was its discussion of trade-offs between energy efficiency and network performance. The study acknowledged challenges such as increased control complexity, potential impacts on quality of service and reliability concerns when switching devices on and off. The lack of standardized energy metrics and real-time monitoring tools were also identified as a barrier to widespread deployment. The study was highly relevant for researchers and practitioners working in optical communications, green networking and sustainable ICT systems. In 1997 Starkey [19] examined the role of networks and networking as strategic tools for development, particularly in rural and agricultural contexts. Rather than focusing on technical computer networks, the study emphasized human, institutional and organizational networks and the way they could enhance information sharing, coordination and collective action in development initiatives. The study was grounded in extensive practical experience, especially from African animal traction and rural transport networks. A major contribution of the paper was its conceptual clarification of networks and networking. The study defined different network types and explained reason networking was essential for development activities that involved multiple stakeholders, disciplines and institutions. The study identified benefits such as improved communication, shared learning, professional capacity building and enhanced policy influence. The work also provided a critical discussion of common networking problems, including lack of clear objectives, domination by powerful actors, excessive centralization, donor interference, resource constraints and weak monitoring and evaluation mechanisms. The second part of the study drew on experiences from animal traction networks in Africa, including WAATN and ATNESA. These case studies illustrated the use of networking in supporting technology dissemination, professional standards, training and farmer involvement. The study adopted a qualitative, experience-based approach, combining case studies, workshop discussions and reflective analysis. This work was highly relevant to development studies, rural planning, agricultural extension and transport development. While rich in practical insight, the study was less focused on quantitative evaluation or formal theoretical modelling. The examples were largely drawn from rural Africa, which may limit direct generalization, although the principles themselves were broadly applicable. By combining theory with

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real-world experience, the study provided valuable lessons on how networks can effectively support innovation, collaboration and policy influence in development contexts. In 1997 Bhattacharjee et al [3] introduced an early and influential architectural framework for Active Networking, a paradigm that redefined the role of networks from passive carriers of data to programmable computational entities. The study aimed to demonstrate that embedding computation within the network could enable application-aware processing, improve performance and more flexible network services, while still maintaining security, scalability and deployability. The core contribution of the study was a function-based active networking architecture, where packets carry control information that specified which network-supported functions should be applied during packet processing. This design choice striked a balance between flexibility and control, distinguishing it from capsule-based approaches that allowed arbitrary code execution. The study presented a generic packet-processing model that generalized traditional forwarding mechanisms which enabled incremental deployment and backward compatibility with existing networks. The study focused on programmable congestion control as a near-term application. Using MPEG video streams as a case study, the study demonstrated that application-level semantics could guide intelligent packet to discard decisions. Mechanisms such as frame-level discard, group-of-pictures (GOP) discard and early discard triggers were evaluated experimentally. It was shown that the active networking significantly improved signal-to-noise ratio (SNR), preserves important I-frames and reduced wasted bandwidth compared to traditional packet-level discard. Providing a practical and secure active networking model, demonstrating incremental deployability and using strong experimental validation using real multimedia traffic were some strengths of the study. Relying on predefined functions, limiting flexibility compared to fully programmable networks, not exploring processing overhead and scalability issues in high-speed core networks were some limitations of the study. The study made a strong case for controlled programmability within the network and remained a valuable reference in networking research. Frodigh et al [11] in 2000 provided a comprehensive introduction to the concept, principles and challenges of wireless ad hoc networks. Unlike traditional wired or infrastructure-based wireless networks, ad hoc networks operated without fixed infrastructure, relying on the cooperative behaviour of mobile nodes to establish communication dynamically. A major contribution of the paper was its clear explanation of multi-hop wireless communication, where nodes acted both as hosts and routers. The study emphasized the self-organizing and self-configuring nature of ad hoc networks, which allowed nodes to join or leave the network freely without disrupting overall communication. This decentralized architecture made ad hoc networks highly adaptable to dynamic environments. The study discussed the central role of routing protocols in ad hoc networks. Since network topology changed frequently due to node mobility, routing became a complex task. The authors outlined key routing challenges such as route discovery, maintenance, scalability and energy efficiency. The discussion highlighted that efficient routing was critical for ensuring reliable communication in the absence of centralized infrastructure. The study identified several important application domains for wireless ad hoc networks, including military and tactical communications, disaster recovery and emergency response, sensor networks and environmental monitoring, temporary networks for conferences and events and vehicular and mobile computing environments. A balanced perspective was provided by addressing the limitations and challenges of ad hoc networks. These included limited bandwidth, power constraints, security vulnerabilities, interference, and scalability issues. It was noted that the lack of centralized control complicated tasks such as authentication, access control and network monitoring. The study was primarily conceptual and survey-oriented, making it an excellent introductory reference for students and researchers new to wireless ad hoc networking. Its strength lied in presenting complex networking ideas in an accessible manner while clearly articulating the open research problems in the field.

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Ganesan et al [12] in 2003 provided a comprehensive overview of the key networking challenges in Wireless Sensor Networks (WSNs), a class of networks composed of small, low-power sensor nodes deployed to monitor physical or environmental conditions. Due to severe constraints on energy, processing power, memory and communication bandwidth, WSNs required networking solutions that differ significantly from those used in traditional wired and wireless networks. The study systematically discussed several critical networking aspects, including topology control and deployment, focusing on node placement, density, and self-organization routing and data dissemination, emphasizing energy-efficient multi-hop communication and data aggregation, medium access control (MAC) protocols designed to reduce collisions and idle listening, transport-layer challenges, such as reliability, congestion control and flow management and data-centric communication, where queries and events were more important than node addresses. A major strength of the paper was its detailed discussion of energy consumption models and the way communication costs dominated computation costs in sensor nodes. The study highlighted the challenges of maintaining network functionality in the presence of node failures, dynamic topology changes and harsh deployment environments. Scalability was addressed through hierarchical routing and localized control mechanisms, while fault tolerance was achieved through redundancy and adaptive protocols. The study outlined common security issues such as key management, authentication, data integrity and resilience against node compromise. This study served as an important foundational reference for researchers and practitioners working in WSNs. By clearly articulating the constraints and networking problems unique to sensor networks, it helped to guide the design of protocols and systems for applications such as environmental monitoring, healthcare, industrial automation, and military surveillance. Vleuten and Kaijser [20] in 2005 explored the concept of networking as a strategic instrument for cooperation, integration and development within the European context. The study emphasized the growing importance of networks social, institutional, professional and informational in addressing complex economic, social and policy challenges across Europe. The study explained that networking enabled the sharing of best practices, strengthens collective problem-solving and supported coordinated responses to common challenges. The study also underlined the importance of communication technologies and organizational structures in sustaining effective networks as networking enhanced inclusiveness by connecting diverse sectors such as policymakers, researchers, practitioners and civil society organizations. The study identified several benefits of networking, including improved information flow and knowledge dissemination, enhanced innovation through collaboration, stronger policy influence and coordination and capacity building at regional and local levels. These benefits were particularly relevant in the European context, where diversity of languages, cultures and governance systems required adaptable cooperation mechanisms. A major contribution of the study was its discussion of European networking frameworks, including cross-border partnerships, thematic networks and institutional linkages supported by European initiatives. Alongside its advantages, the study critically discussed challenges faced by European networks, such as coordination difficulties, unequal participation, resource constraints and sustainability issues. The study was highly relevant for researchers and practitioners working in European studies, development policy, regional planning and organizational management. The study situates networking as a response to increasing interdependence among European regions, organizations and stakeholders. In 2008 Berthold and Blair [2] provided a comprehensive overview of the evolution of optical networks over more than 25 years, highlighting technological advances, architectural changes and future challenges. The authors systematically examined that due to increasing traffic demands and new services had driven innovation in optical transmission, switching and control. The study began by describing the transition of networks from voice-dominated traffic to data- and video-centric services and explained that this shift led to the coexistence of multiple service types, including packet services, TDM services and wavelength (wave) services. A key contribution was the discussion of Optical

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Transport Network (OTN/G.709) as a convergence layer that enabled transparency, interoperability and effective management of diverse client signals over DWDM systems. The study compared traditional optical–electrical–optical (O-E-O) architectures with optical-bypass-enabled architectures and demonstrated that optical bypass significantly improved scalability by reducing the number of transponders, lowering power consumption and decreasing operational costs. The study explained the role of ROADMs, OADMs and all-optical switches in enabling flexible and reconfigurable networks. Another important contribution was the discussion of network agility, enabled by tunable transponders, reconfigurable optical elements and software-based control planes. The study highlighted the role of GMPLS and ASON control planes in automating provisioning, enabling fast restoration, and supporting dynamic services. The study analyzed two main approaches to increasing network capacity increasing wavelength bit rates and increasing the number of wavelengths per fiber. It critically evaluated the trade-offs associated with each approach, including optical impairments, grooming complexity and cost efficiency. Its strengths lied in its clear historical perspective, balanced technical analysis and forward-looking discussion. The study served as an essential reference for researchers, students and practitioners interested in optical network architecture, scalability and future Internet infrastructure. In 2008 Weaver and Morrison [22] provided an insightful overview of the concept of social networking, tracing its evolution from traditional human social structures to modern Internet-based social networking platforms. It was argued that social networking was not a new phenomenon but rather a natural extension long-standing tendency of humanity to communicate, collaborate and form communities, now amplified by digital technologies. A major contribution of the paper was its clear explanation of the paradigm shift from top-down information dissemination to bottom-up, user-generated content. The study emphasized that modern social networking empowered individuals to create, share and control content, fundamentally changing how information flows on the Internet. The study highlighted the widespread adoption of social networking among younger users and discusses generational differences in technology use. Through real-world examples, such as the role of Facebook during the Virginia Tech incident and each case study illustrated a different model of online social interaction MySpace emphasized media sharing and self-expression, Facebook focused on real-world identity and peer relationships, functioning as a social platform with third-party applications, Wikipedia represented collaborative knowledge creation through voluntary participation and YouTube demonstrates community-driven media sharing and content moderation. The study also addressed challenges associated with social networking, particularly privacy, security and information reliability. Concerns related to user-generated content, misuse of personal information and online etiquette was discussed, highlighting the need for responsible participation and improved platform governance. The study discussed efforts toward standardization, such as Google's OpenSocial initiative and suggested that the future Internet will increasingly function as a social utility rather than merely an information source. The study predicted that social networking would continue to reshape communication, collaboration and digital culture. The study served as a valuable introductory reference for understanding the role of social networking in modern Internet evolution. In 2008 DiMicco [7] investigated the reason employees used an internal enterprise social networking site while focusing on motivations, patterns of interaction and types of content shared. The study was based on Beehive, an internal social networking system deployed within IBM and using a mixed-methods approach, the research combined in-depth qualitative interviews with seventeen active users and quantitative analysis of system usage logs involving tens of thousands of employees. A key contribution of the paper was its identification of three primary motivations driving employee participation caring, climbing, and campaigning. Caring reflected desire to form personal connections and build social bonds at work, especially with weak ties. Climbing related to career advancement, where employees strategically presented skills, experiences and interests to gain visibility within the organization. Campaigning involved promoting ideas, projects or initiatives and

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mobilizing organizational support beyond formal hierarchies. Another significant finding was that employees predominantly used the platform to connect with weak ties and new colleagues, rather than maintaining close working relationships. The study also highlighted that employees were more willing to share personal and professional content within the enterprise network compared to public platforms. Privacy concerns were notably lower, as users trusted the organizational context and controlled access. The study offered important implications for enterprise system design and recommended supporting open sharing, flexible self-presentation, public commenting and discovery mechanisms to foster networking, career development, and innovation. The study further showed that internal social networking tools could provide strategic value to organizations by enhancing employee engagement, visibility, and informal communication. The well-structured analysis, strong empirical grounding, and novel motivational framework deepen the understanding of social networking in professional contexts. While the study was limited to a single organization, its findings were broadly applicable and offer valuable guidance for future research and enterprise social platform design. In 2009 Brandtzæg and Heim [5] investigated the motivational factors driving user participation in social networking sites (SNSs). Recognizing the limited empirical research on SNS motivations particularly outside the United States a large-scale study was conducted in Norway to provide a European perspective on why people engage with social networking platforms. The study adopted a mixed quantitative–qualitative research design. Data were collected through an online survey conducted among users of four popular Norwegian SNSs, yielding over 5,000 responses. For in-depth analysis, the authors selected 1,200 detailed open-ended responses and applied content analysis to identify recurring motivational themes. Inter-rater reliability testing strengthens the validity of the coding process. The analysis revealed that SNS usage was driven by multiple overlapping motivations rather than a single dominant factor. Twelve distinct motivational categories were identified, with the most significant being meeting new people was 31%, maintaining contact with friends was 21% and socializing with 14%. Other motivations included information seeking, debating, content sharing, time-killing, free messaging services, and entertainment. Notably, family interaction and identity presentation were reported less frequently as primary motivations. By mapping the identified motivations onto the Uses and Gratifications framework, the study demonstrated that SNS behaviour largely fitted established media-use theories. The study highlighted that SNSs facilitated both bonding and bridging social capital, enabling users to maintain existing relationships while forming new ones. A major strength of the paper was its large and diverse sample and the combination of qualitative depth with quantitative rigor. However, the study was limited by its focus on Norwegian SNSs and self-selected participants, which might affect generalizability. Jacobson et al [14] in 2009 presented a novel networking paradigm known as Networking Named Content (NNC), which shifted the focus of communication from host-based addressing to content-based addressing. These names were used directly in the network layer for routing and forwarding decisions. By decoupling content from hosts, the architecture enabled transparent replication, in-network caching and efficient multicast delivery. The network forwarded requests for named content and retrieved the closest available copy, whether from the original publisher or an intermediate cache. This mechanism significantly reduced redundant traffic and improved content availability. A major strength of the proposed approach was its native support for mobility, since content names remained valid regardless of the location of producer location. The architecture also enhanced fault tolerance, as content could be retrieved from multiple sources. Content objects could be cryptographically signed, ensuring data integrity and authenticity independent of the delivery path. This model aligned well with caching and replication mechanisms. The study distinguished Networking Named Content from traditional IP networking as well as from overlay-based content delivery networks (CDNs). Unlike CDNs, NNC integrated content awareness directly into the network layer, eliminating the need for application-level workarounds. The study acknowledged several open challenges,

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including scalable name-based routing, name resolution overhead, namespace management and incremental deployment alongside IP networks. These challenges highlighted the need for further research before widespread adoption.

Zyl [25] in 2009 provided a comprehensive literature-based analysis on Web 2.0–enabled social networking technologies influenced by modern organisations. The primary objective of the study was to enhance understanding of Social Networking 2.0 and to evaluate its benefits, risks and organisational implications, particularly from a knowledge management and business perspective. A major contribution of the paper was the clear conceptualisation of Social Networking 2.0. The study defined it as the use of Web 2.0 technologies to support the maintenance of relationships, discovery of new connections and transformation of potential ties into weak or strong ties. The study identified key components such as digital user profiles, social feedback mechanisms and multiple modes of computer-mediated communication, including one-to-one, one-to-many, and many-to-many interactions .The study strongly emphasized the positive organisational impact of Social Networking 2.0. These technologies enhanced knowledge management by enabling the identification of experts, reducing knowledge duplication and retaining cumulative organisational knowledge in a searchable form. Alongside the benefits, the study provided a balanced discussion of the risks associated with Social Networking 2.0. Key concerns included decreased employee productivity, misuse of organisational resources, data leakage, malware threats, misinformation and damage to organisational reputation. The open and user-generated nature of these platforms introduced challenges related to information reliability, security and governance, which organisations must address through appropriate policies and controls. The strength of the paper lied in its comprehensive literature review and balanced evaluation of both positive and negative impacts. While the study did not include empirical data or technical implementation details, it successfully synthesised existing research to provide valuable strategic insights. The discussion was equally relevant to business organisations, academic institutions and libraries, enhancing its applicability across domains. Fotiou et al [10] presented a detailed overview of the Publish–Subscribe Internet Routing Paradigm (PSIRP) and introduced PURSUIT as its natural evolution. The study addressed fundamental limitations of the current Internet architecture by advocating a clean-slate, information-centric networking (ICN) approach, where information not hosts or locations formed the core abstraction of communication. The PSIRP architecture was built upon flat, endpoint-independent identifiers, combined with the novel concept of scopes to organize and limit information reachability. This design effectively separated identity from location, enabling scalable information dissemination. The security framework particularly Packet Level Authentication (PLA) further strengthened the architecture by embedding trust, accountability and privacy into the network fabric rather than treating them as add-ons. The study supported the architectural claims through prototype implementations, NetFPGA-based evaluations, large-scale simulations and a multi-site European testbed. Performance results related to multicast efficiency, caching effectiveness and mobility handling reinforced the practicality of the PSIRP approach. The study effectively positions PURSUIT as a refinement and expansion of PSIRP. PURSUIT aimed to complete missing components, improve scalability and extend information-centric principles down to the link and physical layers, including wireless and optical networks. While the study was strong conceptually and experimentally, it largely focuses on architecture and mechanisms rather than detailed quantitative comparisons with competing ICN approaches. Scalability beyond experimental testbeds and long-term economic validation remained open challenges, which PURSUIT aims to address. The study clearly distinguished the work through its native inter-domain focus, flat identifiers within scopes and strong security integration, setting it apart from name-based or overlay-centric alternatives. Bianzino et al [4] in 2010 provided a comprehensive overview of research efforts aimed at reducing energy consumption

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in communication networks, a field commonly referred to as green networking. The primary objective of the study was to classify and synthesize existing green networking research, offering a unified perspective on how energy efficiency could be achieved across different layers of the network stack. Rather than proposing a single solution, the survey organized diverse approaches and highlighted trade-offs between performance, quality of service and energy savings. The study applied layer-wise categorization of green networking techniques and discussed energy-saving mechanisms at the device level, link level, network level and application level, making it easier for readers to understand where and how energy optimization could be applied. The survey used measurement models and metrics to evaluate energy efficiency, which was critical for fair comparison of different approaches. An important contribution of the study was its discussion of open issues and research challenges, such as balancing energy efficiency with performance guarantees, deployment complexity, lack of standardized metrics and compatibility with existing Internet infrastructure. The study was highly relevant in the context of modern networking, cloud computing and data center growth. While comprehensive, the survey mainly focused on wired and traditional network architectures, with relatively limited coverage of emerging paradigms such as software-defined networking (SDN) and information-centric networking, which later became important enablers for green networking solutions. It served as a foundational reference for understanding green networking concepts, methodologies and future directions and remained a useful resource for both academic study and practical network design. Dressler and Akan [8] in 2010 presented a comprehensive overview of bio-inspired networking, an emerging research area that draws inspiration from biological systems to address complex networking problems. The motivation behind this approach lied in the observation that biological systems such as ant colonies, neural networks, immune systems and genetic evolution exhibited desirable properties like self-organization, adaptability, robustness, scalability and fault tolerance, which were often difficult to achieve in traditional network architectures. One of the major strengths of the paper was its taxonomy-based organization of bio-inspired approaches which helped readers to clearly understand different biological models that addressed specific networking problems. Each bio-inspired technique was explained in terms of its biological analogy, followed by its networking implementation and benefits. This approach made the survey accessible even to readers who may not have a strong background in biology. The study also discussed the advantages of bio-inspired networking, such as decentralization, adaptability to dynamic environments and resilience to failures. These properties were particularly valuable in modern networks like wireless sensor networks, mobile ad hoc networks and large-scale distributed systems. In addition to highlighting benefits, the study critically discussed open challenges, including computational overhead, convergence time, parameter tuning and scalability in real-world deployments. The study also acknowledged that while bio-inspired algorithms were conceptually powerful, their practical implementation often required careful design trade-offs. By consolidating diverse research efforts, the study served as a valuable reference for identifying suitable bio-inspired techniques for specific networking problems. Zaidieh [23] in 2012 examined the growing role of social networking platforms as educational tools in the context of e-learning and modern pedagogy. The study explored that social networking could enhance learning experiences while also highlighting the challenges that limited its effective adoption in educational environments. The study argued that social networking platforms could significantly enhance e-learning environments by introducing interaction, collaboration and a human-centered approach to online education. Drawing on educational theories and prior research, the study explained that social networks helped to overcome the lack of social presence often criticized in traditional e-learning systems. Features such as discussion forums, blogs, chat rooms and multimedia sharing supported active learning and student engagement. The study also reviewed earlier studies demonstrating successful integration of social networking tools in higher education and school-level education. A key strength of the study was its balanced discussion of challenges associated with

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social networking in education. The study identified several major concerns like privacy issues, due to the public nature of social networking platforms, questionable quality of online friendships and information reliability, excessive time consumption, which may negatively affect health and academic focus and miscommunication, as online interaction lacked non-verbal cues present in face-to-face learning. These challenges highlighted the risks of uncontrolled or poorly managed use of social networking technologies in educational contexts. Alongside the challenges, the paper emphasized significant opportunities offered by social networking in education. These included flexibility in learning, repeatability, convenience and accessibility and enhanced interaction and collaboration. The strength of the study lied in its comprehensive overview and clear organization, making it accessible to educators, students and researchers new to the topic. Although it lacked empirical data or experimental validation, it effectively synthesized existing research to highlight both the potential and limitations of social networking in education. The study served as a useful reference for studies in e-learning, educational technology, and digital pedagogy.

Dannewitz et al [6] in 2013 presented Network of Information (NetInf) as a comprehensive and scalable realization of the Information-Centric Networking (ICN) paradigm, addressing fundamental limitations of the host-centric Internet architecture. Motivated by the explosive growth of content distribution, mobile traffic and machine-to-machine (M2M) communications, it was argued that current overlay-based solutions such as CDNs and P2P systems were inefficient and insufficient for future networking demands. A major strength of the paper lied in its clear articulation of design requirements for future networks, including scalable content distribution, persistent and location-independent naming, inherent support for mobility and multihoming, improved data availability under challenged network conditions, and object-level security. The study proposed a flat, self-certifying namespace, which decoupled naming from topology and organizational structure. This approach enhanced name persistence and supported in-network caching while ensuring data integrity without mandatory reliance on trusted third parties or PKI. Another significant contribution was NetInf's hybrid object retrieval mechanism, which combined name-based routing and name resolution services (NRS). Unlike ICN architectures that rely exclusively on one approach, NetInf flexibly switched between routing and resolution on a hop-by-hop basis. The study provided a detailed architectural discussion covering naming, security, caching strategies (on-path, off-path, and peer-side caching), convergence layers, routing, and inter-domain communication. Comparative analysis with other ICN proposals such as CCN/NDN, DONA, and PSIRP further clarified NetInf's unique position, especially its emphasis on name resolution, off-path caching and PKI-independent security. This strengthens contribution by situating NetInf clearly within the broader ICN research landscape. The study offered a well-structured, technically rigorous, and forward-looking architecture for information-centric networking. In 2013 Mc Carroll and Curran [16] examined the growing role of Social Networking Sites (SNSs) and Web 2.0 technologies in modern educational environments and explored that social networking, traditionally viewed as a leisure activity, could be effectively integrated into formal and informal learning contexts to enhance collaboration, communication and student engagement. The primary aim of the study was to analyze the educational potential of social networking technologies while critically addressing the risks and challenges associated with their use. The study provided a strong theoretical foundation by discussing Web 2.0 principles, including collective intelligence, rich user experiences and the web as a learning platform. It emphasized constructivist and collaborative learning, where students actively participate in knowledge creation rather than passively consuming information. Tools such as blogs, wikis and social media platforms were highlighted as enablers of peer learning and content co-creation. A significant contribution of the study lied in its detailed discussion of use of SNSs in education. The study examined collaborative learning through wikis and blogs, student motivation and engagement via social

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interaction, social networks as supported systems for academic and cultural adaptation, integration of SNSS with learning management systems (LMSS) and the impact of mobile technology on anytime, anywhere learning. The study critically addressed several concerns related to the use of social networking in education, including data privacy and security issues, cyber bullying and inappropriate online behaviour, reliability and quality of user-generated content, distraction and misuse of mobile devices and lack of teacher training and institutional readiness. It was argued that without proper guidelines, policies and digital literacy initiatives, the educational benefits of SNSs may not be fully realized. This study was valuable as it combined theoretical insights with practical observations, making it relevant to educators, researchers and policymakers. It highlighted a clear gap between the potential of social networking technologies and their actual implementation in education and emphasised on educating educators. Zhang et al [24] in 2014 presented a clean-slate Internet architecture Named Data Networking (NDN), that shifted the network paradigm from host-centric communication to data-centric communication. Instead of addressing packets to specific hosts, NDN focused on retrieving data by names, reflecting the dominant use of modern Internet as a content distribution platform. The study builds on the earlier Content-Centric Networking (CCN) concept and was part of the NSF Future Internet Architecture initiative. NDN communication was driven by consumers through the exchange of Interest packets and Data packets. Consumers request data by name using Interest packets and Data packets carrying the requested content were returned along the reverse path. Each NDN router maintained three key data structures the Pending Interest Table (PIT), Forwarding Information Base (FIB) and Content Store (CS). These structures enabled stateful forwarding, in-network caching, multicast support, and efficient flow control. A notable feature of the architecture was its hierarchical naming system, which supported name aggregation and scalable routing while allowing applications flexibility in namespace design. Routing and forwarding decisions were based on name prefixes rather than addresses, eliminating issues such as address exhaustion and NAT traversal. Security was integrated directly into the architecture through data-centric security, where every Data packet was cryptographically signed. This ensured data integrity and provenance regardless of where the data was retrieved from. NDN also improved network efficiency through in-network caching, native multicast and receiver-driven congestion control. The study discussed several prototype applications, including video streaming, real-time conferencing, building automation systems and vehicular networking, demonstrating the practicality of the NDN architecture. Despite its advantages, the study acknowledged open research challenges such as scalable name-based routing, trust management, namespace design and forwarding strategy optimization. Deployment and coexistence with the existing IP infrastructure also remained significant concerns. The study combined architectural clarity, practical experimentation and forward-looking research challenges, making it a key reference in the field of information-centric networking. O'Toole Jr. [17] in 2014 contributed to public administration literature that critically examined the growing importance of networks and networking in contemporary governance. The study revisited earlier arguments and evaluated the progress made in network-related research over nearly two decades. One of the major strengths of the study was its clear conceptualization of networks as structures of interdependence involving multiple organizations where no single actor exercised complete hierarchical control. The author identified multiple research agendas, including conceptual and descriptive agendas, empirical and theoretical agendas and practical and normative agendas. The study highlighted advances in social network analysis, descriptive mapping of administrative networks and empirical studies demonstrating that networks and managerial networking significantly influenced public sector performance. The author reviewed extensive empirical evidence showing that networking activities by public managers could enhance organizational outcomes, especially in complex and resource-dependent environments. However, the study avoided uncritical optimism by acknowledging that networks may also generate negative consequences such as

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coordination problems, accountability gaps, unequal influence and dark networks. The study offered important practical implications for public administrators, emphasizing that effective management increasingly required skills in collaboration, negotiation, trust-building and boundary spanning. While the study provided a comprehensive synthesis of existing research, it is largely conceptual and reflective, relying on secondary literature rather than new empirical data. The study successfully demonstrated that networks and networking were central to modern public management while identifying critical gaps that warrant further research. Keller and Rexford [15] introduced a novel networking paradigm inspired by cloud computing, where network infrastructure management was decoupled from service management. Drawing an analogy with Platform as a Service (PaaS) in cloud computing it was argued that networking should move beyond basic connectivity and traditional network virtualization models to better support innovation and simplify service deployment. The core contribution of the study was the proposal of a single-router abstraction instead of exposing a virtual network composed of multiple virtual routers, the infrastructure provider presented each customer with the illusion of a single, powerful router. This abstraction included routing control, data-plane configuration and general-purpose processing capabilities, enabling advanced in-network functionality such as customized routing, monitoring, firewalls and caching. Customers interacted with this platform through programmable APIs rather than static configurations, allowing dynamic adaptation to network events and service requirements. The study thoroughly discussed the challenges of implementing this abstraction on a distributed and shared physical infrastructure. In shared environments, the model supported multiple customers by running a unified control plane while maintaining logical separation through contextualized policies, thereby improving resource utilization compared to strict virtualization. A key strength of the paper was its critical comparison with virtual network approaches. The proposed PaaS model reduced operational complexity for customers, improved resource efficiency for infrastructure providers, enabled service differentiation beyond commodity connectivity and facilitated innovation in in-network services. While conceptually strong, the study was largely architectural and design-oriented, with limited experimental validation. Practical challenges such as security isolation, performance guarantees and deployment feasibility were acknowledged but not fully resolved. By proposing a higher-level abstraction centered on a single programmable router, the study presented a compelling alternative to virtual networks. Astuto et al [1] in 2014 presented a comprehensive overview of Software Defined Networking (SDN), a networking paradigm that separated the control plane from the data plane to enable centralized, programmable and flexible network management. The survey aimed to consolidate existing SDN research, explained its core concepts, and highlighted challenges and future research directions. A major contribution of the paper was its clear explanation of the SDN architecture, which consisted of three main layers application layer, control layer and infrastructure layer. The survey reviewed key technologies that supported SDN, including openFlow for flow-based forwarding, network virtualization, network function virtualization (NFV) and policy-based and programmable networking. The study compared SDN with traditional networking approaches and demonstrated where network applications and services reside. The study discussed a wide range of SDN applications, such as data center networking, traffic engineering and load balancing, network virtualization and cloud computing, security enforcement and monitoring and wireless and mobile networks. An important strength of the paper was its discussion of open challenges in SDN, including scalability and performance of centralized controllers, reliability and fault tolerance, security vulnerabilities in controllers and control channels, interoperability with legacy networks and standardization and deployment complexity. The study was well organized making complex concepts accessible to readers with basic networking knowledge. Although it does not included experimental results, its value lied in synthesizing existing research, categorizing SDN approach and identifying research gaps. Richter and Koch [18] addressed an important research gap in the study of Social

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Networking Services (SNS) by systematically identifying and categorizing their core functionalities. The study did analysis in knowledge management and computer-supported cooperative work (CSCW) research and emphasized a shift in organisational knowledge management from document-centric repositories to people-centric networking, where employees themselves were seen as key knowledge holders. The study was drawn on social and communication theories, including Goffman's theory of self-presentation and Granovetter's theory of weak ties, to explain why SNS were effective tools for collaboration and knowledge sharing. The core contribution of the study was the identification of six basic functionalities of social networking services that was enabling users to present themselves through profiles and control access to personal information. Supporting the identification of people with specific skills, expertise, or interests, helping users recognize shared backgrounds, interests, or connections, thereby fostering trust, allowing users to create, maintain and organize their personal networks, providing awareness of activities and changes within a user's social network through indirect communication and supporting direct and indirect communication, such as messaging, sharing content, and collaboration artifacts. To validate the framework the study conducted a large-scale online survey of SNS users in Germany. The survey results showed that the dominant motivation for SNS usage was keeping in touch with existing contacts, rather than meeting new people. Functions related to exchange and network awareness were rated as the most important, confirming the relevance of the proposed functional categories. Providing a clear and systematic functional taxonomy of SNS, using strong theoretical grounding combined with empirical validation were some strengths of the study. The study was geographically limited to Germany and focused mainly on open SNS, which may affected the generalizability of results to enterprise or closed social networks. Additionally, the survey was cross-sectional rather than longitudinal, limiting insights into long-term usage patterns. By clearly defining and validating the core functionalities of SNS, the paper provided a solid framework for future studies, system development and organisational adoption of social networking technology.

Wang et al [21] in 2017 presented a comprehensive and forward-looking survey on the integration of machine learning (ML) techniques into networking systems. The study aimed to guide networking researchers in understanding that ML could be systematically applied to address complex networking problems and to highlight recent advances and future research opportunities. A key contribution of the study was the formulation of a standardized workflow for Machine Learning for Networking (MLN). The proposed workflow consisted of several interconnected stages like problem formulation, data collection, data analysis and feature extraction, model construction, model validation, and deployment with online inference. This structured framework served as a practical guideline for researchers to systematically apply ML techniques to networking problems and avoid common pitfalls such as poor problem abstraction or biased data collection. The study provided a selective yet representative survey of recent ML-driven networking advances, organized according to major networking objectives. These include information cognition and network measurement, traffic prediction and classification, resource management and network adaptation and performance prediction and configuration extrapolation. An important strength of the paper was its critical discussion of feasibility and deployment challenges. The study highlighted issues such as computational overhead, real-time inference constraints, robustness, generalization across diverse network environments and the lack of interpretability in ML models and emphasized that ML was not a universal solution and must be carefully integrated with domain knowledge and system constraints to be effective in real-world networks. The study outlined several promising research opportunities, including the development of open networking datasets, automated protocol and architecture design, intelligent resource scheduling, cross-layer optimization and improved interpretability of ML-based networking solutions. It was shown that by applying ML in networking could, in turn, drive advances in machine learning by exposing new challenges related to robustness,

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accountability and online learning. In 2018Finnegan and Brown [9] provided a comprehensive and systematic analysis of Low-Power Wide-Area Network (LPWAN) technologies, which have emerged as a key communication solution for Internet of Things (IoT) applications requiring long-range connectivity, low energy consumption and low data rates. The survey aimed to compare major LPWAN technologies and highlighted their strengths, limitations, and suitability for different application scenarios. The study presented a detailed overview of prominent LPWAN technologies, including LoRa and LoRaWAN, Sigfox, NB-IoT,LTE-M and **o**ther emerging LPWAN standards each technology was discussed in terms of architecture, communication model, network topology, and protocol stack. A major strength of the study was its comparative evaluation of LPWAN technologies based on key performance parameters such as communication range, energy efficiency and battery lifetime, data rate and payload size, latency and scalability, network capacity and deployment cost and complexity. It was clearly shown that no single LPWAN technology was universally optimal. For example, unlicensed-band solutions like LoRaWAN and Sigfox offered low deployment costs and long battery life, while licensed-band solutions such as NB-IoT provided better reliability, quality of service, and integration with existing cellular infrastructure. The study highlighted a wide range of IoT application domains supported by LPWANs, including smart cities, smart metering, environmental monitoring, agriculture, industrial IoT and healthcare. In addition to advantages, the study discussed key challenges and open issues associated with LPWAN technologies. These included scalability constraints, interference in unlicensed bands, limited data rates, security vulnerabilities, and regulatory restrictions. The study served as a valuable reference for researchers, system designers and practitioners working in IoT and wireless communication.

Conclusion

The study highlights the importance of emerging networking and social networking technologies in improving communication, collaboration and information sharing. Despite their advantages, challenges such as security, scalability and efficient resource management remain, indicating the need for continued research in this field.

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