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Advanced Content Networking: A Literature Review of Information-Centric Networking, Edge Computing, and Intelligent Content Delivery

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ABSTRACT

The explosive growth in multimedia data flow, cloud-based services, mobile apps, and IoT devices is changing the needs of today's network infrastructures. The classical Internet designs based on hosts are facing difficulties with meeting the need for reduced latency, improved scalability, effective content delivery, and overall user experience. Thus, advanced content networking has become an essential research field associated with content delivery in the context of content-centric architecture, edge computing, intelligent caching, and software defined networks. This literature review analyzes scientific progress in advanced content networking between 2016 and 2026, paying attention to Information-Centric Networking, Content-Centric Networking, Named Data Networking, edge computing, cloud-to-edge continuum architectures, and artificial intelligence content delivery. Comparative findings from the reviewed literature indicate that Information-Centric Networking architectures, particularly Named Data Networking, improve network performance through in-network caching and content-based routing. Studies report cache hit ratio improvements of approximately **20–40%**, reductions in backbone traffic, and lower end-to-end latency compared with conventional host-centric architectures. However, these benefits are offset by challenges related to forwarding-table scalability, name-based routing complexity, and cache management, highlighting the performance trade-offs that remain barriers to Internet-scale deployment.

Keywords— advanced content networking, information-centric networking, content-centric networking, edge computing, caching, named data networking, cloud-edge continuum

INTRODUCTION

The current Internet is becoming more oriented toward content consumption than host-to-host connectivity. Video streamers, cloud apps, social networks, virtual reality environments, and IoT-based systems produce huge amounts of traffic on the network. Traditional IP-based networking architectures, which have been initially built to enable host-oriented communications, prove inefficient in distributing the content demanded by many hosts simultaneously.

To overcome these shortcomings, advanced content networking architecture approaches have been developed and put forward by researchers that are based on content delivery as opposed to host location. ICN, CCN, and NDN represent some of the most successful examples of such networks, which provide improved content availability along with reduced congestion and latency. Several recent surveys suggest ICN as one of the key components for the future Internet infrastructure, because it offers fast, reliable and scalable content delivery.

This paper aims to perform a literature review of the development of advanced content networking since 2016 until 2026. This research will cover architecture innovations, smart caching, edge computing, quality of service aspects, and challenges in the area.

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BACKGROUND LITERATURE

Content networking is defined as an array of networks and technologies that help optimize content storage, delivery, and processing in a distributed manner. Content networking does not consider the physical location of information since its goal is to facilitate the efficient distribution of data.

One of the most promising models in content networking is Information-Centric Networking. ICN decouples the identification of content from the addressing of hosts and thus allows users to get access to information via content names without knowing where it is stored. Several core features are typical of this model: in-network caching, routing using content names, content replication, and increased content mobility.

Edge computing brings some additional advantages to content networking as it brings computation closer to end users.

The quick development of Internet traffic, cloud computing, multimedia streaming, and the Internet of Things (IoT) has considerably affected the manner in which digital content is generated, delivered, and accessed. The Internet architecture that has been developed using the transmission control protocol/internet protocol (TCP/IP) model has mainly been focused on host-to-host communication and not content delivery. In the current world, the main interest of modern users is the delivery of content irrespective of the physical location of the data; therefore, the weaknesses of the host-based Internet paradigm have become evident. Some of the weaknesses include high latency, poor use of bandwidth, congestion, and problems related to scalability of content-heavy applications.

The paradigm that offers the greatest promise among these is Information-Centric Networking (ICN), which represents a significant departure from the current system in terms of how communication operates. Rather than communicating with a certain host through the use of an IP address, the users will communicate with the data through the use of content names. The network will be charged with the responsibility of finding out the nearest copy of the content irrespective of where the content originated from. The network becomes more efficient and more scalable due to support for content names, routing, and caching in this paradigm. Some of the most popular ICN paradigms include Named Data Networking (NDN) and Content-Centric Networking (CCN).

The distinguishing characteristic of the ICN model is in-network caching, which involves storing frequently demanded content by routers in the system temporarily. When later users demand similar content, then instead of connecting to the original producer of the content, it can be provided from the closest cache. The process greatly enhances efficiency and improves the user experience. In-network caching is especially useful for applications such as video streaming, software downloading, online learning, and IoT systems, where similar content is demanded frequently by many different users. Studies have proved that intelligent caching techniques greatly enhance network efficiency and reduce communication overheads.

The evolution of edge computing technology has led to further enhancement of the content-centric network through bringing computation, storage, and application services closer to the users as well as the data source. Unlike cloud computing technology, which involves sending of all data to the cloud data center, edge computing technology ensures that data processing is carried out by the edge nodes that are near end-devices. With this technology, there is reduced communication delay, reduction of traffic on the backbone network, improved reliability, and real-time decision making. Edge computing technology has proven important to latency-critical services such as autonomous cars, industrial automation, healthcare monitoring, augmented/virtual reality applications, smart cities, and next generation IoT applications.

Current research has pointed out the increasing significance of Artificial Intelligence in content networking. The use of AI in content networking includes machine learning, deep learning, and other such methods, which are applied to optimize predictive caching, intelligent routing, congestion control, traffic engineering, and resource allocation. In predictive caching, algorithms consider the behavior of users, access history, and context to cache the popular contents prior to any request from the users. In a similar manner, AI-based routing allows for selecting an optimal route depending on the current network status, resulting in higher throughput and lower latency.

The combination of cloud computing with edge computing has resulted in the emergence of a cloud-to-edge continuum approach whereby computational resources are dynamically allocated between cloud servers, edge nodes, and endpoint devices depending on application needs. This system allows for migration of workloads,

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intelligent services placement, and resource allocation with a balance of computational performance, latency, power consumption, and cost. Distributed systems like this are anticipated to form the core of future internet infrastructure that will support 6G communication, digital twins, and intelligent cyber-physical systems.

Though all these technologies have been developed, there are still some problems that exist. One of the biggest problems is security since cached information may be subjected to such dangers as cache poisoning, denial of service, illegal content modification, and leakage of private information. Authentication, trust management, encryption, and access control schemes are necessary for secure dissemination of contents. The scalability problem exists due to increasing number of named content items and demands efficient forwarding table and routing schemes that can work at Internet scale. Also, smart cache replacement algorithms are required to increase cache efficiency, reduce storage costs and latency time. The interoperability problem between the existing IP environment and the new ICN technology is also one of the major issues.

According to predictions, upcoming research will be dedicated to the development of intelligent, safe, and scalable networking architectures integrating Information-Centric Networking, edge computing, artificial intelligence, SDN, NFV, and novel 6G architecture. In addition, there are studies being conducted on in-network computing, edge intelligence, explainable artificial intelligence, blockchain-based trust management, and autonomous networking as promising technologies required for future digital ecosystems. It is assumed that these innovations can bring faster content delivery, higher network reliability, improved security measures, and efficient use of communication and computing resources which will lead to the development of next-generation internet services.

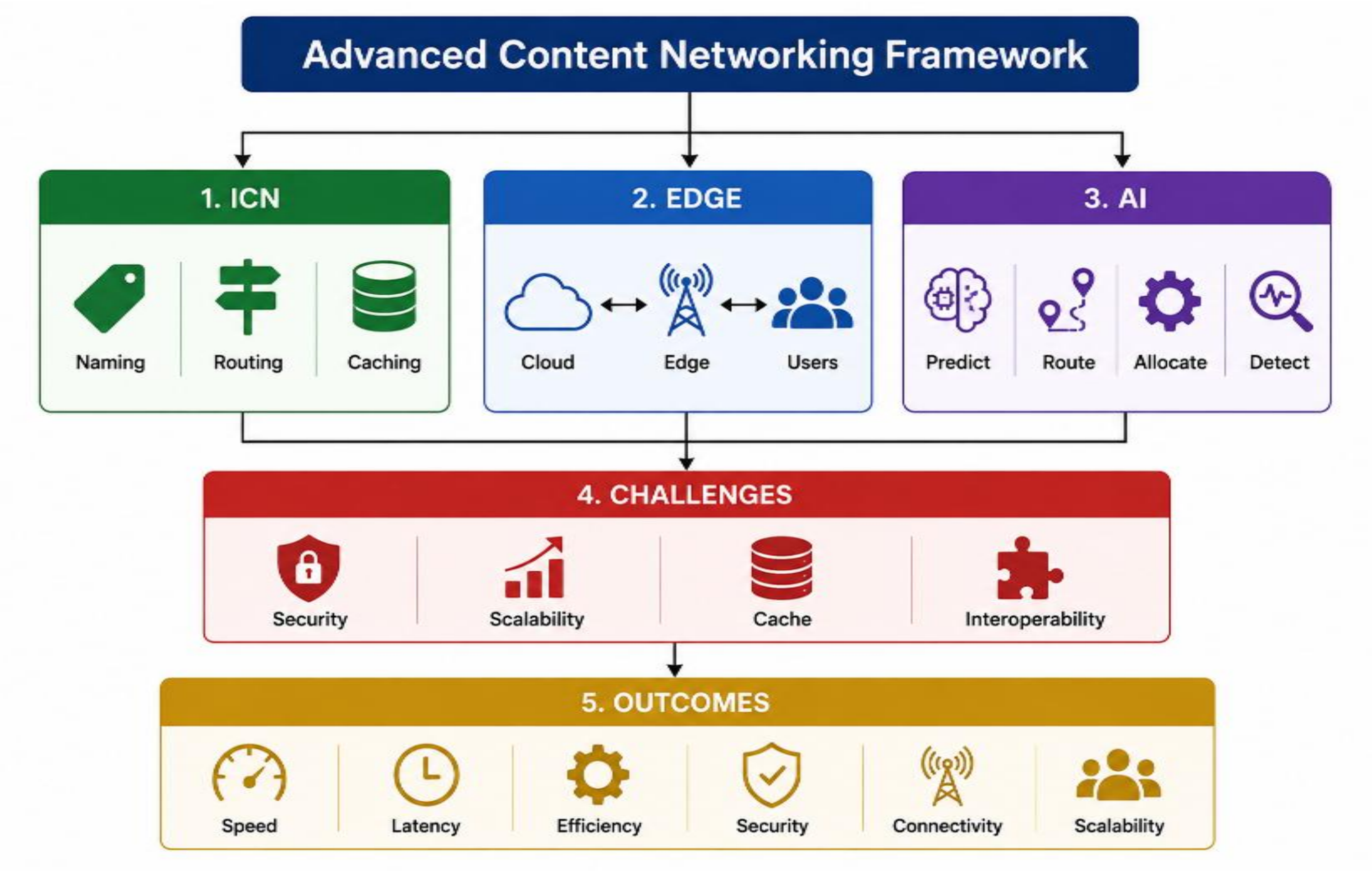

Figure 1. Conceptual Framework of Advanced Content Networking

METHODOLOGY

Narrative literature review approach is used in this work for synthesizing academic literature on this topic written during the period of 2016 - 2026.

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Review procedure included:

1. Identification of journal articles, conferences, survey works and systematic reviews.

2. Selection of works addressing content networking, ICN, CCN, NDN, edge computing and caching techniques.

3. Identification of themes, architectures, performance improvements and issues in implementation.

4. Thematic synthesis of results in research categories.

The selected body of literature includes contributions from networking, distributed systems, cloud computing and Internet architecture research fields.

LITERATURE REVIEW

Evolution from Host-Centric to Content-Centric Networking

Conventional Internet systems make use of IP addresses for addressing communication entities. However, contemporary Internet usage is mostly content-oriented, meaning that there is a lack of concern about the place where the content originates.

Information-Centric Networking offers a solution to the problem through the introduction of content names as the central elements of the networks. Studies have revealed that ICN-based networks can be used for disseminating content in a scalable way while using less bandwidth and minimizing the dependence on servers.

Named Data Networking is one of the most explored ICN solutions. The main idea of NDN consists of request-response mechanism according to which the users ask for content instead of directly communicating with servers.

In-Network Caching and Content Distribution

Caching represents one of the most significant inventions in the realm of sophisticated content networking. Contrary to traditional networks, in which content is usually accessed from origin servers, ICN solutions utilize caches placed inside intermediate network nodes.

Several scientific publications state that in-network caching allows decreasing latency and network congestion, as well as reducing server load. Popular content can be delivered by means of in-network caching, which makes the network more efficient.

Modern scientific works are related to the development of intelligent cache replacement strategies in order to increase the effectiveness of usage of storage resources. In this case, classification-based cache replacement techniques allow assessing popularity of content, its access frequency and other contextual characteristics. Thus, such solutions prove their high effectiveness. The latest developments represent adaptive caching algorithms for Named Data Networking environment.

In contrast to the traditional Content Delivery Networks (CDNs), which rely on geographic replication of servers using the services provided by the centralized provider, Named Data Networking (NDN) leverages caching in the network routers using the technique of in-network caching. It results in different content retrieval patterns. The traditional CDN is designed to decrease the latency by routing requests to the closest replica server; however, NDN can retrieve the requested content from any intermediary node, which had cached this information before.

It has been shown in all the existing literature that NDN is more efficient in terms of caching in comparison with the conventional host-based architectures, despite the fact that the degree of efficiency depends on the cache placement/replacement scheme used. For instance, Jin et al. (2017) showed that intelligent cache management in Information-Centric Networking (ICN) increases the hit ratio of caching by 20-40% compared with the traditional one while also decreasing the amount of backbone traffic. Similarly, Batool et al. (2024) proved that

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the classification-based cache replacement outperforms traditional LRU/LFU approaches in terms of cache effectiveness and reduces redundant content retrievals in case of dynamic traffic.

Yet, the improvements have their price. Higher cache hit rates decrease end-to-end delays and lower bandwidth usage but increase storage demands on the side of the routers and introduce more complex cache management techniques. The higher is the number of named objects, the bigger are the forwarding tables, which poses significant scalability problems that do not arise in case of conventional CDN systems. According to Asaeda et al. (2024), the issues of forwarding scalability and cache coordination are among the main barriers for the Internet-scale implementation of ICN despite its superior performance.

The performance characteristics are also different for both approaches. Conventional IP routing offers extremely efficient address-based forwarding using optimized forwarding tables, providing the fastest forwarding possible. However, NDN routing uses name-based forwarding using names of varying lengths and, hence, is less efficient than conventional routing methods. Nevertheless, thanks to advanced algorithms and optimized forwarding structures, routing performance has been greatly improved, yet line-rate name lookup remains among the most important technical challenges in Internet-scale implementations.

As such, from the literature review, it is clear that there is no one architecture that consistently surpasses the other. CDNs can be regarded as better for practical implementation in commercial scale owing to their ease of operation as well as routing optimization, while NDN is better suited for popular and widely distributed content owing to its caching and content-based routing capabilities. This means that there is a need for making a trade-off on cache performance, routing complexity, scalability, and infrastructure cost rather than technology substitution.

Feature	**Traditional CDN**	**Named Data Networking (NDN)**	**Key Findings from Literature**
Caching	Edge servers	In-network router caching	NDN improves cache hit ratio by approximately **20–40%**
Routing	IP address-based	Content name-based	NDN reduces redundant transmissions but increases lookup complexity
Latency	Reduced through replica servers	Reduced through nearest cached copy	Lower end-to-end latency reported in ICN studies
Scalability	Mature infrastructure	Forwarding table growth remains challenging	Major research challenge identified by recent surveys
Trade-off	Simple routing, centralized cache	Better content efficiency but higher routing complexity	Performance gains come with increased management overhead

Table 1. Comparative Analysis of Traditional Content Delivery Networks (CDNs) and Named Data Networking (NDN) Performance Characteristics

Edge Computing and Content Networking

Edge computing is one of the technologies which can be considered complementary, as it increases performance of content networking. It involves the use of local storage and computing capabilities rather than using centralized cloud-based infrastructures.

It has been found out that edge computing provides substantial improvements in latency reduction and quality of services, in particular, allowing support of real-time applications including AR/VR, autonomous systems and industrial automation.

Edge computing can be effectively used together with content-centric architecture, which will provide an opportunity for localized processing of content and intelligent resource management.

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Current surveys of cloud-to-edge continuum architectures prove the efficiency of infrastructures, built through the use of computing, caching and communication resources. In addition, there are computation offloading techniques, which help resource-constrained devices offload computation tasks to edge nodes.

Quality of Service and User Experience

Quality of Service (QoS) and Quality of Experience (QoE) are key performance measures in content networking. Modern applications demand the successful transmission of high-quality video, cloud gaming, virtual reality, and other multimedia contents.

Studies have found that ICN technologies offer natural benefits in providing QoS in terms of content replication, efficient routing and caching processes. This results in higher availability of content while reducing delays and losses of packets.

The more advanced content networking solutions are using AI algorithms to optimize resource utilization and traffic.

Artificial Intelligence and Intelligent Content Delivery

AI is increasingly becoming a significant aspect of advanced content networking. AI methods allow for the making of intelligent decisions in regard to issues like caching, routing, congestion control, resource allocation, and traffic prediction.

Current research shows that content delivery systems using AI technology provide network efficiency through adaptation to users' habits and traffic patterns. Machine learning can be used to predict popular content and move it close to its location of demand.

It is predicted that the combination of AI, 5G, edge computing, and network slicing will help in providing very personalized content delivery in the future.

Security Challenges in Content Networking

While there are many security benefits of using content-based architecture, there are certain security problems posed by such an approach as well.

Content poisoning is one of the major concerns that involve corrupting the contents by putting invalid content in the network cache. Content verification, management of trust, and cache validation are some of the key areas where research needs to be done. There are various other problems as well such as privacy protection, content naming schemes, access control, mobility support, etc.

DISCUSSION

The literature shows that there has been a trend of transitioning from traditional host-oriented networks to more advanced content-based networks able to handle modern Internet usage patterns. Information-Centric Networking, Named Data Networking, and Content-Centric Networking can serve as examples of network architectures which allow for effective dissemination of content based on name routing and caching within the network.

Edge computing can complement these architectures by providing benefits such as decreased latency and localization of processing. Cloud-to-edge continuum architectures can be used as a means of accommodating future application development with strict performance requirements.

Artificial intelligence is gradually becoming an important part of content networking through the implementation of predictive caching, intelligent routing, and resource allocation.

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However, at present there is a list of existing problems related to security, scalability, cache management, and interoperability. Future research should be aimed at designing intelligent, secure, and scalable content networking infrastructure able to support future digital applications.

There is evident evidence indicating a paradigm shift from the traditional host-based networking architectures to the more sophisticated content-based network architectures. Traditional Internet protocol (IP) network systems communicate using the locations of the hosts; users have to locate a certain server before they can access any information. Although this system has been working effectively for many years now, the explosion of multimedia contents, cloud computing, Internet of Things (IoT), and mobile computing has exposed some shortcomings regarding efficiency, bandwidth utilization, scalability, and latency.

However, there are some limitations associated with traditional networks. For instance, traditional routing is based on location, which makes the network highly dependent on host locations while searching for data. Moreover, in order to access some data, the user needs to make a connection to a specific server, which might increase latency and decrease performance in many cases. Thus, in order to overcome these disadvantages, researchers have suggested a new concept – Information-Centric Networking (ICN), which is the next-generation networking concept. Communication in ICN is carried out not based on locations but based on names of content. Instead of requesting some information from a particular server, the user requests it by its name, and the network itself finds the closest copy of that content. The most famous ICN architectures are Named Data Networking (NDN) and Content-Centric Networking (CCN).

The advent of edge computing makes the use of content-centric networking even more advantageous through bringing computing capabilities, storage and data processing much nearer to the end users. Rather than sending data to cloud data centers in a central location, edge computing brings distributed computing capabilities closer to edge nodes that can be scattered throughout the geography, thus reducing communication latencies, saving bandwidth on the network and facilitating real-time decision making. This feature is especially necessary for applications where there is no tolerance for any latency, including autonomous cars, smart cities, automation in industries, health monitoring, virtual reality and IoT systems.

The Artificial Intelligence (AI) technology is an ever-increasing aspect of content networking. Several functions in content networks have been optimized by using machine and deep learning-based approaches. These functions include the following:

• Predictive Content Caching

• Intelligent Routing

• Traffic Engineering

• Congestion Control

• Resource Allocation

• Network Anomaly Detection

In terms of predictive content caching, AI uses predictive caching algorithms that are capable of analyzing user behavior, historical access patterns, and context to pre-store popular content close to expected users to improve latency and cache hit ratio. AI also offers intelligent routing algorithms that can change their routing decision based on real-time network state, level of congestion, and QoS requirements, thus offering better use of network resources.

While these improvements have been made, there still exist many problems which need to be overcome for content-centric networking to reach a state where it can be deployed on a wide scale. Security has remained a major problem because of cache poisoning, content authenticity validation, denial-of-service attacks, privacy protection, and key management. While ICN encrypts content rather than channels of communication, trust

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management and cryptography issues have remained a focus of research. Scalability is also one of the difficulties which exists since there is an increase in the number of named content objects.

Another challenge is interoperability, because the Internet infrastructure available today is mostly IP-based. Various researchers have been looking into how to allow smooth integration of IP-based networks and ICN technologies while still keeping compatibility with the Internet protocol suite and services currently used on the Internet. Standardization and hybrid approaches will most probably play an important part in such transition to CCNs.

Further research will probably be oriented towards building intelligent, secure, scalable, and sustainable network infrastructures, which would support the emergence of new digital ecosystems. Innovations in network automation using artificial intelligence, software-defined networking, network function virtualization, 6G technologies, edge computing, and blockchain technology for trusted management will presumably improve the efficiency and security of content networking even more. With the growing demands for low latency, high reliability, scalability, and security of digital applications, the combination of information-centric networking, edge computing, and AI seems to be an essential element of future Internet.

CONCLUSION

Content networking is considered an essential change of Internet architecture due to its ability to focus on content instead of hosts in order to ensure more effective content distribution by means of information-centric networking, content-centric networking, and named data networking.

The research shows that in-network caching, edge computing, cloud-edge networking, and AI-based optimizations can substantially enhance the performance of content distribution. Yet, the issues related to security, scalability, mobility management, and quality assurance are among the research challenges.

Content-centric architectures will probably be combined with AI and edge intelligence in future networks in order to enable emerging applications like 6G communications, immersive media, autonomous systems, and IoT.

REFERENCES

1. Amadeo, M. (2025). Exploring in-network computing with Information-Centric Networking: Review and research opportunities. Future Internet, 17(1), 42. https://doi.org/10.3390/fi17010042
2. Asaeda, H., Matsuzono, K., Hayamizu, Y., Hlaing, H. H., & Ooka, A. (2024). A survey of Information-Centric Networking: The quest for innovation. IEICE Transactions on Communications, E107-B(1), 139–153.
3. Batool, S., Kaleem, M., Rashid, S., Mushtaq, M. A., & Khan, I. (2024). A survey of classification cache replacement techniques in the content-centric networking domain. International Journal of Advanced and Applied Sciences, 11(5), 12–24.
4. Cao, L., Huo, T., Li, S., Zhang, X., Chen, Y., Lin, G., Wu, F., Ling, Y., Zhou, Y., & Xie, Q. (2024). Cost optimization in edge computing: A survey. Artificial Intelligence Review, 57, 312.
5. Carofiglio, G., Gallo, M., Muscariello, L., & Perino, D. (2013). From content delivery today to Information-Centric Networking. Computer Networks, 57(16), 3116–3127. https://doi.org/10.1016/j.comnet.2013.07.002
6. Dhawan, G., & Asati, V. K. (2024). Information-Centric Networking in IoT: Technologies, challenges and benefits. Journal of Electrical Systems.
7. European Telecommunications Standards Institute. (2023). Multi-access Edge Computing (MEC) Standards.
8. Information-Centric Networking: Principles and Applications. (2018). CRC Press.
9. Imran, M., Ur Rehman, M. A., & Kim, B. S. (2021). Information-centric edge computing: A survey. IEIE Transactions on Smart Processing and Computing, 10(3), 250–258.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

10. Jacobson, V., Zhang, L., Afanasyev, A., Burke, J., et al. (2012). Networking Named Content. Communications of the ACM, 55(1), 117–124.
11. Jin, H., Xu, D., Zhao, C., & Liang, D. (2017). Information-centric mobile caching network frameworks and caching optimization: A survey. EURASIP Journal on Wireless Communications and Networking, 2017(33).
12. Kanupriya, Chana, I., & Goyal, R. K. (2024). Computation offloading techniques in edge computing: A systematic review based on energy, QoS and authentication. Concurrency and Computation: Practice and Experience, 36(13), e8050.
13. Kurose, J. F. (2014). Information-centric networking: The evolution from circuits to packets to content. Computer Networks, 66, 112–120. https://doi.org/10.1016/j.comnet.2014.04.002
14. Maia, A., Boutouchent, A., Kardjadja, Y., Gherari, M., Soyak, E. G., Saqib, M., Boussekar, K., Cilbir, I., Habibi, S., Ouledsidi Ali, S., Ajib, W., Elbiaze, H., Erçetin, O., Ghamri-Doudane, Y., & Glitho, R. (2024). A survey on integrated computing, caching, and communication in the cloud-to-edge continuum. Computer Communications, 219, 128–152.
15. Mastorakis, S., Ullah, S. S., Hussain, S., Ali, I., & Khattak, H. (2025). Mitigating content poisoning attacks in Named Data Networking: A survey of recent solutions, limitations, challenges and future research directions. Artificial Intelligence Review, 58(42).
16. Quevedo, J., Corujo, D., & Bruno, R. (2022). Selective content retrieval in Information-Centric Networking. Sensors, 22(22), 8742. https://doi.org/10.3390/s22228742
17. Sadat, N., & Dai, R. (2025). A survey of quality-of-service and quality-of-experience provisioning in Information-Centric Networks. Network, 5(2), 10.
18. Ullah, R., Ahmed, S. H., & Kim, B. S. (2018). Information-centric networking with edge computing for IoT: Research challenges and future directions. IEEE Access, 6, 73465–73488. https://doi.org/10.1109/ACCESS.2018.2884536
19. Wang, Y., Zhang, Y., & Liu, H. (2020). Information-Centric Networking solutions for the Internet of Things: A systematic mapping review. Computer Communications, 159, 37–59.
20. Xu, B., Wang, L., & Zhao, P. (2017). Information-centric mobile ad hoc networks and content routing: A survey. Ad Hoc Networks, 58, 255–268.
21. Xylomenos, G., Ververidis, C. N., Siris, V. A., Fotiou, N., Tsilopoulos, C., Vasilakos, A. V., Katsaros, K. V., & Polyzos, G. C. (2014). A survey of Information-Centric Networking research. IEEE Communications Surveys & Tutorials, 16(2), 1024–1049.