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An appraisal of Information-Centric Networking Architecture for Content Retrieval over the Internet of things

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ABSTRACT

Information-Centric Networking has emerged, evolved over the last few years, and has grown out of Host centered architecture. Data transmitted does not rely on address, communication process, ICN is believed to enhance data transmission optimally. It however uses encryption of data transmitted making it not interested as to where it originated from. This paper entails the importance of ICN when compared with IP-based networks describing how data is transmitted over the network, issues encountered by ICN, its improvement over the years, and its relevance over the Internet of Things. It finally suggests the advantage of ICN based on its efficiency, safety, and reliability over a Host-based network which is the traditional means of transmitting data.

Keywords : Caching, Internet, Security, Transmission, Information-Centric Networking, Mobility, Content. Interest Packet

I. INTRODUCTION

The introduction of the internet gave rise to issues based on the medium through which data is transmitted. Data is transmitted through a medium and the medium management relies on the IP. In the course of transmission, several issues may arise like bandwidth wastage and insecurity, and minimal cache space. According to (Vishnu Priya & Sastry, 2018), developing Networks based on information transmission is the recent and future shift for industrialists as well as researchers who are assiduously looking into it. Information-centric Networking is the technique in which data is communicated across the internet away from traditional means of information transmission. Information-Centric Network is a new model where the networking layer is responsible for equipping users with content rather than making available the transmission channels or addresses between the hosts making use of the name of the content instead. The Information-Centric network is the future internet that encourages information transmission rather than the host-to-host communication which constitutes the present-day internet. The present IP network needs hosts to create a link to convey data on a route depending on the Target destination(IP address) on the network and since host-based transmission techniques do not aid content-oriented application, it gives rise to inadequacy in content delivery based on the work of (Hang Liu et al., 2019)

II. Statement of Problem

The idea of the internet was introduced to overcome the issues of telephone dial connection and packet switching was introduced which was faster. The exchange of data can occur over a short or long distance and information is broken down into packets. The speed to which data travels relies on the internet connection, the quantity of the data, and each data contains the original information as well as the IP address. The internet uses routers to manage the traffic and provides the best route for the data to be transmitted. However, When two or more people request the same information from a server, the server sends this information the same number of times as requested by users which causes congestion on the network. This invariably affects the network in terms of quality when it comes to video requests due to high congestion and high delay of information delivery (Winter, R. 2020) The idea behind the genesis of the Information-Centric Network is to institute trust relationships and transmit safely without depending on any monitored infrastructure, to reduce the cost of transmission, retain quality and reduction in transmission delay, and also to ensure important applications are assisted directly with adequate transparency (Duggan, P. 2020).

III. Aim and Objectives of the Study

The aim of the study is to evaluate the performance ability of ICN for a safer, faster means of data transmission over the network without a need for a host based on the information-centric network, IP address While maintaining the quality of the data transmitted over the traditional means adopted by the internet of things. The objective of the study is to show an overview of why information-centric networking has its relevance in the nearest future if the present issues its facing can be sorted.

Scope of the Study

This study is concerned with the overview of ICN and its efficient and secure pathway for data transmission on a network based on hierarchy and name without the need for IP address and host.

IV. Research Contribution

ICN is the future of the present internet which involves requesting the network for specific information based on names rather than IP addresses, the Network gets the request and sends it to where it is needed using the nearest and fastest route. Information-centric networking makes use of Cache which is an auxiliary memory and uses hierarchical structure as well as flag naming. Data is retrieved regardless of where it is coming from and a copy of the data can be cached somewhere close to the user unlike using the IP address where data needs to be retrieved from the server upon every request. The study shows an appraisal of why information-centric networking should be the new normal while ensuring the data requested are delivered safely and in the same quality as expected.

There is a possibility of having a network design that will bring and sustain the standard of activity to end-users when system transmission fails. Resilience has always been achieved through path recovery and traffic re-directing through an alternative route, To handle network failure that denies interest forwarding management technique by looking for and identifying contents cached by both interface and client. (Sourlas et al., 2018)

V. Literature Review

The need for Information-Centric Networking is to enhance information transmission rather than host to host which will improve Interest forwarding control and forwarding mechanism as well safe data transmission. The table below shows several pieces of

literature on information-centric networking and its relevance to the network.

Hierarchy partitioning technique based on content communication was implemented to make it easy for the network topology with arbitrary graph design while the content communication procedure is clarified. The overall cache budget was allocated to each node and it is proportional to the overall weight. The cache size allotment issue was solved for a given overall cache budget in an ICN network. However, Content distribution or procedure should be analyzed more effectively based on the actual event of the network.

In his work (Garmani et al., 2020) explained that the Hierarchical embedded technique is based on diverse CPS and multiple ISPs while using a game-theoretic technique to determine the association between CPS and ISPs. The numerical model showed that the suggested game technique brought about win-win results. Nash equilibrium needs a party to identify the opponent's move on the network. Furthermore (Asmat et al., 2020) Suggested a caching scheme for the internet of things content called the Central Control Caching (CCC) which places a middle entity within diverse autonomies computing that controls storage and upgrades the content available in diverse autonomies systems when contents become too old, the same data indicates the autonomy system with an imitation of the obsolete message, also explained simulation report displayed the suggested scheme out-matched minimized energy usage, response latency and cache-hit in contrast to state-of-the-art works and simulation reports CCC technique effectively acts better than traditional Caching techniques with respect to energy usage, it should however It Should be tested on the field relating to the Internet of Things on Mobile to determine its efficiency.
(Kumar & Reddy, 2020) suggested a system simulation using python to develop -GEANT, a topology that encourages association on projects in biological science to earth observation, arts, and culture which used an automated cache management framework dynamically allocates information to the caches of an ICA and re-allocation resolutions are dependent on real-time data linked locality of request and observed popularity but there is need for a new hybrid shortest path Proximate algorithm to enhance the efficiency of cache management in ICN.

Using the Light-weighted Allocation Method to tackle the allocation situation of all types of caching networks, such as ICN, CDN (Content Distribution Network), Cloud Network, and ENC is suggested by (Y. Li et al., 2020) to tackle content placement issues in ICN. ENC provides improvement compared to the previously used caching scheme but an on-path caching scheme under arbitrary network topology and with changing content is needed for the optimization of caching scheme of the ICN network. (Fan et al., 2017) mentioned a common and profit resident caching technology (PGBCS) to modify what is contained in Chunk can provide smooth Cache management. It was further explained that the method efficiently encourages nodes' cache ratio, minimizes user request delay, and improves network service delivery. The gap identified is that Flood routing should have been looked into since nodes select the next hop based on routing protocols rather than broadcast sent to all ports that accept the interest packet. Integration of ICN with Vanet using sensors available in cars. showed that Vanet implementation minimizes accidents according to (Din et al., 2018), Vanet despite its advantages also faces issues like car mobility and network unrest.

Reintegrated learning with a random neural network (NDNFS-RLRNN) provides efficient delivery as mentioned by (Akinwande, 2018) that the technique suggested brought about better presentation than a forwarding technique but Evaluation of congested processes and attention on denial of service attacks should have been considered. The adoption of the

Artificial Intelligence technique help to make decision-based on exact service requirements under a dynamic situation and deep Q-learning EDQS as mentioned by (Xu et al., 2019) A software-defined information-centric – IOT (IC-IOT) technique to deliver caching and computing possibilities associated with internet network. The simulation report shows the efficiency of the software-defined IC-IoT model and joint resources allocation scheme and convergence in diverse ways

2.1 Overview of Information-Centric Networking Architecture Methodology

ICN is the whole of internet design that measures the content and data as the focal point rather than host-centric design.

2.1.1 Caching Algorithm

Caching is significant in the future of internet paradigms such as Information-Centric Networking like on the web, the content of the Cache is present all over the network even if there is network downtime. (Vaithinathan et al., 2021)ICN uses a cache algorithm which is a rule a computer system adopts to control data cached on the system when outrightly occupied, the algorithm determines what data is preserved or deleted. According to (Hongyu Liu & Han, 2021)

One of the advantages of Cache is the lag reduction and flexibility and allotment of Cache size and data allotment well have a significant effect on the efficiency of the ICN. (Y. Li et al., 2020)

2.1.2 Named Data Networking,

NDN is a future design of ICN since it can optimally resolve the issues of present IP resident internet of things and also it can be applied with several Caching algorithms and replacement rules. NDN makes it possible to retrieve (Meddeb et al., 2018) data regardless of the address and it encourages safety, reliability, data spread, and flexibility. (Aboodi et al., 2019) Network data networking is related to content-centric networking as a result of data resident on the routers and spread to clients through the closest router which helps during future needs. The data stored is doubled for availability, minimizes response time, eases device cost, and lightens congestion on the network which then boosts the utilization of the system devices.

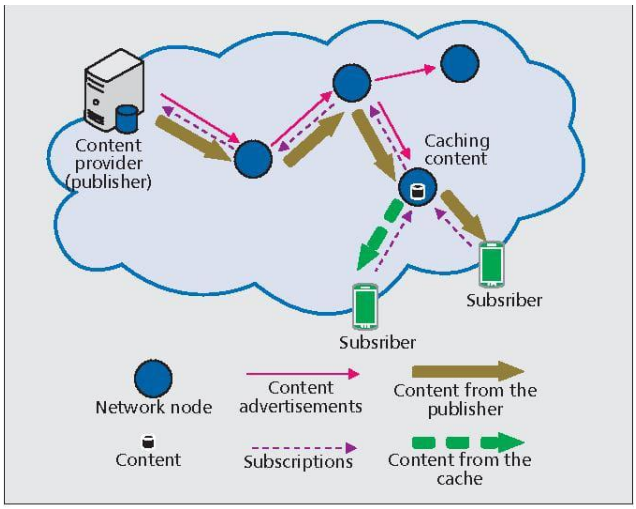

Figure 1. Information-Centric Networking model: shows the flow of requests by a user and caching of content before arriving at a destination.(Liang et al., 2015)

In the present design, the IP address identifies the host but in NDN design, hierarchical names are responsible to recognize details. It comprises two swap-able packets namely interest as well as data, while the client employs an interest packet to request for content and the interest consists of demand and information administrator e,g node or server reply with information packet resident in the content asked for (Fethellah et al., 2019)

2.1.3 Content centric Networking

The transmission of content in content-centric networking is based on names rather than addresses and uses its protocol of transportation.

2.1.4 Hybrid ICN

In the work of (W. Li et al., 2021), a two-way hybrid means of network efficiency was proposed based on an edge path that ensures accessibility of contents faster and a non-edge path for allocation and use of contents.

5.1.5 Advantages of ICN

i. ICN provides lesser traffic on the network

ii. Content retrieval is faster, accessible, and more reliable

iii. (Carofiglio et al., 2019) mentioned 5G networks have presented lower latency occurrence during transmission as a result of ICN

5.1.6 Challenges of ICN

ICN still faces several limitations as a result of its architecture, these include:

i. Content Security: inability to assure the safety of content transmitted.
ii. Cache management: Based on the volume of content, the cache storage might be lesser than the volume of content required.
iii. Duplication of information on cache could introduce new transmission errors.

Interest Packet	**Data Packet**
Used by Nodes to request stored content	Once stored content is found through the packet interest table, data packets are returned by the nodes

Table 1. Interest and Data packet comparison

5.1.7 Applications of ICN

Ever since the emergence of information-centric networking, it has been adopted in many areas including mobile computing. It was mentioned by (Marques et al., 2022) that ICN is gaining ground in a vehicular network system.

5.2 Resource Allocation

As a result of high traffic on the network due to improvements in technology like language processing and face recognition, ICN with its reliability is believed to be the emerging technology that will proffer solutions for quality service during video streaming as well as file sharing since wireless network could not provide the solution. According to (Wang et al., 2019), resource allocation can help overcome optimization problems using a gradient algorithm by proving cache storage on close nodes which can minimize traffic through reinforcement learning.

5.2.1 Cache management

It involves the ability of the router to store the information transmitted for easy retrieval by the user based on packet names and to also minimize cost. According to (Qin et al., 2021) it was mentioned that for a smarter and high-performing network, services rendered by cache should be administered based on relevance in a network filled with diverse nodes.

5.2.2 Routing/Path identification

According to (Banerjee et al., 2017), the interest packet identified based on name ensures the content is directed from the origin towards the data requester and once it's true positive it is cached at every node, and upon a request, the cached data is transmitted through backward route to the destination.

5.2.3 Hop Counting

Occurs on the network of nodes analyzing and calculating the distance of one node from source to another node destination on the network. (Jakob Pfender,Alvin Cerdena Valera, 2019) mentioned that the latency period of delay is affected by the number of hop count that occurs from source to destination of any requested data.

5.2.4 Time management

For effective management of the network, a time measurement system where information stored in Cache should only stay for an allowed period and to also control latency.

5.2.5 Pending Interest Table

Information-Centric Network models comprise interest and data packets based on the technique of

Name Data Networking which details data packets containing user content needs that are sent to a destination encrypted in data packets. It was further explained that interest forwarding is saved in a pending interest table and the data packet delivers its content by PIT in a backward interest packet direction. (Karrakchou et al., 2020). It saves all interest packets yet to be satisfied.

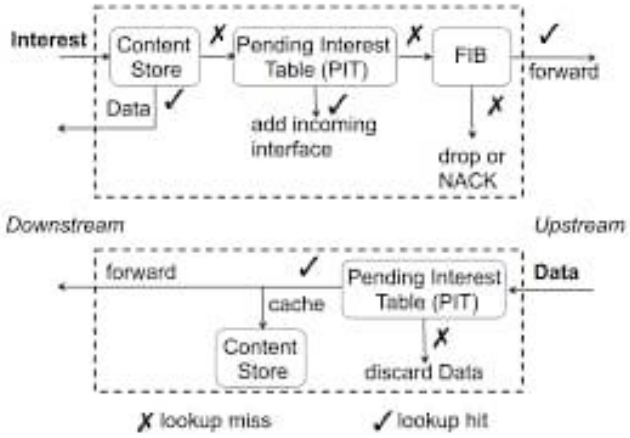

Figure 2. Transmission of Interest: describes transmission and lookup of content on PIT table the upstream and downstream which shows if the content is checked on cache, if not found PIT drops or discards it (Dr. Mayutan Arumaithurai, n.d.2022)

5.3 Internet of things

According to (Ray, 2018), the global impact of IoT has through enhanced technology growth improved information transmission. It has made the connection between the real world and the digital world easier. IoT provides diverse services that detail information analysis, gadget control, and modeling. One of the services rendered is Networking, an ability to link and have access to resources digitally regardless of the location, and also cloud computing which leverages sharing resources stored on the cloud, one of the challenges IoT faces is information confidentiality and data protection(Villamil et al., 2020)A major shift of internet is from circuit switching to packet switching which entails breaking down of packets into smaller sizes and rearranged at the destination to form a whole message with its content unchanged.

Table 2. ICN and TCP/IP Model Comparison

	ICN MODEL	TCP/IP MODEL
Cache storage	Resident on each node	Resident on server
Data Transmission	Relies on an Information-Centric technique	Relies on Host-Centric technique
File naming	Based on Hierarchical names	Based on a non-source name

5.4 Analysis of ICN over IoT

To overcome the issues of high traffic on the network as a result of Internet services, it was mentioned by (Lindgren et al., 2016), that ICN can provide better services using Data naming by ensuring contents requested are transmitted directly to the destination without the need for location address and it was further mentioned that storing data on different caches can reduce power consumption and minimize latency.

The advancement in technology globally entails the use of Big data as well as several devices connections which presents challenges on the network like data loss, quality of service the internet provides, this however as mentioned by (Mars et al., 2019) that this can be minimized or tackled by ICN approach on internet connectivity through coaching.

A way of overcoming protocol requirements in an internet-dependent network to minimize unavailability of storage on the network and enhance easy content retrieval, ICN promotes easy retrieval of

content and better security for IoT. (Arshad et al., 2019)

(Fang et al., 2019) identified that for an enhanced quality of network service, a shift from having IP address as both indicator and location which relies on transport layer thereby increasing the complexity of the network can be tackled with ICN which is based on data details and can accommodate several paths on the network layer.

(Nour et al., 2020) mentioned that the effect of traditional IP locations on the network for content retrieval and location monitoring over IP can be treated by the adoption of ICN, a paradigm of IoT which can solve mobility-related problem occurrences on the internet network.

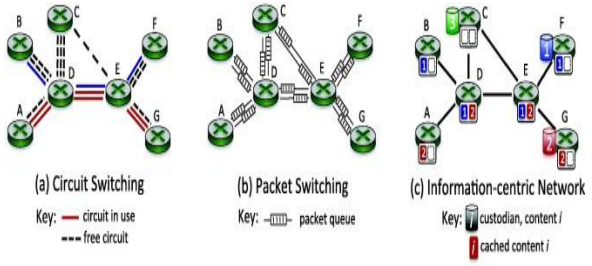

Figure 3. Circuit, packet, and ICN network: shows the information passed in circuit switching in comparison with packet switching which involves breaking down messages conveyed into packets for ease of transmission, and compared with ICN which caches any request on every node to enhance accessibility and minimize delay in course of transmission (Kurose, 2014)

VI. 3.0 Methodology

This section details identifying different ICN architecture models used to proffer solutions for ease of content retrieval and content accessibility.

3.1 Artificial Intelligence: this entails the use of A. I analyze techniques based on hybrid ICN using embedded reinforcement learning technology to overcome content monitoring issues.

3.2 Data Forwarding: A technique with higher efficiency than NDN tackles storage-related issues using location mapping which provides easy content retrieval.

3.3 Edge Computing: To minimize latency and promote easy content retrieval, EC stands as an option to help in conjunction with deep learning models with IoT and ICN for a better quality of service.

3.4 Protocol: In any IoT, the efficiency of a network can enhance reliability and limit mobility using ICN, Proxy mobile provision to enhance and minimize packet loss as well as latency.

VII. Result and Findings

This paper aimed at furnishing a look at the future internet design called Information-Centric based Network, which is a shift from traditional means of transmitting data on the network without the need for a central host but rather based on hierarchical names and also uses Cache to store messages so that if there is a request for the same message by different users, messages are not sent from the remote source rather the closest ICN, It was learned that Router which Cache the data upon the initial request then sends the required information and retransmitted based on decentralization technique. The aim of ICN is to use stateful forwarding which keeps track of the message, data can be encrypted and does not require an IP address. Data conveyed on the network is made of an interest packet requested for and a data packet for transmission. ICN is not particular about where data originates from provided the required document is delivered safely and on time. ICN is identified for availing users with content rather than displaying the communication medium between hosts.

VIII. Conclusion and Recommendation

Information-Centric Networking has several issues yet to be resolved regarding caching, Hop counting and routing amongst other issues but it can be categorically indicated that it provides safer and faster data transmission on a network due to its advantage

of caching. Though Caching takes time during memory management, it is very important and needed, every node on the network can cache. ICN uses stateful forwarding which adds essential intelligence by monitoring the interests and in the data message, each data in the ICN can be encrypted. Further study is needed to perfect all issues surrounding ICN using artificial intelligence technique which is the future of the internet as mentioned.

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