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A novel scalable network architecture for the evolution of robot swarm networks with dual connectivity application in control-data plane

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ABSTRACT

The swarm robot network is the widely used wireless communication technology, and significantly, it has higher uplink and downlink throughput than the conventional communication networks. Apart from the appreciable advantages, there are various challenges like minimized data retention rate, low data transmission rate, countless handovers over a short time, and a short transmission range due to higher data transmission usage. To resolve these challenges, Scalable Network Architecture with Dual Connectivity Application (SN-DCA) in control and data plane is proposed to improve data retention rates and minimize network usage by controlling unwanted access in the distributive clouds during transmission. Here, Two-stage control data plane splitting (TSCDP) is introduced to enhance network usage by optimizing unwanted access. It further improves the data retention rate during transmission. The analytical performance of the proposed techniques has been validated computationally and examined through simulation studies. The Simulation results show that these techniques achieve a higher performance ratio in the network with a minimum transmission delay and a high data retention rate.

1. Introduction to the present robot swarm network in Wireless Communication Networks

In recent decades, mobile communication networks have experienced enormous advancements [1]. The improvement in wireless generation indicates the upgraded system's changes, data speed, techniques, and range. Each wireless generation has generalized standards, capabilities, technologies, and certain new features that differentiate the communication networks from the previous generations [2-4]. Mobile network is a network of communications with cellular links. It is spread through land zones known as "cells", where each is served by three base cell or base transceiver stations, and not more normally. These base stations give the cell the network coverage that can be used to transmit voice, information and other content types. A cell usually uses an alternate set of frequencies from neighbouring cells to prevent interference and guarantee a standard of service in each cell. A computer network is essentially a computer system collection or community and other associated hardware devices interrelated across various communications channels to implement effective communication and associated networking methodologies. Data Communication is essentially a transmission mechanism involving the transference of digital data between two or more computers or the like, and vice versa. In general, this method of transmission is independent of the technical media, interphases and geographical locations. It focuses on the various technologies and approaches to allow any form of electronic communication.

Among the various generations, the robot swarm communication network provides the best network services in the aspects of high speed, High capability, better Quality of Service (QoS), authenticated security at low cost for both voice and data services [5,6]. All the 4G network services are IP based system architecture. Long Term Evolution and Wireless Interoperability for Microwave Access is the new technique in 4G evolved from previous generations [7]. The first security line for traffic in and out of a network is the network firewall. The firewall checks traffic to ensure it complies with the organization's security specifications and blocks unauthorized attempts. In recent years, firewall security has gone a long way. For defending against unlicensed access, a firewall provides a buffer between a device or network and the Internet. Presence technology is the capacity of a network system to recognize and assess its position as another device on the same network.

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All the transmission services under the 4G IP-based service are carried out by the network's control data plane [8,9]. The C-plane is purely responsible for routing information as it contains details about the path traffic [10]. The C- plane function includes the configuration and management of a system [11,12]. It can have the ability to choose the path and routing protocols that can easily make the forward packet decisions perfectly [13]. In particular, the main functions of the control plane related services are represented as AAA (Authorisation, Authentication, Accounting) [14], IP registration, QoS in signalling, and installation to resolve traffic and security issues [15]. The routing protocols are the collection of rules specified for the communication between source and destination by routers. They can hardly update the routing table that includes the details and does not forward the information to a source's terminus. The protocols for Network Routers allow users to specify how routers interact. It will enable the network to choose routes from a computer network between any two nodes.

The data plane refers to the functions and processes of transmission of data frames between the interfaces [16]. It ensures the fast and efficient transmission of information on every device. Simultaneously, it can handle numerous communications by maintaining multiple protocols [17]. Like the control plane, the data plane has several main functions: classification, scheduling, and forwarding to maintain end-to-end traffic flow. However, both control and data plane is the primary origin for the IP based network transmission in the 4G transmission [18]. Synchronous communication is effective, accurate and often used for a large quantity of data. The data transfer rate is faster, and there is an increased risk of mistakes. It helps the connected devices to communicate in real-time. The clocks get out of sync over time, and the target computer will have the wrong time, which could destroy some bytes due to missing bits. Traffic analysis is the method of intercepting and analysing messages to extract data from traffic patterns that can be carried out even though messages are encrypted. The higher the number, or even interception and store of messages, the more traffic can be deduced. An analysis of traffic may be carried out concerning military intelligence, counterintelligence or life pattern, and a computer security issue. Here particular software programs of the machine can back up traffic analysis activities. Advanced techniques for traffic analysis could involve different ways of analysis of social networks.

Even though the control and data plane are responsible for effective transmission, there are some limitations like signalling delay, frequent handovers in a short duration, high traffic, low data rate, and small transmission range [19]. Signalling is important for the railway's safe operation to ensure safe spacing of trains and prevent conflicting movement. The 'traffic light' signals on the rail tell the train driver whether it is safe to travel along the line. A driver should not have been issued a red signal, as with road lighting. The signal failure refers to different things going inappropriately that cause a train to stand at a red signal. A stationary train easily causes delays, resulting in major delays with the rail network busier than ever.

A scalable network for dual connectivity is needed to improve the evolving robot swarm network to address these issues. Simultaneously, a modified control/data plane has introduced to manage unwanted access in the distributive clouds. The robot swarm network has a higher access range by changing the parameters with such improvements than the previous generations. The analytical expressions for the above-said parameters have been developed, and the model can be verified using simulation studies.

Section 2 elaborates on various recent research works and their issues. Section 3 constitutes the detailed computation of mathematical relation for introducing the scalable Dual connectivity architecture in the C/D plane for the evolution of robot swarm network with the development of a two-stage C/D plane for the proper access of the internet in the cloud base service of robot swarm. Section 4 discussed the verification of the analytical results versus the simulation results of the performance rate and transmission delay and followed by a conclusion and future aspects in Section 5.

2. Review of literature

The authors of [20] identified more challenges and problems in the mobility management of 4G communication Networks. Different issues behind the mobility drawback are discussed, and a method called Forwarding directive, Association, Rendezvous Architecture (FARA) is discussed as a solution. Since it had some advantages toward mobility, some failures like the low capability of forwarding multiple data frames, security, etc., have been reported by the authors.

In [21], the authors analyzed a model called Always Best Connected (ABC) to resolve the quick fluctuations in the network QoS and manage the service unavailability. The model maps to an Np-hard problem for the analysis of the concepts. Since it is a new paradigm in communication, the method is limited due to the absence of cost analysis which results in the model with a lack of optimization.

The authors of [22] developed the CNetVerifier (CNV), a tool for protocol diagnosis that addresses the issues like the design and operational problems in the control plane. The cross-layer, cross-domain, and cross-system had analyzed in the model. The discussion achieves good results, whereas more research is needed for getting a clear idea about the tool and the control plane activities of wireless communication networks.

The authors of [23] proposed a model to resolve the handover problem of communication by introducing a heterogeneous network (HetNet) to enhance the system capacity. It evolves between the macro and micro nodes; the same remains a negative impact since high cell density exists.

In [24], a Hybrid Network Model (HNM) is proposed for a useful device to device transmission. The model combines the poison and k-means clustering process. It achieves a high-performance rate in throughput, with an optimized signal to noise interference ratio. The drawback of the co-channel interference and the network capacity was not modelled by HNM as reported.

The authors of [25] presented a framework of Fixed Mobile Convergence (FMC) to provide the control plane's design objectives in 5G networks. It made use of the Software-Defined Network (SDN) technique to enhance multi-network scenarios. In addition to that, the control plane had rapid service requirements in the FMC model. Apart from the advantages, the major disadvantage of the model is inflexibility during transmission.

Based on the Survey, the unresolved issues in the 4G network have been resolved using the proposed SN-DCA and TSCDP approaches in the evolution of future fifth-generation networks have been discussed below.

3. A Scalable Network Architecture with Dual Connectivity Application (SN-DCA) in control and data plane with Two-Stage Control- Data Plane (TSCDP)

More details about the proposed SN-DCA based on the network coupling phenomena using dual connectivity in the Long Term Evolution (LTE)/Wi-Fi band of the standard structure of the C/D plane are elaborated as follows.

3.1. Overall system architecture of SN-DCA

Fig. 1 illustrates the proposed SN-DCA network overlapping of LTE/Wi-Fi sub-clouds with a continuous LTE evolving Node Base station (eNB) coverage. Each sub cloud is a cluster of several Wi-Fi / LTE dual connectivity band cells attached to a sub cloud controller. The LTE eNB is connected to an Entity through the control plane interface, and the service gateway through a user interface according to the 3rd Generation Partnership Project (3GPP) standard. As seen in the Fig. 1, the current multiple Radio access techniques design is based on a multistage process that is entirely consistent with the potential wireless storage framework. The physical linking approach for a radio-based

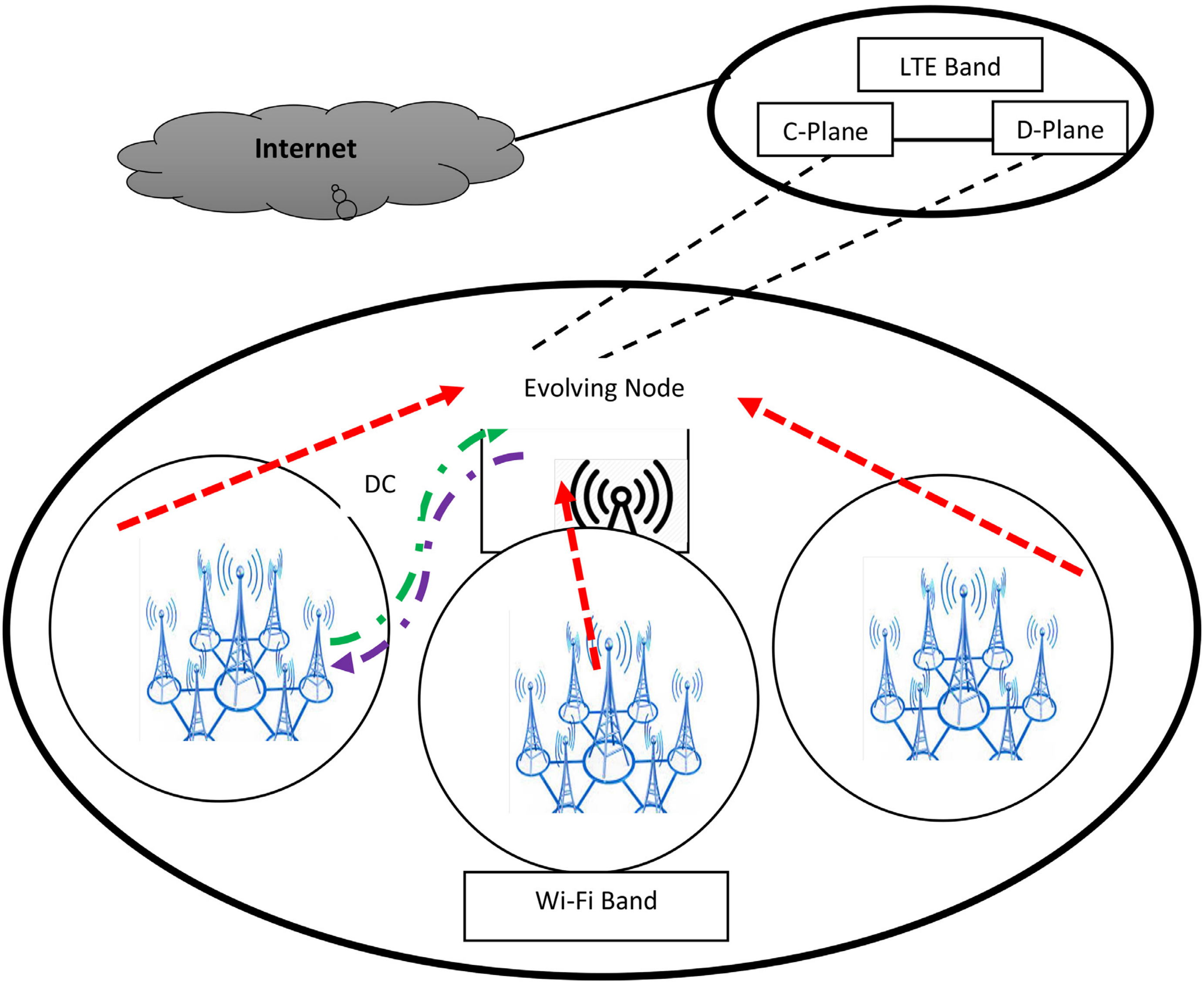


Fig. 1. Sn-DCA Architecture

communication network is Radio Access Technology. Most modern mobile phones support multiple multistage processors, including Bluetooth, WLAN and GSM in one unit. A mobile terminal conducts neighbouring cell measures and sends a measuring report to the network when linked through a Radio Access Technology. The network will initiate handover from one potential wireless storage framework to another based on the mobile terminal's measurement report.

At the first connectivity, the LTE eNB is used as the primary user equipment, and sub-cloud network as the sub-plan is transmitted directly via the minimum data rate on the Long-Term Evolution radio networks WLAN availability through WLAN-unlicensed radio bands. The sub cloud controller is used on the positioned local focal point for analyzing the sub clouds in the corresponding second connectivity and based on availability; it determines the path between the Wi-Fi and the LTE channel. Therefore, though user equipment mobility inside the same sub cloud is unique, the data route between eNB and controller remains the same. Utilizing various LTE/Wi-Fi units, dual-band Wireless Lan Aggregation (WLAN- aggregation) is feasible on the user equipment side. To ensure UE capacity, Wi-Fi/LTE modules will be active based on the dual-link mode. Otherwise, the Wi-Fi/LTE connections are in the turn-off state.

A two-stage control and Data Plane (TSCDP) networking is implemented in the SN-DCA instead of the traditional radio access networks system. The TSCDP is utilizing C/D splitting, in which LTE eNB protects the inter-cloud point customer. Further, the background details like current location and demand for traffic are transmitted by a 1st stage C-plane connected to the eNB LTE with the indications relevant to mobility management, radio resource management, etc...Therefore, the LTE can notify the user equipment to download its data traffic from the selected sub cloud within a Wi-Fi / LTE sub cloud. The 2nd Stage D-plane is connected to the Wi-Fi channel. The C plane performs the dual-action inside the sub-cloud without any LTE eNB interference. It then passes all the signalling details necessary to handle the device transport inside the sub-cloud, which increases the delay and increases the retention rate. A dual-band router is a router that uses 2.4GHz and 5GHz frequency bands simultaneously to provide increased efficiency for data transmission. The dual-band router has higher signal strength and range coverage. A dual-band router will automatically switch bands when required. Instead of a new rival, allow Wi-Fi / LTE sub cloud team to stay with the business. It needs a little imagination, although it could also mean a compounding gain, the downside of withdrawing after a specific point or endless supplements that make feel that your service is continually changing for customers to try to locate a single point of

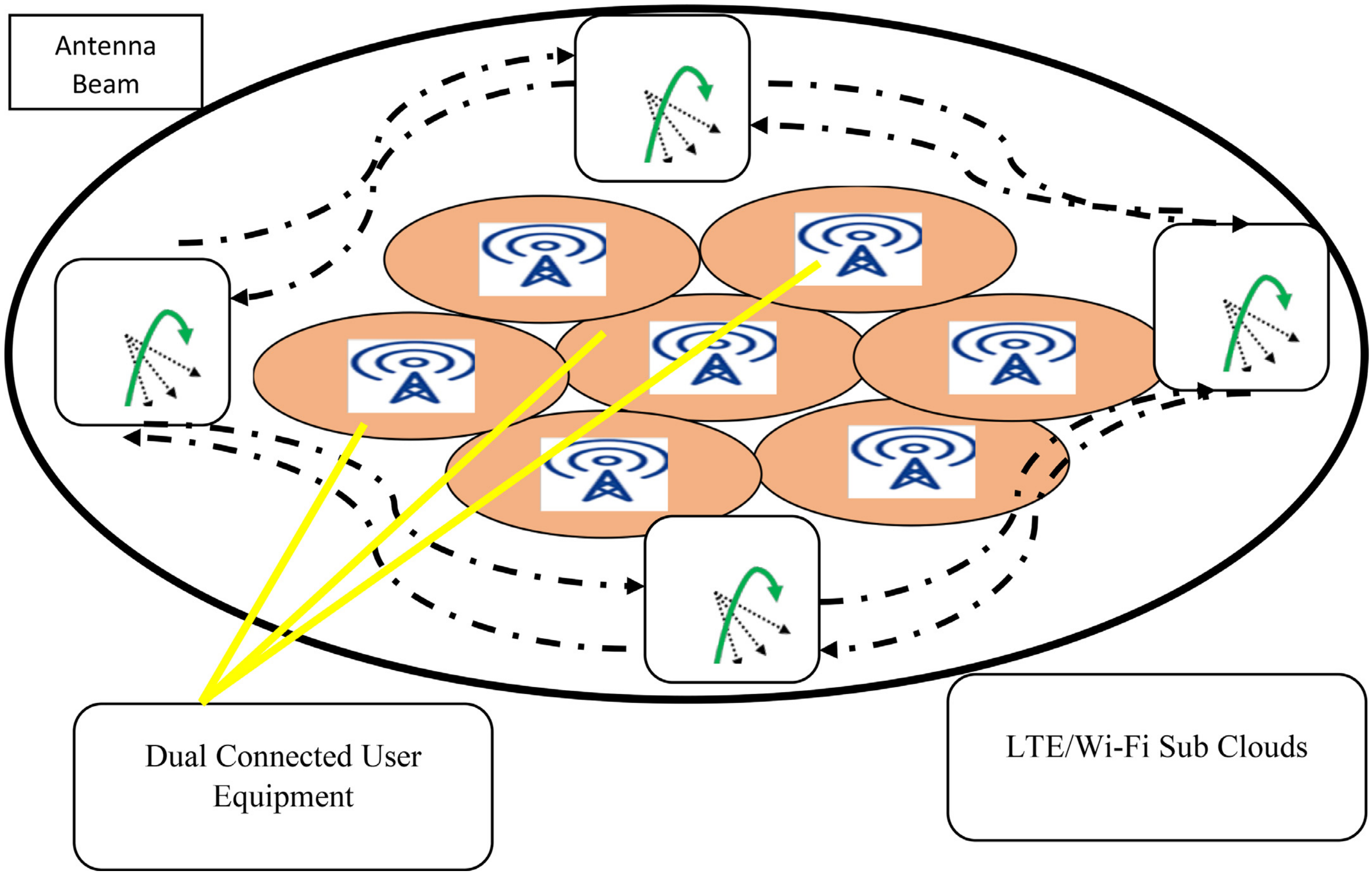


Fig. 2. Location-Based Initial Access

sale. While many customer relationships are focused upon a business-to-business arrangement, one person's loyalty to another is fundamental to your relationship.

3.2. Sub cloud performance

The dual connectivity scheme, along with the TS C/D plane, is used for LTE first connection inside the Scalable Network sub cloud. As seen in the Fig. 2, based on its possible power capabilities, the SN-DCA selects a set of users to protect the user equipment at its approximate location. The SN-DCA locates a group of best LTE sub cloud geometrically to conduct the retention test with the user equipment cantered on its approximate position. Hence, The SN-DCA does not pick up the approximate Line of Sight (LOS) along with the initial set of antenna beams above it to address transmission error. Many factors often cause delays in the shift; however, mostly by inadequate maintenance or high miles. In addition to acting as a cooling system, the transmission fluid retains internal dents lubricated to avoid hardening or wear out. Transfer delay or store and forward delay, sometimes known as packet delay, is the time taken to pass all the packet bits into the wire within a network based on packet switching. It means that the data rate of the connection is causing the delay. Spectrums and frequencies are the operations of the range of frequencies for a real LTE telephone. Various regions work in varying frequencies across the world. A higher frequency does not mean a better network because a lower frequency is better in rural areas. LTE modifies the current flow of data to the Internet protocol system. Instead of transferring big data packets and simplifying the service as both CDMA and GSM do, it would transfer small data quantities.

3.3. Connection distribution models

In this section, the connection distribution models for different Wi-Fi/LTE bands to maintain network usage and reduce the transmission delay have been shown.

3.3.1. LTE connection model

A macro-eNB connection represents a 3GPP Urban macro system model. The power obtained in the user equipment at a distance l from the eNB measured in dBm, RP_a^{LTE} is as follows:

$$RP_a^{LTE}[dBm] = TP_a^{LTE}[dBm] - PPL_a^{LTE}[dBm] \tag{1}$$

Where, $RP_a^{LTE}[dBm]$is the eNB Receiver capacity $TP_a^{LTE}[dBm]$ is eNB transmitter capacity. $PPL_a^{LTE}[dBm]$ reflects a range-dependent loss of direction for a user equipment at the eNB level, which is represented as follows:

$$PPL_a^{LTE}[dBm] = SD_{LTE} + log_{10}\left(\frac{r}{r_0^L}\right) + L_N^{LTE} \tag{2}$$

Where, r_0^Limplies a reference distance equal to 0.1 km from the eNB. $L_N^{LTE}$is the shadowing log-norm criteria in the zero meanSD_{LTE} and the normal range of the LTE model.

3.3.2. Wi-Fi connection model

For Wi-Fi communication, the outdoor distribution paradigm is used. In dBm, the obtained power is calculated as follows in user equipment at a distance l from a Wi-Fi signal:

$$RP_l^{Wi-Fi}[dBm] = TP_l^{Wi-Fi}[dBm] - PPL_l^{Wi-Fi}[dBm] \tag{3}$$

Where, $RP_l^{Wi-Fi}[dBm]$is the Wi-Fi Receiver capacity $TP_l^{Wi-Fi}[dBm]$ is the Wi-Fi transmitter capacity. $PPL_l^{Wi-Fi}[dBm]$ reflects a range-dependent loss of direction for a user equipment at the Wi-Fi user equipment level, which is as follows:

$$PPL_l^{Wi-Fi}[dBm] = SD_{Wi-Fi} + log_{10}\left(\frac{r}{r_0^w}\right) + L_N^{Wi-Fi} \tag{4}$$

Where, r_0^w implies a reference distance equal to 0.1 km from the eNB. $L_N^{Wi-Fi}$is the shadowing log-norm criteria in the zero meanSD_{Wi-FI} and the normal range of the Wi-Fi model.

This outdoor Wi-Fi connection model uses the Wi-Fi external link Power in dBm is calculated as following in user equipment situated at a distance y from outdoor Wi-Fi Signal:

$$RP_l^{o(Wi-Fi)}[dBm] = TP_l^{o(Wi-Fi)}[dBm] + AG_{db}(\theta,\varphi) - PPL_l^{o(Wi-Fi)}[dBm] \tag{5}$$

Where, $RP_l^{o(Wi-Fi)}[dBm]$ is the outdoor Wi-Fi Receiver capacity $TP_l^{o(Wi-Fi)}[dBm]$ is the outdoor Wi-Fi transmitter capacity. $PPL_l^{o(Wi-Fi)}[dBm]$ reflects a range-dependent loss of direction for a user equipment at the outdoor Wi-Fi user equipment level, which is as follows:

$$PPL_l^{o(Wi-Fi)}[dBm] = SD_{o(Wi-Fi)} + log_{10}\left(\frac{r}{r_0^{ow}}\right) + L_N^{o(Wi-Fi)} \tag{6}$$

Where, r_0^{ow}implies a reference distance equal to 0.1 km from the eNB. $L_N^{o(Wi-Fi)}$is the shadowing log-norm criteria in the zero meanSD_{Wi-FI} and the normal range of the Wi-Fi model.

$AG_{db}(\theta,\varphi)$in Eq. (5) refers to the elevation angles θ *and* φ, antenna gain in a certain direction, respectively, that can be expressed as in Eq. (6):

$$AG_{db}(\theta,\varphi) = AG_{\max(db)} - (\left(\frac{\varphi-\varphi_0}{\varphi}\right) - \left(\frac{\theta-\theta_0}{\theta}\right))^2 \tag{7}$$

$$AG_{\max(db)} = \frac{\pi}{(\theta_{3dB} - \varphi_{3dB)}} \tag{8}$$

Where the maximum antenna gain in dB is $AG_{\max(db)}$.The elevation angle of the antenna is measured by the (θ_{3dB} and $\varphi_{3dB)}$ half-powered beam diameter and beam direction, respectively.

3.4. Two-stage control- data plane (TSCDP)

This section includes descriptions of the existing Wi-Fi/ LTE network usage management and the protocol stacks. The general 3GPP guidelines will usually be adopted in building LTE / Wi-Fi internet architecture, such as preventing any interface in the C/D plane, mitigate the effect of network specifications, boost WLAN network mobility, and the signalling cost. The suggested TSCDP design considers all these specifications and incorporates them. Mobility means that a client computer can transfer or switch from one access point (AP) to another while maintaining an active network link in a Wi-Fi context. When it comes to roaming, customers can switch from one region to another and roam from AP to AP without interrupting applications that need continuous network connectivity. If the current connection becomes sub-optimal, a Wi-Fi client system can go from one AP to another. When the consumer moves away from a related AP, the signal intensity decreases, and the region usually increases RF interference.

Fig. 3 shows the planned internetwork of WLAN (LTE/Wi-Fi) is implemented very closely with the PHY layer since it is unnecessary to combine it with another network's physical and MAC layers. The integration of the Physical layer with the C/D plane includes major improvements in IEEE standards criteria without breaking the above 3GPP guidelines. Incorporating the MAC layer often includes implementing multi-band protocols by removing complicated problems of synchronization of networks. As shown in Fig. 3.

Here, a new LTE/Wi-Fi dual connectivity protocol is introduced to promote the existing LTE/Wi-Fi hierarchy configuration. Dual connectivity (DC) aims to use the radio source in multiple carriers to increase new LTE/Wi-Fi performance, similar to carrier aggregation (CA). In their program circumstances and execution, the difference between DC and CA is Dual Connectivity (DC) allows an EU to simultaneously transmit and receive data on multiple partner carriers from 2 cell groups via master Node and secondary nodes, e.g. a relative delay between DC nodes can boost users' performance, provide mobility power, and help Nodes for load balancing. The actual internet interfaces should be separated from the LTE layer and concealed because they are used for the processing and conversion of signals between previous WLAN and LTE and vice versa. The signals are sent to the LTE evolving node and Wi-Fi respectively for 1st stage C-plane and 2nd stage D-plane, and that Wi-Fi signals are executed in higher range frequency bands in real-time. Dependent on its range, the D-plane can be supported by LTE/Wi-Fi. In telecommunications, a multi-band device is a communication device that can accommodate several radio frequency bands, particularly a cell phone. Each system with more than one channel uses different frequencies; however, a band has several frequencies. Various mobile device bands support roaming between regions in which different requirements for mobile phone services are used. If frequency bands are widely segregated, parallel circuits must be provided for transmitting or receiving signal paths which enhance the cost, complexity and power requirements for multi-band devices.

3.4.1. C/D plane guideline stack

Two control and Data planes (C/D) distribute power signalling between internetwork architectures. The LTE evolving node transmits a C-plane signal, and the distributed DD-plane signals are transmitted from the SN-DCA of a wireless network for the evolving robot swarm networking.

User equipment works with these C/D planes: C-plane for carrying messages for the robot swarm LTE/Wi-Fi user equipment driving units and the other D-plane for carrying messages for user equipment LTE/Wi-Fi receiver unit.

3.5. Computational analysis

Analytical concepts are defined in this section to effectively relate the standard's accomplishments and the new LTE/Wi-Fi bands. To evaluate the effects of the proposed SN-DCA with TSCDP in LTE/Wi-Fi network band usage, LTE energy consumption, and evolving node signalling load, analytical models are added for several interrelated parameters. This paper uses the simple Markov models for the stability of a standard D-plane's probabilities as the D-plane described a close interaction with the LTE/Wi-Fi domains. LTE in telecommunications is a standard for broadband wireless communication based on GSM/EDGE technologies in mobile devices and data terminals. It improves capacity and speed with a different radio interface and strengthens the core network. For both GSM and CDMA2000 networks, the LTE is the upgrade route to operators. The different LTE frequencies and bands in various countries allow LTE in all countries where they are assisted by multiband telephones.

By considering the user, equipment is bound to the maximum range of the D-plane data rate. Simultaneously, it is still available; the C-plane's inter-cloud condition exists to prolong the C-evolution is observed. Similarly, the intra-condition C-plane exists as long as C-Wi-Fi is detected. The inter-cloud condition of C-plane Exchanges operates based on some preferences and restrictions between cloud providers. Inter-cloud Exchanges use the Inter-cloud Roots resource catalogue to provide a D-plane data rate for fast inquiries. Cloud services continue to engage with each other until the talks are ended actively. Cloud computing has been described as a form of a distributed parallel system that provides virtualised resources internally. It is commonly regarded as a cost-effective model for technical resource rental.

Fig. 4 depicts the process of the two-stage C/D plane states. It is assumed that the user equipment will enter the band wherever possible,

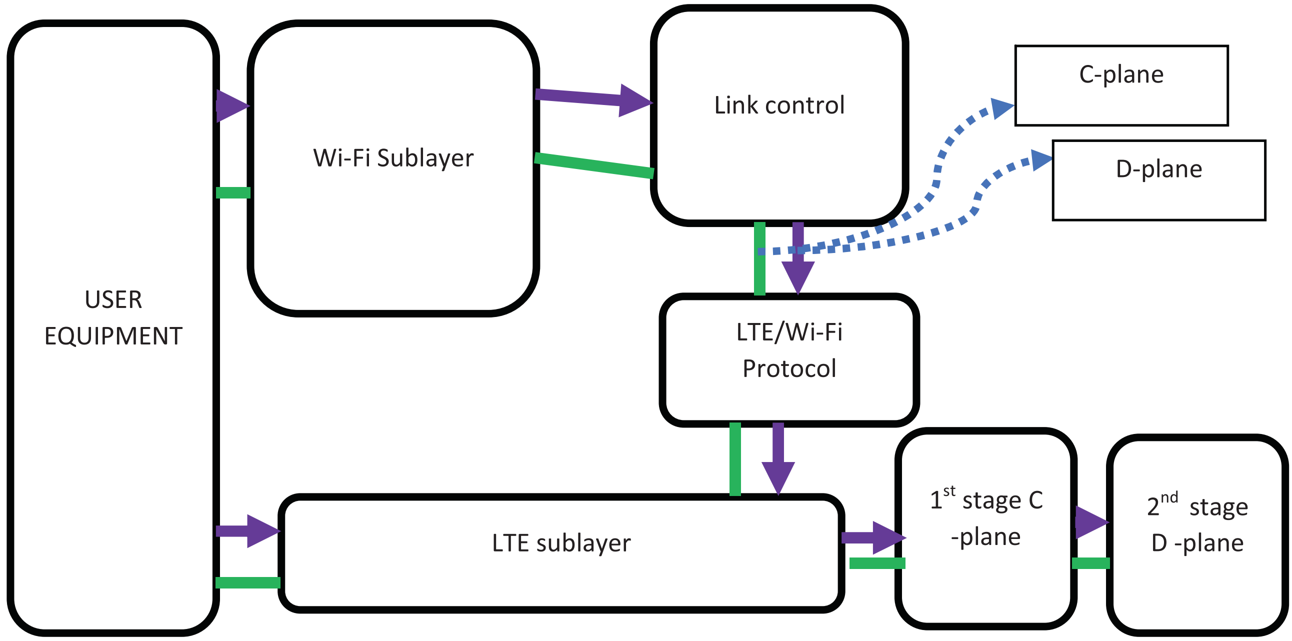


Fig. 3. LTE/Wi-Fi Internetworking C/D Plane

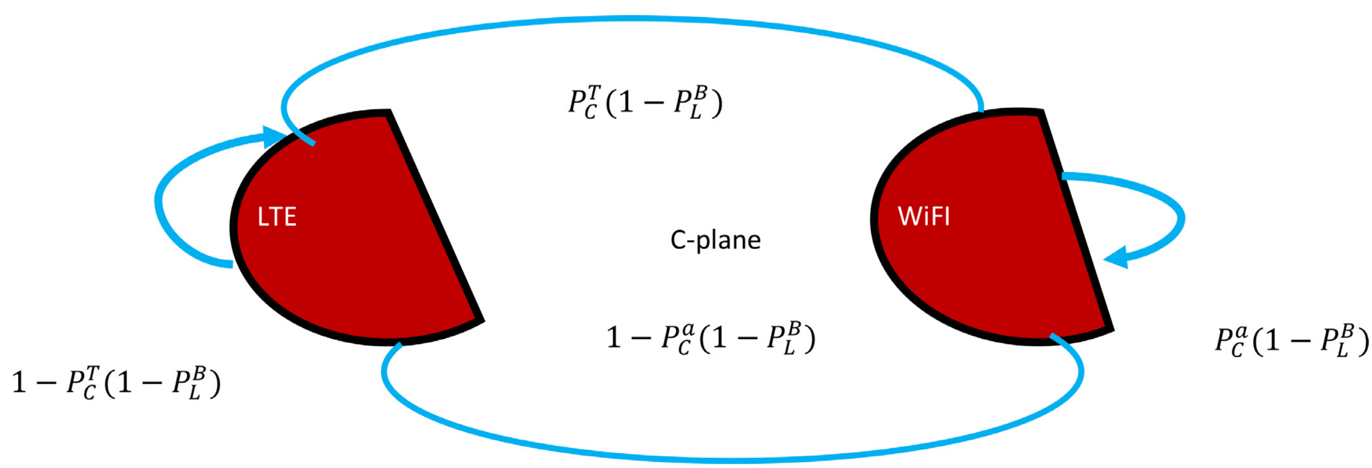


Fig. 4. operation of the two-stage C/D plane

which provides the highest data rate. The transmission matrix will describe this as in Eq. (9),

$$TM_{LTE/Wi-Fi} = \begin{pmatrix} 1 - P_C^T(1 - P_L^B) & P_C^T(1 - P_L^B) \\ 1 - P_C^a(1 - P_L^B) & P_C^a(1 - P_L^B) \end{pmatrix} \tag{9}$$

Where, P_L^Brefers to the Loss relation between robot swarm LTE/Wi-Fi networking and user equipment to the blocking possibility. $P_C^T$is the likelihood that a D-plane from LTE to Wi-Fi can migrate correctly, which can be represented as in (10):

$$P_C^T = P_C^a(1 - P_C^{FAULT}) \tag{10}$$

Where,P_C^a is the real LTE band availability and the percentage of the overall evolving node coverage. P_C^{FAULT} This is mostly due to the LTE-based user equipment placement errors in the robot swarm LTE unit; However, located within their range, it is described as the probability of the User equipment in the review places of sub clouds. Lower values suggest greater proportions of the chance of fault for supplying the user equipment in LTE sub clouds with a high power range. Long Term Evolution (LTE) is a wireless communication 4G standard which offers smartphone, tablet and other mobile devices the fastest Internet speed. 4G uses electromagnetic waves, which provides greater coverage and penetration through regions than 3G, which uses microwaves. Wi-Fi is a networking protocol that provides a fixed location with Internet access. Like LTE, it requires a data provider's services; however, the key distinction is the necessity of a router or other wireless system. Once a router is strategically built at home, it transmits information and sends a signal for devices in its range.

The LTE/Wi-Fi C-plane probabilities P_C^T in the steady-state can be represented as: by direct solving (9) in the SN-DCA, as shown in (11):

$$P_C^T = \frac{P_C^a(1 - P_C^{FAULT})(1 - P_L^B)}{1 - P_C^a P_C^{FAULT}(1 - P_L^B)} \tag{11}$$

Fig. 5 shows the opposite action of the proposed two-stage C/D -plane and the transformation and examining matrices are:

$$P_C^{OT} = \begin{pmatrix} 1 - P_C^{PT} & P_C^{PT} \\ 1 - P_{PT}^a & P_{PT}^a \end{pmatrix} \tag{12}$$

Where the P_C^{PT} reflects the likelihood that represents intercloud status and can be transferred to intracloud status properly and can be formulated as:

$$P_C^{PT} = P_{PT}^a(1 - P_{PT}^{FAULT}) \tag{13}$$

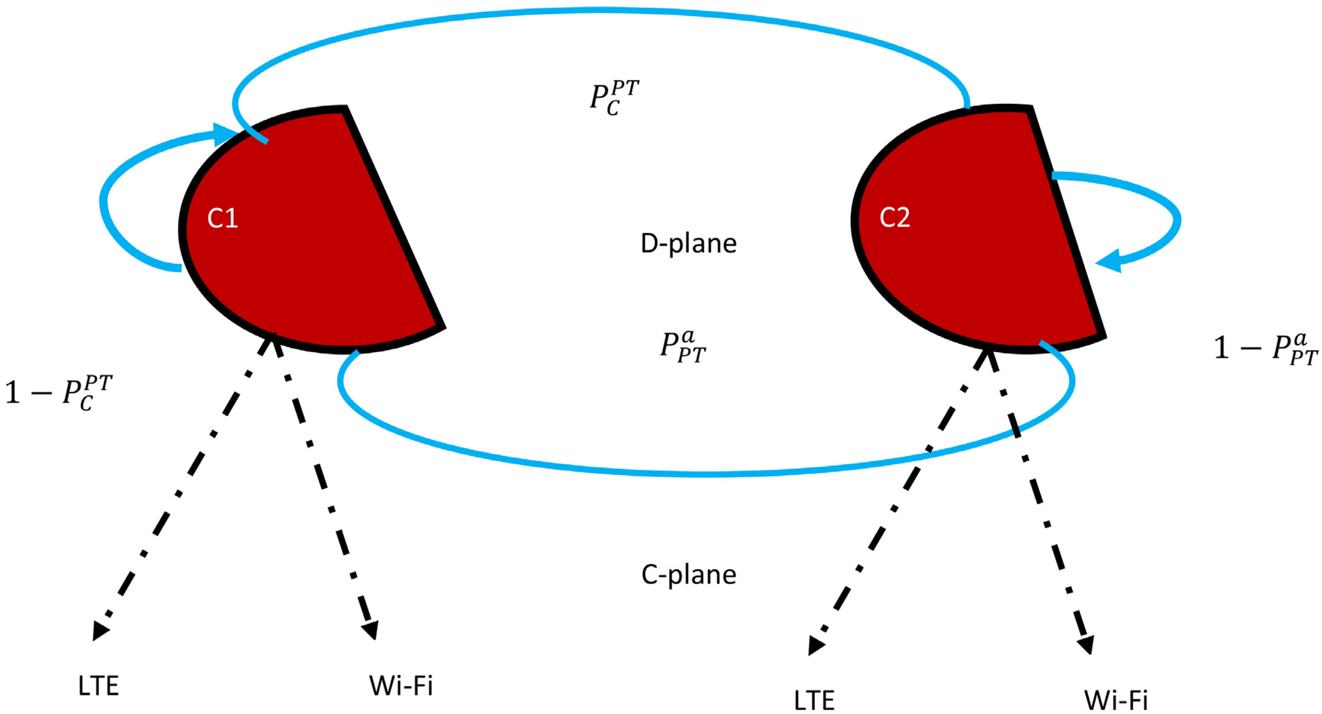


Fig. 5. opposite action of the proposed two-stage C/D -plane

Where, P_{PT}^{a} and P_{PT}^{FAULT} are the real functionality and the missteps inside the LTE Small value of P_{C}^{OT} that fails again the low percentages based on the lack of linking to a sub cloud.

$$P_{C-D}^{LTE} = 1 - \left(\frac{P_{PT}^{a}\left(1 - P_{PT}^{FAULT}\right)}{1 - P_{PT}^{a} P_{PT}^{FAULT}} \right) \tag{14}$$

$$P_{C-D}^{Wi-FI} = \left[\frac{P_{PT}^{a} - P_{C}^{a}\left(1 - P_{C}^{FAULT}\right)\left(1 - P_{L}^{B}\right)\left(1 - P_{PT}^{FAULT}\right)}{1 - P_{PT}^{a} P_{PT}^{FAULT}} \right] \tag{15}$$

From the analysis, the probability of the transmission used in the C/D plane of LTE/Wi-Fi cloud distribution is given as in Eqs. (14) and (15).

4. Results and discussion

This section, consolidated with detailed computational simulations and the proposed SN-DCA's efficiency with TSCDP for evolving robot swarm LTE/Wi-Fi networking, has been analyzed. Moreover, similarities with the findings come from the statistical context, and computational simulations demonstrate the precision of the retention rate, usage access, and delay transmission delay. The delay reduction is generally accomplished at the expense of short lifetime or transmission times are shortened by the uncertainty that is compromise rather than an overall optimization. The latency of the network explains delays in network transmissions. Although the latency involves a device or workflow period, the network latency includes any delays in data transmitted from one part of the network through another.

4.1. Simulation aspects

The goal environment is designed to cover an LTE evolving node. This macro-region is overlaid to virtually mask this field with the amount of robot swarm LTE/Wi-Fi sub clouds. Dual connectivity bands for robot swarm LTE/Wi-Fi are deployed in each sub cloud. As a key concept of the robot swarm networks, the Network densification approach is considered; the number of sub clouds per set of ranges to determine node output within various transmission range values has been analyzed based on the evolving node. LTE refers to the unlicensed 5 GHz spectrum of its networking to replace the current corresponding second connectivity and based on availability. In high-congestion areas, LTE adds speed and service system simultaneously connecting to a standard LTE link when the nearby LTE signal gains extra bandwidth. According to the regulations laid down in the law, the LTE system must meet existing power constraints of about 300 feet concerning Wi-Fi devices. Therefore areas such as shopping centres and stadiums are the key aims to improve LTE congested traffic. As the user equipment is protected by the macro infrastructure, the evolving node supports the two-stage C/D plane. Instead, the data enters a sub cloud, in which the Wi-Fi band-supported by2 carries out all the signal- stage C-plane and the D-plane for robot swarm LTE/Wi-Fi bands. Wireless Wi-Fi refers to the ability to transmit two separate forms of the antenna, both on the 2.4 GHz and the 5 GHz band at the same time. Dual-band routers include two separate forms of wireless radio as opposed to standard Wi-Fi equipment. Dual-band routers first launched a few years ago supplied 802.11a and 802.11b/g and were created to use a mixture of Wi-Fi users in business networks.

Table 1
: Simulation Parameters

Parameters (LTE/Wi-Fi)	Values
Carrier Frequency (GHz)	2/60
Bandwidth (GHz)	0.2/0.4
Time	5 min
Height (m)	25/3
No. of Sub clouds	10

Table 1 describes the key parameters of the simulation and their corresponding values.

In the evaluation, the data retention rate, Network usage access, and the delay have been compared with the evolving Generations' conventional network architecture. The time to process a packet in the switch buffer refers to the queuing delay. The delay depends on the incoming packets' arrival rate, the transmitting power of the outgoing link, and the network's traffic design. One-band router is compatible with most broadband modems and cards as an old technology because they use a

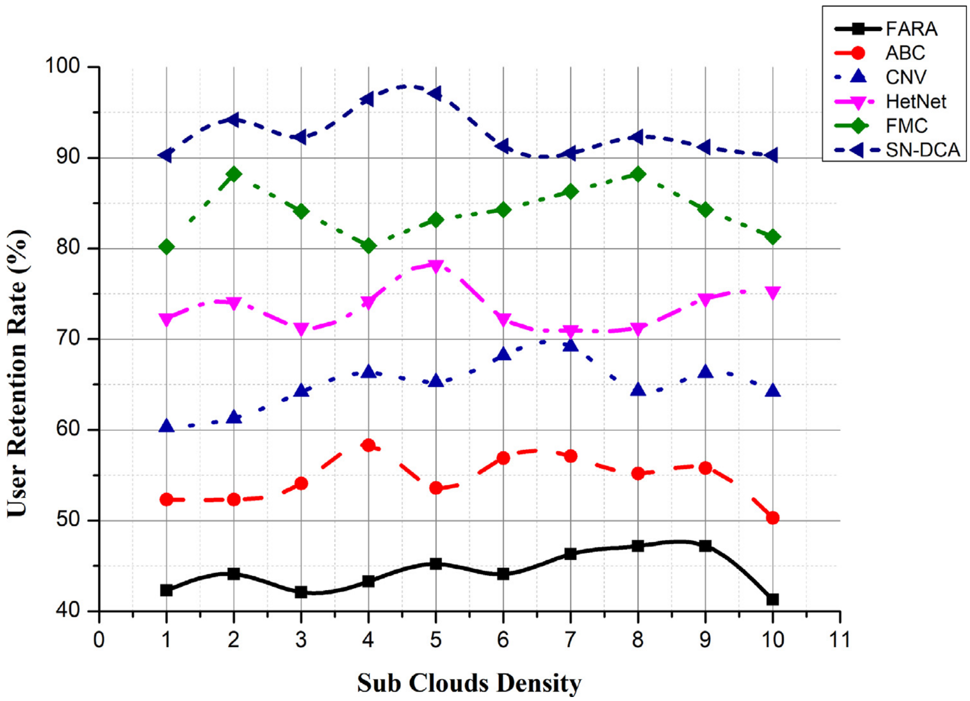


Fig. 6. User Retention Rate (%)

2.4 GHz band. The double-band router is compatible with both old and new smartphone, modem and wireless receiver, utilizing both frequencies.

4.2. Data retention rate

The Network Data Retention Rate is evaluated using the proposed SN-DCA with a Two-stage C/D plane. The mathematical findings have been demonstrated using simulation studies. The results are compared with the conventional network infrastructure. By the end, the data usage retention rate is generalized using the Eq. (16) based on the probabilities of transmission as linked based on the Eqs. (14) and (15).

$$U_R = \frac{P_C^T.T}{P_C^T.T + \left[\left(1 - P_C^a\right).P_C^{FAULT} + P_C^a.P_L^B\right].T} \tag{16}$$

$$E_R = \frac{P_C^T P_P^T.T}{P_C^T P_P^T.T + \left[\left(1 - P_C^a P_P^a\right).P_C^{FAULT} P_P^{FAULT} + P_C^a P_P^a.P_L^B\right].T} \tag{17}$$

Fig. 6 shows that the user data retention rate reaches a very appreciable increase by applying the Scalable propose architecture of dual connectivity application. The comparison results of the data retention usage between various methods show the proposed method's uniqueness and high precision. Data retention policies weight questions related to legal issues and companies' privacy and concerns about time retention, archival laws, data formats and the permitted storage, access and encryption methods. Data retention typically refers to the preservation by governments and private organizations of call information records for telephony, Internet traffic, and transaction data in the telecommunication industry. In the conservation of government data, typically the retained data are made and retrieved through telephone calls, e-mails sent and received, and websites visited. As the fault detection works well and faults of the proposed C/D method reduced than the conventional way, it should be a better technique for the evolving robot swarm network generation.

The user data retention and the energy retention of the data obtain a good accuracy in the proposed C/D – plane method as shown in Fig. 7. Energy efficiency is an important parameter for the network structures, and the present techniques achieve it and seem to be good compared with the pre-available methods.

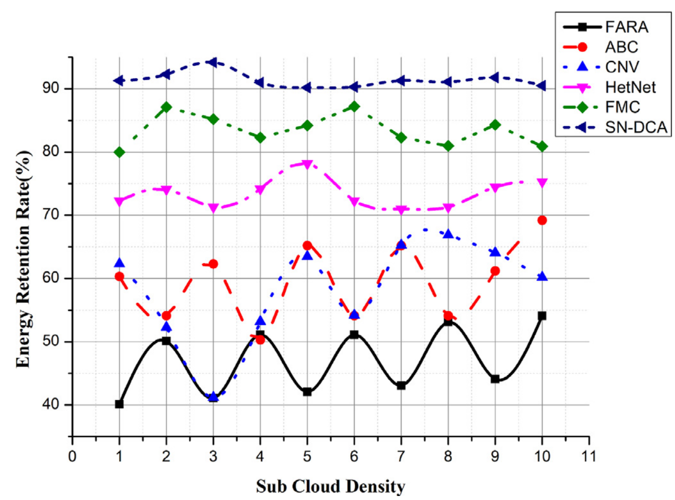
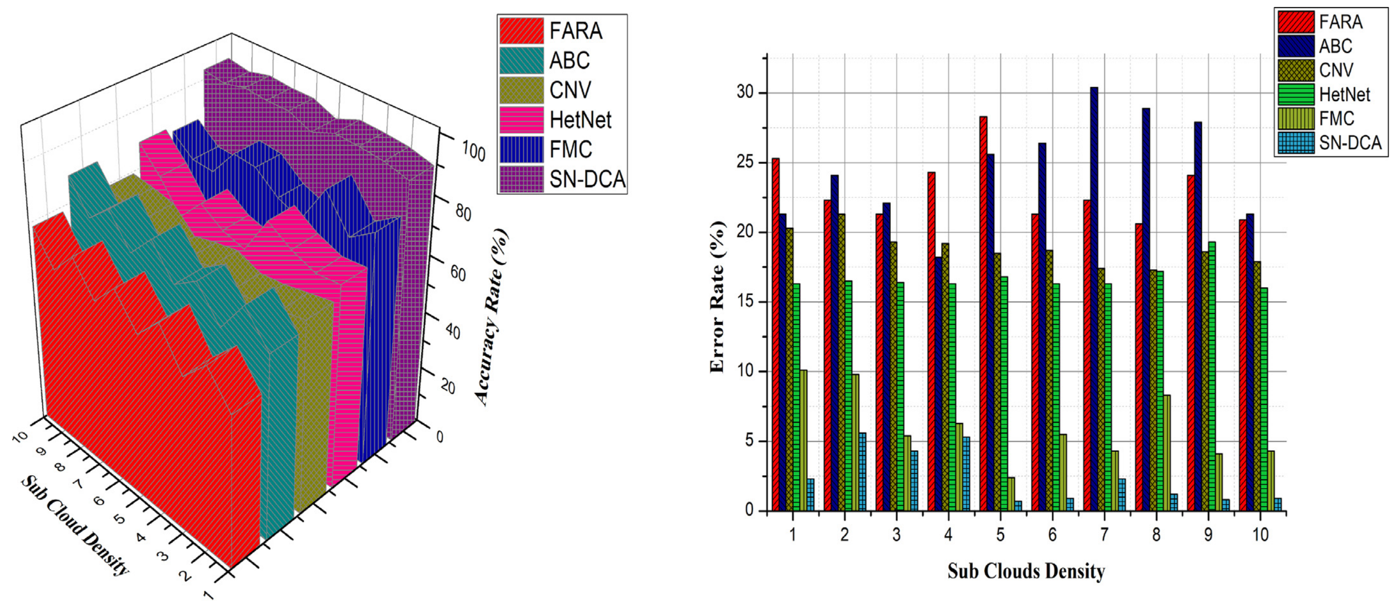


Fig. 7. Energy Retention Rate (%)

4.3. Performance accuracy ratio

The research work achieves a better performance ratio by obtaining the highest accuracy and lowest error rate. Fig. 8 (a) and (b) show the accuracy result and error rate resulting from the dual connectivity technique. The higher accuracy of the method in Fig. 8(a) infers the suitability of the dual connectivity technique for the evolving fifth-generation networks. The proposed method achieves an accuracy rate of 93.4% in the transmission of data, whereas the traditional methods obtained less accuracy than the dual connectivity technique.

From Fig. 8(b), It is inferred that the transmission error is less than the traditional methods. Since dual connectivity is applied in the evolving architecture of a robot swarm network, the error rate is lowered with the dual increase in the good transmission of data. The proposed method achieves a lower error rate of 0.9% than the conventional methods. As the error rate decreases, it increases the model's positive aspects



(a). Accuracy RateFigure. **(b). Error Rate**

Fig. 8. Accuracy Vs Error Rate.

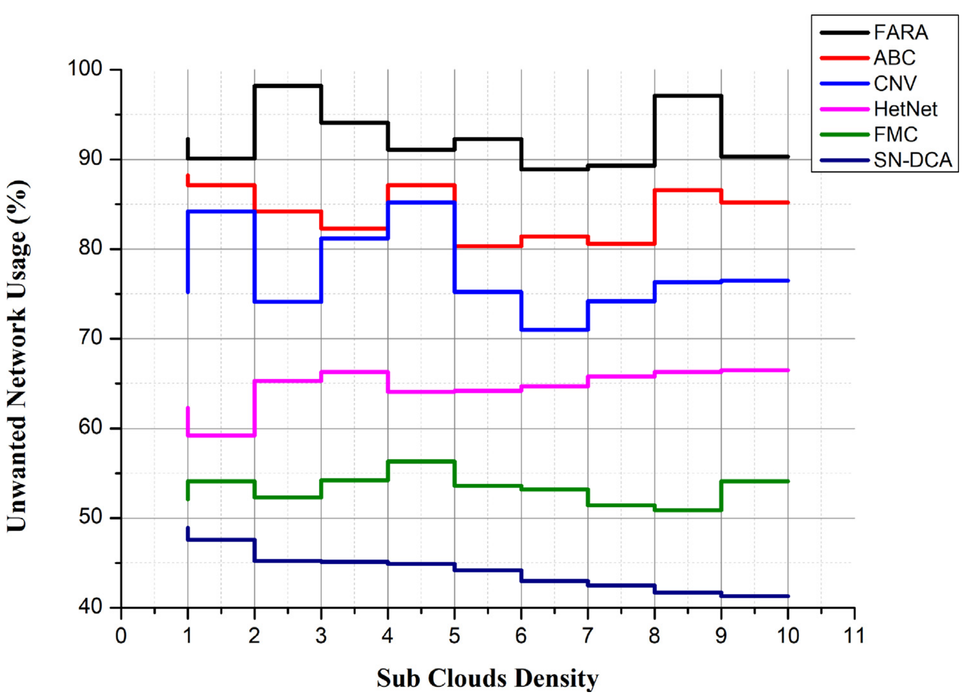


Fig. 9. Unwanted Network Usage rate (%)

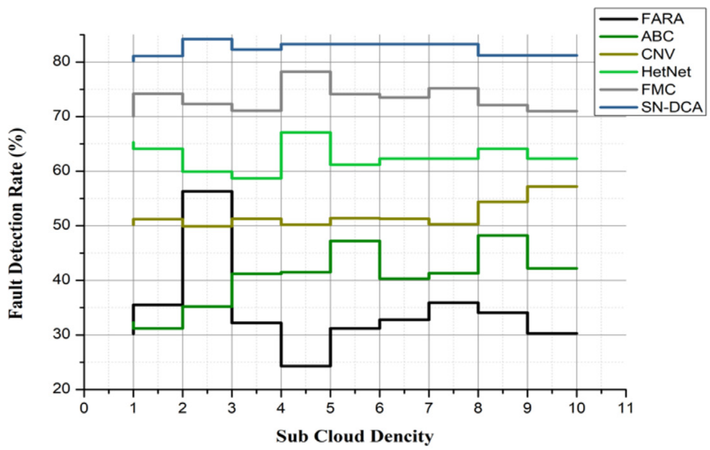
and increases the suitability of the proposed approach to the evolution of future generation of networks.

4.4. Network usage access

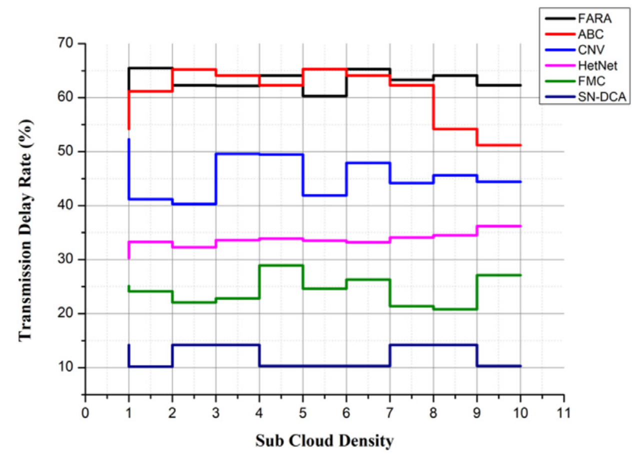
The current techniques over the swarm robot LTE architecture increase unwanted network usage access in the distributive clouds. To reduce that, improper access to the two-stage C/D plane method is proposed and implemented using the simulation. From the simulation studies, Fig. 9 inferred that unwanted network access is probably reduce using the proposed C/D plane technique. The network usage increased due to the increase in users. Hence, to reduce the unwanted usage with the increasing number of users, the proposed method paves away with a reduced access ratio than the available methods.

4.5. Fault detection rate and transmission delay

The Fault Detection Rate increased with the proposed technique, and it is evaluated using comparison with the conventional techniques as shown in the Fig. 10 (a) and 10(b). Fault detection is a very important parameter. As it is increased, it is neglected using the blocking probability, and it automatically decreases the delay and unwanted usage access.



(a). Fault Detection Rate Figure.



(b). Transmission Delay Rate

Fig. 10. . Fault Analysis

The increased fault detection reduces the delay of transmission, which remains the major problem in the present robot swarm LTE networks. Transmission delay or storage and forward delay, known as packet delay in the network depending on the packet switching, is the amount of time taken to transfer all the packet bits through the cable. In other words, the data rate of the connection causes this delay. Delay of transmission is a function of the packet's duration and has little to do with the distance between the two nodes. The transmission capacity increases the time the packet takes to transmit. It is proportional to the length of the packet in bits. Brand teams have two methods of evaluating retention: for themselves and other businesses. Retention evaluates and trend-devise steps against their own results week after week and month after month. For example, the product team should be concerned and try to isolate triggers if retention is downward. If they are up, product teams should aim to isolate and capitalize on the associated improvements in functionality, marketing strategies and cohort behaviour. The transmission delay is general because of the large number of users, and it should be reduced to increase the efficiency of the method. The dual connectivity method and the C/D plan increase the fault detection rate, reducing the delay and making the method more efficient. The analytical performance of the proposed techniques has been validated computationally and examined through simulation studies. The Simulation results show that these techniques achieve a higher performance ratio in the network with a minimum transmission delay and a high data retention rate.

5. Conclusion

Long-Term Evolution bands' complementary capabilities are effectively used to incorporate a dual connected robot swarm LTE/Wi-Fi scalable architecture for cellular networks with robot swarm. A novel principle of a two-stage C/D plane has been developed to establish contact between the proposed scalable architecture elements. In addition to the protocol guidelines, the comprehensive network design and necessary protocol stacks are adopted from the proposed SN-DCA. The statistical efficiency of the proposed method against its key parameters is mathematically strong. The research indicates that the SN-DCA has a lower likelihood of missing and false detection than the standard one that allows it easier for the network to be available more and used. Moreover, the proposed method renders that it is incredibly comfortable and precise with the versatility in signalling load and the related LTE/Wi-Fi signals.

Author statement

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Declaration of Competing Interest

None.

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