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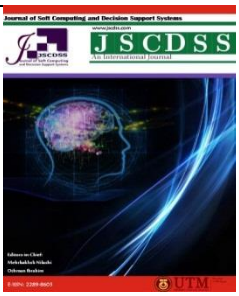

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Review of Terrestrial and Satellite Networks based on Machine Learning Techniques

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Abstract

It has been broadly admitted that the upcoming networks will require to provide meaningfully more capacity than the existing ones to be able to deal with the growing traffic requirements of the users. Specifically, in the areas that optical fibers are improbable to be spread out because of the economical limitations; so, this would be a very crucial challenge. To address the above-mentioned issue, the combination of Terrestrial and Satellite Networks (TSNs) together would be an option. Satellite networks can cover enormous regions and current improvements have significantly raised the existing capacity while diminishing the cost. However, the characteristics of the geostationary satellite links are potentially various than the frequent terrestrial ones, essentially because the propagation time of the signal is high. The current study reviews the cutting-edge issues with respects to TSNs with machine learning methods.

Keywords: 5G, Satellite Communication Networks, Terrestrial Communication Networks, Quality of Service, Machine Learning

1. Introduction

Nowadays in mobile communication networks, the developments and integrations play a crucial role and these factors present clear effects in social and economic advancement. During the years, the recent and emergent networks have been required to have this ability to handle powerful growth regarding the traffic volume (An et al., 2016). For instance, the future Fifth Generation (5G) communication networks that are recently being clarified and are anticipated to be prepared for the trade by upcoming year, it is expected to have low latency, more reliability, tenfold yield per user and higher traffic volume (Johansson et al., 2015). The multiple amounts of traffic volume will present a significant problem for operators, specifically in the countryside regions (Khan et al., 2011). As an example, the technologies which have been utilized in the backhaul segment in today's life that includes Microwave Radio Links (MRLs) (Boccardi et al., 2014), Optical Fibres (OFs) (Soldani & Manzalini, 2015) and Copper Connection (CC) (Mukherjee, 2018) are avoided by the ecumenical limitations (Niephaus et al., 2016). Furthermore, the latest method related to the network supplies links which are free of congestion cannot deal with the anticipated expansion in the data traffic. Therefore, the networks should be taken into account as a resource restriction (Rost et al., 2014).

To solve this issue, a promising methodology is to combine the Satellite Communication Networks (SCNs) as an original part of current terrestrial infrastructures (Deng et al., 2019; Wu et al., 2019; Zhu et al., 2019). As the Sattelite (SAT) links provide broadband coverage and elastic services everywhere, these can transfer highly throughput connections and extra volume wherever it requires on a quite pliable foundation (Takahashi et al., 2019). While in comparison with the most of the Terrestrial Network (TN) (Huang et al., 2019) technologies, there are high various features in terms of permanence of the link and latency in the links regarding both wire and wireless links of the Satellite Networks (SN) (Yan et al., 2019).

Although the goal of the current methods is to provide services through Geostationary Earth Orbit (GEO) satellites it is not possible to obtain the same Quality of Experience (QoE) to TNs while the application (which are in the real-time mode) are being utilized (Niephaus et al., 2018). In SNs, when the time in signal propagation is high, the rate of the latency rises significantly; as a result, the QoE of the user will be low (Parvez et al., 2018). From the other points of view, SNs are provided to transmit and multicast different services, while they can achieve a possibly infinite number of receivers by one broadcast. Provided the supremacy of video traffic in the upcoming networks (Khambari & Ghita, 2019) and emergent edge catching methods (Chang et al., 2018). The list of acronyms used in this work is provided in Table 1.

Table 1
List of acronyms.

Acronyms	Description
TSN	Terrestrial and Satellite Network
TN	Terrestrial Network
SN	Satellite Network
IoT	Internet of Things
CR	Cognitive Radio
5G	Fifth Generation
ML	Machine Learning
SON	Self-organizing Network
SL	Supervised Learning
UL	Unsupervised Learning
RL	Reinforcement Learning
MLB	Mobility Load Balancing
MRO	Mobility Robustness/Handover Optimization
ICIC	Inter-Cell Interference Coordination
RACH	Random Access Channel
KPIs	Key Performance Indicators
COC	Cell Outage Compensation
CCO	Capacity Optimization
COD	Cell Outage Detection
ES	Energy Saving
QoS	Quality of Service
Q-L	Q-Learning
FQ-L	Fuzzy Q-L
DP	Dynamic Programming
K-MC	K-means Clustering
MPR	Multivariate Polynomial Regression
FC	Fuzzy Control
SOM	Self-Organizing Map
ANN	Artificial Neural Network
SMM	Semi-Markov Model
FANN/Q-L	Fuzzy ANN/Q-L
FL	Fuzzy Logic
AC	Actor Critic
DM	Diffusion Map
NB	Naïve Bayesian
SVM	Support Vector Machine
K-NN	K-nearest Neighbor
LOF	Local-Outlier-Factor
HMM	Hidden Markov Model
DT	Decision Tree
BSVM	Bagged-SVM
LC	Linear Correlation
RM	Regression Model
MDT	Minimization of Drive Tests
PCI	Physical Cell Identity
RLF	Radio Link Failure
MEC	Mobile Edge Computing
SDN	Software Defined Networking
NFV	Network Function Virtualization
SCN	Satellite Communication Network
GEO	Geostationary Earth Orbit
QoE	Quality of Experience
M2M	Machine 2 Machine
IN	Intelligent Network
LEO	Low Earth Orbit
RA	Resource Allocation
ICN	Information Centric Network
UAV	Unmanned Aerial Vehicle
5GPPP	5G Public Private Partnership
CNS	Communication Network System
D2D	Device 2 Device
FA	Frequency Allocation
UDSC	Ultra-Dense Small Cell
MIMO	Multiple Input Multiple Output
WCN	Wireless Communication Network
BS	Base Station
SAT	Satellite
MTC	Machine Type Communication
URLLC	Ultra-reliable Low Latency Communication
eMBB	enhanced Mobile Broadband
MNO	Mobile Network Operator
SNO	Satellite Network Operator
LoS	Line of Sight
SMEC	SAT Mobile Edge Computing
MEC	Mobile Edge Computing
CoMP	Coordinated Multi-Point
PA	Power Allocation
CSI	Channel State Information
CN	Cognitive Network
SNR	Signal-to-Noise Ratio

The rest of this paper is organized as follows: Section 2 provides the literature review of 5G and TSNs. In Section 3, the motivation and TSN demands are discussed. Section 4 represents the principal application domains. Section 5 presents the research challenges and the open problems and finally, Section 6 summarizes the paper.

2. Background and literature review

Satellite networks have been considered broadly in different kinds of research during years. Thus, multifarious points of view regarding the satellite and terrestrial network convergence have been argued. In the following subsections, we categorize the current literature to recognize the gaps related to them.

A novel survey was investigated based on the intelligent systems and the relationship between the users and the application employment. The author's concentration in this research was the awareness of the context in these smart frameworks such as the applications of the Internet of Things (IoT), energy and femtocell issues (Al-Turjman, 2019). In another research, the current challenges and technologies of both subjects (5G Networks and IoT systems) have been analysed. Then, they explained the main methods in 5G and IoT systems and discussed the future of IoT systems (Zhao et al., 2019). Furthermore, a review paper was conducted based on how to supervise the 5G network and how to use the benefit of Machine Learning (ML) techniques in this technology. Then, the authors explained about Self-organizing Networks (SONs) and how to manage these kinds of networks (Moysen & Giupponi, 2018). Moreover, new research based on key technologies such as Mobile Edge Computing (MEC), Software Defined Networking (SDN) and Network Function Virtualization (NFV) was performed. In this research, the authors also studied the current papers, scenarios and related cases that would be activated by 5G technologies and would be recognized the future high-quality service demands (Blanco et al., 2017).

Additionally, a novel approach based on SAT Mobile Edge Computing (SMEC) approach in TSNs was proposed which in this model the user devices regardless of a proximal Mobile Edge Computing (MEC) server was able to use the services of MEC through SAT links. The authors also presented a powerful network virtualization method to combine the resources of the network and additional form a Collaborative Computation Offloading (CCO) design to obtain identical computation in TSNs. Then, they explained the task scheduling design in SMEC in details and they utilized an elemental experience to assess the efficiency of their suggested CCO method in SMEC (Zhang et al., 2019). A Software-defined TSN was introduced in another paper to manage the sources regarding catching, networking and computing simultaneously. Furthermore, the researchers in this paper formed the mutual RA issue as a hybrid optimization case and applied a deep Q-L method to resolve this problem (Qiu et al., 2019). In the work presented by Hau et al. (2019), a new framework of Coordinated Multi-Point (CoMP) communication in TSNs regarding Unmanned

Aerial Vehicles (UAVs) was presented. They studied the downlink communication that UAV and Base Station (BS) could help the ground clients cooperatively with distributing the spectrum of licensed SAT networks. Their research aimed to boost the obtainable rate of the ground client through mutually enhancing UAV and BS broadcasting of Power Allocation (PA) and UAV, mastering the threshold of the interference temperature which was required on SAT network and UAV flow limitation. Furthermore, Yan et al. (2019) provided an approach to examine the impact of defective Channel State Information (CSI) on the Cognitive TSN that the secondary SN was accompanied with the primary TN via applying the underlay cognitive approach and the SAT client was permitted to enter the licensed spectrum regardless of declining the performance of the ground client. Especially, they obtained the scientific explanations for the interruption probability and capacity regarding the Cognitive Network (CN) that was presented as an effective method to assess the effects of the incomplete channel evaluations for various links on the efficiency of the examined network. Moreover, a single interruption probability method in the high Signal-to-Noise Ratio (SNR) management was provided to show the variety and coding of the Cognitive TSNs.

Table 2 shows the significant SON use cases and Table 3 demonstrates the literature review for managing the network by using ML methods with regards to SON and every key function, survey important background and ML methods which have been carried out to solve the problem are discussed here.

Table 2
List of key SON regular cases (Moysen & Giupponi, 2018).

Name of SON Function	KPIs
ES	Reduce the use of energy
MLB	Enhance the capacity/QoS
COC	Reduce pause
MRO	Reduce ping/pong result, call drops and RLFs
ICIC	Reduce the interference of the intercell
CCO	Reduce edge, cell and coverage yield

Table 3
List of previous studies of ML techniques for managing network.

References	ML Methods	Problem	Algorithm	Name of SON function
(Franco & de Marca, 2015)	SL	Prediction	MPR	MRO
(Ali et al., 2016)	SL	Prediction	ANN	MRO
(Moysen et al., 2015)	SL	Prediction	RMs	MDT
(Moysen et al., 2017)	SL	Prediction	BSVM	MDT
(Daróczy et al., 2015)	SL	Prediction	SVM, Adaboost	Core Networks
(Moysen et al., 2018)	SL, UL	Prediction	BSVM	Self-coordination
(Moysen et al., 2016)	SL, UL	Prediction	RMs	MDT
(Onireti et al., 2015)	SL, UL	Anomaly detection	K-NN, LOF	COD
(Khanafer et al., 2008)	SL, UL	Diagnosis	NB	COD
(Alias et al., 2016)	UL	Pattern identification and Grouping	HMM	COD
(Chernogorov et al., 2011)	UL	Anomaly detection	Diffusion maps	COD
(Ternon et al., 2014)	UL	Pattern identification and Grouping	Clustering	ES
(Dudnikova et al., 2015)	UL	Decision making	FL	ES
(Farooq & Imran, 2016)	UL	Prediction	SMM	MRO
(Sinclair et al., 2013)	UL	Pattern identification and Grouping	SOM	MRO
(Bergner, 2012)	UL	Planning	K-MC	MLB
(Peng et al., 2013)	UL	Control Optimization	Clustering	PCI
(Moysen & Giupponi, 2015)	RL	Control Optimization	AC	Self-coordination
(Iacoboaiea et al., 2014)	RL	Control Optimization	AC	Self-coordination
(Onireti et al., 2015)	RL	Control Optimization	AC	COC
(Moysen & Giupponi, 2014)	RL	Control Optimization	AC	COC
(Muñoz et al., 2013)	RL	Control Optimization	Q-L	MLB
(Miozzo et al., 2015)	RL	Control Optimization	Q-L	ES
(Muñoz et al., 2015)	RL	Control Optimization	Q-L	Self-coordination
(Mwanje & Mitschele-Thiel, 2013)	RL	Control Optimization	Q-L	Self-optimization
(Bennis et al., 2013)	RL	Control Optimization	Q-L	ICIC
(Galindo-Serrano et al., 2011)	RL	Control Optimization	Q-L	ICIC
(Mwanje & Mitschele-Thiel, 2014)	RL	Control Optimization	Q-L	MRO
(Qin et al., 2013)	RL	Control Optimization	Q-L	MRO
(Li et al., 2012)	RL	Control Optimization	FQ-L	CCO
(Dirani & Altman, 2010)	RL	Control Optimization	FQ-L	ICIC

3. Motivation and TSN Demands

As 5G (5GPPP) presents a particular view about the emerging scientific areas for network framework, extensive data transmission demands and mobile communication have quickened the service to combine calculating and storage supports toward a complex Communication Network System (CNS) (Wang et al., 2019). The network works in a complicated situation defined as a heterogeneous CNS due to the co-existence of diverse access systems. As technologies are improved for multifarious communication forms and services such as Machine to Machine (M2M) communication or Human to Human (H2H) interaction. Furthermore, the numerous users and devices are demanded extra spectrum to transfer information with more powerful data rates. Moreover, in a similar situation that supports 5GCNS, the uniformity and QoS in terms of space and time are provided. The requirement to boost the capacity and efficiency of the system while using QoS persists a large difficulty. Regarding the accessible sources without cooperability and dependency assigned in TSNs, scholars require to explore proper resolves for efficient networking combination. In this section, we examine and explain the motivations and the demands of TSNs.

3.1. Motivation

Next-generation CNSs concentrates on a system that has flexibility, accessibility, high reliability, high efficiency and flexible communication capability, particularly while it is required to manage the situations with large alternating traffic movement and complicated calculational tasks (Chitre & Yegenoglu, 1999). It is imperative to recommend a new integrated TSNs to allow a totally connected and wireless community.

The excess of current advancements in technologies creates a possibility to combine TNs and STs, including IoT, SDN, Cognitive Radio (CR) and the satellites with high efficiency. Even though the Device 2 Device (D2D) communication networks and the Ultra-Dense Small Cell (UDSC) can mitigate the burden effected through increasing the number of extensive demands, the restrictions of the ground frameworks to encounter the 5G technology are clearly high (An et al., 2017). For instance, the CNSs that are located based on TN and D2D systems require proper Frequency Allocation (FA) design and in the locations that clients may be prevented by houses and apartments, the D2D system performance would be diminished. Meanwhile, the UDSC systems require to handle complicated backhaul supervision policies and interference produced by the other clients and cells (Kamel et al., 2016). Now, it is time toward TNs to explore cooperation from SNs as the united networks can make extra advantage than the disadvantages.

From one point of view, SNs in the united networks can improve the coverage of the system as well as transmission capacity. First of all, they present primary links to the clients, by utilizing the benefits of Multiple Input Multiple Output (MIMO); furthermore, SCNs can present a high volume of communication connections (Jiao et al., 2018). Secondly, TSNs intend to present a secure communication among different technologies and SCNs can promote the fast-moving architectures with more limited handover system. Especially, the convergence increases the service domains to the sky. For example, SCNs cannot just spread general information to the ground carriers, but also, they can do this through aircraft and UAVs (Khawaja et al., 2019). Regardless of the telecast SCNs ability, the interference will be growing and require further allocation. Thirdly, from the geographical point of view, in very distant areas or in the countryside regions the use of TN infrastructure is quite challenging and the role of SCNs is important to communicate the information (Di et al., 2019).

From the other points of view, the combined TSNs present secure and on-demand Wireless Communication Network (WCN) to destination regions. During the natural catastrophes such as a tsunami, earthquake and snowstorm occur, the infrastructure of transmission in the TNs is impaired sharply. In this case, SCNs can be used for connectivity. Furthermore, in a few areas that hold sports matches and celebrations, BSs in TNs are regularly overload (Yang et al., 2017). SNs also can support the TNs and the offload tasks to mitigate the requirement.

Moreover, SNs propose an effective solution to handle the transmitting information to the CNSs. By transmitting the information to TNs, SCNs can address the difficulties created with numerous demands of similar information in the TNs (Feng et al., 2017) and this is in comparison with the traditional TNs. Additionally, by using the client-centric information like information demand delivery, SCNs can promote the information more precisely and efficiently to BSs.

From the implementation viewpoint, a few current important SAT plans have previously set the basis of the TSNs convergence. There are a number of mega constellation SCNs comprised of LEO SATs that they have introduced to perform in the space communication networks and these consist of OneWeb, SpaceX, Google System, LeoSAt and Kuiper Amazon (Sánchez et al., 2017).

The LEO SATs with very low latencies play a crucial role in the 5G communication networks and these are time effective and adjustable to extend. In addition, in comparison with GEO SCNs, the loss of signal in the LEO SCNs and in the TNs would be poorer because of a more precise propagation range and it reduces the ambiguity regarding the link state and supports the terminal on the TNs to reach to the perfect design.

Regarding the fully connected and WCN community, it is necessary to offer a new hybrid TSNs. To achieve this goal, the RA management of SCNs should be resilient and adaptive to employment demands. From the implementation point of view, accepted standards for hybrid TSNs limit the unique service-producing capability (Lagunas et al., 2015). Additionally, the problem of designing the TSNs should be solved and a new controlling infrastructure that can arrange the assigned sources should be reviewed and improved for the unified information transition framework. To sum up, the motivations of TSNs coverage are as follows:

- Increasing the coverage of the service region and presenting QoS secured services
- Equipoising ineffective communication RA
- Transferring the information to the network edge.

3.2. Demands

The goal of hybrid TSNs is to present a network that can help everyone everywhere at any time to communicate with each other. It is essential to overcome different hurdles. When the network function efficiently as a reliable and universal wireless service framework, the scholars should take the subsequent demands into account:

3.2.1 A Broad Variation of the Supporting Services Eligibility

TSNs in the upcoming CNSs should hold extensive applicability in SNs as well as TNs. It means that the coming network should combine CNSs, navigation frameworks and the remote sensing frameworks simultaneously and it can present firm settings, guarded settings, guaranteed settings and marketing settings (Celandroni et al., 2013). It should provide to customize the settings with diverse preferences, therefore, meeting the demands of the 5G communication networks consist of large Machine Type Communication (MTC) (Shariatmadari et al., 2015), Ultra-reliable Low Latency Communication (URLLC) (Popovski et al., 2019) and enhanced Mobile Broadband (eMBB) (Anand et al., 2020).

3.2.2. Monolithic Coverage of the Services

The unique serviceability has two applications that include as follows. From one point of view, TSNs are in the coverage of the same services. This means that during the time that the traffic and the capacity are high in the TNs, then SCNs can present a complement to overcome the requirement regarding the transmission of the data. More particularly, in this case, SNs play as a relay node (Nomikos et al., 2019) or piece of the backhaul network (Liu et al., 2019). The SAT links should present another route rather than a single link. By this, the required information should be spread accurately over TSNs. On the other point of view, for the regions that require the ground bases such as remote or countryside areas, SNs play important roles in such distant regions. Actually, SNs in these cases can strengthen the security through the presenting connected platform services and allow the scalability with multi-broadcasting the data to the edges of the network.

3.2.3. Management of the Hybrid Network

It is assumed that in the hybrid framework, a network control system should be introduced to enhance the effectiveness of the communication. The various communication structure with combined benefits requires a united control system that includes a collection of rules and interferences cooperative with a resilient theory. It is speechless to update the software regarding the payload of the conventional SATs, as the latest technology is time-consuming (Rao, 2015). The settings will require huge cost support and cause the stability of the network control. Furthermore, there is a problem that various operators improve their bases while there are no rules. Moreover, the case in which various operators improve their bases during no rules has been enhanced leads to an ecosystem that is extremely complex to control. The solution to this issue is to take an evolving system to unite the autonomous networks. The principal issue to be done is a concern that who manages what. Is it Mobile Network Operators (MNOs) catching administration of the Satellite Network Operators (SNOs) or another method?

3.2.4. Guarantee the Reliability

The TSNs is like a complicated CNS which is included of spacecraft in diverse orbit SAT and ground BSs. SAT CNS are sensitive to safety violation dangers and eavesdropping menaces since the channel of wireless broadcasting is permitted to everyone who has a similar receiver. The basic communication plan ends in a feeble safety framework, particularly for the situations in which there is an eavesdrop. Moreover, for some business SNs in the space, there is a demand separation as they are utilized with an army and residential public living; therefore, it is requested for a firm flexible and the safety-guaranteed information CNS for risks and attacks (Xiong et al., 2019).

4. Principal Application Domains

Combined STNs connect to various communication sources and they allocate to the domain of space, time and frequency to improve or allow varied service demands via the trade. It is anticipated to enhance the quality of the public by creating findings in universal connectivity. For years, discoveries in micro and nano SNs have quickly grown and have been highlighted in further investigations (Jiuling et al., 2018). Especially, joining with M2M, SNs play important roles in numerous applications like monitoring the environment, transferring the information, etc. (Meloni & Atzori, 2017). Furthermore, the modern framework predesignates the business and meets demanding reliability for the upcoming services.

4.1. Civic security and disaster mitigation

Civil security and emergency mitigation present the secured communication support following the condition which the TN defaults to operate regularly while unexpected artificial accident occurs. Requiring TN infrastructure that supports backhaul information and individual in the crisis region are denied the communicating outward. The combination of STNs performs a significant effect in changing the conventional network in a strong and immediate reply. For instance, SNs in the earthquake situation that nearly all the eNodeBs are damaged can build multi-hop space backhaul (Zhang et al., 2016).

4.2. Supervision of the jungle fire

Controlling the fire of the jungle is critical for managing the ecosystem and it requires proper planting and farming systems. Jungle fire normally occurs in countryside regions that hardly can expand the terrestrial links and make large financial troubles and menace of lives. An expected notice and prompt destruction are useful to diminish the loss to the lowest level in the conventional form. Moreover, the analysis of the image and remote sensing approaches were performed for SNs to recognize the hot spot. However, because of the characteristics of these approaches, they cause many problems to the swift reply. Regarding, the joined SNs and sensor networks, a method was presented for efficient preparation of specific fire detection, For instance, sensors for detecting the fire, the stations for weather monitoring and so on were utilized to economy Satcom for installing SFEDONA (Calarco et al., 2010). Therefore, the service made by STNs was proper for monitoring the fire and other environmental assurance actions.

4.3. Intelligent Network (IN)

The combination of the spread power grid and information technology has decreased the consumption of energy in various energy-starved sections for ages. M2M communication for monitoring the distribution of the energy increases the performance of electrical networks. Furthermore, defining the intellect, sensing the improper distribution and modify the scheduling of the power in the right time is important in IN. In energy transportation, managing the power control in a real-time way from the generation site to the consumers is completely crucial. Alike to the monitoring of the fire, long-range broad region grid promotes the low power broad region girds more accessible to space grid for more reliable distribution and communication monitoring (Burian et al., 2019). Since the communication and distribution monitoring in the grid space require a huge region, SNs at a great height able to improve the additional power distribution. It is anticipated that the grounded sensors can help the SNs synchronically in different IN purposes.

4.4. Well-being and health

In the era of technology, the combination of STNs for inaccessible health advising or telemedicine is an enthusiastic subject to develop the individual’s life throughout the globe. Low Earth Orbit (LEO) SNs can implement strong connectivity to the health centres with the areas that individuals require help and support. Particularly, the health application in STNs is one of the important issues considered in far scenarios. Throughout the past decades, some structures were designed for far health scenarios. The communications between audio and video should be assured since many systems demand precise questions and comments. To obtain this aim, STNs ensured QoS for better performance (Lin et al., 2019; Zhang et al., 2019). As far as association network systems might be affected by malware in the forthcoming future, more consideration should be taken into account on the STN’s security (Romano et al., 2019).

5. Research Challenges and Open Problems

Until now, we have conducted a review of various viewpoints of combined TSNs. According to the previous works that we studied, the challenges and open problems related to the networks are critical in the upcoming discussions. Communication system, control, security scheme and RA acquired in the implementation of the combined network processes are challenging. But there is not any combined architecture that would be adaptable to each scheme that appeared in the forthcoming generation of the networks. In this part, we distinguished the challenges and difficulties regarding the propagation of signal and open problems of the future improvement viewpoint as follows.

5.1. Structure

In the combined TSNs, the scalability is a primary issue. However, the structure is resulting to adjust different platforms and requires high performance and effectiveness. The contemporary structure might not be cooperative with the requirement of 5G technology. Therefore, three important challenges can be developed as follows:

5.1.1. Networks Combination and Various Supported Protocols

Regarding the future services which will be complex, remote sensing, communication networks and so on must support to resolve the issue related to the inadequate functioning technique in the remote information frameworks. Soon, the services are singularly established by autonomous architectures. To enhance the communication network, a combination of protocols for varied services should be guaranteed since it is the basis for industrialisation. For instance, UAV (Laliberte & Rango, 2009) is described as a different protocol in the wireless communication networks, as lately it is joined to worldwide abilities. Furthermore, there are several SDN phases that will proceed to release. Also, this protocol can be used with versatility and has more economical charges for installing. Moreover, regarding SDN systems, they can present a comprehensive design and designate the UAV protocol to the proper region. The mixture of SDN and UAV is quite a helpful approach, however, extra special terms should be taken into account while the administrator requires to join them toward TSNs. Certainly, SDN system-based UAV protocol performs more reliable. Additionally, in emergency regions and fighting ground, the quasi-stationary quality is proper to create a moderately firm network topology. Besides, effective resource usage in a similar situation is remarkably significant as traffic requirements are notably high (Xiong et al., 2019). As SDN system-based UAV protocol with TSNs combine mutually, the scalability and cooperability framework is required to meet the complicated conditions in TSNs to be flexible, versatile and smart in terms of payloads, topology and bandwidth. It is important to unite the designations of modern technologies and innovative data communication systems. For example, how to implement the millimeter Wave technology or terahertz antenna into the upcoming STNs? How to ensure the data communication of remote sensing network or navigation network?

5.1.2. Combination of specialized frameworks

The hybrid TSNs are organized uniquely to develop the performance regarding the various viewpoints. But there is a demand for collaboration between varying layers and objects to boost the total performance of the system, despite the fact that Software Defined Network (SDN) trials are used and completely examined. More reliabilities, in connection with lately developing technologies, might bind an extra resilient framework. For instance, in the other work, the authors suggested an SDN framework based on the ICN method for hybrid TSN. In their model, they presented QoS, a unique communication framework and adjustable resource usage. It was considered that the comprehensive framework with cooperative and modern methods could obtain more advantages (Zhang et al., 2016).

6. Conclusion

TSNs have been increasing as the next generation of CNSs and they are a universal and reliable network framework for different public purposes. To provide the requirement of the 5G CNSs, the TSNs orchestration will be an avoidable trend. SAT networks functioning at high attitude can present a huge service and Line of Sight (LoS) links to client devices and terrestrial stations. Furthermore, the broadcasting capability can diminish extra charge for that SATs and can transmit necessary information at the same time. On the other hand, the hybrid SNs and modern TNs are a complex issue and the characteristics such as fast flow, high latency, broken links and resource limitations make SNs separate from the different networks in the TNs. Therefore, the extra specifications should be taken into account to united TSNs.

This paper reviews a full view of the contemporary researches regarding TSNs and ML techniques. To sum up, in the beginning, we present the literature review regarding the hybrid TSNs. Motives and the demands of TSNs are discussed to fully understand the ideas of the collaborative networks. In the motivation section, we categorize the benefits made by the hybrid TSNs. These networks produce advantages to CNSs to perform the hybrid demands and these services have characteristics like capability, unique coverage, management and safety. Furthermore, to present the possible hybrid information efficiently, important enablers in SNs are summed to present a comprehensive improvement design in space. In the future studies, our research will be based on hybrid ML and evolutionary computing methods (Ahmadi, 2019a, 2019b, 2020; Ahmadi & Akbarizadeh, 2018; Ahmadi et al., 2019; Nilashi, Ahmadi, et al., 2020; Nilashi, Samad, et al., 2020) in order to boost the rate of reliability, speed up the transmission of the information among SNs and TNs, and also reduce the complexity of the system.

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