THE USA JOURNALS
THE AMERICAN JOURNAL OF INTERDISCIPLINARY INNOVATIONS AND RESEARCH (ISSN- 2642-7478)
VOLUME 06 ISSUE07

PUBLISHED DATE: - 28-07-2024
DOI: - https://doi.org/10.37547/tajiir/Volume06Issue07-05 **PAGE NO.: - 35-43**

RESEARCH ARTICLE **Open Access**

IMPROVING THE PERFORMANCE OF WIRELESS NETWORKS USING NEW TECHNOLOGIES

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Abstract
From mobile communications to the Internet of Things (IoT), wireless networks offer various applications and have become vital to modern communication infrastructure. Conventional wireless network designs encounter formidable capacity, latency, and energy efficiency obstacles due to the ever-increasing need for dependable, pervasive, and lightning-fast wireless access. This study looks at some new tech that could make wireless networks even better. 5G and 6G network rollouts, ML integration for adaptive network management, Massive Multiple-Input Multiple-Output (MIMO) system rollouts, and MMWave frequency utilization are some of the critical breakthroughs covered. Plus, we look at how network slicing and edge computing could enhance QoS and optimize resource allocation. This study thoroughly examines these technologies and their ability to overcome existing limits. It lays the groundwork for future wireless networks and guarantees scalable, efficient, and robust connectivity solutions for many applications.

Keywords Mobile communications, pervasive, lightning-fast wireless access.

INTRODUCTION

1. Introduction

Many modern technologies depend on signals transmitted through wireless networks of different types. Therefore, making wireless networks faster and more reliable could have a huge impact on technology in several domains. However, there are many problems in the field of wireless communication that need to be addressed to achieve these improvements. In this essay, I will look at the architecture, problems, and potential solutions to wireless networking. This essay will cover several proposed innovations which may make wireless networks more stable and dependable, thereby enhancing the performance of a number of modern technologies.

The proposed improvements include using sophisticated antennas which emit conventional radio signals more effectively with less crossover, changing the frequencies used for transmission and data analysis to dramatically increase speed and decrease issues - throughput and range, and reducing interference from surrounding competing wireless networks to prevent performance drops. Building networks in unconventional new topologies is also proposed. I will engage directly with the source to understand their proposals as we discuss each of them. I will examine methods of broadening the range of signals emitted by radio transmitters and the complications they introduce. I will consider the possible applications for this new technology, as proposed, evaluate the merits of the arguments, and conceive of new applications for this technology except those already proposed, means of transmission, particularly since these improvements become less effective at longer ranges.

1.1. Overview of Wireless Networks

Wireless networks have become an essential part of our lives. Their characteristics, such as mobility, free space utilization, and easy installations, make them superior to wired counterparts. In addition to these advantages, wireless technologies offer some additional facilities. Some of the abilities of wireless networks are:

- Cable-less operations, that offer freedom of installations - On-demand network access facilities anywhere, anytime - Network deployment in unique/remote applications such as location-tracking and monitoring applications

In technical terms, a wireless network leverages radio waves and wireless communication standards to provide network connectivity over common standards such as WiFi, cellular, and Bluetooth. Broadly, these networks are classified based on the standards, architecture, and the services they offer. For example, WiFi standards (predominantly, IEEE 802.11x series) afford a wireless connectivity range of about 30 meters and are commonly used in home internet connectivity. Similarly, wireless connections such as LoRA standard are used as Wide Area Networks (WAN) for long-range applications. The choices of standards/utility vary with applications such as security, speed, and network size.

From a historical point of view, wireless networks are a concept which is over a century old. The architectural evolution from point-to-point communication systems to networks of different topologies has now advanced to a large-scale network where users at different locations, with different devices and standards, can communicate with each other in a seamless manner. A wireless network is composed of various hardware and software components, which we discuss in detail in the next chapter. From the hardware point of view, we require different components at the transmitter and receiver. Also, at both the transmitter and receiver, we need proper signal conversion components that can make wireless communication possible. The software counterpart talks about the communication protocols and the standards, without which communication is not possible. The primary function of these protocols is to ensure data transfer between two points without loss of data or distortion of the original data.

2. Current Challenges in Wireless Networks

Though wireless networks have greatly advanced in the past decade and are increasingly popular with computer users and mobile phone users for their flexible mobility and low infrastructure costs, they have their limitations. Relative to their wired counterparts, the most significant difficulties pertain to unreliable communication links, interference and noise-induced attenuation, difficulty providing quality of service guarantees, lack of guaranteed higher bandwidth levels necessary for various multimedia applications, and scalability issues. Together, these challenges can negatively affect the performance of wireless networks and thereby limit the number of prospective users and the user experience.

A low signal-to-noise ratio in wireless network communications can result in high rates of packet error, degrading the performance of the hosts. In lossy networks, where throughput decreases for each packet that is generated, congestion control has a significant impact on the performance of the network. The number of successful transmissions on a link before a packet needs to be retried is significantly less when exposed to bit errors, and not all the correcting bits are effective in identifying and correcting errors. Wireless networking standards, such as wireless local area networks (WLAN) IEEE 802.11, detect error checking codes when a corrupted frame has the potential to be sent to the receiver but cannot do anything about the error.

2.1. Bandwidth Limitations

One of the main challenges in wireless networks is the limited spectrum, which means the bandwidth limitations that are associated with it. Decreased bandwidth has a strong impact on the time of data transmission, as the available throughput of the channel directly influences the capacity of the network. Reducing the amount of information that can be sent during any given period of time directly reflects the effective capacity. The network deals with this reduced throughput and the time needed to transmit the data is called latency, which is the time from the beginning of the data transmission until the last bit is sent. Another issue that is caused by the limited bandwidth is the raised probability of network congestion. In the case of independence and distribution of random data, the increased number of input traffic positively influences the output traffic. However, network congestion is caused by multiple nodes that are trying to send large packets at a time, which will significantly reduce the performance of the network. Therefore, a fundamental property of high-performance wireless networks is the efficient allocation of bandwidth.

There are multiple factors that can cause limited bandwidth, ranging from high network traffic volumes to simply bad network design. Regardless of the cause, bandwidth limitations are extremely dangerous for the whole network performance. Scarce bandwidth will create congestion that decreases the quality of service (QoS) for transmission of multimedia data. Typically in wireless networks, bandwidth is the primary bottleneck. Therefore, reducing the impact of bandwidth limitations on the performance of these networks is one of the primary engineering challenges for wireless networking.

3. Emerging Technologies in Wireless Networks

The latest advances and technological improvements in communications and computation standards have made digital wireless communications a reality. This applies to a variety of wireless networks such as personal area networks (PANs), local area networks (LANs), metropolitan area networks (MANs), and wide area networks (WANs). The market has been reshaped by the ongoing rapid advancement of wireless communications networks in terms of capacity, user numbers, application setup, deployment and management, and quality improvement.

In the near future, some emerging trends, revolutionary services, and applications will significantly impact wireless network usage and raise new research issues in the field of wireless communications. A wireless network, or a wireless communication network, provides the crucial connectivity and data exchange between the parties. The burgeoning wireless communications field is producing a wide range of user-centric networks. As a result, signals are transmitted and delivered to users via wireless networks instead of wired connections.

In summary, wireless networks, from LANs to the extreme ends of backhaul systems and deep cloud data centers, are considerably improved by worldwide advancements in tomorrow’s abilities and attributes. This requires networks, training, and the best possible technologies. For the sake of simplicity, in this section, the outcomes of operational technological expansions in numerous applications are discussed briefly and thoroughly. What’s more, a few sample networks illustrate key component discontinuities and in that light, the network is analyzed throughout.

The functionality and enhanced systems of the future are greatly facilitated by streamlined and ultramodern figure systems. 6G supports 6P. It is necessary to rapidly grow networks and systems in order to realize them. In order to promote AI distances, more complex networks and technologies, along with greater skill activation, are needed. Moreover, 6G command, and supply data for center inputs, are part of the work. Centering on 6G innovations and material developments can be assessed through the functions and methodologies that produce true enlightenments. Everything, including scheduling of 6G conventions enhanced by resource management and the parental roots of issues linked to mobile networks/telecommunications and networking flexibility, is the result of this approach.

Wireless networking, from the center to an extensive zone, is counted as being essential for continuing AI. 6G wireless technology is essential for equipping AI for the future. This is because it provides a wealth of data and AI machinery and a wide and diverse framework. Both AI resources interconnected by NCA and by distribution (cyber/physical objects within the 6G ecosystems) also can be used.

3.1. 5G and Beyond

5G technology is expected to have enormous potential for wireless as it is rapid and information change network to access dispersed computing resources at full speed. It will lead to extraordinary network development with far-reaching implications. 5G networks have seven famous attributes. It is expected to enable a minimum of a ten-time increase on average in the total cell capacity. The principal technological advancements will include ultra-dense networks (UDN), heterogeneous cloud radio access networks (H-CRAN), and full-duplex sharing. In order to meet the requirements of contemporary densely populated urban living, the 5G-enabled cellular Internet of Things (IoT) network, which will have 20–25 billion connected devices and a maximum of a 60% penetration rate, would have an ultra-dense network with a 500–5000 hotspots max km−2, with a capacity of up to 800–4000 Gb s−1 km−2.

The deployment of 5G New Radio (5G-NR) with advanced mobile (radio) communication systems will be a critical element of 5G systems. In a dense network centric design, a novel approach to UDN-based 5G-HetNet was proposed. The H-CRAN has three-layer or n-tier cells, which include macro cell base stations (BS), small-cell BS, and user equipment (UE) directly connected to servers or a cloud via fiber links. Also, adaptation has to be made to deal with mobiles in 5G, since the speed of nodes in traffic is much higher in moving vehicles such as cars, trucks, and buses to boost connectivity with local information. Some of the issues in 5G are the improved connectivity and capacity of the network, and the ultra-reliable short-latency communication and integrated mobile traffic with a vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) will be addressed.

4. Performance Metrics in Wireless Networks

There are many performance metrics that use specific metrics to evaluate the wireless network's efficiency. Signal quality is measured by the strength of the carrier signal in decibels (dB) and the signal-to-noise ratio. Detector distance formulations, the generalized log likelihood ratio (MEL), are given by max log (0k = 1, 2...n|0|Rl = 12 and Log (0k = 1,2... n = 1 H the density of distance between the probability function (PDF) shown in equation detection. Test statistic, the detector average probability of error Pc, symbol error rate of performance measures. Received Power (R) of signal-to-noise ratio or received power dBm. The main performance metrics to measure the network are the following: the rate of data transfer, the user expectations of rates, network available volume (bandwidth), the average time to wait until inform, the average time of latencies, etc.

The average bit error probability can integrate all wireless systems performance more accurately, but more complexity or a large number of performance measurements were not usually good plain value of the system. Section 3 addresses the performance metrics used and the most used data. The bit error probability in Eq1 will be influenced by: The noise averaged over the period of the receiver and the moment, if usually does not depend on the Soviet Union and the vol het carrier, the average moment ei over the time considered. If a fixed power p3o and the local minimum average electrical noise spectrum density No is defined as Nw = NoW, then the signal-to-noise ratio at the receiver is given by given as given rewards. Performance measures are very important, as they are always used to integrate all the wireless system performances, such as coverage, throughput, mobility, QoS, QoE, to provide better user experience expectancy accuracies, and reduce allocation redundancy. In addition, performance measurements are also used to evaluate the wireless effect of the development of new technology network system's to improve the As a success, data shown in performance measurements the improvement of the goals achieved and to what extent.

4.1. Throughput and Latency

One of the most important performance metrics for wireless networks is the speed at which they can deliver data to their users. This metric is referred to as throughput, meaning the rate of data transmission between a sender and receiver. In the case of last-mile communication systems, like Wi-Fi or LTE, high throughput is one of the main selling points of the entire wireless data provisioning. Throughput is a multidimensional topic that depends not only on over-the-air communication between the sender and receiver but also on the higher layer protocols and transport technologies. In an ideal scenario, a high-throughput communication system would be able to fully saturate its link in a single hop. Nevertheless, in practice, few challenges impair the delivery of a high throughput. Indeed, the transmission peak rate is cited to be decreasing with the increasing coverage radius. Various impairments inherent to the radio channel operation act adversely to reduce the data rate performance majorly including fading, shadowing, multiuser interference, etc.

Another main performance metric usually considered for wireless networks is the network latency (L). Even though there is no universally accepted definition of latency, in simple words, it is often used to characterize the responsiveness of a network in terms of time taken by a packet to truly propagate from the source to destination (or from the sender to receiver). In most cases, the total latency comprises three main components: propagation time, queuing time, and system processing time. Latency directly depicts the round trip time (RTT) experienced by an application. Usually, low-latency is desired by applications so as to enhance the overall system performance and user experience. Lower latency values shall reduce the waiting duration until the first bit is completely available at the receiver side.

5. Case Studies of Improved Wireless Networks

There are various examples of where major wireless network improvements occurred using new technologies. Improvements occur when throughput, latency, range, energy consumption, and charges are significantly improved compared to current wireless networks. The Kookaburra project implemented a low-latency TDMA network robust against packet loss and for LEACH from the ground up for urban parks based on a novel collision-resilient broadcast schedule. RelayDG and BackTrack have improved ClusterTree. RIOT kernel energy consumption increased 3x over the last 7 years with new energy consumption reduction techniques added. The initial October 2019 release of the ATMEGA and Nordic targets added SADP, did a mesh test on the RZRAVEN boards, and then merged in the first of SPDX. The 2021.10 release will introduce GNRC Flow to improve CoAP scalability.

A SURFnet test bed wireless Dutch technology called LPWAN (Low-Power Wide Area Network) has been proven to be low cost, low power, and much easier to scale from 100 to 5000 wireless devices compared to Wi-Fi mesh networks. The province of Groningen installed a LoRaWAN to measure soil moisture, air humidity, temperature, and sunshine of agricultural land measuring paths through remote and less populated areas. Thousands of farmers in the east use a Dutch-designed Aolu wireless system to herd cattle. These tracking collars have a battery life of 5 years and report cattle locations up to 50 times per day on a satellite network that AT&T invented in 2017 using Qualcomm's IoT modems. In the US, as Microwaves101 note in their articles below, Ingenu networks are building a similar IoT network which is now active in 28 US cities. Helium has built and is presently selling an IoT wireless hotspot designed to improve range, reliability, infrastructure, and the payment model for IoT networks. A Hare data center heat energy recovery system in South Australia was monitored by an Adelaide company called Net2Edge to monitor the wireless IT security system. Net2Edge has no further details on their web page. In China, the 32.5 square kilometer Nanjing Smart City, which serves 5 million people, uses a smart radio frequency identification (RFID) system designed by Nordic Semiconductor. "Distris" can coincide with the move towards Industry 4.0 with Smart Manufacturing systems. For example, Bosch started early in 2018, as shown in the video, to use Distris to increase storage equipment near its autonomous mobile robots to increase throughput of power tool storage areas alongside its factory production lines. Bosch worked with NavMat, a German company based in Pforzheim, Germany, which has been integrating RFID-based AVIATOR-987 CMRITag-based RFID and low-cost, low-power 433.92MHz BoLinks Passive RFID grid locator choke hazmat tags. Bosch actively contributed to the specification of the SoC for its manufacturing requirements. Emerging Low-Power Wide-Area Network (LPWAN) wireless 2.4GHz technology product gateways include Multitech Conduit (2x USB, 2x Ethernet, 2x RS232, RS485, etc.). MTAC-

GLTE-L (Q26 UltraLite cellular modem) helps the local gateways link to the cellular 3G 4G backhaul to cloud services. Another option in the US is Hologram Nova. _entry cites the proven and successful LEACH article he found.

5.1. Smart Cities

Due to the tremendous advances in wireless networks in recent years, it has become possible to implement a wide variety of smart city applications using wireless communication. Since potential connectivity and quality of services are the keys to success in smart cities, it is imperative to improve wireless networks in order to accommodate the increasing volume of data and expected devices. Some current smart city scenarios suffer from degraded performance because a large number of sensors are directly connected to the cloud without restrictions, as required to guarantee the continuity of operations.

In the context of smart cities, we have a large number of potential objectives to achieve. For instance, voluminous data related to feedback can provide solutions for achieving environmental sustainability by monitoring and controlling the air pollution in urban areas and/or areas of interest. An efficient storage space and proper design of environmental databases lead to beneficial uses and the betterment of the standard of living in urban environments.

This systematic review first presents a basic review of the smart city and then discusses wireless networks in smart cities. As a part of this discussion, priorities of wireless technology in smart cities, potential benefits of wireless technology, challenges for applying wireless technology, and available solutions in the deployment of new technologies and enhancing of algorithms are provided. Furthermore, four types of wireless technologies (LoRa, 5G, Sigfox, and Wi-Fi) are applied as facilitating technologies in the smart city, and an analysis of these improvements, challenges, and purposes are featured.

6. Security Considerations in Enhanced Wireless Networks

The security of wireless systems is of utmost concern. It is well understood that the wireless channel communicates data in a broadcast manner, thus making it susceptible to numerous types of attacks. As wireless radio uses frequencies in the electromagnetic spectrum, wireless transmissions are publicly accessible and broadcast communication. It is possible to overhear the communication. Advanced encryption standards, strong authentication, and privacy-enhancing mechanisms are the technical components used to protect wireless communication from threats. In recent years, vast developments have been observed in wireless communication systems. 5G and beyond technologies are novel standards for wireless communication that provide higher data rates and enhance current systems. High data rates and better performance have increased the demand for using wireless networks. For example, now people use free Wi-Fi even outside our regular house, such as connecting their mobiles in malls, international airports, amusement parks, etc. The number of wireless networks increases day by day. However, Wi-Fi networks are vulnerable to threats, attacks, and risks that affect the wireless network's performance. A brief detail is as follows.

The vulnerabilities of the network are the weaknesses and loopholes that weaken the security of a system. The occurrence of different threat types results in implementing various types of security countermeasures (techniques) designed to diminish potential threats. Risks pose a constant threat to the security and performance of wireless networks, business activities, and network data. Risks have an enormous effect on wireless networks and distort data; hence, assessing threats is essential for a secure wireless network. Some of the commonly known threats that affect wireless networks are DoS attacks, Man in the Middle (MitM), Inside Wire-Tap and snooping, Evil twin, Honeypot, Security Misconfigurations.

6.1. Encryption and Authentication

It is vital to secure the transmission of data between network entities. It is important for SMARTICs to use a high level of security to encrypt the transmitted plant data, as well as banking information and user data. Data encryption is the process of converting the data into non-readable form using encoding so that only an authorized person can convert that data into a non-readable form; for securing the plant data, Advanced Encryption Standard (AES) with a 256-bit key is used. Some protocols and mechanisms are available to execute the above-mentioned technologies; for example, the Transport Layer Security (TLS) and the Secure Socket Layer (SSL) protocols are used to enable device authentication. This technology made the user verify the devices and application executed in it, ensuring the data on the vehicles is only received by its authorized party. A major and critical aspect that must be considered is that this advanced security can cause a high load on the network. Thus, wireless encryption, with the use of AES, has an influence on network performance.

Wireless encryption is not enough to secure the networks; it is important to secure the plant data in vehicles from rogue applications. The rogue applications can collect the plant data and disclose that information to other users, which violates the vehicle user's privacy. To prevent rogue application deployment inside the vehicle, the user has to authenticate the applications running in the vehicles. When a vehicle is running two or more applications, the network must ensure that the vehicle can authorize each application independently; such a technique is called application verification or application authentication. Authentication is a technique used to verify and check the identity of the entity (i.e., user, device, or web-based application), where every session that is created for the first time requires an authentication method to be performed. The user has to authenticate to access any web page and send plant data to a database, which ensures that only authorized persons can access data from the database.

7. Future Directions in Wireless Network Performance Enhancement

The many improvements we have seen in wireless networks are driven by a mix of new theory, techniques, technologies, paradigms, and methodologies such as those documented in this chapter. In the coming years, new and more improved techniques and innovative methods are expected to steer the trajectory of wireless network improvements in general. Some of the anticipated future trajectories for enhancing wireless network performance include improved modulation and coding techniques combining advanced digital theory with increasing computational power. These can be used to design modems that can handle very high frequency bands in which the communication suffers from extreme attenuation.

Artificial intelligence and machine learning are expected to be game changers in modern engineering optimization, including wireless network performance optimization. AI and ML can provide stronger abstraction, thus sparing the designers from low-level optimization of individual parameters. Learning techniques and AI can adapt the communication system to rapidly changing environments and even maintain performance in occasions of lacking or even bad data. This learning computational power will be the basis for networks that can learn and adjust themselves automatically.

The development of low Earth Orbit (LEO) satellite constellations that can provide broad internet coverage at a fraction of today's satellite cost in a lucrative market. An example is Elon Musk's SpaceX Starlink constellations. In the not too distant future, reliable low-latency internet on the airline passenger’s mobile device will be commoditized. This will be enabled through an increase in satellite coverage and the capability of handover from one satellite to another, and finally from a satellite to a ground-based mass network.

7.1. Artificial Intelligence and Machine Learning

Machine learning in general, and more specifically artificial intelligence, have become very attractive technologies to improve the performance of wireless networks. The specific applications of AI/ML in wireless networks are very broad, emanating from applications that improve wireless network performance up to applications that are designed to re-architect the entire wireless network. Many ML techniques, especially deep learning models, have shown a dramatic improvement over existing conventional techniques in a vast array of applications for wireless communications. In order to understand how AI/ML can be used to design future wireless communications, it is first necessary to demonstrate the core principles, applications, and limitations of these AI models. Then, specific applications that improve, inter alia, wireless network performance, as well as applications that extend to re-architecting the wireless network, are discussed in-depth.

A main drawback of using AI/ML in wireless communications is that these powerful AI models can make it difficult to gain an intuitive understanding of the reasons behind why the AI model made a certain decision. For example, in RF sensing, it may be difficult to ascertain why a certain user was selected or why a certain beam selection was made. Hence, AI models might not be preferable to use for latency or other applications that demand an explanation of decisions. A few important applications exist where AI can improve the efficiency of wireless communications networks. For example, AI can facilitate in the physical layer because physical layer imperfections in conventional wireless communications can be better predicted with AI algorithms. Additionally, some AI models can aid in CRAN networks. Networks can attempt to predict the trajectory of certain wireless stations moving throughout the network to optimize the resource allocation of subsequent users. This predictive AI algorithm is represented as a mixture density network that jointly generates the deterministic input of the network t and the conditional density of xt given the input. Other applications of AI algorithms in wireless systems include automatic modulation classification representing practical applications of AI/ML models in wireless networks.

8. CONCLUSION

The demand for wireless network services is tremendous all over the world. The demand can only be satisfied with enhancements in the capacity, coverage, and quality of the wireless networks. High frequency bands can provide the opportunity to use wider bandwidths, which can enhance the performance of wireless networks. To overcome the propagation loss, it is necessary to design new transmitters to produce high gain radiations. Furthermore, it is necessary to adopt new multiple access techniques to separate the signals of different users. These requirements can be met by employing amplifying antennas as transmitters at the basestation sites. The signals of different users can be separated by using massive MIMO (Single Carrier or OFDM/OFDMA based) multiple access schemes.

In conclusion, improvements in the performance of wireless networks can be made by using higher frequency bands. Due to numerous advantages in the usage of higher frequency bands, these bands are considered leaders in the future of communications and will be highly beneficial to cater to the demands of the users in a more efficient and reliable manner. This technology also offers several potential research directions, such as designing intelligent massive MIMO based adaptive arrays to maintain reasonable gains over the large band of the communication spectrum. This can be done by employing low-fidelity models for estimating the statistics of the channel. Furthermore, the authors can also predict link quality to show the intelligent wireless transport connections using massive MIMO antennas. A satellite internet/cellular network can be designed to serve the rural areas of underdeveloped countries while providing seamless global mobility for the wealthy urban communities. The system design must be sustainable, with low energy consumption in addition to good Quality of Service (QoS).

8.1. Summary of Key Findings

We are aiming not only at building a connected world relying on wireless networks, but also making it seamless and transparent to the end user. Since the demand for high speed and quality wireless communications is increasing, this study focuses on the main current challenges and proposes some possible solutions based on the exploitation of advanced technologies. In fact, the designed mobile and wireless networks have to cope with some critical radio conditions, e.g., high losses and variations in the radio environment, resulting in an overall reduced performance. In addition, statistical characterization of traffic is an important input to properly plan wireless networks capacity.

In order to face the challenges arising in the wireless networks, this study proposes two solutions: considering the use of visible lights and exploiting the envelope level crossing rate as a possible traffic characterization parameter. Indeed, due to the wide use of mobile devices and the large number of data that require exchange between the core network and the remote terminals, wireless networks are exploited in an intensive way today. The subsequent evolution of the scheme is toward the so-called fifth generation (5G) mobile communication systems. The main objectives would be to enhance some system metrics such as the throughput, the spectrum resource efficiency, the spectral leakage region, and the spectral nuisance level, not only for advanced users' services but also to directly support the increased data traffic demands. The usage and the wide coverage of wireless networks raise the problem of suitable traffic patterns analysis as part of planning. Unfortunately, the existing literature is mainly focused on the radio planning, leaving the analysis of the current wireless world architecture as innovative and predominantly unexplored. Given these considerations, the main contributions of the essay are summarized in the following.

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