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Mobile Computing Principles (ICT3142)
Assignment - 01

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Table of Contents

Introduction

5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.

5G wireless technology is for delivering higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users.

The objective of this report is to review ten research papers about 5G Cellular Networks. The ten research papers are,

1. A Survey of 5G Network: Architecture and Emerging Technologies
2. 5G Cellular Network Integration with SDN: Challenges, Issues and Beyond
3. 5GReasoner: A Property-Directed Security and Privacy Analysis Framework for 5G Cellular Network Protocol
4. Comprehensive survey on self-organizing cellular network approaches applied to 5G networks
5. Towards 5G cellular network forensics
6. A Collaborative Hotspot Caching Design for 5G Cellular Network
7. Cellular Network Traces Towards 5G: Usage, Analysis and Generation
8. Edge Computing in 5G: A Review
9. A Centralized SDN Architecture for the 5G Cellular Network
10. Interference Management for Different 5G Cellular Network Constructions

(Please refer to the References page for more details.)

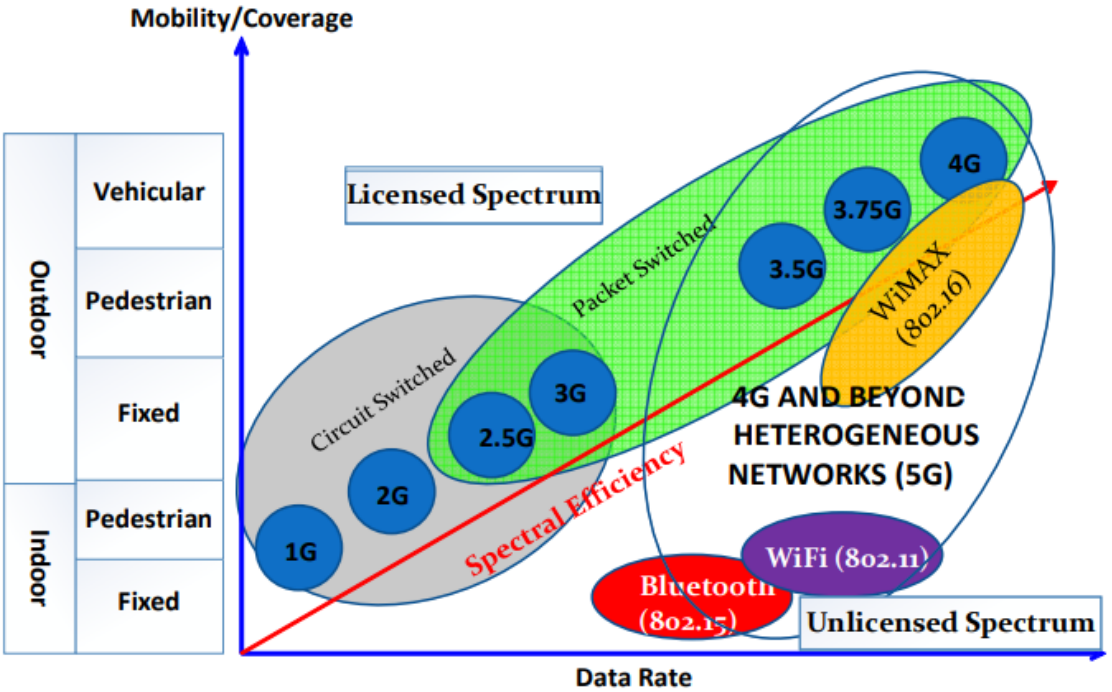
Review

A Survey of 5G Network: Architecture and Emerging Technologies

This paper presents the results of a detailed survey on the fifth generation (5G) cellular network architecture and some of the key emerging technologies that are helpful in improving the architecture. The prime focus is on the 5G cellular network, Massive MIMO technology, and Device to Device Communication (D2D).

5G wireless network architecture has been explained with massive MIMO technology, network function virtualization (NFV) cloud and device to device communication. Short range communication technologies, like WiFi, Small cell, Visible light communication, and millimeter wave communication technologies have been explained.

Evolving generations of wireless technologies in terms of data rate, mobility, coverage and spectral efficiency.



5G Cellular Network Integration with SDN: Challenges, Issues and Beyond

5G is an upcoming goal in 2020 communication providing new norms of connectivity and communication enabling a smart ecosystem. Standards for 5G are still not established and significant research is carried out to establish a unified 5G architecture. A cellular network lacks programmability, agility, security and data management due to the huge amount of connected devices and data produced.

SDN (Software-defined networking) is a network paradigm where disassociation of control plane from data plane provides vendor independence and operator sovereignty. SDN is generally associated with network routing and acting as an orchestrator for network level management. The most witnessed applications of SDN are viable in-data centers and cloud computing.

There are some advantages of implementing SDN with 5G.

1. Improve 5G Data rate and Volume
2. Reduced latency in 5G
3. Improved energy efficiency
4. Enhanced key Features of 5G Architecture

5GReasoner: A Property-Directed Security and Privacy Analysis Framework for 5G Cellular Network Protocol

The paper proposes a framework for property-guided verification of control-plane protocols spanning across multiple layers of the 5G protocol stack. It has identified 11 design weaknesses resulting in attacks having both security and privacy implications.

Those design weaknesses are.

1. Counter reset
2. Uplink NAS Counter Desynchronization
3. Exposing NAS sequence number
4. Neutralizing TMSI refreshment
5. Cutting of the device using `reg_request`
6. Cutting of the device using `ue_dereg_request`
7. Downgrade using reject messages
8. Linkability using `authentication_failure`

9. Paging channel hijacking
10. Panic attack
11. Linkability/Tracking using `sec_mode_command`

In this research, they have developed a framework that can formally reason about desired properties of the 5G control-plane-protocols. Their evaluation of 5GReasoner with respect to desired properties obtained from the specification revealed 11 new 5G design weaknesses. In the future, they will improve their 5G protocol model to include other key control-layer protocols.

Comprehensive survey on self-organizing cellular network approaches applied to 5G networks

Self-Organizing Network (SON) stands for a key concept characterizing the behavior of the future mobile networks. SON was proposed to offer agile on-demand services to the users through providing self-adaptation capabilities. This paper presents a detailed and exhaustive survey on SON evolution from 4G towards 5G networks.

SON solutions applied in 5G

1. Load balancing
2. Coverage and capacity optimization
3. Mobility management and handover parameters optimization
4. Resource optimization
5. Backhaul optimization
6. Caching optimization
7. Cell outage detection
8. Fault detection
9. Self-recovery of NE software

This research paper elaborates a comprehensive and exhaustive overview on the SON paradigm. It illustrates the challenges that SON needs to face in order to be applied in 5G cellular networks. It also exhibits a few works that handle some use cases of SON for 5G and ML solutions to face SON challenges.

Towards 5G cellular network forensics

The fifth generation (5G) of cellular networks will bring 10 Gb/s user speeds and 1000-fold increase in system capacity. Each of these 5G features requires system adaptations to enable acquisition and forensic processing of cellular network evidence. This paper reviews the digital forensics mechanisms for Lawful Interception and user localization available in LTE and LTE-Advanced networks.

1. LTE cellular network forensics
    a. Lawful Interception
        i. Interception-Related Information (IRI)
        ii. Content of Communication (CC)
    b. Lawful Access Location Services - LALS
2. Cellular network forensics in 5G
    a. Control and User Plane Separation - CUPS
    b. Network Function Virtualization - NFV
    c. Network slicing
        i. Lawful Interception adaptations for network slicing
        ii. Lawful Access Location Services adaptations for network slicing
    d. Cellular Internet of Things - CIoT
        i. Lawful Interception adaptation for CIoT
        ii. Lawful Access Location Services adaptation for CIoT
3. Cellular network forensics - legal and privacy aspects
    a. Cellular network forensics in the European Union
    b. Cellular network forensics laws in the USA
    c. Cooperative cellular network forensic investigations

The forensic capabilities of LI and LALS currently available in LTE/LTE-Advanced networks were reviewed to propose adaptations and discuss implementation challenges for 5G. Different correlation mechanisms per technology, multiple streams of IRI and CC records, and potential inclusion of third parties are just some of the challenges LEAs need to address. Equally relevant is the legal aspect of conducting cellular network investigations.

A Collaborative Hotspot Caching Design for 5G Cellular Network

In this paper, they propose a new CCN scheme for 5G wireless networks. The focus of their work is on the placement and retrieval of highly popular contents. They aim to extend the results of the proposed scheme from the perspectives of energy consumption, constraints of quality of service guarantee and service migration optimization model.

The rapid expansion of video data traffic places significant strain on future 5G networks. By decreasing duplicate content retransmission, caches at the radio access network (RAN) and evolving packet core (EPC) in the 5G network can efficiently ease this load. By combining Zipf distribution and knapsack, our suggested strategy maximizes the use of hotspot cache storage while also accommodating user requests that are only partially available in the network hotspot.

Cellular Network Traces Towards 5G: Usage, Analysis and Generation

Deployment and demand traces are a crucial tool to study today's LTE systems, as well as their evolution toward 5G. They use a set of real-world, crowdsourced traces, coming from the WeFi and OpenSignal apps, to investigate how present-day networks are deployed, and the load they serve. Present-day LTE deployments consist of multiple, entangled, medium- to large-sized cells, and will need substantial capacity improvements in order to face the load increase forecasted between now and 2020.

Using ITU propagation models, FCC license records and experimental data, they have developed a methodology to assess the ability of LTE networks to support today's traffic load. They exploited projections on the growth of mobile data traffic and evaluated how LTE networks can cope with that. Their study first unveils the quite dense and tangled deployment of macro and micro-cells of today's urban LTE networks.

They presented a synthetic trace generation methodology. Their main intuition is to reproduce not only the global features of real-world traces, but also the local ones, e.g., the traffic differences between neighboring BSs. To this end, they use a Markovian model for the demand and a Bayesian model for the deployment.

Edge Computing in 5G: A Review

5G is the next generation cellular network that aspires to achieve substantial improvement on quality of service, such as higher throughput and lower latency. Edge computing is an emerging technology that enables the evolution to 5G by bringing cloud capabilities near to the end users. In this paper, we establish a taxonomy of edge computing in 5G, which gives an overview of existing state-of-the-art solutions. We explore, highlight, and categorize recent advancements in edge computing for 5G.

Edge computing is a computational paradigm that enables edge servers in mini clouds to perform computationally-intensive tasks at close proximity to end users. Edge computing is preferred to cater for the wireless communication requirements of next generation applications, such as augmented reality and virtual reality. These highly interactive applications are expected to generate a massive amount of data up to 30.6 exabytes per month.

Applications of edge computing in 5g

- Healthcare
- Virtual reality, augmented reality, and mixed reality.
- Tactile internet.
- URLLC
- Internet of things,
- Factories of the future,
- Emergency response
- Intelligent transportation system,

In this paper, they present a review of the state-of-the art development in edge computing in 5G networks. The key requirements of edge computing are to provide real-time interaction, local processing, high data rate, and high availability. A taxonomy is established in which the edge computing approaches are classified according to different characteristics (e.g., objectives, computational platforms, and attributes).

A Centralized SDN Architecture for the 5G Cellular Network

The author proposes a novel method for adapting the Third Generation Partnership Project (3GPP)'s 5G architecture to the principles of Software Defined Networking (SDN). It relocates the control functionality present in the 5G Radio Access Network (RAN) to the network core, resulting in the conversion of the base station known as the gNB into a pure data plane node. This brings about a significant reduction in signaling costs between the RAN and the core network, and also results in improved system performance.

In this paper, they have proposed an SDN based modified architecture for the 5G cellular network in order to centralize the control functionality and place it in the core network. The elimination of the NGAP layer due to the displacement of RRC protocol from the gNB results in the reduction of processing time required for encoding and decoding of header data. We have also demonstrated that centralization of the RRC layer and RRM functions leads to better system throughput due to improved mobility management in a dynamic environment.

Interference Management for Different 5G Cellular Network Constructions

Ultra-Reliable Communications (URC) is considered one of the novel features for 5G. The most obvious limitation that faces the URC is the interference which is

severe at the cell edges. In this paper, the FFR and SFR performance analysis would be carried out and compared for each of the regular, irregular and hybrid cellular networks in both downlink and uplink scenarios.

A study has shown that FFR1 is better than FFR3 for the regular, irregular and hybrid schemes in downlink and uplink scenarios to overcome interference in 5G networks. In downlink analysis, it was shown that the capacity and capacity density for cell edge region and cell center region have better performance for the hybrid and regular models than that of the irregular model.

Spectral efficiency using FFR1 and FFR3 techniques has been carried out in case of BW of 10 MHz and 20 MHz for the three models. It is shown that; when the SIR increases, the spectral refraction also increases. The performance of the regular, irregular and hybrid models all have better performance when the values of the power control factor and exponent increase.

Conclusion

5G is the next generation of mobile networks. It directly affects the emergence of internet technologies in upcoming technologies of networking.

Researchers have found many improvements, applications and weaknesses of 5G infrastructure and they have proposed solutions and improved methodologies as results. According to the research papers which are received under this research review, 5G technologies can be integrated to other technologies, and 5G can be improved and enhance it’s security with various kinds of technologies.

5G will be the next generation technology which will be used in daily life as currently dominating 4G technology.

Methodology

The goal of this review paper was to collect 10 different research papers about 5g technology and review them one by one. Research papers are obtained through the IEEE site and other sites which are included in the references.

The reviews are summarized into special points which are mainly focussed on the research. All summarized contents have been stated in the relevant order to give more clarity to the reader.

All reviews are summarized as per my personal reference and may be differ from others priorities on the researches. Thanks for the original researchers.

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