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# Ease of Communication with Wireless Advancements

Mohammed Faizan Uddin

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## ABSTARCT

Communication Systems can be Wired or Wireless and the medium used for communication can be Guided or Unguided. In Wired Communication, the medium is a physical path like Co-axial Cables, Twisted Pair Cables and Optical Fiber Links etc., which guides the signal to propagate from one point to other. Such type of medium is called Guided Medium. The term wireless refers to the communication or transmission of information over a distance without requiring wires, cables or any other electrical conductors. Wireless communication is one of the important mediums of transmission of data or information to other devices. The Communication is set and the information is transmitted through the air, without requiring any cables, by using electromagnetic waves like radio frequencies, infrared, satellite, etc., in a wireless communication technology network. At the end of the 19th century, the first wireless communication systems were introduced and the technology has significantly been developed over the intervening and subsequent years. Today, the term wireless refers to a variety of devices and technologies ranging from smart phones to laptops, tabs, computers, printers, Bluetooth, etc. On the other hand, Wireless Communication does not require any physical medium but propagates the signal through space. Since, space only allows for signal transmission without any guidance, the medium used in Wireless Communication is called Unguided Medium. In the present days, wireless communication system has become an essential part of various types of wireless communication devices that permits user to communicate even from remote operated areas. The recent advances in wireless communication technologies allow mobile users to access various data services anytime and anywhere on land, while it is one of challenging issues to provide reliable data communications for maritime users due to the geographic features on the sea. There are many devices used for wireless communication like mobiles. Cordless telephones, GPS, Wi-Fi, satellite television and wireless computer parts. Current wireless phones include 3G, 4G & 5G networks, Bluetooth and Wi-Fi technologies. This paper is focused on elements of Wireless Communication system, Types of Wireless Communication, Advantage & Disadvantage of it, Smart city, wireless network security.

**INDEX TERMS** Long-term evolution (LTE), New Radio (5G NR), Radio, Maritimecommunication, Data service, testbed.

## I. INTRODUCTION

The increasing demands of emerging data services requiring high data rates such as ultra-high definition (UHD) video have driven the rapid advances in wireless communication technologies. Recent communication technologies like long-term evolution (LTE) and Wi-Fi can provide data rate over dozens of megabits per second to mobile users. In the near future, i.e., beyond 4G, the fifth generation (5G) will be launched with the objective of 10 to 100 times improvement in the number of connected devices and their data rates. It is expected that 5G could support the data rates up to tens of gigabits per second with the help of emerging solutions such as massive multiple-input and multiple-output (MIMO) and millimeter wave (mmWave) . Contrary to these revolutionary improvements of wireless communications on land, providing reliable and high-speed data services for maritime users is still a challenging issue. In general, maritime environments have the geographical limitation for developing communication infrastructures such as base station (BS) of LTE and access point (AP) of Wi-Fi. This makes that maritime communications need more extended communication coverage than terrestrial communications. Legacy maritime communication systems such as automatic identification system (AIS) and global maritime distress and safety system (GMDSS) have the extended communication coverage based on medium frequency (MF), high frequency (HF), and very high frequency (VHF). However, due to the small channel bandwidth allocated for these maritime systems, they cannot support high data rate services. In addition, although satellite communication systems could satisfy the communication needs for high data rate and extended coverage, the cost and size of satellite communication remain severe obstacles for typical maritime users' .By considering these limitations of current maritime systems, there is a strong need by maritime users as well.

**Diagram of Wireless Advancements (GSM, WIFI, LTE, 5G)**

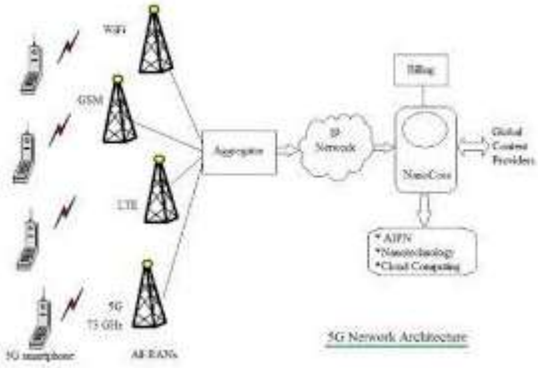


Figure 1 Communication Networks

In order to meet the communication requirements of Endusers &the objective of providing the communication Speed of wide range and high data rates in the order of megabits per second.. Throughout this paper, we focus on answering the question ‘‘couldExisting technology satisfy the communication coverage and data rate requirements in Current App-Data environments?’’. This paper is organized as follows.

In section II, as a motivation of study, we present the Data service requirements and reliable Speed App Coverage. This survey indicates that there is a consistency Requirement of Speed & Synchronization services to Ease of Usersin Existing Communication networks.

In section III, we introduce the performance objectives and specific characteristics of Communication Networks with Artificial Intelligence.

In section IV, the testbed implementation and on board experiment results are described in order to validate the feasibility of LTE Throughput. The results show that 5G-AI-LTE can achieve the data rates over 10 Mbps even at a distance of 100 km from BS and it can be a practical solution for communication. Further, some technical challenges associated with the Implementation of 5G-AI-LTE are discussed in section V. Finally, we conclude this paper with future research directions.

## II. MOTIVATION OF STUDY

Fig. 1 depicts a general communication network architecture for Geographical Land. A main component of the architecture is two-way communication links between User-to-N/W and N/W-to-User. The other one is various data services used for users through the communication links. In this section, we present a comprehensive survey of data services and communication systems. The survey focuses on specific use cases of User data services and their communication requirements, and technical characteristics of existing networks in terms of data rate, communication coverage, a

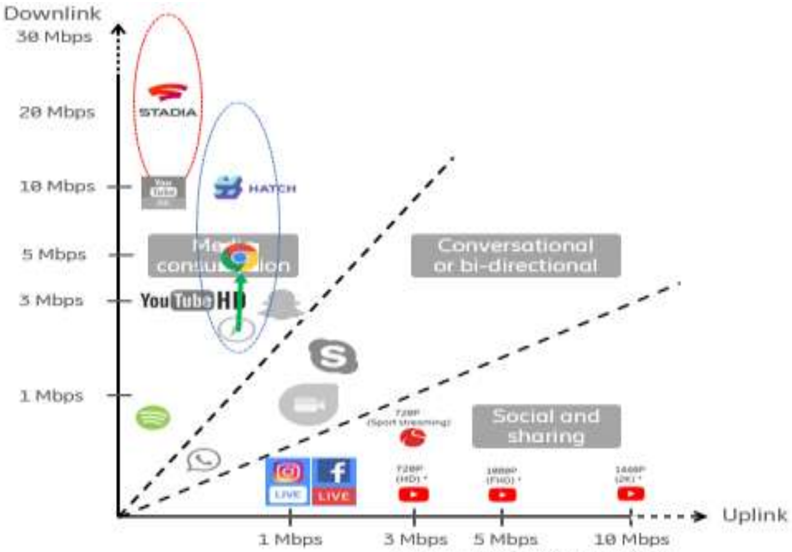


Figure 2 Types of Services

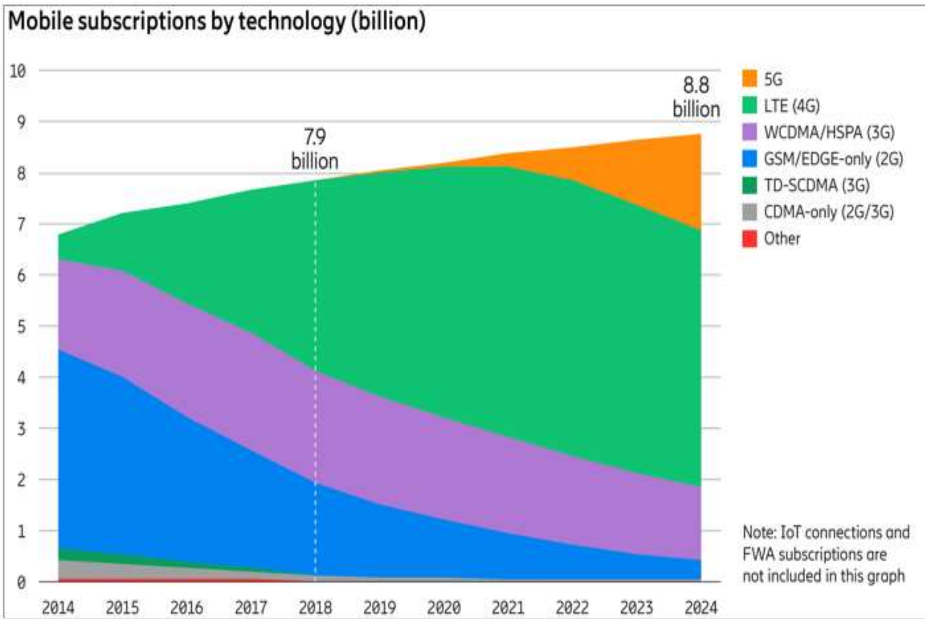


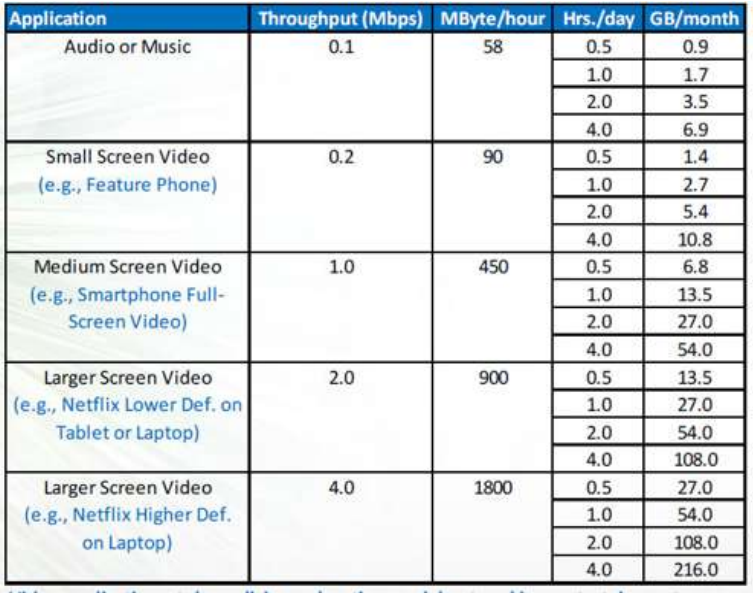
Figure 3. Mobile Subscriptions by Technology

### A. NETWORK SERVICE REQUIREMENTS

Communications services can be divided into three types of three service, Main-Consumption service, Bi-Directional commercial service and Social & Sharing as Classified in Fig .2. Based on this classification, data services and their Application-Data-Rate requirements are summarized in Table 1. Typical Communication services Parameters such as Throughput, BER, BLER, ModulationCoding Schemes information with graphs & chart updates are used in monitoring. These services require Consistency Vary data rates and their maximum requirement is greater than 100 mbps. However, as Communication equipment and services are modernized, the data rate requirements of Communication services have been gradually increasing. For example, as Shown in Figure 3. Mobile Subscriptions by Technology. It is estimated that 8.8 billion Mobile Subscription & they need the data rates will Increase drastically based onPredictions. Further, in order to prevent delay in Services Control Plane & User Plane are Separated as specified by Third Generation Partnership Project 3gpp Release 14 in Core

Network, to process Control Signalling & User Data more Efficient. It is reported that the Frame transmission inUser Plane collected from User Request will processed Much More Synchronized & Efficient within couple ofseconds. Users Smartphone Battery Drain issue is also considered with Increasing Demand of Data Rates and Services to avoid Interrupted Services and enjoy the daily of life on the Voyage as well. The infotainment (information and entertainment) service for social communication and interaction with family and friends requires the data rate of 1.5 Mbps. It is noted that although the communication requirements above mentioned could vary depending on user preferences and service types, various data services for maritime stakeholders also have been Considered and their communication requirements have also been increasing in the order of megabits per seconds

Table 1.Application-Data-Services



| Application | Throughput (Mbps) | MByte/hour | Hrs./day | GB/month |
|---|---|---|---|---|
| Audio or Music | 0.1 | 58 | 0.5 | 0.9 |
| | | | 1.0 | 1.7 |
| | | | 2.0 | 3.5 |
| | | | 4.0 | 6.9 |
| Small Screen Video (e.g., Feature Phone) | 0.2 | 90 | 0.5 | 1.4 |
| | | | 1.0 | 2.7 |
| | | | 2.0 | 5.4 |
| | | | 4.0 | 10.8 |
| Medium Screen Video (e.g., Smartphone Full-Screen Video) | 1.0 | 450 | 0.5 | 6.8 |
| | | | 1.0 | 13.5 |
| | | | 2.0 | 27.0 |
| | | | 4.0 | 54.0 |
| Larger Screen Video (e.g., Netflix Lower Def. on Tablet or Laptop) | 2.0 | 900 | 0.5 | 13.5 |
| | | | 1.0 | 27.0 |
| | | | 2.0 | 54.0 |
| | | | 4.0 | 108.0 |
| Larger Screen Video (e.g., Netflix Higher Def. on Laptop) | 4.0 | 1800 | 0.5 | 27.0 |
| | | | 1.0 | 54.0 |
| | | | 2.0 | 108.0 |
| | | | 4.0 | 216.0 |

## B. RADIO COMMUNICATION NETWORKS

Radio Communication network has attracted significant attention to Chipset Manufacturer & Application Developer to keep pace with the increasing demands of data services as show

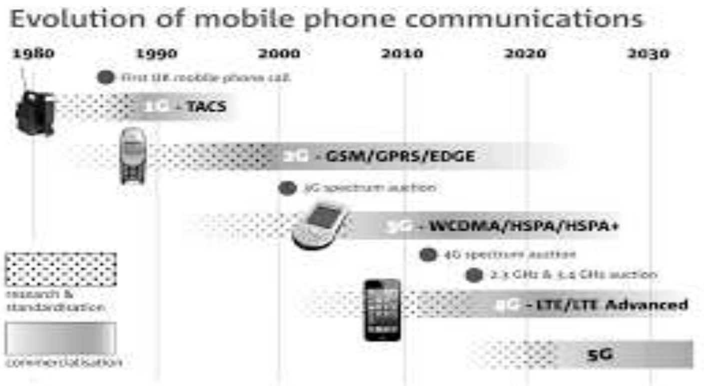
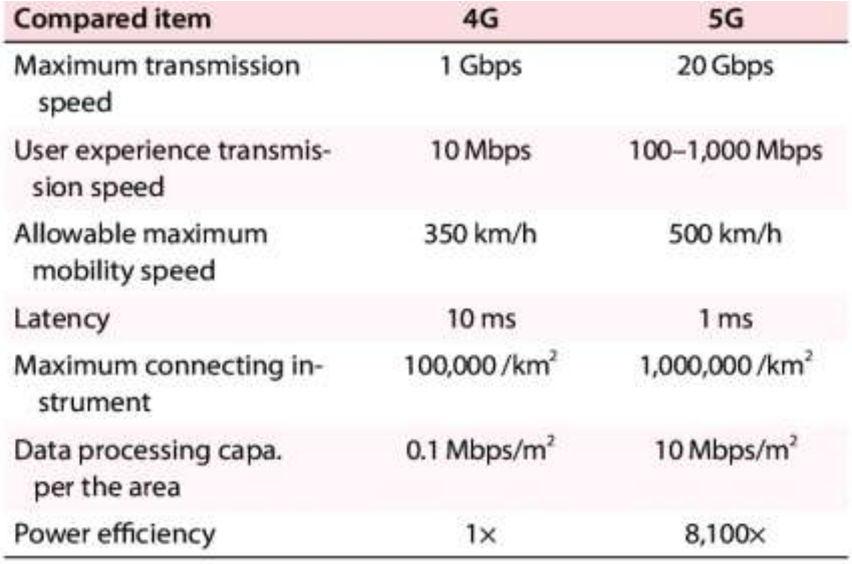


Figure 3.Evolution of Mobile Phones

Figure 3 &Table 2 summarizes Evolution of Mobile Phones &in the previous section. LTE & 5G communication networks and their technical characteristics.

Table 2. Comparison of LTE & 5G Characteristics



| Compared item | 4G | 5G |
|---|---|---|
| Maximum transmission speed | 1 Gbps | 20 Gbps |
| User experience transmission speed | 10 Mbps | 100–1,000 Mbps |
| Allowable maximum mobility speed | 350 km/h | 500 km/h |
| Latency | 10 ms | 1 ms |
| Maximum connecting instrument | 100,000 /km$^2$ | 1,000,000 /km$^2$ |
| Data processing capa. per the area | 0.1 Mbps/m$^2$ | 10 Mbps/m$^2$ |
| Power efficiency | 1× | 8,100× |

In Maritime Communication and conventional Communication systems such as digital selective calling (DSC), AIS, navigation data (NAVDAT), and VHF data exchange system (VDES) communicate with the shore by using frequency bands of MH, HF, and VHF. They are generally used for the safety of ships and provide the communication coverage of several hundred kilometres with low cost. However, they are not applicable for transmitting substantial data services like video and LiDAR due to their limited channel bandwidth. For example, NAVDAT and VDES systems can support the data rate up to 18 kbps and 307 kbps, respectively. The satellite systems have been used for global communications, which are classified into low earth orbit (LEO), medium earth orbit (MEO), geostationary orbit (GEO), and high elliptical orbit (HEO) according to satellite orbits. With advanced communication technologies, recent satellite systems can support high data rates as well as global communication coverage. For example, the data rates of Inmarsat and VSAT commonly used in maritime environments are up to 50 and 46 Mbps, respectively. Nonetheless, the high cost of launching, operation, and communications charge remains a disadvantage of satellite systems. For example, Fleet Broadband G service provided by Inmarsat costs 0.4~20.85 U.S. dollars per megabyte. In order to deal with these limitations of legacy maritime communications, many studies are trying to apply existing terrestrial wireless technologies to maritime communication systems. In Singapore, a wireless broadband access for seaport (WISEPORT) provides the data rate up to 5 Mbps with the coverage range of 15 km based on worldwide interoperability for microwave access (WiMAX) technology. In TRION project, a wireless mesh network is proposed to extend the communication coverage based on the IEEE 802.16d mesh technology. The mesh nodes consist of ships and buoys, and they can route and relay the packets for other nodes according to own routing protocol developed in the project. In maritime broadband communication (MariComm) project proposes a wireless heterogeneous multi-hop relay network based on LTE and WLAN. The experiment results show that the MariComm system can provide the data rates over 1 Mbps and the transmission distance of 100 km from the coast with the support of multi-hop relay functionality. In BLUECOM+ project, a wireless heterogeneous multi-hop relay network is proposed by using the tethered balloons above the ocean surface, where the balloons are used as a wireless router for air-to-air links. The simulation results show that the proposed network can achieve the data rate of 3 Mbps and the communication coverage up to 150 km with two hop relays. However, the practical experiment in maritime environments remains as future work. In India, a heterogeneous wireless mesh network is proposed, where long range (LR) Wi-Fi is used to extend

## III. LTE-MARITIME-GEOGRAPHICAL NETWORK

LTE & 5G aims at developing a newnetwork Environment that enables users to access a variety of Application & data services requiring Vary data rates .The overview of LTE-Maritime communication architecture in the project is illustrated in Figure 4 with Reference of LTE

Architecture in Figure 5 and the main features of LTE-Maritime are followings.

- LTE-Maritime is based on LTE technology that is a promising solution for wireless maritime network.

LTE is capable of providing increased data rate, capacity, and spectral efficiency even in dynamic propagation environments with theSupport of advanced Techniques Such as MIMO
and aggregation.

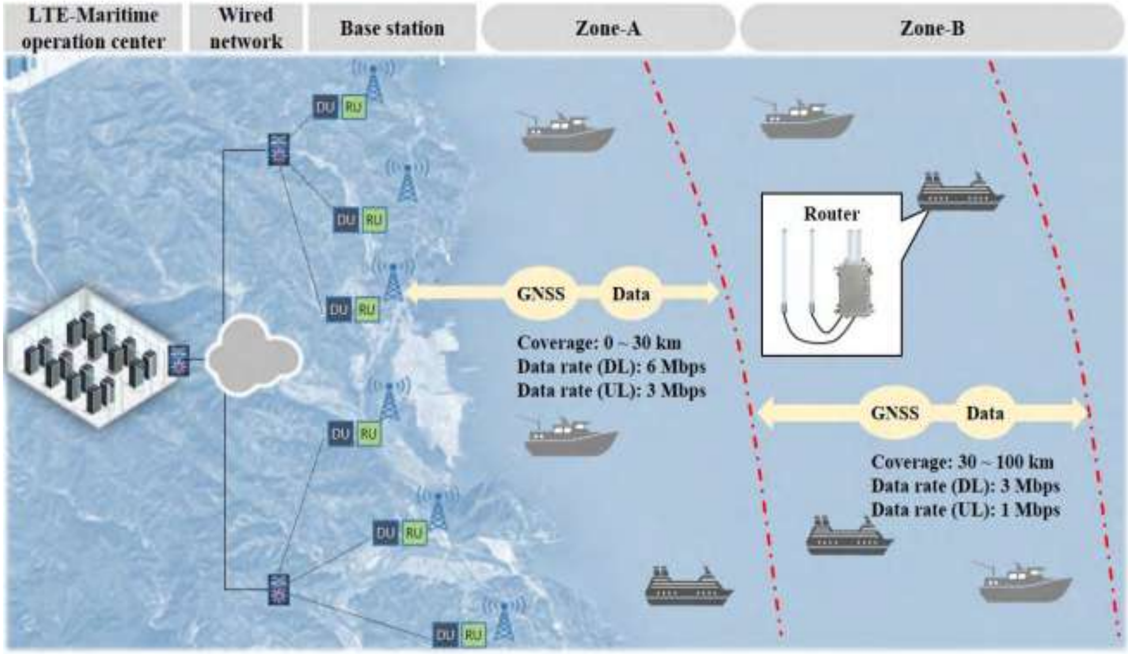


Figure 4 LTE Maritime

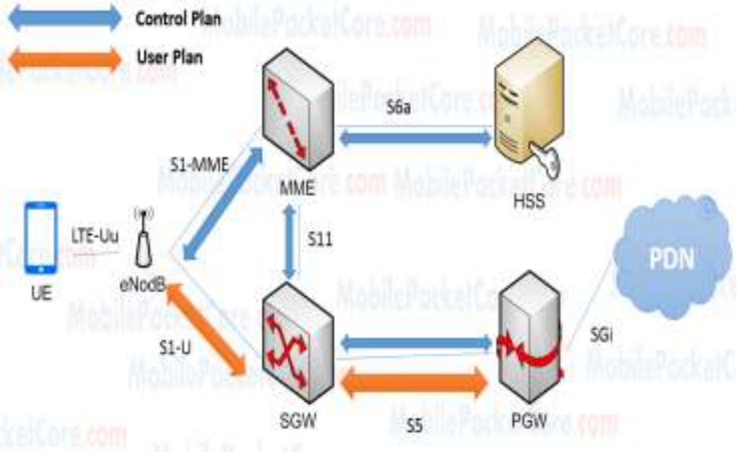


Figure 5 LTE Architecture

Furthermore, it has the potential to provide the communication coverage about 100 km depending on the cell environments, though LTE for commercial mobile communication is designed with a relatively short cell coverage. This superiority of LTE makes us develop a single-hop network enabling ship-to-shore data communication based on LTE technology. In general, the wireless mesh networks are vulnerable to link failures caused by radio interference and they could not assure reliability. Contrary to existing maritime networks for extending the communication coverage with multi-hop transmission, LTE-Maritime enables ships to communicate with onshore BSs directly and it can improve reliability. Therefore, it is more suitable especially for the safety related maritime services that require high reliability as well as low latency.

- LTE-Maritime with Reference of LTE Architecture consists of base stations (BSs), evolved packet core (EPC) equipment, and routers. A number of BSs are located at a high altitude of mountainous areas along the coastline to assure the line of sight (LoS). Each BS is composed of multiple radio units (RUs) and digital units (DUs). The RU and DU are responsible for radio transmission and reception, and for data processing, respectively. Every DU is connected to LTE-Maritime operation center through the wired network. An EPC is located in the operation center and its entities are serving gateway (S-GW) for packet routing and charging with policy and charging rules functions (PCRF); packet data network gateway (P-GW) for quality of service (QoS) management and anchor point of external networks; mobility management entity (MME) for mobility control, authentication, and authorization; and home subscriber server (HSS) for subscriber management. On shipside, we developed the LTE-Maritime router suited for maritime environment. It is equipped to compass deck of ship with high gain antennas of 6 dBi and the antenna length of 1.2 m. It could provide better communication performance than typical mobile devices.

- The performance goal of LTE-Maritime is divided into two cases depending on the distance from the coastline. The objective of region A is to cover the area from BS to 30 km with the average data rates of 6 Mbps and 3 Mbps for downlink (DL) and uplink (UL), respectively. The objective of region B is to cover the area from 30 km to 100 km with the average data rates of 3 Mbps and 1 Mbps for DL and UL, respectively. The coverage objective was set based on the fact that 88% of marine accidents in Korea happen in non-SOLAS ships within the coverage of 100 km [25]

In addition, LTE-maritime network could provide various data services for maritime users with improved reliability, high data rate, long enough coverage, and low cost compared to current maritime networks.

## IV. TESTBED IMPLEMENTATION ON DATA SERVICES

In order to validate the feasibility of Data Rates on Communication Technologies Such as 5G, LTE, WCDMA & GSM, we implemented a Local-Network testbed Setup with Simulators conducted a lot of Users- End-Case Scenarios Executed. In this section, the details of experiment environments are explained and the performance results of LTE- 5G are analysed

**A. EXPERIMENT ENVIRONMENTS** As shown in Fig. 3, for an LTE testbed, 1 Baseband connected with 1 Radio Unit. In addition, all Radio Ports are terminatedexcept 1 for Network Analyser. The laptops for performance measurement are connected to the Network Analyser and they measure main communication parameters such as reference signal received power (RSRP), signal to interference and noise ratio (SINR), throughput, physical cell identity (PCI), and the number of resource block (RB) using a diagnostics monitor (DM) software installed on the laptops. In addition, for data transmission, a file transfer protocol (FTP) auto-call server was used where DL, UL, and idle periods were set to 1, 1, and 3 minutes, respectively. The Band and frequency range of LTE network is Band 1 Whose Frequency range 1920-1980 for UL and 2110-2170 MHz for DL.

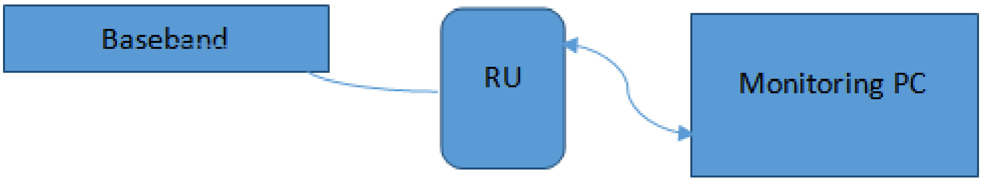


Figure 6 Experiment Environment

**B. RESULTS OF EXPERIMENT** Fig. 6a shows the measured experimental results in LTE DL & UL and 5G DL & UL.

Figure 6a Experimental Graph of DL & UL of LTE & 5G

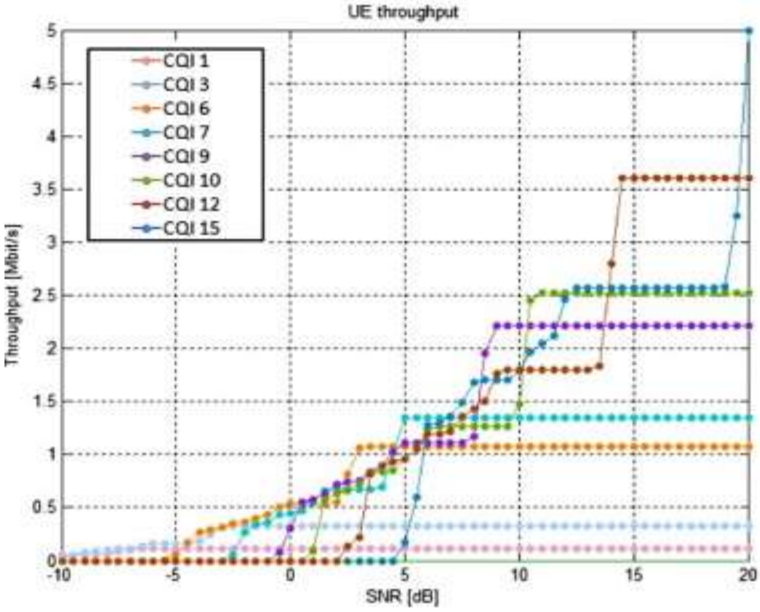


Figure 7 Throughput Performance with SNR & CQI

The Figure 7 represents the average values of RSRP, SINR, and throughput and graph shows the variation of each parameter varies with Fading Profile Such as Distances, antenna Tilt , Modulation Techniques and Rx/Tx Power. the variation of RSRP and SINR values has three kinds of patterns. In the red dotted box, both values gradually increase. This is because, when the User is near the Network, it cannot assure LoS environment due to surroundings such as buildings and it also be interfered with other radio signals from terrestrial region.

For LTE-Maritime below, Scenarios are covered and above graph Can Considered In the blue dotted box, RSRP and SINR decrease as the signal strength of the neighbouring cell becomes much stronger than that of the serving cell. After PCI number is changed from 420 to 421 (i.e., a handover (HO) occurs at that point), both values start to increase. In the rest of the route, the values of RSRP and SINR obviously decrease according to the distance between the Radio Unit and User. In addition, the average throughput for both DL and UL is over 11 Mbps with the maximum coverage of about 100 km. For the South sea case, onboard experiments Can conducted from One-point to another on an international passenger ship, in which the antenna tilt and transmission power of BS were adjusted from 0 to 10 degree and from 46 to 43 dBm considering the impact of propagation interference on a neighbouring country. The orange dotted box shows a similar trend with the East sea case near the board due to the non-LoS environment and interference. On the other hand, the values of RSRP and SINR rapidly decrease and the communication link between the BS and ship is intermittently disconnected near the destination because the radio signal is blocked by Tsushima Island. The average throughput for both DL and UL has relatively high values compared with the East sea case. For example, the average DL throughput from Tsushima to Busan is 27.8 Mbps. The reason is that the South sea experiment has a relatively short route of 65 km resulting in much stronger RSRP values. The experiments on the Yellow sea have a distinct characteristic different from the other cases. In this area, there are a lot of Islands and they interrupt the transmission and reception of the radio signal. Therefore, in order to reduce the performance degradation caused by Islands, more BSs were developed in the Yellow sea region. This environment leads to frequent HOs and wide fluctuation in RSRP and SINR values as shown in the green dotted box. Nevertheless, LTE Throughput can achieve the average throughput over 22 Mbps for DL and 12 Mbps for UL with the maximum coverage of about 107 km. Looking at these results in terms of the maritime network performance, we can find that the LTE-Maritime testbed satisfies the maritime user’s need for high-speed communication over Mbps as well as long communication distance of 100 km. Furthermore, when the cell planning optimization that decides the network deployment such as the number and location of BSs, antenna tilt, and transmission power level is applied by 2020, the communication performance of LTE could be more improved

## V. DISCUSSIONS

The Terrestrial and maritime networks have unique characteristics different from in terms of communication requirements and propagation environments. In this section, several technical research challenges found in the testbed experiments and related studies are addressed.

### A. CELL COVERAGE

The coverage requirement of maritime networks is generally longer than that of terrestrial networks. In order to estimate the cell coverage, it is essential to use an appropriate path loss model in the cell planning stage. The signal path loss indicates the signal strength reduction while the signal propagates from transmitter to receiver. Modeling the path loss for any communications is a challenging issue due to the unique features such as varying Speed of User, reflection, scattering, and ducting effect, it is observed that the height of transmitter and receiver antennas is an important factordetermining the communication distance. That is the reason why we developed the BSs of LTE-Maritime at a high altitude of mountainous regions near the coastline. To further design a practical LTE communication system, we need to modify existing path loss models to be suitable for the Communication environment.

### B. INTERFERENCE

Interference leads to SINR degradation and increased collision probability resulting in the reduction of overall network performance. In general, mobile communication systems suffer from intra-cell interference and inter-cell interference, which are caused by adjacent channels within the same cell and the same frequency channels from neighbour cells, respectively. The effect of interference on the performance degradation becomes more severe when a mobile user is in the crowded areas and at cell edges. In order to deal with these interference issues in Network domain, the transmission scheduling scheme and the position-power control scheme of the pilot sequences have been proposed. Moreover, Overload networks may suffer from interference by the unwanted spurious signal from adjacent Networks. In order to confirm the existence of spurious signal and its impact on the LTE performance,

In order to address interference problems, the interference mitigation and avoidance techniques such as interference cancelation, adaptive beamforming, frequency reuse, cell coordination, and frequency filtering need to be further considered for LTE communications .These services are strictly required to guarantee low latency and high reliability. In order to satisfy delay sensitive QoS requirements, LTE has the capability to determine QoS class identifier (QCI) level based on service characteristics and allocates the limited radio resource based on QCI information for each service.

Together with these functionalities of LTE, QoS management schemes for LTE or 5G need to be further developed by considering Upcoming Data Services & App Services. The QoS control schemes include packet scheduling, adaptive modulation, channel coding, adaptive power control, and cross layer optimization

## VI. CONCLUSION

In this paper, we provide a survey on the wireless Communication networks to confirm how much existing communication systems can support the emerging Data service requirements. This survey reveals that existing Communication systems have the limitations of the low data rate compared to Upcoming Requirements.

In addition, Undergo small Survey on maritime communication System based on LTE technology, we introduce LTE-Maritime that is an ongoing research project in the Republic of Korea. Contrary to recent efforts for extending the communication coverage with multi-hop and mesh networks.Communication

## REFERENCES

[1]. A. Gupta and E. R. K. Jha, ‘‘A survey of 5G network: Architecture and emerging technologies,’’ IEEE Access, vol. 3, pp. 1206–1232, Jul. 2015.

[2]. M.-T. Zhou et al., ‘‘TRITON: High-speed maritime wireless mesh network,’’ IEEE Wireless Commun., vol. 20, no. 5, pp. 134–142, Oct. 2013.

[3]. M. Manoufali, H. Alshaer, P.-Y. Kong, and S. Jimaa, ‘‘Technologies and networks supporting maritime wireless mesh communications,’’ in Proc. Wireless Mobile Netw. Conf. (WMNC), Dubai, United Arab Emirates, Apr. 2013, pp. 1–8

[4]. Y. Xu, ‘‘Quality of service provisions for maritime communications based on cellular networks,’’ IEEE Access, vol. 5, pp. 23881–23890, Oct. 2017.

[5]. S. Jiang and H. Chen, ‘‘A possible development of marine Internet: A large scale cooperative heterogeneous wireless network,’’ J. Commun. Comput., vol. 9247, no. 4, pp. 199–211, Aug. 2015.

[6]. Maritime Radio Communications Plan, IALA, Saint-Germain-en-Laye, France, Dec. 2017.

[7]. A. A. Allal, K. Mansouri, M. Youssfi, and M. Qbadou, ‘‘Toward a new maritime communication system in Detroit of Gibraltar where conventional and autonomous ships will co-exist,’’ in Proc. Wireless Netw. Mobile Commun. (WINCOM), Rabat, Morocco, Nov. 2017, pp. 1–8.

[8]. M. Höyhtyä, J. Huusko, M. Kiviranta, K. Solberg, and J. Rokka, ‘‘Connectivity for autonomous ships: Architecture, use cases, and research challenges,’’ in Proc. Inform. Commun. Technol. Converg. (ICTC), Jeju, South Korea, Oct. 2017, pp. 345–350.

[9]. D. Kidston and T. Kunz, ‘‘Challenges and opportunities in managing maritime networks,’’ IEEE Commun. Mag., vol. 46, no. 10, pp. 162–168, Oct. 2008.

[10]. F. Bekkadal, ‘‘Emerging maritime communications technologies,’’ in Proc. Intell. Transp. Syst. Telecommun. (ITST), Lille, France, Oct. 2009, pp. 358–363.

[11]. T. Yang, H. Liang, N. Cheng, R. Deng, and X. Shen, ‘‘Efficient scheduling for video transmissions in maritime wireless communication networks,’’ IEEE Trans. Veh. Technol., vol. 64, no. 9, pp. 4215–4229, Sep. 2015.

[12]. M.-T. Zhou and H. Harada, ‘‘Cognitive maritime wireless mesh/ad hoc networks,’’ J. Netw. Comput. Appl., vol. 35, no. 2, pp. 518–526, Mar. 2012.

[13]. H.-J. Kim, J.-K. Choi, D.-S. Yoo, B.-T. Jang, and K.-T. Chong, ‘‘Implementation of MariComm bridge for LTE-WLAN maritime heterogeneous relay network,’’ in Proc. Int. Conf. Adv. Commun. Technol. (ICACT), Seoul, South Korea, Jul. 2015, pp. 230–234.

[14]. R. Campos, T. Oliveira, N. Cruz, A. Matos, and J. M. Almeida, ‘‘BLUECOM+: Cost-effective broadband communications at remote ocean areas,’’ in Proc. MTS/IEEE OCEANS, Shanghai, China, Apr. 2016, pp. 1–6.

[15]. S. N. Rao, D. Raj, V. Parthasarathy, S. Aiswarya, M. V. Ramesh, and V. Rangan, ‘‘A novel solution for high speed Internet over the oceans,’’ in Proc. IEEE Int. Conf. Comput. Commun. (INFOCOM), Honolulu, HI, USA, Jul. 2018, pp. 906–912.

[16]. D. Palma, ‘‘Enabling the maritime Internet of Things: CoAP and 6LoWPAN performance over VHF links,’’ IEEE Internet Things J., vol. 5, no. 6, pp. 5205–5212, Dec. 2018.

[17]. R. Al-Zaidi, J. C. Woods, M. Al-Khalidi, and H. Hu, ‘‘Building novel VHFbased wireless sensor networks for the Internet of marine things,’’ IEEE Sensors J., vol. 18, no. 5, pp. 2131–2144, Mar. 2018.

[18]. W. Ejaz, K. Manzoor, H. J. Kim, B. T. Jang, G.-J. Jin, and H. S. Kim, ‘‘Twostate routing protocol for maritime multi-hop wireless networks,’’ Comput. Elect. Eng., vol. 39, no. 6, pp. 1854–1866, Aug. 2013.

[19]. G. Araniti, C. Campolo, M. Condoluci, A. Iera, and A. Molinaro, ‘‘LTE for vehicular networking: A survey,’’ IEEE Commun. Mag., vol. 51, no. 5, pp. 148–157, May 2013.

[20]. A. Elnashar and M. A. El-Saidny, ‘‘Looking at LTE in practice: A performance analysis of the LTE system based on field test results,’’ IEEE Veh. Technol. Mag., vol. 8, no. 3, pp. 81–92, Sep. 2013.

[21]. R. Kreher and K. Gaenger, LTE Signaling: Troubleshooting and Performance Measurement, 2nd ed. Hoboken, NJ, USA: Wiley, 2016.

[22]. T. Roste, K. Yang, and F. Bekkadal, ‘‘Coastal coverage for maritime broadband communications,’’ in Proc. MTS/IEEE OCEANS, Bergen, Norway, Jun. 2013, pp. 1–8.

[23]. G. Egeland and P. E. Engelstad, ‘‘The availability and reliability of wireless multi-hop networks with stochastic link failures,’’ IEEE J. Sel. Areas Commun., vol. 27, no. 7, pp. 1132–1146, Sep. 2009.

[24]. M. R. Sama, L. M. Contreras, J. Kaippallimalil, I. Akiyoshi, H. Qian, and H. Ni, ‘‘Software-defined control of the virtualized mobile packet core,’’ IEEE Commun. Mag., vol. 53, no. 2, pp. 107–115, Feb. 2015.

[25]. Korean Statistical Information Service (KOSIS). (Dec. 2018). Marine Accient Status. [Online]. Available: http://kosis.kr/statisticsList/statisticsListIndex.do?menuId=M_01_01&vwcd=MT_ZTITLE&parmTabId=M_01_01&parentId=D2.1;116_12320.2;#SelectStatsBoxDiv

[26]. I. J. Timmins and S. O’Young, ‘‘Marine communications channel modeling using the finite-difference time domain method,’’ IEEE Trans. Veh. Technol., vol. 58, no. 6, pp. 2626–2637, Jul. 2009.

[27]. B. P. A. Sumayya, K. Sasidhar, and S. Rao, ‘‘A survey based analysis of propagation models over the sea,’’ in Proc. Int. Conf. Adv. Comput. Commun. Inform. (ICACCI), Kochi, India, Aug. 2015, pp. 69–75