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Analysis of a Cooperative NOMA - VLC System with a Perfect SIC for Mobile Network Simulation

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Abstract— In the present days, the increasing demand of mobile Internet and the Internet of Things (IoT) poses challenging requirements for 5G wireless communications, such as high spectral efficiency and massive connectivity. Communication (VLC) system, which can address some of these challenges for 5G wireless communications. As this is different from the conventional Orthogonal Multiple Access technologies, Non-Orthogonal Multiple Access (NOMA) can accommodate much more users via non-orthogonal resource allocation. A key feature of NOMA is that users with better channel cIn this project, a promising technology, Non-Orthogonal Multiple Access (NOMA), has been reported for Visible Light onditions have prior information about the messages and communication of other users. This prior knowledge is fully exploited in our project, where a co- operative NOMA scheme is used in this project. The performance of this co-operative NOMA scheme has been analysed based on BER & outage probability.

Keywords — *V*isible Light Communication,Non - Orthogonal Multiple Access, Cooperative NOMA,Energy Harvesting ,Power Allocation.

1.INTRODUCTION

Communication using light is not a new concept but is attributed to ancient Greeks and Romans. During battles, they used polished shields for transmitting signals using reflected sunlight. In the 1790s, semaphore lines based optical communication systems were developed. Claude Chappe invented the first visual telegraphy system in 1792. In 1810, the range for communication was increased using new inventions like heliograph which used a pair of mirrors to send a controlled beam of light to a distant station. Subsequently, the demand for such instruments for military purposes during the late 19th and early 20th century motivated Graham Bell and he invented photophone in 1880 which transmitted speech on modulated sunlight over a distance of about 200m. Figs.1.1 & 1.2 show the Photophone transmitter and receiver respectively. The drawback of this device was that it didn't work well in cloudy weather. In 1935, the German army modified this photophone where a tungsten filament lamp with an IR transmitting filter was used as a light source. In 1962, using light-emitting GaAs diode, MIT Lincoln lab was able to establish OWC link and transmitted TV signals over a distance of 30 miles. In 1979, F. R. G feller and G. Bapst verified the technical feasibility of indoor optical wireless communication using infrared light emitting diodes (LEDs). A transceiver system based on fluorescent lamp has been used to achieve low data rate communication. With the advancement in LED illumination industry, the fast switching characteristic of visible light LEDs encouraged active researchers on high- speed VLC. In 1999, a concept of the optical signal transmitter using the traffic light LED was first proposed by Pangetal. Later on, at Keio University in Japan, a series of fundamental studies were carried out by S. Haruyama and M. Nakagawa. They investigated the possibility of providing illumination and communication to the simultaneously using white LEDs for the VLC systems. Meanwhile, they explored VLC applications at relatively low rates and also analysed the effects of light reflection and shadowing on the system performance. Not only individual research groups, there are undoubtedly large-scale organizations and research teams worldwide that have significant contribution in development and standardization . VLC system. In 2008, a project named HOME Gigabit Access. (OMEGA) was launched in order to develop a novel wireless indoor network which could provide gigabit data rate to the users .The University of Oxford, University of Cambridge, France Telecom, Siemens, and other companies and universities were the project members who finally were able to demonstrate a real time VLC system using sixteen white LEDs on the ceiling of Consortium (VLCC) which was founded in Japan (2003) was evolved to Visible Light Communication Association (VLCA) to collaborate various industries closely with the purpose of realizing the visible light communication infrastructure and providing social infrastructure, Internet, computer, semiconductor, etc. In the United States there are prominent research groups in the VLC system i.e., the Ubiquitous Communication by Light Centre (UC-Light), Centre on Optical Wireless Applications (COWA), and Smart Lighting Engineering Research Centre (ERC). The aim of UC-Light is to create new technological inventions, economic activities, and energy-saving benefits. COWA focuses on optical wireless applications of communications, networking, imaging, positioning, and remote sensing. ERC concentrates on LED communication systems and networks, supporting materials and lighting devices, and applications for detection of biotic and biomedical threats. In China two large teams were built in 2013 to focus on the research of OWC over broad spectra, including VLC. One team was sponsored by National Key Basic Research Program of China, together with about 30 researchers from top universities and research institutes. Another team was funded by National High Technology Research and Development Program of China. Both project teams have done incredible hard work on theory breakthrough, technology development, and real-time VLC system demonstrations. They were able to achieve real time data rate of 1.145 Gbps at 2.5 m to provide multimedia services, and the maximum off-line data rate of 50 Gbps was attained at a shorter distance. To mutually prompt commercialization of VLC technologies, Chinese Visible Light Communications Alliance (CVLCA) was founded in 2014, which grabbed the attention from various universities and industries in lighting, telecommunication, energy, user electronics, and funding agencies.

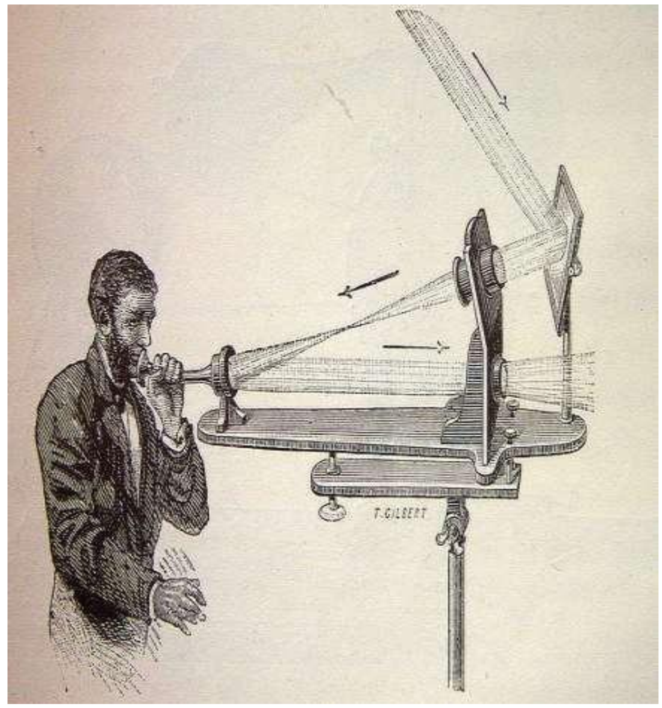
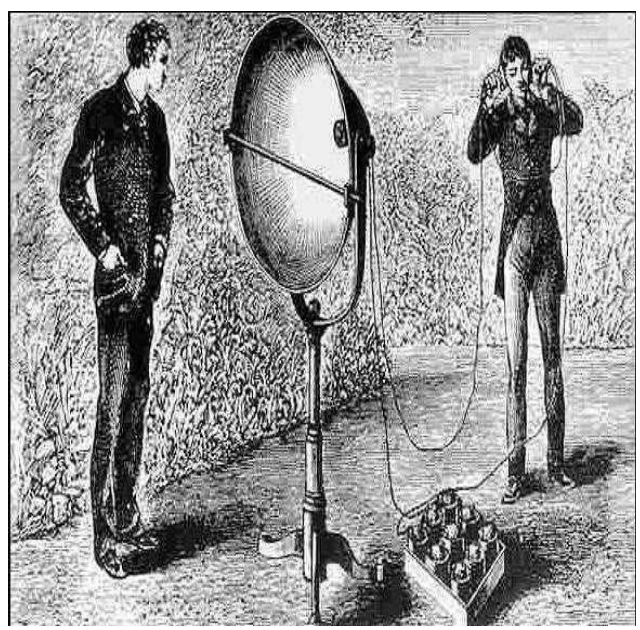


Fig:1 Reflected sunlight used in Photophone for transmitting signals and Photophone receive



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1.1 Introduction to VLC:

Visible light communication (VLC) is a data communications variant which uses visible light between 400 and 800 THz (780–375 nm). VLC isa subset of optical wireless communications technologies.The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbit/s, or LEDs for up to 500 Mbit/s over short distances. Systems such as RONJA can transmit at full Ethernet speed (10 Mbit/s) over distances of 1–2 kilo metres (0.6–1.2 mi).Specially designed electronic devices generally containing a photodiode receive signals from light sources, although in some cases a cell phone camera or a digital camera will be sufficient.The image sensor used in these devices is in fact an array of photo diodes (pixels) and in some applications its use may be preferred over a single photo diode Such a sensor may provide either multi - channel (down to 1 pixel = 1 channel) or a spatial awareness of multiple light sources.

VLC can be used as a communications medium for ubiquitous computing, because light-producing devices (such as indoor/outdoor lamps,TVs, traffic signs, commercial displays and car headlights/taillights)are used everywhere.

Since light can’t penetrate the walls and hence it is highly secure as compared toRF. As RF waves easily penetrate the walls, they suffer from security issues. The VLC receiver only receives signals if they reside in the same room as the transmitter, therefore the receivers outside the room of the VLC source will not be able to receive the signals and thus, it has the immunity to security issues that occurs in the RF communication systems. Also, VLC requires less power than RF because visible light source can be used for both illumination and then can be use communication. The additional advantage like non-licensed channel makes VLC one of the promising candidates. Fig. 1.4 shows the block diagram of the VLC system. In the VLC system, the information is transmitted by modulating the instantaneous optical intensity in response to an input electrical signal. The information thus sent on VLC channel is not contained in amplitude, phase or frequency of the transmitted optical waveform, but rather in the intensity of the transmitted signal. This process of electro-optic conversion is termed as optical intensity modulation which is done by LEDs. To ensure that the LEDs work in its operating range, an LED driver is required which maintains a constant amount of power to the LEDs. A bias Tee is used in the transmitter side to combine DC driving current with the message signal. In the receiver side, the received light signals are converted to electrical signals by a photodiode. This process of opto-electrical conversion is performed by direct- detection of incident optical intensity

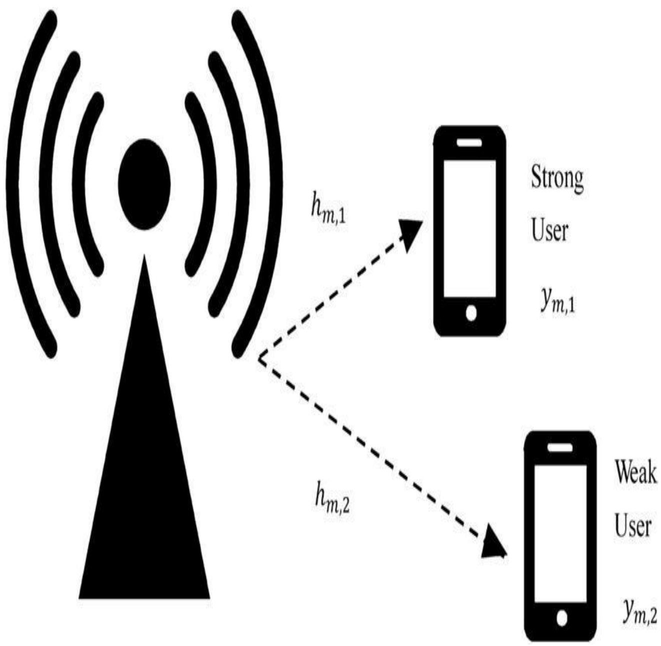
2.EXISTING SYSTEM

Orthogonal frequency-division multiple access:

Orthogonal frequency-division multiple access (OFDMA) is a multi-user version of the popular orthogonal frequency-division multiplexing (OFDM) digital modulation scheme. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users. This allows simultaneous low-data-rate transmission from several users.

OFDMA is the multi-user variant of the OFDM scheme where multiple access is achieved by assigning subsets of time-frequency resources to different users, allowing simultaneous data transmission from several users. In OFDMA, the radio resources are 2D regions over time (an integer number of OFDM symbols) and frequency (a number of contiguous or non-contiguous subcarriers).Similar to OFDM, OFDMA employs multiple closely spaced subcarriers that are divided into groups of subcarriers where each group is called a resource block.

The grouping of subcarriers into groups of resource blocks is referred to as sub-channelization. The subcarriers that form a resource block do not need to be physically adjacent. In the downlink, a resource block may be allocated to different users. In the uplink, a user may be assigned to one or more resource blocks. Sub-channelization defines subchannels that can be allocated to mobile stations depending on their channel conditions and service requirements. Using sub-channelization, within the same time slot (i.e., an integer number of OFDM symbols) an OFDMA system can allocate more transmit power to user devices with lower SNR and less power to user devices with higher SNR.



2.1 Problem with Existing System:

• Higher sensitivity to frequency offsets and phase noise.

* Asynchronous data communication services such as web access are characterised by short communication bursts at high data rate.

* Few users in a base station cell are transferring data simultaneously at low constant data rate.

* The fast channel feedback information and adaptive sub-carrier assignment is more complex than CDMA fast power control.

3. Proposed System

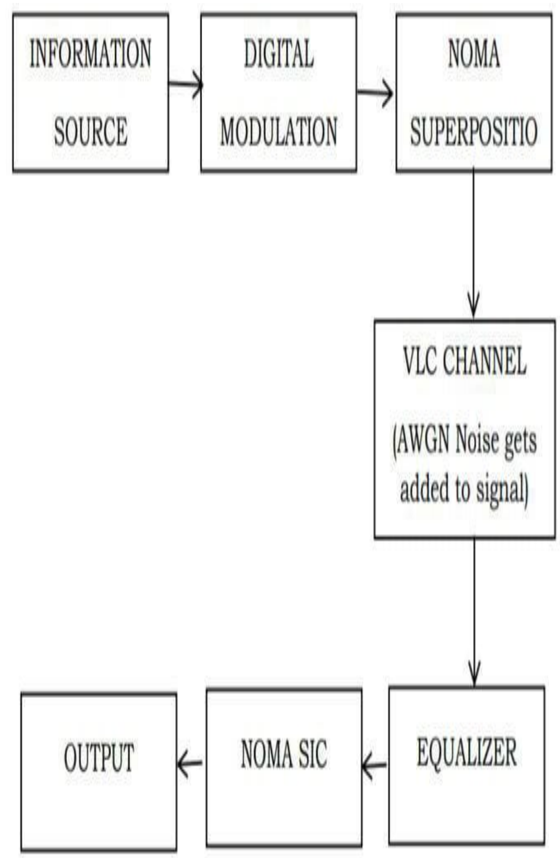
Non orthogonal multiple access (NOMA) is one of the most promising radio access techniques in next-generation wireless communications. Compared to orthogonal frequency division multiple access (OFDMA), which is the current de facto standard orthogonal multiple access (OMA) technique, NOMA offers a set of desirable potential benefits, such as enhanced spectrum efficiency, reduced latency with high reliability, and massive connectivity. The baseline idea of NOMA is to serve multiple users using the same resource in terms of time, frequency, and space. The available NOMA techniques can broadly be divided into two major categories, i.e., power-domain NOMA and code- domain NOMA.

Code-domain NOMA can further be classified into several multiple access techniques that rely on low-density spreading and sparse code multiple access. Other closely related multiple access schemes in this context are lattice-partition multiple access, multi-user shared access, and pattern- division multiple access.Recent studies demonstrate that NOMA has the potential to be applied in various fifth generation (5G) communication scenarios, including Machine-to_x0002_Machine (M2M) communications and the Internet-of-Things (IoT).Moreover, there are some existing evidence of performance improvement when NOMA is integrated with various effective wireless communications techniques, such as cooperative communications, multiple-input multiple-output (MIMO), beam forming, space–time coding, network coding, full-duplex, etc.Given all advancements and experimental outcomes, standardization of NOMA has been established for the next-generation American digital TV standard (ATSC 3.0) under the term layered-division multiplexing (LDM), and has been initiated for the third-generation partnership project (3GPP)under the name multi-user superposition transmission (MUST).

Block diagram of NOMA-VLC System :

Working Process :

Non-Orthogonal Multiple Access (NOMA) is a multiple access scheme for 5G. The fact that NOMA allows multiple users to transmit and receive simultaneously using the same frequency may appear intriguing.The two key operations that make NOMA possible are superposition coding which must be done at the transmitter side and successive interference cancellation (also known as SIC) at the receiver side. In this post we will see about superposition coding. An equalizer (also called an “EQ”) is an audio filter that isolates certain frequencies and either boosts them, lowers them, or leaves them unchanged.



We know that NOMA serves multiple users simultaneously in the same frequency. There, it was concluded that, if the number of users is increased beyond a limit, the sum throughput of the network will actually begin to drop. So, we cannot increase the number of users per carrier indefinitely. Hybrid NOMA is a combination of NOMA with any OMA technique. For example, let's consider TDMA+NOMA, as shown in Fig. 1. Let's say we have a time slot of 4 ms duration. We have to support 4 users within this time slot. Now, TDMA will divide the 4 ms slot into four 1 ms slots and assign one slot to each user. NOMA, will assign the whole 4 ms slot to the four users. As we know,this will increase the SIC complexity and processing delay. Hybrid NOMA, on the other hand, divides the 4 ms slot into two 2 ms slots and assigns two NOMA users to each slot.

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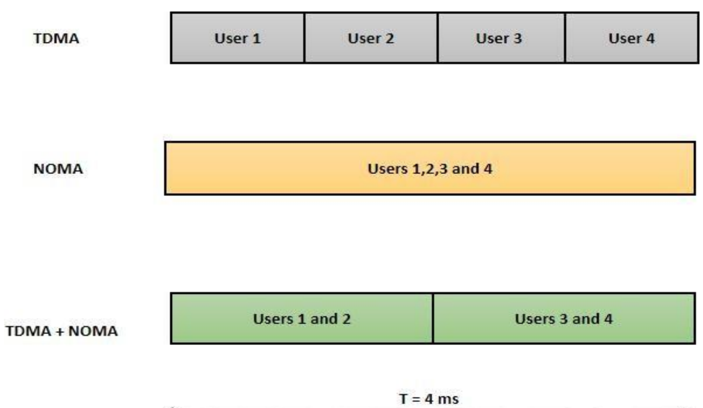
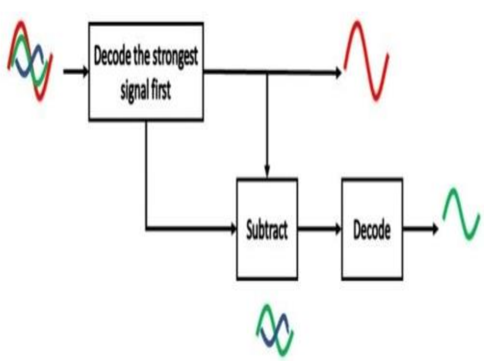


Successive Interference Cancellation (SIC



The first decoded signal is then subtracted from the received signal and if the decoding is perfect, the waveform with the rest of the signals is accurately obtained. SIC iterates the process until it finds the desired signal

Co-Operative NOMA:

We know that NOMA involves successive interference cancellation (SIC), where one user decodes the message of the other user, from the superposition coded received signal, before decoding his own message. Specifically, the near user decodes the information of the far user while performing SIC. There is no escaping this step. The near user must decode the far user's data anyway. Now that the near user has far user's data, he may as well relay that information to the far user to aid him. Since the far user has a poor channel with the transmitting base station (BS), the re transmission of his data by the near user will provide him diversity. That is, he will receive two different copies of the same message. One from the base station, and one from the near user who is acting like a relay. Thus, we can expect the outage probability. This concept is called cooperative communication/cooperative relaying. We can see that NOMA naturally allows cooperative communication because the near user has the far user's data because it must decode it anyway.

4.SIMULATION RESULTS

Outage probability for far user with NOMA and Cooperative NOMA :

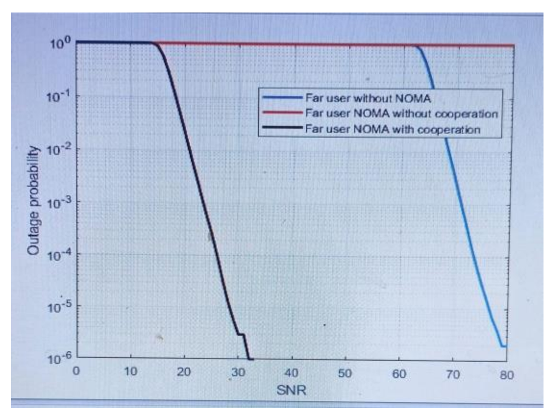


Figure : Outage probability Vs. SNR for different Target rate of farur

Advantages :

Following are the benefits or advantages of NOMA:

➡It offers higher spectral efficiency due to use of multiple users on same frequency resource.

➡It offers massive connectivity by serving more uses simultaneously at the same time.

➡It offers lower latency due to simultaneous transmission all the time rather than dedicated scheduled time slot.

➡It offers better QoS (Quality of Service) to all the users using flexible power control algorithms. It helps in increasing cell-edge throughput and better user experience at cell-edges.

➡The NOMA along with MIMO delivers enhanced performance.

5.Conclusion

From this project we concluded that the Outage and Bit Error Rate probability of the coming data within the room. By considering the successive Interference Cancellation (SIC) we concluded the Cooperative NOMA VLC system. Successive Interference Cancellation (SIC) will works upto SNR <= 80. i.e., the target rate R = 9. High data rates can be transmitted for communication in indoor VLC system i.e., This is ought to happen because higher data rate means less coverage area.

References

1. X. Liu, Z. Chen, Y. Wang, F. Zhou, Y. Luo, and R. Q. Hu, "BER analysis of NOMA-enabled visible light communication systems with different modulations," IEEE Trans. Veh. Technol., vol. 68, no. 11, pp. 10807–10821, Nov. 2019.
2. J. Liu, N. Kato, J. Ma, and N. Kadowaki, "Device-to-device communication in LTE-advanced networks: A survey," IEEE Commun. Surv. Tut., vol. 17, no. 4, pp. 1923–1940, Oct.–Dec. 2015.
3. Z. Ghassemlooy, W. Popoola, and S. Rajbhandari, Optical Wireless Communications: System and Channel Modelling with Matlab. Boca Raton: CRC Press,2019.
4. F.-M. Wu, C.-T. Lin, C.-C. Wei, C.-W. Chen, H.-T. Huang, and C.-H. Ho, "1.1-Gb/s white-LED- based visible light communication employing carrier-less