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# PAPR Reduction using Huffrith Algorithm with APSK Modulation Technique in 6G System

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**ABSTRACT**

Non-Orthogonal Multiple Access (NOMA) is very useful in 6G network system requirements, also a solution to improve spectral efficiency and user fairness. NOMA gives a new dimension that increases spectral efficiency, massive connectivity, low transmission latency, and cost of signalling. Hence, NOMA as multiple access schemes can solve user problems from scarce time or frequency domain resources. 6G data traffic reduction by storing the most popular contents in advance at the network edge whereas content caching restricts duplicate of multiple data transmission. The most concerning problem would be the impact of a few subcarriers on the PAPR reduction in NOMA systems is needed to avoid signal degradation. The objectives of this research are to reduce the PAPR. The method applied is by using the Huffrith algorithm with the APSK modulation technique in the NOMA system. The results were obtained by comparing the contribution method with variations of the coding technique, which is the Huffman, Arithmetic, and Huffrith algorithms. Huffrith algorithm is the higher improvement using 512 subcarriers with 8.6 % and PAPR values of 8.5 dB. For 1024 subcarriers get 8.7 dB and 12.12% percentage of improvement.

## 1. Introduction

The International Telecommunication Union (ITU) Focus Group Technologies for Network system 2030 and beyond was established to explore the technologies. 6G concepts are new holographic media, Internet protocol (IP), services, and network architecture [1]. The main goal of the 6G system is to meet the demands of the information society 10 years from now and significantly go beyond 5G. Four key aspects of 6G vision are intelligent connectivity, deep connectivity, holographic connectivity, and ubiquitous connectivity [2,3]. Currently, the 6G concept is still in the early stage to be discussed, and quite diverse by researchers in different countries. Non-orthogonal multiple access (NOMA) as advanced modulation scheme based on multicarrier scheme. NOMA designing through the superposition coding (SC) and successive interference cancellation (SIC) [4]. NOMA considers

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motivation factors whereas improve spectral efficiency, support massive connectivity and enhanced user fairness; achieve low latency, diverse QoS, minimal wireless network traffic, low-cost devices, and Internet of Things (IoT). This system also shares time and frequency resources among users in the same spatial layer through power domain or code domain multiplexing [5]. NOMA superposes the signals of multiple users at transmitting part and an algorithm reacts as super-positioned signal separation among respective users at receiver part.

The combination of NOMA and multi-antenna multi-input multi-output (MIMO) technologies exhibits a significant potential in improving spectral efficiency and providing better wireless services to more users. In this research, we introduce the basic concepts of MIMO-NOMA and summarize the key technical problems in MIMO-NOMA systems. MIMO offers excessive degrees of freedom to further improve the system throughput of NOMA [6]. The key feature of NOMA is to exploit the difference between user's channel conditions. In scenarios with single-antenna nodes, channels are scalar, and it is easy to order the users based their channel conditions. In MIMO, channels are in form of matrices or vectors, which makes difficult to order users [7,8]. It is not clear how to design optimal precoding or detection strategies. Amplitude and phase shift keying (APSK) responds to digital modulation system that modulates both reference signals by transmitting data. APSK is an ideal modulation scheme for satellite transmission that would provide better spectral efficiency than QPSK but would be more distortion resistant than QAM. In order to overcome this problem, author in previous studies [9] suggested APSK as a way of obtaining the best of both worlds. In APSK, the symbol points are set in constant amplitude concentric rings. Most researchers focus on the complexity of NOMA without considering the impact of modulation schemes on NOMA performance versus OMA. As mentioned in previous studies [10], comparison both system NOMA and OMA by the sum rate but unfortunately not provided for further discussion of their behaviour towards the same modulation scheme. In the meantime, clarification of the MIMO NOMA benefits over OMA is discussed in previous studies [11], which explores the MIMO NOMA formulation, beamforming, user clustering, and single or multi cluster power allocation issues along with their literature drawbacks. Unfortunately, the modulation technique output is not simulated.

## 2. Methodology

Figure 1 illustrates the proposed NOMA block diagram. Input data is generating using contribution method which Huffrith algorithm and APSK modulation scheme. User with their respective signal is fed into transmitter with additional of cyclic prefix. The relevancy of using cyclic prefix for proposed NOMA method capable to remove Inter-Symbol Interference (ISI) caused by multipath channel in the transmit signal. Then, input signals will be superposed through superposition coding that is essential for SIC operation later. The transmitted signal is then pass-through Rayleigh channel. Then, reverse process done with the additional of SIC in NOMA at receiver part. Hence, order of decoding is vital for multiple user connection to cancel out the interference from the stronger signal.

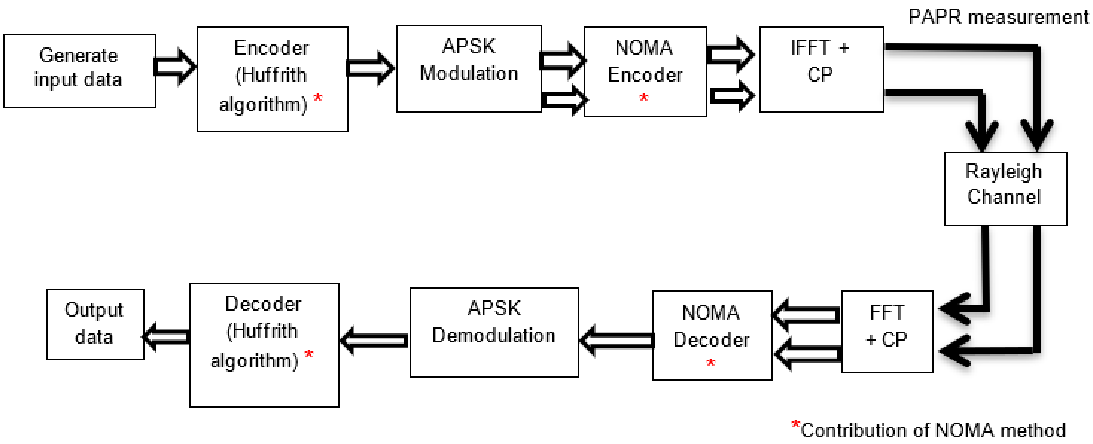


**Fig. 1.** Block diagram of NOMA system

Figure 2 shows the flow simulation process through this research. PAPR result is obtained in final stage after done simulate the signal. This research differentiates two of iteration number which is meeting the objective. Huffrith algorithm is contributed as block coding technique using NOMA system. Starting the simulation by enters the number of iterations, then the data signal will generate randomly. The signal will encode using Huffrith algorithm and APSK modulation in NOMA system. IFFT combining with cyclic prefix encode the signal and analyse the PAPR performance before thoroughly into Rayleigh channel. Lastly, the signals pass through into decoder part. This part compares and evaluate the results which is achieved the objective to reduce the PAPR or not. If satisfy the results the simulation was ended.

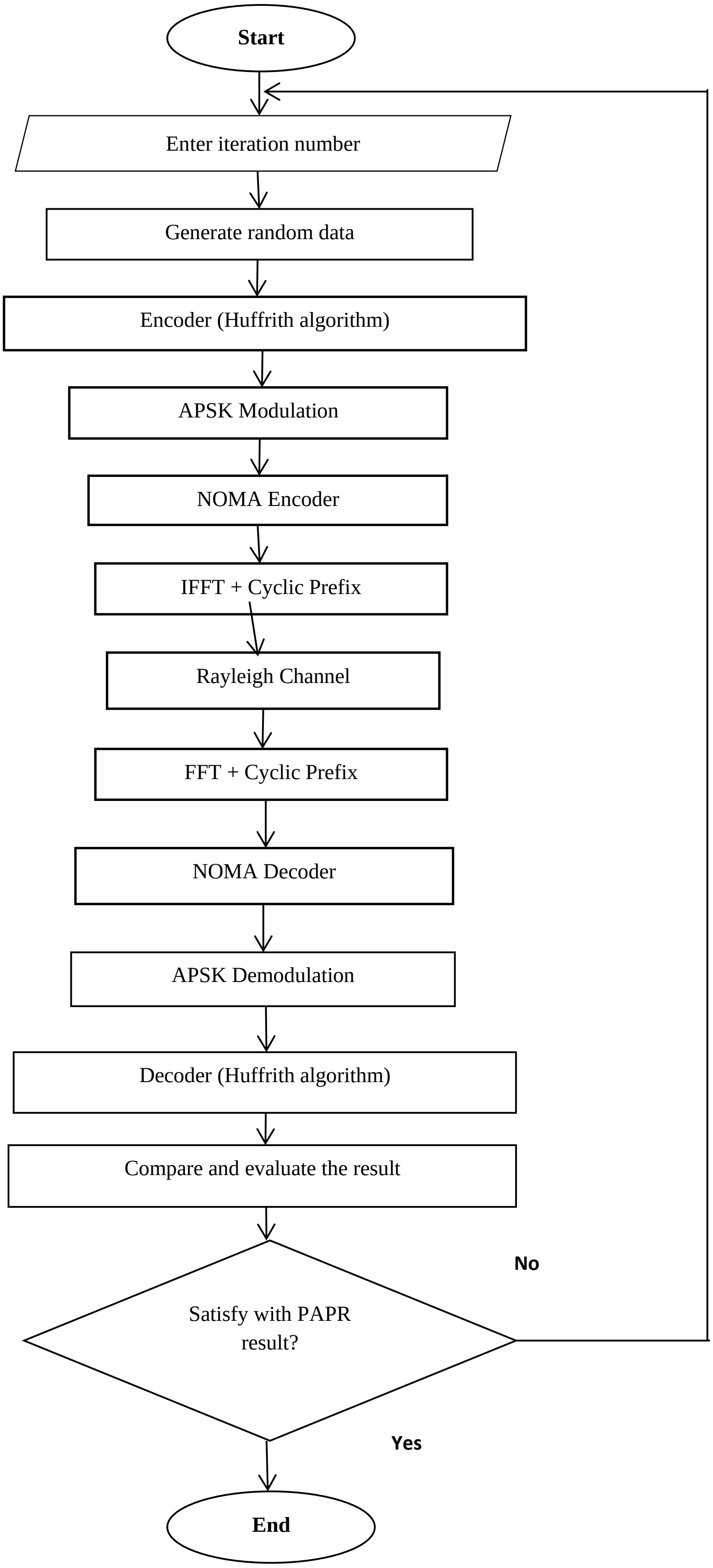


**Fig. 2.** Simulation process flowchart

## 3. Proposed Method

### *3.1 Non-Orthogonal Multiple Access*

NOMA is to simultaneously serve multiple users over the same spectrum resources at the expense of inter-user interference. NOMA consider power domain with superposition coding (SC) at transmitter part. Meanwhile, successive interference cancellation (SIC) as the main operation in the receiver part to retrieve user data NOMA [12-14]. During SIC the user first decodes the undesired, stronger signal intended for the far user and subtracts it from the received signal, after which the desired weaker signal may be decoded. The user located far from the base station with a lower received signal quality, will be assigned a stronger weight and thus the high-power signal within the multiplexed symbol and will only decode their own signal [15]. In this case, SIC is implemented iteratively for multiple users, decoding the largest power within the received multiplexed signal and subtracting it from the received signal until the signal of interest is the strongest in the remaining signal so it is possible to finally decode the data. In the NOMA, $x_1$and $x_2$ are superposition coded as [16]

$$x = \sqrt{a_{huffrith}}x_1 + \sqrt{a_{huffrith}}x_2 \quad (1)$$

The transmit signal at user is represented as

$$y_i = h_i x + w_i, \quad (2)$$

where $h_i$ is the complex channel coefficient between user and the base station. $w_i$ is the receiver Gaussian noise including inter-cell interference and $P_i$ is transmission power. PAPR is expressed in terms of dB, given as: [17]

$$PAPR_{dB} = 10\log_{10}\frac{Maximum[|y_i(t)|^2]}{\frac{1}{T}\int_0^T[|y_i(t)|^2]dt} \quad (3)$$

where T is the period of the NOMA symbol. The complementary cumulated distribution function (CCDF) is a significant parameter which indicates the effectiveness of reduction method.

### *3.2 Huffrith Algorithm*

Huffrith algorithm is new contribution for this paper which is combination between Arithmetic and Huffman equation. Each coding technique have their advantages and disadvantages, so by combining both will get more advantages which is compliment with each other. The Huffrith algorithm expressed as below;

$$a = n\ x\ s \quad (4)$$

$$P_1 = min(a)\ , P_2 = max(a) \quad (5)$$

$$a_{huffrith} = \frac{255\ [a - P_1(a)]}{P_2} \quad (6)$$

Assume that $n$ is number of bits per symbols of NOMA system or number of subcarriers, and $s$ is number of symbols. $P_1$ and $P_2$ is probability of codeword. Huffrith algorithm as a modulation scheme that used to encode the string. Besides that, Huffrith also react as data encoder which is the process conversion of data compression, data transmissions and data storage.

## 4. Results and Discussion

The start-up parameter based on Table 1 is set to generate random data such as the number of subcarriers in 64 APSK modulation technique. The initialization is important to provide the system settings, including the channel profile, IFFT/FFT size, and SNR to the simulation. Over 1000 symbols are randomly data input created. The entry of the data integers is then being processed using the modulation function, which is then being mapped into the APSK modulation technique. These symbols are demodulated at the receiver, and then the reverse mapping process is used to recover an estimate of the original data inputs. The PAPR performance of NOMA with different coding technique using APSK and various subcarriers is analysed.

**Table 1**
Simulation parameters [13]

| Parameter | Specification |
|---|---|
| Subcarrier per resource block | 512, 1024 |
| Channel | Rayleigh Fading |
| Transmission waveform | 64 APSK |
| Sampling factor, n | 28/25 |
| FFT size | 1024 |
| Cyclic prefix | 0.25*FFT size |

Based on the observation of Figure 3, the PAPR performance of four different type of coding technique using 64 APSK modulation scheme can be explicitly compared. Huffrith algorithm led to better PAPR performance than others type of coding technique. Referring to $10^{-1}$, shown Huffrith gets much better results which is 8.5 dB. Meanwhile, following by minor gap between Huffman and Arithmetic gets 8.7 dB and 8.8 dB. The original data is 9.3 dB. The original not apply any modulation scheme like others, when applying the modulation scheme especially Huffrith gets smooth graph and more improvement of percentage error.

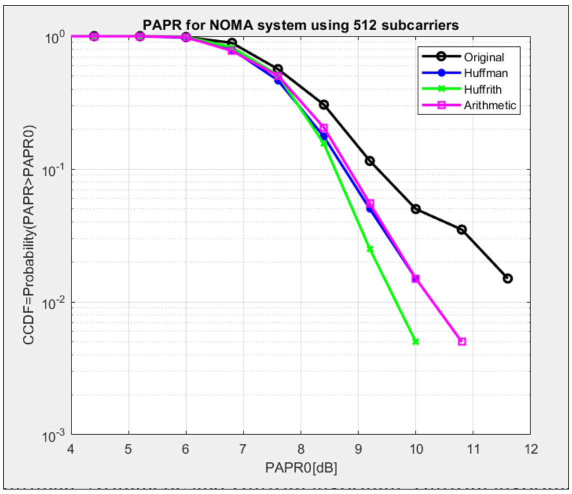


**Fig. 3.** PAPR performance graph of 512 subcarriers in NOMA

In Figure 4 portrays the PAPR performance of four different type of coding technique using 64 APSK modulations. Huffrith algorithm has better PAPR performance compared to others type of coding technique. By referring at $10^{-1}$, Huffrith shown PAPR reduction with 8.7 dB, following by Arithmetic is 8.75 dB, Huffman is 8.9 dB and original data is 9.9 dB. Huffrith method is very useful to reduce the PAPR in NOMA system. These algorithms as block coding technique to compress the data signal randomly.

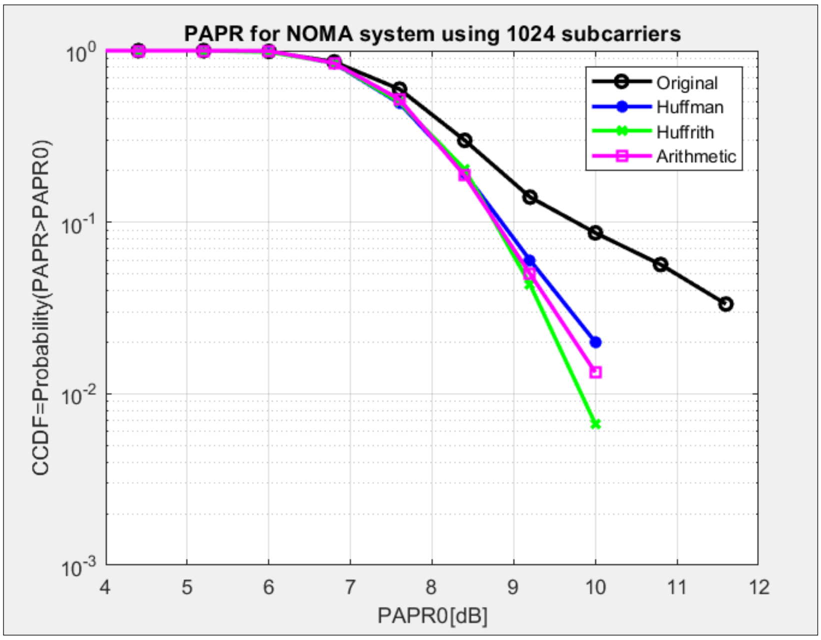


**Fig. 4.** PAPR performance graph of 1024 subcarrier in NOMA

Table 2 tabulate the summary result from simulation between different subcarriers in NOMA system. PAPR reduction is simulating using 64 APSK modulation scheme in NOMA system. For 512 subcarriers, Huffrith led better with highest percentage of improvement which is 8.6%. Followed by Huffman and Arithmetic is 6.45% and 5.38%. For 1024 subcarriers, Huffrith algorithm get more percentage of improvement is 12.12% with 8.7 dB. Followed by Arithmetic and Huffman is 11.62% and 10.10%. Seems 512 and 1024 subcarriers is more reliable and suitable for Huffrith algorithm. Between both subcarriers shows 1024 subcarriers more improve the percentage of error.

**Table 2**
Summary of PAPR value using different technique in NOMA

| Modulation Scheme | Number of Subcarrier | Coding technique | PAPR values at $10^{-1}$ (dB) | Percentage of improvement (%) |
|---|---|---|---|---|
| 64 APSK | 512 | Original | 9.3 | - |
| | | Huffman | 8.7 | 6.45 |
| | | Huffrith | 8.5 | 8.60 |
| | | Arithmetic | 8.8 | 5.38 |
| | 1024 | Original | 9.9 | - |
| | | Huffman | 8.9 | 10.10 |
| | | Huffrith | 8.7 | 12.12 |
| | | Arithmetic | 8.75 | 11.62 |

## 5. Conclusions

This paper gives better interpretation in NOMA in terms of its concept and performance evaluations. High PAPR will affect the signal degradation and NOMA system is to solve user problem from the scarce time or frequency domain resources. PAPR is analysed the performance with the variation number of subcarriers which is 512 and 1024 in 64 APSK. As for NOMA, proportional fairness is achieved between the users. Both subcarriers more reliable and achieved the objectives of this paper to reduce PAPR using Huffrith algorithm in 6G network system. The results obtained 512 subcarriers get 8.5 dB and 8.6 % percentage of improvement. For 1024 subcarriers get 8.7 dB and 12.12% percentage of improvement.


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