CHAPTER I
INTRODUCTION

1.1 Background

The discovery of the concept of Centralized Radio Access Network (C-RAN) was then proposed as a RAN technology that was finally able to realize a 5G network. The concept of centralization in C-RAN requires a low upstream delay and large bandwidth so that an access network with the appropriate delay and bandwidth criteria is required. An access network that is able to provide low delay, large bandwidth, high data transfer speed, and good performance is an optical access network. Next-Generation Passive Optical Network 2(NG-PON2) is an optical access network that is currently being developed where the goal is to meet the needs of communication technology that requires large bandwidth. NG-PON2 is applied to C-RAN technology so that the resulting delay and capacity is better than conventional PON. In upstream NG-PON2, Dynamic Bandwidth Allocation (DBA) is required to dynamically allocate bandwidth. Conventional DBA produces a delay of not less than 0.6 ms, while C-RAN has a strict delay requirement of 0.3 ms [1], so a DBA with a low delay is required..

In the Centralized Radio Access Network (C-RAN), the Baseband Unit (BBU) is centered in one location and separated from the Radio Unit (RU) [1][2][3][4][5][6]. The work system is different from the conventional RAN concept, since RU and BBU are located at the same location, at the Base Station [2][4][6]. The concept of C-RAN aims for better resource management on cellular networks and simplification of the RAN network [2][5]. In research conducted by [1], the Demand Forecasting Dynamic Bandwidth Allocation (DF DBA) algorithm was applied which was then compared with conventional DBA algorithms, namely RR DBA and GIANT DBA. Based on 3 analysis parameters which include Delay, Throughput, and Packet Delivery Ratio, DF DBA gets the best results compared to RR DBA and GIANT DBA due to the reduction in idle time and waiting time on the DF DBA algorithm. In [7] research, the Demand Forecasting Dynamic Bandwidth Allocation (DF DBA) algorithm was applied

which was then compared with conventional DBA algorithms, namely RR DBA and GIANT DBA. Based on 3 analysis parameters which include Delay, Throughput, and Packet Delivery Ratio, DF DBA gets the best results compared to RR DBA and GIANT DBA due to the reduction in idle time and waiting time on the DF DBA algorithm.

In this study, a modified Round Robin DBA algorithm is proposed with considerations related to delay performance in upstream by utilizing excess bandwidth and using forecasting methods. In addition, this research also considers throughput parameters, and Packet Delivery Ratio (PDR) where the study of the maximum Remote Radio Heads (RRH) and Optical Network Terminal (ONT) that can be aggregated using NG-PON2 is also carried out. The use of the modified Round Robin DBA algorithm aims to increase the delay on C-RAN considering the strict delay requirements on the C-RAN network of 300 μs [1]. In the end, this research is expected to improve delay in C-RAN by using the NG-PON2 access network so that its implementation can be considered in real conditions.

1.2 Problem Identification

The use of XG-PON access network on C-RAN has not resulted in good delay and the maximum capacity of Baseband Units (BBU) and Remote Radio Heads (RRH) is small, which is 2-8 units. Therefore, the use of the NG-PON2 access network on C-RAN technology so that the resulting delay and maximum capacity is better than XG-PON is very necessary.

Dynamic Bandwidth Allocation is required to dynamically allocate bandwidth upstream. Conventional DBA in this case produces a delay of not less than 0.6 ms, while C-RAN has strict delay requirements of 0.3 ms so that what is needed in this case is a DBA with low delay.

1.3 Problem Statement

Based on the background of the problem mentioned earlier, the problem statements are as follows:

1. Is the Round Robin (RR) DBA modification on NG-PON2 able to achieve the delay performance criteria on C-RAN?

2. What is the maximum number of RRH and ONT that can be achieved on C-RAN using the NG-PON2 network?
3. How does the modified RR DBA performance compare to conventional RR DBA, Demand Forecasting (DF) DBA, GigaPON Access Network (GIANT) DBA, Extended GIANT (XGIANT) DBA, and Efficient Bandwidth Utilization (EBU) DBA?

1.4 State of the Art

The purpose of this sub-chapter is to show differences in research and experiments that have been carried out with various schemes so that delay criteria can be found on C-RAN and the use of PON networks on C-RAN. In traditional RAN, the location of the Radio Unit (RU) and Baseband Unit (BBU) are in the same location, namely at the Base Station. In Centralized RAN (C-RAN), BBU is centralized in one location and separated from RU. The purpose of the C-RAN concept is for better resource management on cellular networks [3]. The discovery of the C-RAN concept requires high bandwidth in its implementation so that a good access network is needed. 10 Gigabit Passive Optical Network (XG-PON) can support bandwidth up to 10 Gbps symmetrically on Uplink and Downlink [1]. Through this work system, the XG-PON access network technology can support the C-RAN concept which requires high bandwidth.

In research of [1], the evaluation of Dynammic Bandwidth Allocation (DBA) on C-RAN on XG-PON access network with Time Division Multiplexing (TDM) basis was carried out. The research proposes the Optimized Round Robin DBA algorithm with better throughput, delay, and latency compared to other DBA algorithms.

On the other hand, the research conducted by [7], applied the Demand Forecasting Dynamic Bandwidth Allocation (DF DBA) algorithm and compared it with conventional DBA algorithms, namely RR DBA and GIANT DBA. Based on 3 analysis parameters consisting of Delay, Packet Delivery Ratio, and Throughput, it was found that DF DBA produced the best delay compared to RR DBA and GIANT DBA. This occurs as a result of the reduction in idle time and waiting time in the DF DBA algorithm by using forecasting in bandwidth allocation.

In a study conducted by [8] it was proposed Dynamic Wavelength and Bandwidth Allocation (DWBA) algorithm on TWDM-PON to improve energy efficiency, increase OLT and ONU connections, and reduce delay with a minimum wavelength channel. Based on this research, it is concluded that the use of the proposed algorithm is more efficient because it can be connected to more ONUs with fewer active channels, which is 50% of the conventional algorithm.

Research performed by [4] compared the performance of Distributed RAN and Centralized RAN using a 10 Gigabit Passive Optical Network (XG-PON) access network was carried out on uplink and downlink with parameters of average throughput and optimization of resource blocks on 5-15 connected UEs. The highest uplink delay loss found in this study was in distributed RAN with 5 UE by 50%, while centralized RAN had 18% loss delay. Resource Block (RB) utilization can be reached at 100% with 15 UE. The simulation results show that the utilization of RB centralized RAN is found to be better than distributed RAN. The average throughput performance generated on centralized RAN is also found to be better than distributed RAN and Resource Block (RB) which will be more optimal if using centralized RAN rather than distributed RAN.

1.5 Research Objectives

The objectives to be fulfilled in this research are to obtain a C-RAN system with better delay and performance and to meet the bandwidth requirements of complex networks and 5G networks. The following are the specific objectives of this study.

1. To review the delay performance on C-RAN using a modified Round Robin DBA using the NG-PON2 network.
2. To get a delay performance of less than 0.3 ms in accordance with the requirements of C-RAN.
3. To analyze the maximum number of RRH and ONT that can be achieved on C-RAN using the NG-PON2 network.
4. To simulate and compare the performance of the proposed DBA algorithm with conventional RR DBA, DF DBA, GIANT DBA, XGIANT DBA, and EBU DBA..

1.6 Scope of Work

In this study, there are several research limitations as follows:

1. Modified algorithm design for Round RobinDBA, conventional RR DBA, DF DBA, GIANT DBA, XGIANT DBA, and EBU DBA used for upstream bandwidth allocation on C-RAN.
2. The C-RAN system with NG-PON2 access network is designed by using NS-3 software with the following specifications.
    a. The aggregate bitrate in the upstream is 10 Gbps according to the NG-PON2 standard which has been standardized by FSAN G.989.1.
    b. This study refers to the ITU-T NG-PON2 recommendation system.
    c. Using a multiplexing system in accordance with the recommendations by FSAN.
    d. The traffic load is set differently, namely 10%, 30%, 50%, 70%, and 90%.
    e. The distance from OLT to ONU is up to 40 Km with 10 Km spacing.
    f. The splitter ratios used are 1:2, 1:4, 1:8, 1:16, 1:32, 1:64, and 1:128.
    g. Uses propagation delay based on ITU-T G.989..
3. Analysis and evaluation of the advantages and disadvantages of the algorithm.
4. Determine the maximum capacity performance of Remote Radio Heads (RRH) or Optical Network Terminal (ONT) that can be achieved.

1.7 Research Method

The DBA mechanism in NG-PON2 was used to determine the bandwidth allocation for upstream transmission in the Optical Network Unit (ONU) with a queuing system. The use of NG-PON2 in the upstream was in a highly bursty condition according to the needs of the ONU. Conventional DBA algorithms, namely RR DBA and GIANT DBA, condition highly bursty on PON networks. However, the resulting delay in conventional DBA is not less than 0.6 ms. This made a modified DBA algorithm was proposed, namely the modification of Round RobinDBA to improve delay performance on the PON network, especially NG-PON2. This research was conducted by comparing 6 DBA algorithms,

namely RR DBA, DF DBA, GIANT DBA, XGIANT DBA, EBU DBA, and modified Round Robin DBA.

1. Round Robin DBA (RR DBA)

The RR DBA algorithm treats T-CONT in the network evenly with the number of bytes less than or equal to a predetermined fixed limit. The RR DBA algorithm uses burst time to determine the queue in the bandwidth allocation.

2. Demand Forecasting DBA (DF DBA)

The Demand Forecasting DBA Algorithm applies the forecasting method to the DBA with the aim of reducing idle time and waiting time during the transmission cycle. DF DBA implementations can provide upstream bandwidth allocation to the ONU before the ONU makes a request.

3. GIANT DBA

The GigaPON Access Network (GIANT) DBA algorithm is an algorithm commonly used in Giga-PON access networks. In the GIANT DBA algorithm, bandwidth allocation is differentiated by service using Transmission Container (T-CONT).

4. XGIANT DBA

The Extended Giga PON Access Network (XGIANT) DBA algorithm is a GIANT DBA that is optimized for several parameters, including service timers, assured and non-assured ratio to traffic priority. XGIANT DBA was developed by [9] and found to produce better performance when compared to EBU DBA.

5. EBU DBA

The Efficient Bandwidth Utilization DBA algorithm utilizes unused bandwidth on the DBA. The available waiting line ob the byte counter on the EBU DBA can be negative where the unused remaining on the available byte counter can be used for other waiting line.

6. Modified Round Robin DBA

This study proposes a modification of the Round Robin DBA based on the concepts of Optimized RR DBA and DF DBA. Optimized RR DBA Algorithm is

a DBA optimization based on Round Robin DBA. Optimized RR DBA uses excess bandwidth in the DBA algorithm which causes more efficient bandwidth allocation. The use of the Optimized RR DBA algorithm can also reduce overload conditions on T-CONT.

Modifications were made using the Round Robin DBA. This is done because the performance of delay and latency is relatively better when compared to conventional DBA, namely GIANT DBA. Modification of Round Robin DBA is done by utilizing excess bandwidth and using forecasting methods in determining bandwidth allocation in the upstream. The correlation between the RR-DBA modification and the research that has been carried out is visualized in Figure 1.1.

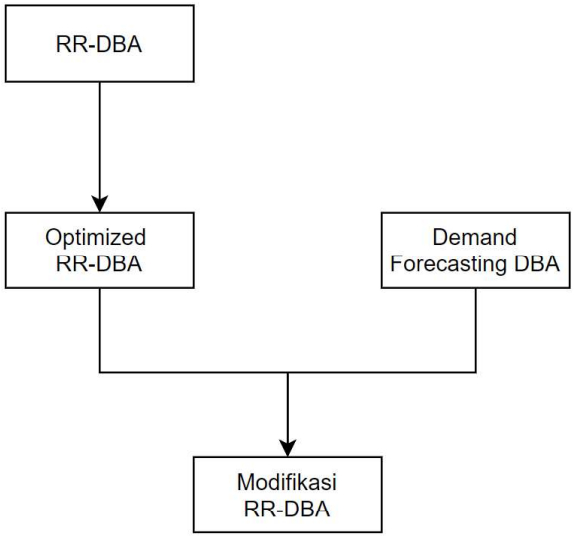

Figure 1.1 The Correlation in RR-DBA Modification

This research took PON2 access network to be applied to C-RAN. Based on the FSAN G.989.1 standard, NG-PON2 is capable of providing an aggregate bit rate of 40 Gbps downstream and 10 Gbps upstream. Unlike the previous PON generation, XG-PON, PON2 only able to provide an aggregate bit rate of 10 Gbps downstream and 2.5 Gbps upstream.