# Cluster Based Dynamic Bandwidth Allocation C-RAN

K. THAMİZHMARAN
Department of Electronics and Communication Engineering
Government College of Engineering, Bodinayakanur, Theni, Tamilnadu
INDİA

*Abstract*: A wireless network is a collection of independent nodes or devices that communicate over a single network through a wireless link. Bandwidth allocation is a critical issue in wireless networks because network performance and costs are heavily dependent on this parameter. Cluster-based Heterogeneous Cloud Radio Access Networks (HC-RANs) represent the most advanced network architecture in the current wireless communication system, facilitating cloud computing in Heterogeneous Networks. In this paper, we suggest an HC-RAN with the help of cluster-based bandwidth allocation, which can reduce energy consumption for wireless data transfer in a multi-hop device-to-device environment. The proposed algorithm provides dynamic bandwidth allocation in a wireless environment, addressing issues arising from the high mobility of users over time. In the design mentioned above, we use clustering combined with joint beam formation for the downlink of a heterogeneous cloud radio access network (HC-RAN), which has been developed to improve the sum rate. The results of the new scheme are compared with existing wireless methods using parameters such as the sum rate and average sum rate, tested through Network Simulator 2 (NS2).

*Keywords*: WSN, Heterogeneous, HC-RAN, Cluster, Bandwidth.

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## 1. Introduction

Our Earth rotates with four different forces: gravitation, electromagnetism (spectrum), weak interaction, and strong interaction. The spectrum is used in various ways in our daily lives; it consists of light, both visible (color lights) and invisible (waves or electromagnetic waves), which are fixed and utilized in many places depending on the different ranges of frequency, wavelength, and energy. When continuous forces are generated in a particular area, they form different frequencies and wavelengths until the forces stop [1]. If more energy is generated, it creates high-frequency and low-wavelength waves. Low-wavelength waves, such as ultraviolet rays, X-rays, and gamma rays, are not suitable for mobile communication due to their inability to travel long distances. Conversely, low-energy waves, with high wavelengths and low frequencies, are ideal for long-distance communication (radio waves). Examples include radio, TV broadcasts, mobile communication, and satellite communication.

Today, the 5G version (enhanced from the fourth generation) networks are implemented without issues because spectrum allocation is specially designed for telecommunication, overcoming low and high data issues by providing separate frequencies for all users, thus avoiding interference. The latest updated version of the 5G (fifth generation) network is especially used for IoT (Internet of Things), which is an excellent communication model supporting multiple applications in all fields with high speed and low complexity, addressing issues such as delay, delivery performance, and congestion. The current model uses MIMO (Multiple Input Multiple Output) technology and a widely used cloud design called CRAN (Cloud Radio Access Networks) [2-4]. Different types of cells and layers are used in HetNets (Heterogeneous Networks), such as femtocells, microcells, picocells, and macrocells. Macrocells are further classified into three different layers: macrocell 1, macrocell 2, and macrocell 3, as shown in **Figure 1** of the heterogeneous networks.

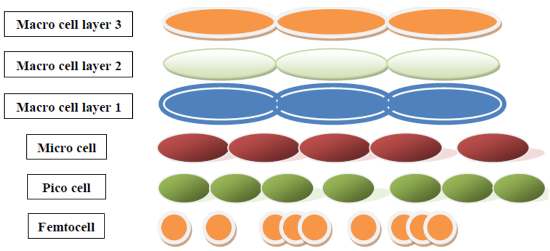



**Fig 1 Heterogeneous Networks**

A Radio Access Network (RAN) is broadly classified into two types: Open Radio Access Network (ORAN) and Closed Radio Access Network (CRAN). ORAN opens up these interfaces, giving operators faster and more flexible deployment options while enabling new functionalities like network automation, analytics, and network slicing. CRAN uses proprietary interfaces between the radio and baseband units [5-8].

5G CRAN high-power internet access scenarios include enhanced mobile broadband (eMBB), massive machine-type communications (mMTC), and ultra-reliable low-latency communications (URLLC). These techniques are designed for future development strategies and require important parameters for telecommunication cost of ownership. Today, a hot topic in the IT field is cloud-based information technology. CRAN (Cloud Radio Access Network) or centralized radio access network design is for high data services because of HSPA (High Speed Packet Access) and LTE (Long Term Evolution), which have increasing demand for data services and users [9-11].

Traditional RAN has certain characteristics: it is part of second, third, and fourth-generation networks. Each base station connects to a fixed number of antennas, which cover a small area and handle TX/RX within that area, with capacity limited by interference. However, they face challenges such as the need for a large number of base stations (investment, site support, management rental, etc.), low base station utilization rates, inability to share base station processing unit power among others, and faster data services (network upgrades). Future RAN aims to provide mobile broadband internet access to wireless users with low bit cost (reducing total bit cost), high spectral efficiency, support for multiple standards, and a platform for additional revenue-generating services. As fewer broadband units are required, outdated circuits can reduce network operation costs by lowering energy and power consumption [12-14].

The initial rollout of the 5G system was scheduled for 2020. It is anticipated to offer wireless area capacity about 100 times higher than the existing 4G system and use up to 90% less energy per service. The predicted benefits of 5G systems include more than 1000 Gbit/s/km² area spectrum capacity in congested metropolitan contexts and 10 times longer connected device battery life [15].
Significant advancements in baseband and radio frequency (RF) are necessary for the fifth-generation network. A substantial and progressive baseband calculation is essential to meet the complex requirements of novel solutions. The efficient operation of ultra-dense radio nodes depends on recent advances in integrated access nodes and heterogeneous convergences shown in **Figure 2** [16].

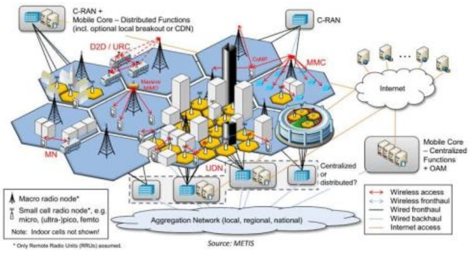


**Fig 2 Cloud Radio Access Networks**

## 2. H CRAN
## H-CRAN (Heterogeneous Cloud Radio Access Network)

H-CRAN is designed to leverage the positive outcomes of both cloud computing networks and heterogeneous networks, achieving better spectral and energy efficiency. Geologically dispersed antennas are used to collect radio frequency signals using radio heads, which are then remotely transferred over fronthaul links. As a result, spectral efficiency (SE) and energy efficiency (EE) performances are significantly enhanced compared to current HetNets and C-RANs. This updated technology meets the expectations and limitations of wireless communication [17-19].

The main key technologies of heterogeneous cloud-based radio access networks include large-scale cooperative multiple antenna processing and cloud computing-based coordinated multipoint transmission. These technologies challenge some open issues, such as performance analysis with stochastic geometry and performance optimization of constrained fronthaul. Multiple base stations with various transmitting powers, like high power nodes for macro cells and low power nodes for micro, pico, and femto base stations, are utilized to provide additional area capacity within dense traffic regions like underlying cells [20].

**Bandwidth Allocation**
There are three types of spectrum allocation:

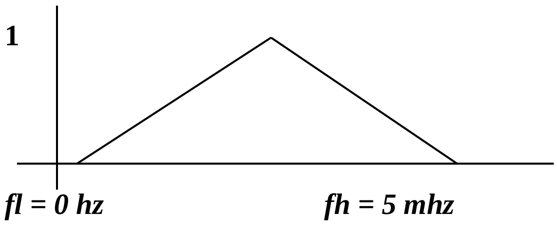
1. No one may transmit (only for research purposes and cannot be used by anyone).
2. Anyone may transmit (commonly used for power generation like AC power).
3. Only licensed users/organizations may transmit (particularly for

telecommunication, TV broadcast, or radio) – this type of spectrum is approved by the government of each country [21-22].

In 1994, the Indian government decided to sell spectrum allocation for 900 MHz. After that, it continued to sell spectrum in 1997, 2000, 2001, and 2012. In the year 2020, the government decided on the fifth-generation spectrum allocation, estimated at nearly 5 lakh crore rupees, due to the very high data rate speed of 100 Gbps, supporting 100 times better performance than 4G users under the control of DRDO [23]. Bandwidth is an important parameter of the wireless communication spectrum and is classified into two types:

1. Significant signal (a signal that passes between starting and ending points with a fixed frequency, e.g., normal video).
2. Insignificant signal (a signal that passes between starting and ending points with a non-fixed frequency, e.g., HD video).

Further classifications include channel bandwidth and signal bandwidth.




$$\mathbf{BW = positive\ high\ frequency - positive\ low\ frequency}$$

$$\mathbf{BW = 5\ MHZ - 0 = 5\ MHZ}$$

Minimum loss and maximum performance fulfill the following condition

$$\mathbf{channel\ bandwidth > signal\ bandwidth}$$

Dynamic bandwidth allocation: High speed wireless broadband create new use causes using multi homing futures and they specially designed called dynamic bandwidth with number of wireless access network ports (one access network port for one broadband in wireless), the router fixed speed for load balancing algorithm.

**Fixed speed** $f\,(t)$

**Pay as you use** $p(t)$

it provide 8 ports for 8 YES dongles to achieve the dynamic bandwidth and availability, dynamic fourth generation network they achieve better network performance like delivery ration and throughput when they inserted multi number of YES dongles, this is novel evaluation of MIMO (multiple input and multiple output) technology.

$$Wbw = frequency\ of\ input\ before\ system\ response$$

**Velocity of linear system** $\mathbf{Gv\,(S)} = \frac{\emptyset(s)}{Vs\,(S)}$

This types of bandwidth are varied for different hours of the day and different days of week, they have much better for the benefits of sufficient bandwidth and quality of service with availability and mobility requirement, available solution for existing problem like multi homing multi IPS, load balancing and virtual server mapping etc.

## 3. Background Work

In this section, we discuss and analyze the existing developed work and identify research gaps. Joint user selection and beamforming in downlink millimetre-wave NOMA based on user positioning were explored by Mahmoud Mohamed (2020). A joint angle and distance-based user pairing strategy for millimeter-wave NOMA networks was discussed by X. Lu et al. (2020). The impacts of imperfect SIC and imperfect hardware on the performance of AF non-orthogonal multiple access networks were proposed by Azza Alamir and Hamada Esmaiel (2018). FEBA: a bandwidth allocation algorithm for service differentiation in IEEE 802.16 mesh networks, was suggested by C. Cicconetti et al. (2009). Bandwidth allocation based on traffic load and interference was designed by Sanjeev Jain et al. (2013). The performance of centralized clustering techniques for realistic wireless sensor network topologies was analyzed by Raval et al. (2015). Fuzzy-based clustering and energy-efficient routing for underwater wireless sensor networks were explored by Souiki et al. (2015). A survey of rate-optimal power domain NOMA with enabling technologies of future wireless networks was developed by K. Thamizhmaran (2022). Full duplex non-orthogonal multiple access cooperative overlay spectrum sharing networks with SWIPT was proposed by K. Thamizhmaran (2023). Matching theory-based spectrum utilization in cognitive NOMA-OFDM systems was analyzed by X. Li et al. (2017). A novel compressed sensing-based non-orthogonal multiple access scheme for massive MTC in 5G systems was discussed by K. He et al. (2018). Subchannel assignment for

SWIPT-NOMA-based HetNet with imperfect channel state information was suggested by I. Budhiraja et al. (2019). Resource allocation in NOMA-enhanced backscatter communication networks for wireless powered IoT was measured by G. Yang, X. Xu, and K. Thamizhmaran (2020). Energy efficiency maximization in NOMA-enabled backscatter communications with QoS guarantee was explored by K. Thamizhmaran (2023). The application of quasi-degradation to MISO-NOMA downlink was discussed by K. Thamizhmaran (2023).

## 4. Implementation

In this section, we discuss our newly developed design called a heterogeneous-based cloud radio access network with a cluster head node-based energy-efficient wireless network for efficient bandwidth allocation. This efficient bandwidth allocation is shared among different nodes. The clustering design avoids noise conjunction control and is designed for wireless nodes, making the wireless network very stable with minimized overload to manage the targets of the cluster heads **Figure 3 and Figure 4**.

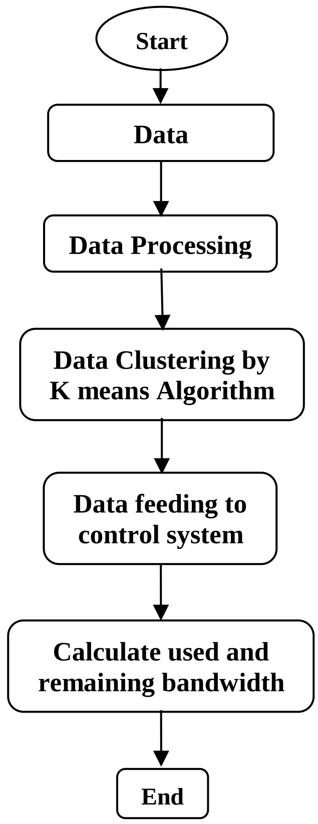



**Fig 2 Proposed Algorithm**

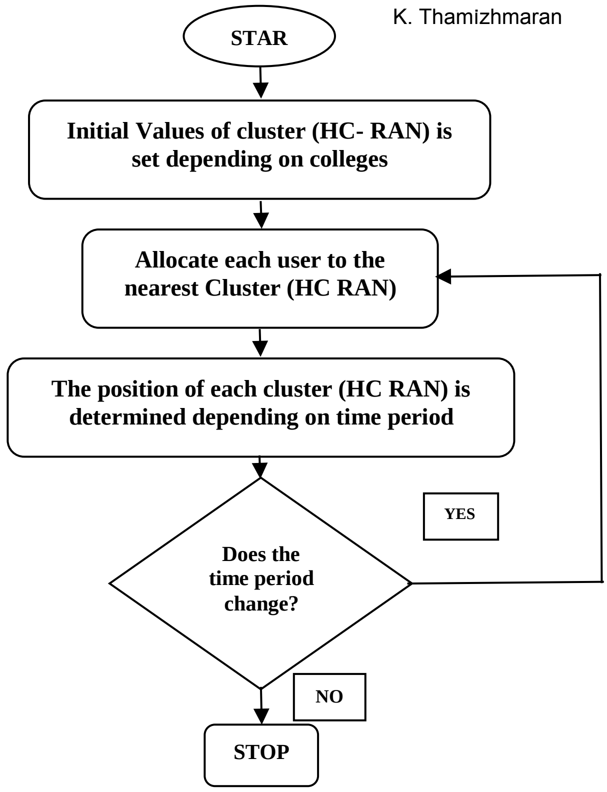



**Fig 3 The Flow for data clustering in the HC-RAN**

**Data Extraction:** The extraction of data is the process of recovering the HC RAN data out of possible data sources.

**Data Processing**: The processing of data includes applying the essential calculation with dissemination of consumers that is time slots, the arithmetical information is converted from transformation steps, the predictable load of each node in HC- RAN network is determined.

**Data Clustering**: Arithmetical data analysis involves processing consumer distributions through the following steps: grouping consumers into clusters and assigning the finest quality of service to build the possible clusters, as shown in Figure 2. The clustering algorithm is denoted as 'K'.

**Improving Data Quality Using Control System**: The control system is improved by the data; the HC-RAN system forms clusters and allocates essential bandwidth to each node.

The recommended dynamic bandwidth allocation approach of the HC-RAN is installed at Allahabad University (AU). The university consists of six main colleges in which students are grouped, as shown in Figure 3.

The timetable for each college is categorized as follows: Classes for each college will be conducted on Monday, Wednesday, and Friday (M, W & F), where each lecture will be 40 minutes long. The timing of colleges starts from 9:00 AM to 4:00 PM, with a 20-minute lunch break between classes. On Tuesday and Thursday (T & T), lectures will be 60 minutes long, starting from 9:00 AM to 4:00 PM, with a 20-minute lunch break in **Table 1**.

The HC-RAN design depends on dynamically allocated bandwidth, considering the position of the users at each college at the proper time. The students' attendance report should be recorded in mathematical order. The students' distribution curve is denoted as a time period of HC-RAN nodes, and bandwidth allocation is done based on the load on nodes. The process of data extraction and its further refining comprises all the parameters like place and time on the AU campus, following these steps:

- If S1 measures the students registered in a particular period and department of colleges.
- If S2 measures the following students not enrolled at the time of admission but enrolled after the offered duration.
- The enrolment of each department-wise student is denoted as S3.
- S measures the government-approved strength of each college.
- The number of predicted students in a specified time of colleges is denoted as S through the following formula.
-

$$S = S_1 + \frac{S_2}{8} + \frac{S_3}{2} \quad 1$$

Note: Enrolled strength of agriculture is $S_3$.

**Table 1 model statistical information of time slots in a campus at Saturday 09:00 Am in each building.**

| *Name of College* | *Registered Students at particular time slots (S1)* | *Registered Students at after time slots (S2)* | *Expected Strength (S)* |
|---|---|---|---|
| *Engineering* | 1550 | 610 | 1855 |
| *Pharmacy* | 450 | 90 | 495 |
| *Medical* | 1013 | 410 | 1218 |
| *Sciences* | 649 | 814 | 1055 |
| *MBA* | 600 | 234 | 717 |
| *Administration* | 445 | 335 | 612 |
| *Arts* | 530 | 110 | 585 |
| *Agriculture* | NA | NA | 1432 |

In the subsequent step, the K-means clustering algorithm is employed to classify the probable groupings of students across the colleges. In HC-RAN, links (nodes) are randomly distributed over hundreds of meters, which helps divide the set of links (nodes) into subsets with closer topographical proximity, reducing the transmission distance and resulting in energy savings. The process of grouping nodes according to the number of users is clustering.
The cluster receives the data, depending on the number of users and the number of lectures in each college at AU campus. The process of bandwidth allocation changes over time as it depends on the number of users in each college at a particular time. The Euclidean distance forms the basis of the K-means clustering algorithm. The formation of clusters depends on four steps. When k centroids are consistently distributed in the network, the K-means process starts. According to the shortest path of the node to its centroid, a node is assigned to each centroid. The average of xix_i and xjx_j determines the new position of the centroid. If the location of the centroid varies, K-means will run once again; otherwise, the process ends.

Clustering with k HC-RAN links or nodes is useful for initiating the process. The Euclidean distance determines the assignment of an input data point to nearby clusters. The following pseudocode is used:

**Algorithm**

- ✓ **‘K’** represents the no. of HC RAN **nodes**.
- ✓ ***Y*** represents the no. of users
  $K_i$
  $i = 1,\dots,k$
  ***k*** random in **Y**
- ✓ Selected active neighbour node (Clusters) for the entire user.
  if $y_t$ **as a** subset of input data ***Y***.
  $D_i \leftarrow 1$
  *if* $\| y - K_i \| = min_j \| y - K_j \|$
  $D_i \leftarrow 0$

Else

- ✓ The nearest node of the individual user is allotted new as *k* (Clusters).

**For** all $K_i$, $i = 1,\dots,k$
$K_i \leftarrow sum\ (D_i\, y)\ /\ sum\ (D_i)$
**End**

HC-RAN Links or nodes *K* ($E_{i1}$, $E_{i2}$… $E_{ik}$)

Where,
$E_{ik}$ is the value of the $k^{th}$
$E_{ik}$ is the value of the $i^{th}$ users

In the clustering algorithms, clustering represent ‘k’ it is to compute the Euclidean distance *D* by the following equation:

$$D_{ij} = \sqrt{\sum_{k=1}^{k} (C_{ik} - C_{jk})^2} \quad (2)$$

Where,
$E_{ik\ and}\ E_{jk}$ is the value of the i or k users
$E_{ik\ and}\ E_{jk}$ is the value of the *i or i* nodes

Each information origin plotted in the cluster is linked with the adjacent source point. The time table of lecturers is marked the information origin point of the new cluster mid point

Let us $E_{ik}$ signifies the midpoint of $k^{th}$
Let us $E_{jk}$ signifies the midpoint of $k^{th}$, above procedure by the following expression:

$$C_{ik} = \frac{\sum_{j=1}^{n_i} C^*_{i,jk}}{n_i} \quad (3)$$

Where,

$E^*_{i,jk}$ is the $k^{th}$ **HC-RAN Links or nodes** of $j^{th}$ users are allotted to the $i^{th}$ user in each clusters

where, $n_i$ *denotes* the number of data points of the cluster *i*.

## 5. Results

The developing procedure using **HC-RAN** of the **Allahabad University** campus for the HC RAN nodes dispersed in the AU campus. It is assumed that the one node will be used in each college, and the four points of procedure are implemented.

In this section, we assume simulation configure to perform the proposed wireless network in open environment is evaluated via network simulator (NS 2.34). The wireless network is simulated using this simulator by varying the time with colleges. The below **table 2** simulation parameters are given.

***Table 2 Simulation Parameters***

| *Parameters* | *Values* |
|---|---|
| *Simulation area* | 1000m * 1000m |
| *Average speed of nodes* | 0–25 m/sec |
| *Mobility model* | Random Waypoint |
| *Transmission range* | 250m |
| *Constant bit rate* | 2 (Packets/Second) |
| *Packet size* | 512 Bytes |
| *Initial energy/node* | 100 joules |
| *Antenna model* | Omni directional |
| *Simulation time* | 500sec |

The expected load for one of the colleges is shown in **figure 4**, which clearly shows that, the load is medium in the morning hours, peak in the afternoon, and low in the evening. The results express the smart allocation of HC-RAN bandwidth of the college shows the below steps to create the link of every student are much stable and fast.

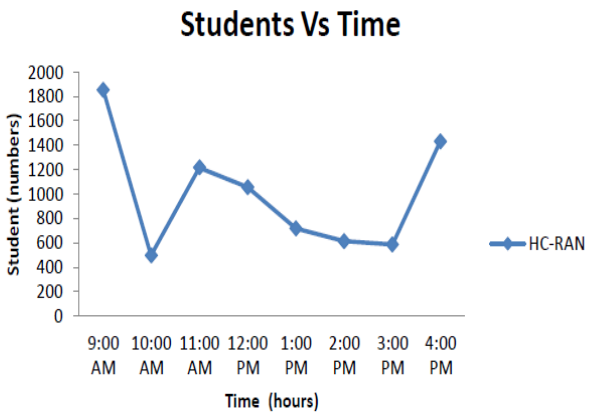



**Fig 4 Expected Load for an Engineering college on Monday.**

**Developed methodology performance distribution in the university,** in each college time at the time period of day starts, in between and ends depends on three classification the following time table ([M, W & F] & [T & T]). The below figure 5 shows a time period of students in a sample distribution 9 to 9.40 with M, W & F and 9 to 9.50 T & T of forenoon respectively **Table 2, 3, 4.**

**Table 2 students attendance time slot 9 to 9.40 (M, W & F) and 9 to 9.50 (T & T) in forenoon**

| *College Name* | *Expected Distribution (S) M, W & F* | *Expected Distribution (S) T & T* |
|---|---|---|
| *Engineering* | 1855 | 1645 |
| *Pharmacy* | 495 | 410 |
| *Medical* | 1218 | 1156 |
| *Sciences* | 1055 | 1253 |
| *MBA* | 717 | 610 |
| *Administration* | 612 | 570 |
| *Arts* | 585 | 371 |
| *Agriculture* | 1432 | 1307 |

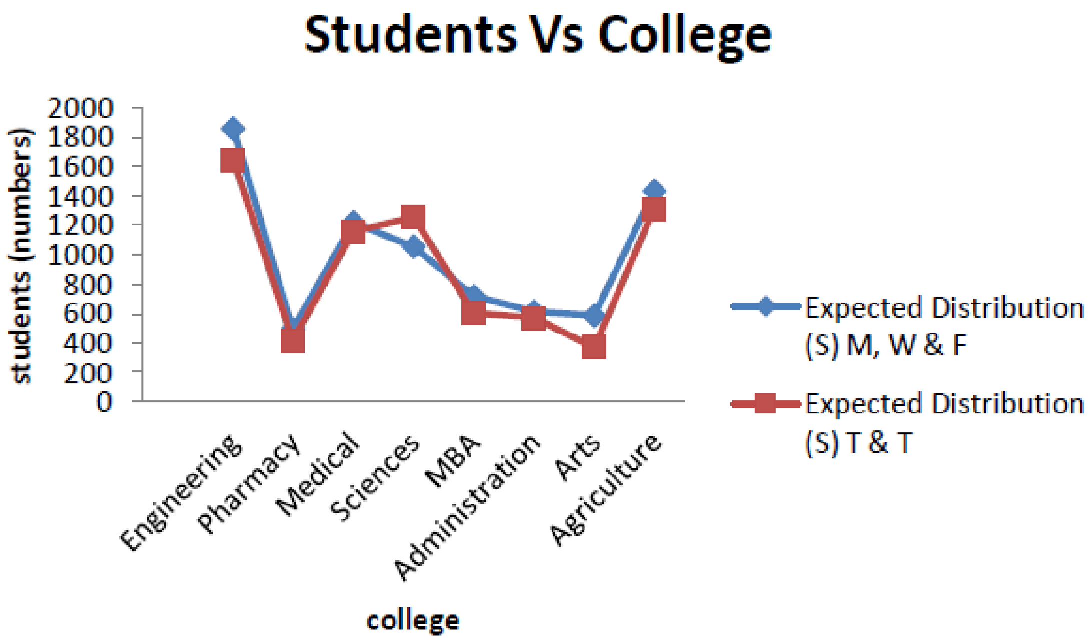



**Fig 5 students time slot for 9 to 9.40 (M, W & F) and 9 to 9.50 (T & T) in forenoon**

**Table 3 students attendance time slot 12 t0 12.40 (M, W & F) 12 to 12.50 (T & T) in afternoon**

| **College Name** | **Expected Distribution (S) M, W & F** | **Expected Distribution (S) T & T** |
|---|---|---|
| Engineering | 1750 | 1710 |
| Pharmacy | 445 | 500 |
| Medical | 1153 | 950 |
| Sciences | 910 | 850 |
| MBA | 650 | 630 |
| Administration | 581 | 521 |
| Arts | 490 | 454 |
| Agriculture | 1432 | 1390 |

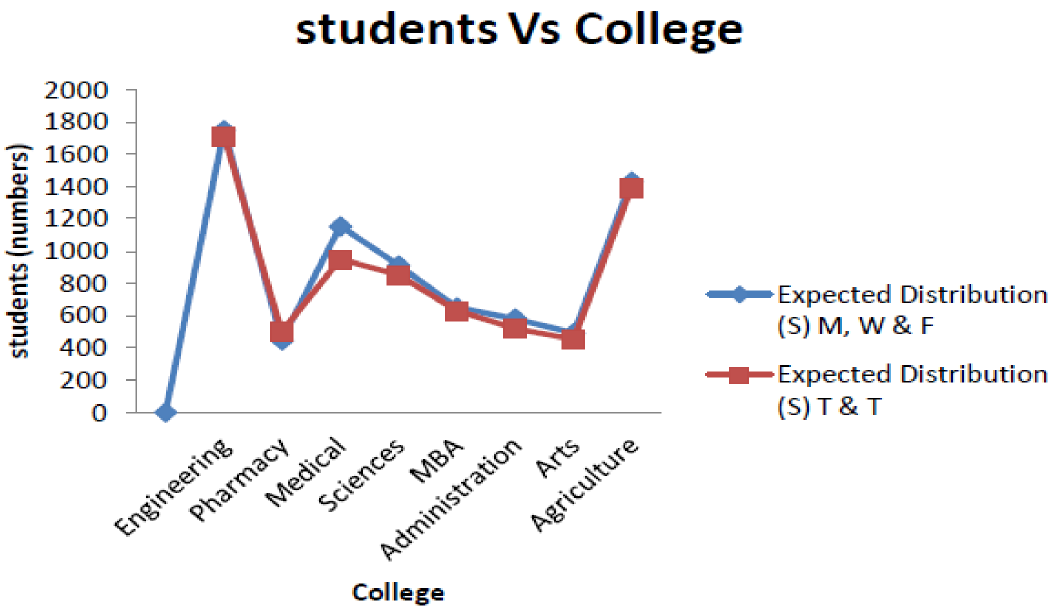



**Fig 6 students time slot for 12to 12.40 (M, W & F) and 12 to 12.50 (T & T) in afternoon**

**Table 4 students attendance time slot 13 to 13.40 (M, W & F) and 13 to 12.50 (T & T) in afternoon**

| *College Name* | *Expected Distribution (S) M, W & F* | *Expected Distribution (S) T & T* |
|---|---|---|
| Engineering | 743 | 701 |
| Pharmacy | 90 | 79 |
| Medical | 810 | 715 |
| Sciences | 487 | 410 |
| MBA | 112 | 105 |
| Administration | 410 | 390 |
| Arts | 240 | 212 |
| Agriculture | 117 | 107 |

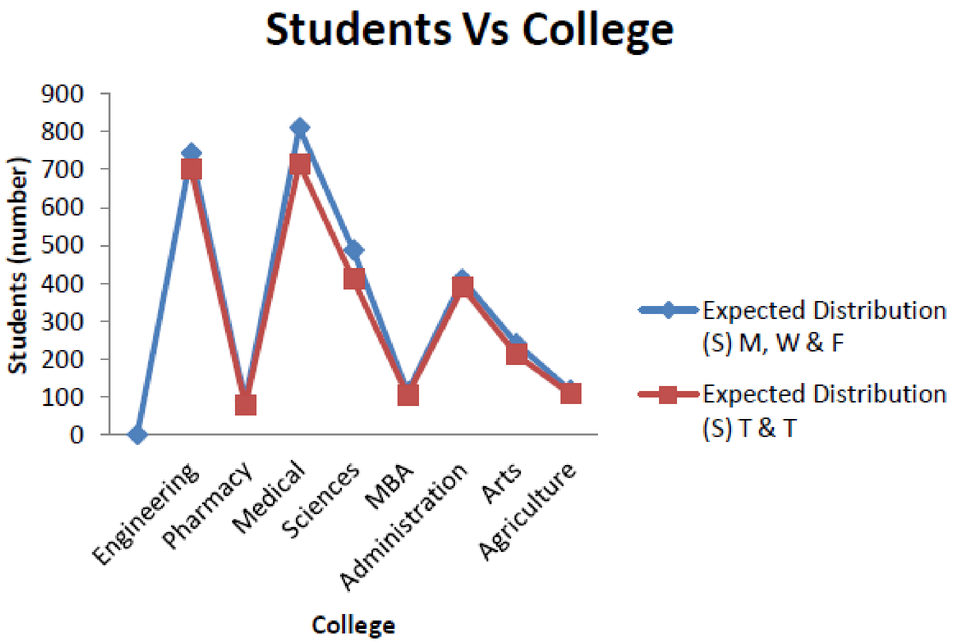
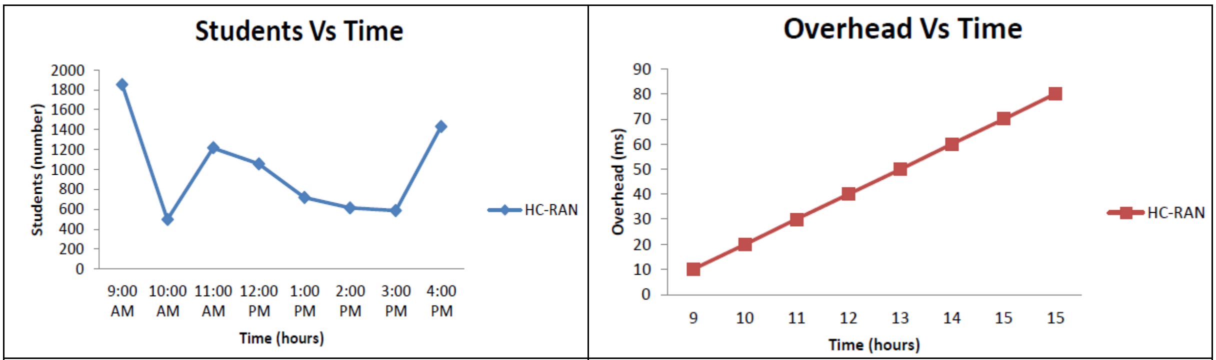



**Fig 7 students at time slot 15 to 15.40 (M, W & F) and 15 to 15.50 (T & T) in afternoon**




| Fig 8 (a) Sum Rate Vs Time | Fig 8 (b) Average Sum Rate Vs Time |
|---|---|

**Fig 8 Sum rate Vs Time**

The above figures 8 shows sum rate & average sum rate express the HC-RAN improved sum rate and average sum rate.

## 6. Summary

Predication, un authorized place and more application very useful technology devices is wireless network, sharing and allocation of bandwidth is changing issue, based on this reason we proposed in this work. Our suggested design called Cluster based Heterogeneous Cloud Radio Access Networks (HC-RANs) is specially designed for wireless technology, above model responsible for the cloud computing in the Heterogeneous Networks. Our suggested HC-RANs tested with different output like Expected Load for an Engineering college on Monday. (Number of expected users per time), the students at time slot 9 to 9.40 (M, W & F) & 9 to 9.50 (T & T) forenoon, students at time slot 12 to 12.40 (M, W & F) & 12to 12.50 (T & T) afternoon, the students at time slot 15 to 15.40 (M, W & F) & 15 to 15.50 (T & T) afternoon for sum rate and average sum rate Vs Time. Above model solved and maximized average sum rate and reduce conjunction also solved energy constraints problem.

- The same concept can be tried to implement in satellite to save more energy.
- The possibilities of adopting the cluster based network to eliminate the delay.
- HC-RAN can be tested in real time network environment.

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Prof. Dr. A. Charles who provides ideas to build the manuscript and also share review comments, corresponding author of this paper Prof. K. Thamizhmaran who has collecting data with implementation using software with manuscript preparation.

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**Conflict of Interest**

I confirm that neither I nor any of my relatives nor any business with which I am associated has any personal or business interest in or potential for personal gain from any of the organizations or projects