

A Dynamic Clustering Approach for Increasing User Throughput in 5G Wireless Networks

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Abstract—In cellular networks, user density and activity across network area vary from cell to another, and even at the same area over the day hours. This results in an irregular utilization of the network resources (i.e., resource blocks "RBs") across the network cells. One of the solutions to improve network utilization is the coordinated multi-point (CoMP) approach which coordinates signal transmission and reception for a user to and from multiple base stations (BSs). However, providing CoMP to all network users could waste RBs. To solve this problem, a novel clustering technique is proposed in this paper to guarantee a wise CoMP service to users based on their area density state (i.e., overloaded or under-loaded) and across different day periods. Through simulations, the proposed dynamic clustering algorithm outperforms other clustering algorithms in improving overall user throughput while maintaining the total consumed energy to acceptable levels.

Index Terms—Dynamic Clustering, Wireless networks, cellular systems, 5G, Tidal Effect, Cell-edge

I. INTRODUCTION

In cellular communication systems, the covering area is partitioned into cells. A Base Station (BS) is centered in each cell area to control the radio frequency (RF) communications. Supported system frequencies are reused among cells so that the adjacent nodes (users/cells) can use different frequencies in order to mitigate inter-cell interference (ICI) and utilize the system resources more efficiently. For large cellular systems, more management and control schemes are needed to maximize the network scalability, balance the network load and prolong the network lifetime. One of the efficient approaches used to control network is the clustering technique as it can allow sharing cell resources among multiple cells [1]. With the growth of 5G applications such as the Internet of things (IoT), wireless communication systems are connected to huge number of sensors that work with limited energy

resources. Clustering is an excellent choice to enhance the network throughput and energy efficiency [2]. Unfortunately, in traditional networks, defining the optimum cluster that best suits each user in the network could be a complex process, as it requires coordination among neighboring BSs on one hand, and between neighboring BSs and the core network on the other hand. In 5G, it is envisioned that multiple BSs will be connected to a central Cloud system. Hence, the joint processing of the user data and optimum coordinated cells could be performed in a timely manner and with minimal overhead due to the existence of all users and cell information in the central Cloud system. A clustering algorithm can collect networked cells into groups (i.e., clusters). In each cluster, a Cluster Head (CH) is in charge of generating a transmission schedule, gathering data from all BSs participating in the cluster, and transmitting the assembled data back to the CH. Clustering algorithms become essential in cellular systems primarily for the following reasons [3]:

- 1) *Longer life-time for the system*: by scheduling the duty cycle among the BSs within a cluster, without affecting the functionality of the network.
- 2) *Energy Savings*: achieved as follows:
 - The core network communicates only with the CH rather than a far located BS in the same cluster.
 - The power usage is distributed throughout the network by using sleep scheduling (BS shutdown).
 - Activating partial BSs in the network reduces the communication latency and energy consumption caused by retransmission.

Most of the existing clustering algorithms emphasis on energy saving, ignoring the diverse behaviors for the users (Tidal Effect [4]). Adaptability to user-density variations is crucial in improving user satisfaction and quality of experience

(QoE). An advanced wireless communication network should be sufficiently intelligent to adapt to spatio-temporal changes in user-density, especially when cellular wireless networks are evolving to 5G with the need to support IoT. One of the 5G objectives is to support a larger number of users and more complex workload scenarios which cannot be achieved without the efficient utilization of the resources. This paper focuses on improving the throughput in loaded areas via intelligently forming the clusters based on the network traffic variation during the day and night time. The proposed load-aware, network-centric, dynamic clustering (LANCDC) algorithm is the first network-centric dynamic clustering algorithm that adapts to user-density variations, to provide the best throughput with no significant change in power consumption compared to user-centric algorithms.

II. BACKGROUND

Clustering techniques gain significant interest due to the emergence of cooperative communications for wireless networks. Beside regular clustering benefits in cellular networking such as energy savings and interference avoidance, the proposed clustering algorithm adapts to user-density variations across the coverage network. In this section, we present a brief description of Tidal Effect [4], Clustering Basics and CoMP [5] [6] [7].

A. Tidal Effect

During the day hours, user density fluctuations at the same cell has lead to a phenomena called "Tidal Effect" in which the load of the network changes in a time-based style according to the type of the cell or area (i.e., residential or business) as shown in Fig. 1. For instance, during the day, the BSs in downtown office areas (such as BS #2 in Fig. 1) are the busiest, while the people density shifts to residential or entertainment areas (such as BS #1 and BS #3) at night. For conventional radio-access network (RAN) architecture supported in the Long-Term Evolution (LTE) system, the BS resources and processing capacity are fixed in each cell and dedicated only to the cell subscribers within its are of coverage. Accordingly, these resources may be wasted in under-subscribed areas, and/or scanty in over-subscribed areas.

To the best of our knowledge, the proposed LANCDC algorithm is the first network-centric dynamic clustering algorithm that adapts to the spatio-temporal variations in the user density across the network, and accordingly, reduces the negative effects of Tidal phenomena.

B. Clustering Basics

In general, a clustering algorithm has two main phases [3]:

- 1) *CH election*: The CH is the leader of a cluster and it is responsible of gathering data (related to cluster identification and messaging) and transmitting the data to the core network.
- 2) *Cluster formation / CH selection*: After being elected, the CHs advertise themselves by broadcasting their information to nearby BSs. Each BS gathers the information

from all the CHs within its communication range and then decide which CH to join based on some communication properties (e.g., communication cost, hop count, physical distance ... etc). In some cases, the size of cluster is also considered when BSs join a cluster.

Algorithms with different CH election or cluster formation schemes exhibit diverse performances [1] [2]. For example, compared to random CH election scheme, energy aware CH election, which can elect high residual energy BSs as CHs, can balance the power usage throughout the network. However, the election process may need more energy and time. All clustering algorithms have their specific CH election schemes and cluster formation schemes [3]. Depending on the requirements of a system, different strategies may be applied in order to achieve specific objectives. The proposed LANCDC algorithm focuses on improving user throughput in crowded areas without neglecting the trade-off between energy savings and throughput maximization as will be illustrated in section VI.

C. CoMP

Coordinated multi-point (CoMP) is a key technology for improving overall network performance at the cell-edge as it enables multiple BSs to coordinate/cooperate to serve cell-edge users simultaneously. CoMP is considered in LTE-Advanced (LTE-A) system as a promising technology to solve the inter-cell interference (ICI) problem [5]. It has been proven that combining clustering of cells with CoMP makes more efficient use of the radio bandwidth [6]. This technology can be divided into two categories in accordance with the transmission scheme: Coordinated Scheduling/Beamforming (CS/CB) and Joint Processing (JP) [7].

- 1) **Coordinated Scheduling/Beamforming (CS/CB)**: Data for one user is available at only one BS in the cluster for a time slot. The main idea of CS is to apply centralized scheduling within each cluster in order to determine which BS(s) in the cluster should transmit for every time slot and to which user equipment (UE). CB targets the best resource blocks (RBs) and associated channel quality in each transmission time interval (TTI) to reduce inter-cell interference (ICI). In LTE-A, CS and CB are often jointly combined. As the user data chunks (packets) might be distributed among multiple BSs, strict pre-coding must be performed in the network core side to avoid user data duplication and inter-cell interference (ICI). This method can enhance the system throughput and spectral efficiency.
- 2) **Joint Processing (JP)**: Data for one user is available at more than one BS in the cluster for a time slot. Joint Processing technology requires sharing data information and channel information among the BSs involved in the cluster. All BSs within the cluster send the same packets to the same service UE in the downlink transmission direction. Some references call JP as Joint Transmission (JT), since multiple BSs jointly transmit to a single user, using the same time-frequency slots. Through JP or JT

technology, the type of inter-cell interference signal in the original system transforms into useful signal, thereby inter-cell interference is reduced and the quality of the received signal is enhanced. This method can achieve the purpose of enhancing user signal quality and throughput as well.

Both types of CoMP (i.e., CS/CB and JP) are used in the proposed algorithm. In addition, a performance comparison is performed in section VI for each CoMP type. In what follows, we review the most recent related work.

III. RELATED WORK

Several clustering classifications are found in the literature. From the controlling-point perspective, dynamic clustering could be classified into two groups: **Network-Centric Clustering** [7], [8], [9], [10] and [11], where the network is responsible for forming cluster of cells, and accordingly any user within the cluster is served by all or sub-group of cells in the cluster, and **User-Centric Clustering** [12], [13] and [14], where users allocate their own desired cluster of cells individually. A review for some state-of-the-arts clustering algorithms in both categories is surveyed in the below sub-sections. In addition, a summary of these selected dynamic clustering algorithms is found in Table I.

A. Network-Centric Clustering

In [8], a clustering algorithm is proposed by initially selecting a cluster-head per cluster so that it has the most quasi-static fading channel. Then, the algorithm dynamically assigns cluster-members around those cluster-heads which maximizes the data rates. This could be ensured by choosing the cluster-member that has the optimum distance and channel conditions with the cluster-head. The algorithm does not consider any load balancing for users across network clusters. In [9], a heuristic approach for clustering that consists of two parts is proposed. The first part implements the Power Efficient Clustering (PEC) of the cells, while the second one performs the Power Optimization Algorithm (POA). The goal of PEC is the formation of adequate cluster areas with high power-reduction potential. Then, POA can be applied to effectively reduce the transmission power of each BS. The approach does not consider increasing the throughput for users in overloaded areas/cells.

In [7], [10] and [11], several algorithms combining BS sleeping with dynamic clustering are proposed to maximize Energy Efficiency (EE). In these algorithms, All BSs are classified into three types. The first type puts the BS into the sleep mode directly when no UE need service. The second type is for those BS with light traffic. Herein, the BS needs to participate in the coordination for a specific time and then they are turned off. The UEs in the coverage of the sleeping BS can be serviced by other BSs of the cluster. The last type contains the rest of BSs with peak traffic. The algorithm starts at forming the network clusters such that each cluster is composed of adjacent BSs that satisfy the best communication channel conditions. Then, each BS in the second and third type

coordinates with an adjacent cluster that applies the highest EE. Finally, JP is applied within each cluster. In addition to the complexity and delay that this algorithm requires in forming the clusters, its criteria are based on maximizing EE only without accounting for the throughput of the system or the users.

B. User-Centric Clustering

In [12], a load aware, user-centric, dynamic clustering (LAUCDC) algorithm is proposed to distribute load from highly loaded cells to neighboring cells with less load for multi-user joint transmission CoMP. Another dynamic clustering approach is proposed in [13] on the basis of signal strength at UEs and thus, the cluster which has the maximum average SINR is included in CoMP scheme at the time of cluster formation. In [14], an adaptive online learning based approach, Smart Access for CoMP (SAC), is proposed to perform dynamic clustering in CoMP along with Carrier Aggregation (CA). SAC finds the cluster size and configuration for CoMP per user dynamically such that the selected cluster can minimize the inter-cell interference and can improve the user throughput. Then, it performs CA for the cluster chosen by considering the present channel condition. User-centric clustering decisions are more complex than network-centric clustering decisions. Also it may cause overlapping, extreme overheads and network congestion if too many users contribute in the clustering.

The literature on clustering can be summarized in Table I that provides some state-of-the-art clustering algorithms, and compares them from the perspective of their mechanism properties (e.g., type, cluster size, method and objective) and targeted key-performance indicators "KPIs" (e.g., energy, BS lifetime, network latency and user quality-of-service "QoS"). It is worth noting that there is no network-centric clustering algorithm available for targeting user QoS.

C. Contribution of This Work

None of the previous work in network-centric clustering considers user-density variations [3] [12]. Most of the existing work emphasis on energy saving, ignoring the diverse behaviors for the users. An intelligent clustering system should be able to adapt to user-density changes within the system, especially when cellular wireless networks are evolving to 5G and IoT, with an aim to support a larger number of users and more complex workload scenarios. To the best of our knowledge, the proposed technique is the first network-centric dynamic clustering algorithm that aims to serve overloaded cells in the network by dynamically forming the cluster such that the load could be redistributed and processed cooperatively with the aid of other under-loaded cells. Hence, the throughput and SINR of users could be increased with the minimal overhead needed compared to user-centric approaches. The proposed algorithm considers some aspects to preserve energy efficiency, as will be illustrated in section IV and evaluated in section VI.

IV. LOAD-AWARE, NETWORK-CENTRIC, DYNAMIC CLUSTERING (LANCDC) ALGORITHM

A dynamic clustering algorithm is developed to enhance the performance of users in overloaded areas/cells. The proposed LANCDC algorithm is a network-centric clustering approach. Hence, signaling overheads are diminished compared to user-centric clustering approaches. LANCDC algorithm starts with identifying the user overloaded cells according to a threshold set by the operator. Then, LANCDC assigns those overloaded cells as the CHs of newly formed clusters. Each CH searches its neighboring list for possible cooperation with the maximum surrounding under-loaded cells. Hence, the algorithm ensures the maximum contribution from under-loaded cells to the overloaded cell in each CoMP set. It is not allowed that two CHs conjoin in one cluster. However, one cluster-member (CM) could join multiple clusters. After finishing the formation of the cluster, the RBs coming from each CM, and dedicated to CoMP, are equally distributed among the participating clusters. The portion of RBs that each CM dedicates for CoMP is a factor that is set by the operator. CHs do not dedicate RBs for CoMP to save them for their served users, who are already overcrowding the cell, and struggling for acquiring RBs as much as possible to increase their throughput. To describe the details of our proposed algorithm, we first make the following definitions:

- The set of cells in the network is denoted as $\{\text{Cell}(1), \text{Cell}(2), \dots, \text{Cell}(N\text{-Cells})\}$, where $N\text{-Cells}$ is the total number of cells in the network.
- The number of users per cell is donated as $\text{Cell}(i)\text{-UE}$.
- The threshold of number of users which determine whether a cell is overloaded or under-loaded is donated as UE-Th .
- The set of elected cluster heads in the network per Transmission Time Interval (TTI) is denoted as $\{\text{CH}_1, \text{CH}_2, \dots, \text{CH}_M\}$, where M is the number of CHs in the network.
- For each CH_j , the set of elected cluster members in the network per TTI is denoted as $\{\text{CM}_{j1}, \text{CM}_{j2}, \dots, \text{CM}_{jL}\}$, where L is the number of CMs that coordinate with CH_j in the same cluster.
- The number of clusters acquired by CM_{jk} is (CM-Repeat_{jk}) .
- The default number of RBs that any CM dedicates for CoMP is $N\text{-RB-CoMP}$.

The overall dynamic clustering algorithm steps (at the beginning of each TTI) are listed as follows:

LANCDC Algorithm

1. For each cell in the network, check the user density of cell "Cell(i)_N-UE" and compare it to the user density threshold (UE-Th), where $1 \leq i \leq N - \text{Cells}$.
2. If $\text{Cell}(i)\text{-N-UE} > \text{UE-Th}$, Assign Cell(i) as a CH_j .
3. Assign all cells in the neighboring list of Cell(i) as CM_{jk} . Exclude CHs.
4. Repeat until all cells in the network are examined.
5. To define the ratio of RBs that will be used in each CoMP set (i.e., cluster), the following steps are performed:
 - (a) Assume the default number of RBs that each cell dedicates for CoMP is $N\text{-RB-CoMP}$.
 - (b) Check the number of clusters (CM-Repeat_{jk}) that each CM_{jk} join.
 - (c) Set the number of RBs that each CM_{jk} provide for CoMP in cluster j as $N\text{-RB-CoMP} / \text{CM-Repeat}_{jk}$.

This algorithm ensures providing the users located at overloaded (i.e., hot spot) areas with additional RBs to use, hence, improving their throughput and avoiding their throttling. The additional RBs are taken from other under-loaded areas surrounding the overloaded area. Unlike other clustering algorithms, each user in overloaded area only is attached to one of the created cluster sets. Users in under-loaded area are served by one BS in order to save network energy. This purpose has been maintained and proven as shown in the results and analysis sections.

V. EXPERIMENTAL SETUP

The proposed algorithm has been deployed into the Vienna LTE system-level simulator [15] [16], which runs on top of MATLAB. The simulation parameters used in our experiments are shown in Table II. The used system bandwidth and carrier frequency are supported in LTE Release-8 [17]. The remaining parameters have been selected to be compatible with the system bandwidth used and to be applicable in the realistic world as well. Without loss of generality, we consider only two slices of time (i.e., day and night time). In each time slice, we assume that the network coverage area includes two hot-spot (overloaded) cells and 18 under-loaded cells as shown in Fig. 2 and Fig. 3, respectively. Also, it is assumed that the threshold of determining whether a cell is overloaded or under-loaded is equal to 30 users/cell.

Through our experiments, the proposed algorithm (i.e., "LANCDC") is deeply investigated and compared to the best recently proposed algorithms. For performance evaluation, two state-of-the-art algorithms are used for comparison against our proposal. The two algorithms are LAUCDC [12] algorithm and the SAC [14] which have been discussed in the "related work" section. LANCDC is based on allocating overloaded cells in the network coverage area and assigning them as CHs for newly created clusters. Then, each CH attaches the maximum surrounding cells to its cluster as members. A CM could be a member in more than one cluster, but a CH cannot.

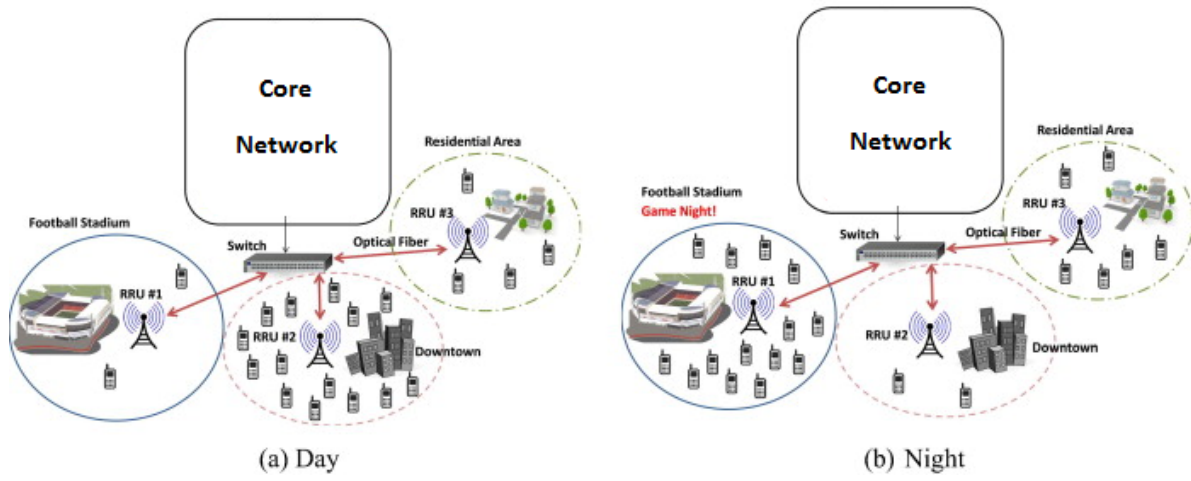


Fig. 1. Tidal effect in wireless networks.

TABLE I
REVIEW SUMMARY FOR RECENT STATE-OF-THE-ART CLUSTERING ALGORITHMS

Algorithm	Cluster Properties				Considered Metrics "KPIs"			
	Type	Cluster Size	Method	Main Objective	Energy	BS Lifetime	Network Latency	User QoS
BS Sleep Mode with Dynamic Clustering (SMDC) [7]	Network-centric	Equal	Dynamic	Energy Savings	Yes	No	No	No
Edge Location Assisted Water-Filling (ELA-WF) [8]	Network-centric	Variable	Dynamic	Max Network Data Rate	Yes	No	Yes	No
Energy-Aware Clustering (EnAC) [9]	Network-centric	Variable	Dynamic	Energy Savings	Yes	No	No	No
Cluster-based opportunistic on/off mechanism for small cell BSs. [10]	Network-centric	Variable	Dynamic	Reduce Clustering Cost	Yes	No	No	No
BS Sleep Mode with Dynamic Clustering Traversal Algorithm (SMDC-TA) [11]	Network-centric	Variable	Dynamic	Energy Savings	Yes	No	No	No
load-aware, user-centric CoMP clustering [12]	User-centric	Variable	Dynamic	User Load Balancing	No	No	No	Yes
Dynamic cluster-based ON/OFF Algorithm [13]	User-centric	Variable	Dynamic	Energy Savings & Reduce Cost	Yes	No	No	Yes
A Learning-based Dynamic Clustering for Coordinated Multi-Point (CoMP) Operation with Carrier Aggregation in LTE-Advanced [14]	User-centric	Variable	Dynamic	Average User Throughput	No	No	No	Yes

TABLE II
SIMULATION PARAMETERS

Parameter	Value
System Bandwidth	20MHz
Carrier Frequency	2.14 GHz
Channel Model	Fast Fading
Total No. of RBs per TTI	100
Antenna per RRH	3
eNodeB Transmit Power	40W
No. of eNodeBs	20
Total no. of active UEs	480
User Application	Multimedia services (Average of 10 Mb/s)
No. of Cells	20
No. of TTIs	100

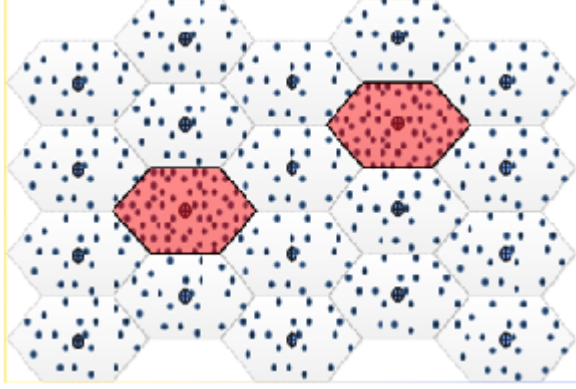


Fig. 2. Simulated network topology at day time.

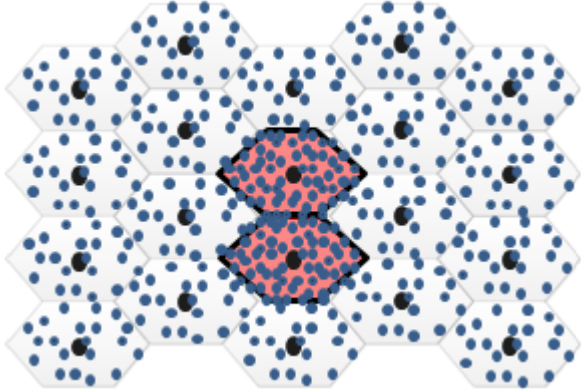


Fig. 3. Simulated network topology at night time.

LAUCDC and SAC are designed to work only in networks that consist of small cells within the coverage area of a large cell (i.e., macro cell). The large cell is served by a high-power BS (i.e., macro BS) which could be used as a central coordinator. Also, this guarantees that each cell in the network is covered by two BSs. However, this is not the general case in practice. The luxury of having two covering BSs (i.e., Macro BS beside a small-cell BS) is not always applicable in the real life networks. Hence, the paper uses a general network topology scenario where the simulated network consists of homogeneous cells, and each cell is

covered by only one BS. Furthermore, there is no need for a central BS coordinator in 5G networks thanks to the centralized Cloud processing supported in 5G Cloud radio access network (C-RAN).

For simplicity, the machine learning approach used in SAC to find the optimum values for both the number of CoMP clusters (i.e., “m”) and the number of cells per cluster (i.e., “n”) has been replaced by an iterative approach that tune both “m” and “n” until the average user throughput is maximized. This achieves the same objective as the machine learning approach used in SAC. Also, the carrier aggregation (CA) technique used in SAC is not implemented as it is unrelated to the clustering concept. Nevertheless, CA could be used with any clustering algorithm, including the one proposed in this paper. The overall users connectivity ratio achieved, the throughput achieved by network users and the BS power dissipation are used as the metrics to assess and compare the proposed algorithm LANCDC against the state-of-the-art algorithms from LAUCDC [12] and SAC [14].

VI. RESULTS AND ANALYSIS

A. Assessing the user connectivity status

The first study is performed on the ability of each clustering algorithm to achieve the best user connectivity status using the same network topography depicted in Fig. 2 and corresponding simulation parameters listed in Table II. Table III shows the percentage of total connected and not connected users from the overall network users when using different clustering algorithms. For the no clustering and no CoMP cases, 79% of network users are connected and attached to the network (380 users out of the 480 total users are connected) at day time. The connectivity percentage is approximately the same at night time. In both time slices, around 80% of not connected users are located in the two hot-spot cells shown in Fig. 2 and Fig. 3. When using the proposed clustering algorithm with CS CoMP technique (i.e., LANCDC/CS), the number of connected users rises to 390 at day (respectively, 386 at night) because more RBs are utilized in the hot spot areas thanks to the CoMP opportunity applied at the cell-edge areas of the two hot-spot cells. For LANCDC/JP, although more RBs are used from the under-loaded cells for CoMP areas as well, these RBs are with the same time-frequency set of other RBs coming from the overloaded (CH) cell. Hence, the received RBs from cooperating cells are utilized by already connected users in the hot spot (CH) cell, hence no significant improvement in terms of the number of serviced users.

User-centric clustering algorithms provide better connectivity percentages than network centric clustering algorithms (including the proposed algorithm) as user-centric algorithms guarantee that each user in the network has its own cluster. However, this does not ensure an adequate throughput for all connected users as will be discussed in the next subsection. For LAUCDC and SAC algorithms, the number of connected users

increases to 406 and 392 users at day (404 and 390 users at night), respectively, as these algorithms ensure that each user in the network is connected to multiple BSs in user's CoMP set. LAUCDC connectivity is better than SAC connectivity because:

- (i) LAUCDC approaches the maximum allowable cluster size. However for SAC, the cluster size per user is estimated only to maximize the user throughput.
- (ii) LAUCDC excluded overloaded cells from any created cluster. However, SAC does not distinguish between overloaded and under-loaded cells during clustering process.

TABLE III
PERFORMANCE COMPARISON FOR THE USER CONNECTIVITY STATUS USING LANCDC VS. OTHER STATE-OF-THE-ART ALGORITHMS

Algorithm	Day Time		Night Time	
	No. of Connected UEs	No. of Not-Connected UEs	No. of Connected UEs	No. of Not-Connected UEs
No-CoMP	380	100	378	102
LAUCDC	406	74	404	76
SAC	392	88	390	90
LANCDC-CS	390	90	386	94
LANCDC-JP	380	100	378	102

B. Assessing the Throughput

The total throughput of all network users has been observed for the different clustering algorithms under investigation, and different time slices. To this end, we keep the total number of users at 480, and those users are distributed among the 20 cells found in the network such that most of users (i.e., 60 users/cell) are condensed in two different cells making them marked as hot spot areas or overloaded cells. The rest of cells have moderate user density (i.e., 20 users/cell). Fig. 4 shows the overall user throughput relative to a no CoMP case (on the y-axis) for different clustering algorithms, and different time slices (on the x-axis). LANCDC-CS algorithm achieves the highest throughput for the overall network user compared to other clustering algorithms and scores an increase of 35% at day, and 27% at night, in user throughput compared to the no-CoMP case. This is due to the ability of LANCDC-CS algorithm to give high attention to hot spot areas as it puts each overloaded cell in the center of a cluster and seeks to surround the overloaded cell with under-loaded cells as much as possible, to perform an effective CoMP operation. LANCDC-JP algorithm also performs well and scores an increase of 18% at day, and 12% at night, in user throughput compared to the no-CoMP case, however, it increases the throughput for the same number of connected users carried out in the no-CoMP case (see section VI.A). Accordingly, this increase does not improve the overall throughput significantly.

For SAC and LAUCDC algorithms, although LAUCDC scores the highest connectivity among all clustering algorithms as illustrated in section VI.A, it does not consider how much

the user throughput is improved. Hence, we could notice that LAUCDC gives high potential to the “quantity” of connected cells for CoMP rather than the “quality” it would return on the services provided to users.

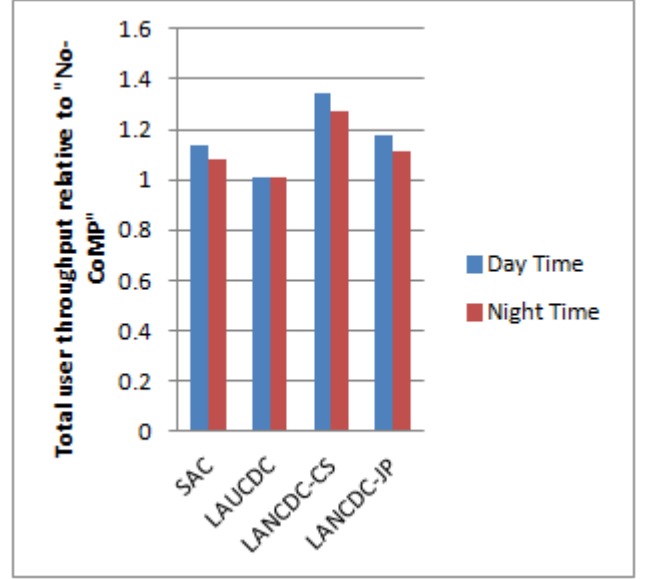


Fig. 4. Total user throughput comparison.

C. Assessing the total BS power dissipation

We examine the total power dissipated by all BSs in the network while using each clustering algorithm. The goal is to check the network cost while using our proposal compared to other algorithms. Fig. 5 depicts the total BS power dissipation relative to the no-CoMP. The total BS power dissipation for LANCDC algorithm is the lowest (3% increase in power at day) compared to other algorithms. Moreover, LANCDC achieves a decrease of 4% in BS power dissipation relative to the no-CoMP at night. This is one of the advantages of being a network-centric algorithm. When creating clusters on a network-basis, each user in overloaded area only is attached to one of the created cluster sets. Users in under-loaded area are kept served by one BS in order to save network energy and power. However, this is not the case in user centric algorithms (i.e., LAUCDC and SAC) as each user is connected to multiple BSs no matter their area, type, or load is. This results in more network power consumption for LAUCDC (40% at day and 28% at night) and SAC (20% at day and 12% at night) compared to the proposed LANCDC algorithm.

CONCLUSION

A novel load-aware, network-centric dynamic clustering algorithm is proposed to increase throughput in wireless network hot spot areas. The proposed LANCDC algorithm has proven to achieve better performance for overall network users compared to other state-of-the-art clustering algorithms. In addition, it is shown that the overhead of power dissipation is very limited. A performance comparison with the leading

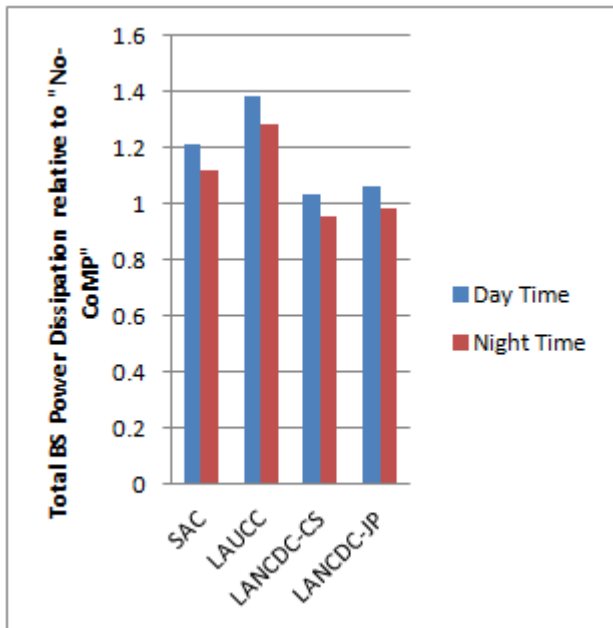


Fig. 5. Total BS power dissipation comparison.

clustering methodologies in LTE and 5G has been quantitatively evaluated. Performed experiments have indicated that the proposed LANCDC algorithm scores 35% increase in overall user throughput relative to no clustering state, which outperforms other state-of-the-art algorithms like LAUCC and SAC. In particular, LANCDC exceeds LAUCC and SAC throughput scores by 33% and 20%, respectively. The power dissipation resulting from using LANCDC is tolerable as it consumes only 3% additional BS power as compared to the no clustering case, which strongly outperforms LAUCC and SAC that consume 40% and 20% additional BS power, respectively. Our algorithm could further take advantage of other 5G techniques (e.g., CA) to increase the overall system performance among all users.

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