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Performance Analysis of C/U Split Hybrid Satellite Terrestrial Network for 5G Systems

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Abstract—Over the last decade, the explosive increase in demand of high-data-rate video services and massive access machine type communication (MTC) requests have become the main challenges for the future 5G wireless network. The hybrid satellite terrestrial network based on the control and user plane (C/U) separation concept is expected to support flexible and customized resource scheduling and management toward global ubiquitous networking and unified service architecture. In this paper, centralized and distributed resource management strategies (CRMS and DRMS) are proposed and compared comprehensively in terms of throughput, power consumption, spectral and energy efficiency (SE and EE) and coverage probability, utilizing the mature stochastic geometry. Numerical results show that, compared with DRMS strategy, the U-plane cooperation between satellite and terrestrial network under CRMS strategy could improve the throughput and EE by nearly 136% and 60% respectively in ultra-sparse networks and greatly enhance the U-plane coverage probability (approximately 77%). Efficient resource management mechanism is suggested for the hybrid network according to the network deployment for the future 5G wireless network.

I. INTRODUCTION

In order to address the challenges to meet and exceed the expected key performance indicators, the revolution of advanced 5G infrastructures has already attracted lots of attentions from both academic research and commercial enterprise in the information and communications technology (ICT) field to enable highly efficient, ultra-reliable, dependable, secure, privacy preserving and delay critical services. Based on these early researches and innovation efforts, intensive standardization activities and large field test trials and testing will take place globally before 2020. The 3rd Generation Partnership Project (3GPP) system standards are heading into the 5G era to further improve capacity and performance, as well as system robustness for better handling of exponential smart phone traffic growth [1]. In Release 12 of 3GPP, the small cells (SeNBs) enhancement scenario is set as one of the critical scenarios, where the architecture is designed based on the soft defined network (SDN) concept to enhance both the C-plane and U-plane services. New technologies, e.g., new carrier type (NCT) and device-to-device (D2D), are also studied under this scenario as the main issues.

According to the idea of control and user plane separation, much effort has been made by rethinking the relationship between control and data transmission. Ericsson proposes an idea of lean-carrier base station with reference signal interference cancellation scheme [2]. Huawei proposes the separation scheme targeting at low control signaling overhead and flexible network reconfiguration for future mobile networks [3]. Key procedures to realize the C/U split terrestrial network are illustrated towards a user-centric “no more cell” architecture in [4]. The obvious advantage of the C/U split architecture is the network can promote the programmability to support the dynamic reconfiguration and resource allocation, while the overhead of signalings can be reduced and the handover procedures can be enhanced for users with dual-connection.

Compared with the terrestrial network, a satellite network could offer significant advantages in terms of the cognitive capability to maximize the utilization of radio resources, the wider spatial coverage to offer control signals to the whole country, and the ability to offload and cache content and realize more efficient multicast delivery. Based on the soft defined features, the C/U split hybrid satellite and terrestrial network could be one of the key enablers in next generation systems to meet various customized scheduling and allocation schemes while maintaining coverage [5]. The 5GPPP (Public Private Partnership) project has been set up in European Union (EU) funding research towards the standardization to develop an integrated 5G standard [6]. It is shown that the hybrid network can indeed provide end-user devices (UE) with adapted and scalable capacity, network coverage and access [7] and satisfy various quality-of-service (QoS) constraints [8]. However, to the best of our knowledge, the performance study has not been analyzed under the C/U split hybrid satellite terrestrial network and the study of efficient resource management strategies are still remaining as open issues.

In this paper, we address the fundamental relationship between key performance indicators and several main parameters, such as overhead cost, density of SeNBs, transmission power and access bias. It is shown that the hybrid network can achieve better performance by taking advantage of the U-plane cooperation between satellite and terrestrial networks. The major contributions of this paper are summarized as follows:

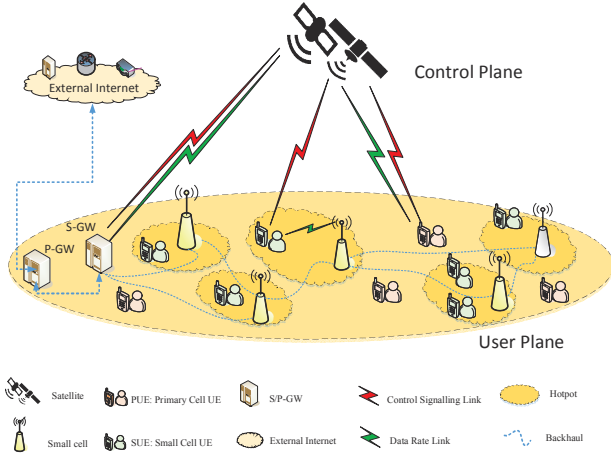


Fig. 1. C/U split hybrid satellite terrestrial network.

- The throughput, power consumption, spectral and energy efficiency, and coverage probability are analyzed comprehensively utilizing a mature stochastic geometry tool
- The novel architecture design based on soft defined features is studied and various U-plane resource management strategies are proposed and compared. It is shown that the cooperation between satellite and terrestrial systems under CRMS in the hybrid network can increase the throughput and EE by nearly 136% and 60% respectively in the ultra-sparse scenario, together with greatly enhancement of U-plane coverage probability (approximately 77%) than the counterparts in the network with DRMS
- An efficient resource management mechanism is suggested for the hybrid network to achieve the orchestration of the network resources according to the context and requirement of services based on the network deployment for future 5G wireless network

The rest of this paper is organized as follows: Section II describes the system model for hybrid satellite terrestrial network based on the soft defined features. The exact throughput, SE, EE and coverage probability are derived in Section III. Section IV provides numerical results to illustrate the difference in various resource management strategies. Finally, Section V concludes the paper.

II. SYSTEM MODEL

In the hybrid satellite terrestrial network, illustrated in Figure 1, the C-plane and U-plane are decoupled from each other, in which the whole seamless C-plane coverage is ensured by the satellite, and high-data rate requirements in hot spots are served by SeNBs. Small cells in high frequency (e.g., 3.5 GHz) are placed within the coverage of one spot beam of the satellite in lower frequency (e.g., 2 GHz).

A. Deployment Model

In this network, the always-on radio resource control (RRC) control signalings, MTC and the low-data-rate services can be guaranteed by the satellite. Meanwhile, the on-demand

high-data-rate requests can be satisfied by SeNBs. As the SeNB cannot provide seamless coverage, the UE beyond the coverage of terrestrial network keeps both Radio Resource Control (RRC) connection and data transmission with the satellite, which is called primary user equipment (PUE). For the UE within the coverage of SeNB, namely secondary user equipment (SUE), it keeps dual connection with both small cell and satellite simultaneously. SeNBs only take charge of the U-plane dynamic resource allocation, while the RRC connection and mobility control are maintained in the satellite in C-plane based on the soft defined features. In addition, small cells are linked through backhaul to realize the cooperation between each other.

The related information about user requirement preference of content, moving speed and direction and other context information are stored and kept updated in the satellite, utilized as Home Subscriber Server (HSS) and Mobility Management Entity (MME). However, as the satellite system itself works as an energy constrained network with limited storage and computing ability, it is more realistic for the gateway (GW) to work as the storage and computing center and take responsibility of transmitting all the related traffic and information back to the satellite. Simultaneously, all of the traffic of the hybrid satellite terrestrial network in both C-plane and U-plane shall be routed back to the external network.

Furthermore, the low earth orbit (LEO) satellite with closer distance to the earth (e.g. 1000 km) is set as the object in our model because of lower delay and higher received power for the terminals. In LEO satellite systems, we focus on one of the spot beam coverage area in this paper. As frequency reuse technology can be applied, there is no interference between narrow spot beams of LEO in our model for simplicity. In this spot beam coverage, the SeNBs are deployed as the classical homogeneous Spatial Poisson Point Processes (SPPP) distribution Φ and the density of SeNB is λ_b . Assume that all the SeNBs are configured with equal transmission power P_{tb} and the nearest distance from the user to the SeNB is r , so that the distribution of r can be derived based on the mature stochastic geometry theory [9]:

$$f_r(r) = 2\pi\lambda_b r \exp(-\pi\lambda_b r^2) \quad (1)$$

B. Pathloss and Fading Model

The received power from SeNB P_{rb} is modeled as

$$P_{rb} = \frac{P_{tb}h_{tb}}{r^\alpha} \quad (2)$$

, where the standard power loss propagation model is used with path loss exponent $\alpha > 2$ and iid Rayleigh fading on all links from SeNBs are modeled as exponential distribution with mean $1/u$: $h_{tb} \sim \exp(u)$.

On the one hand, as the LEO is in non-geostationary orbit, the spot beam coverage can be maintained by the handover between LEOs. On the other hand, the height of LEO orbit is much larger than the distance of terminals movement on the earth. Thus the doppler effect can be neglected for simplicity. In addition, the line-of-sight (LOS) transmission channel is

for simplicity considered as the main factor to determinate the receive power from the satellite, so that the pathloss becomes the dominant factor to be considered. The received power from the satellite can be derived as follows,

$$P_{rs} = P_{ts} G_t G_r \frac{\lambda^2}{(4\pi d)^2 L} \quad (3)$$

, where λ is the downlink wavelength from the satellite to the earth, L is the atmosphere loss and rain attenuation and G_t , G_r are the typical antenna gains of transmitter and receiver.

C. Resource Management Scheme

In this paper, the C-plane coverage are provided by the satellite for both PUEs and SUEs. However, there are two ways for the U-plane service transmission to the terminals:

- Distributed Resource Management Scheme (DRMS): all of the traffic required from UEs are routed from the core network to small cells directly by the gateway, where the satellite only provide C-plane coverage and RRC-connection mobility control information.
- Centralized Resource Management Scheme (CRMS): the gateway with computing and storage capability, worked as HSS and MME, will take charge of the central resource allocation strategy by adjusting the bias θ of probability for user to get access to LEO and SeNBs. In this way, the satellite cooperates with small cells in U-plane under the central control of gateway.

D. Access Strategy

For a typical UE, it is certain that the C-plane access is linked to LEO network, while the U-plane access strategy is based on the resource management scheme. Under DRMS, the U-plane access strategy is based on the Reference Signal Receiving Power (RSRP) from all of the nearby small cells. By contrast, under CRMS strategy, the U-plane access strategy is based on the comparison among the received power from both LEO system and SeNBs, shown as follows:

$$\begin{cases} \theta \frac{P_{tb} E[h_{tb}]}{r^\alpha} > P_{rs}, \text{ get access to SeNBs} \\ \theta \frac{P_{tb} E[h_{tb}]}{r^\alpha} < P_{rs}, \text{ get access to LEO} \end{cases} \quad (4)$$

$$= \begin{cases} \sqrt{\frac{\theta P_{tb}}{u P_{rs}}} > r \Leftrightarrow r < \eta, \text{ get access to SeNBs} \\ \sqrt{\frac{\theta P_{tb}}{u P_{rs}}} < r \Leftrightarrow r > \eta, \text{ get access to LEO} \end{cases}$$

where $\eta = \sqrt{\frac{\theta P_{tb}}{u P_{rs}}}$.

III. PERFORMANCE ANALYSIS

In this section, the distributed and centralized schemes (DRMS and CRMS) are compared from various aspects and efficient resource management mechanism is suggested in the hybrid network.

A. Throughput of Hybrid Network with DRMS

Under DRMS, the throughput of the hybrid network is the sum of U-plane throughput in small cells. According to the classical model of stochastic geometry [9], the spectral efficiency of SeNB can be derived as follows:

$$SE_{b_DRMS} = \int_{t>0} \frac{1}{1 + \sqrt{e^t - 1} \left(\frac{\pi}{2} - \arctan \left(\frac{1}{\sqrt{e^t - 1}} \right) \right)} dt \quad (5)$$

, where the path loss exponent α in (2) is 4 and the thermal noise is ignored because the terrestrial network is an interference limited network. Based on our previous work [7], the overhead of U-plane $O_{\text{verhead_b}}$ is nearly 15%, thus the network throughput can be obtained by

$$\begin{aligned} \text{Throughput}_{DRMS} &= \text{Throughput}_{b_DRMS} \\ &= \lambda_b \times W_b \times (1 - O_{\text{verhead_b}}) \\ &\times \int_{t>0} \frac{1}{1 + \sqrt{e^t - 1} \left(\frac{\pi}{2} - \arctan \left(\frac{1}{\sqrt{e^t - 1}} \right) \right)} dt \end{aligned} \quad (6)$$

, in which the bandwidth of SeNB is W_b .

B. Throughput of Hybrid Network with CRMS

Under the centralized resource management scheme, the gateway will route the traffic from the external network to both satellite through uplink transmission and SeNBs through backhaul in terrestrial network. Combined with the results in (4), the SE of SeNB under CRMS is

$$\begin{aligned} SE_{b_CRMS} &= E\{\ln[1 + SINR_b|r] \times P_{r_{o_b}}(r < \eta)\} \\ &= E\{\ln[1 + \frac{P_{tb} h_{tb} r^{-\alpha}}{\sigma^2 + \sum_{b' \in \Phi/b_0} \frac{P_{tb'} h_{tb'}}{r'^{\alpha}}} |r]\} \times \int_0^\eta f_r(r) dr \\ &= \int_0^\infty \int_0^{\pi \lambda_b \eta^2} e^{-v} \left(1 + \sqrt{e^t - 1} \left(\frac{\pi}{2} - \arctan \left(\frac{1}{\sqrt{e^t - 1}} \right) \right) \right) dv dt \end{aligned} \quad (7)$$

, where the path loss exponent $\alpha = 4$ with noise ignored.

As for the SE of LEO, the probability of getting access to satellite is also considered and the SE of LEO is :

$$\begin{aligned} SE_s &= E\{\ln[1 + SINR_s|r] \times P_{r_{o_s}}(r > \eta)\} \\ &= E\{\ln[1 + \frac{P_{rs}}{k T_{on_earth} W_s} |r]\} \times \int_\eta^\infty f_r(r) dr \\ &= \ln \left(1 + \frac{P_{ts} G_t G_r \lambda^2}{(4\pi d)^2 L k T_{on_earth} W_s} \right) \exp(-\pi \lambda_b \eta^2) \end{aligned} \quad (8)$$

, where the bandwidth of satellite is W_s . The satellite network is not an interference limited network, and the thermal noise $\sigma^2 = k T_{on_earth} W_s$ should be taken into consideration, where k is the Boltzmann constant $1.3806488 \times 10^{-23} J/K$ and T_{on_earth} is the noise temperature of terminal.

The U-plane throughput under CRMS in C/U split architecture is the sum in U-plane of both SeNBs and LEO:

$$\begin{aligned} \text{Throughput}_{CRMS} &= \lambda_b \times (1 - O_{\text{verhead_b}}) \times W_b \times SE_{b_CRMS} \\ &+ (1 - O_{\text{verhead_s}}) \times W_s \times SE_s \end{aligned} \quad (9)$$

, where the overhead of U-plane $O_{\text{verhead_s}}$ is nearly 15%.

C. Power Consumption

As the satellite system is assumed to be powered by solar energy, the power consumption of LEO is not included as power consumed in the grid in this paper. The total grid power consumption of the hybrid network consists of the base station power cost and the gateway (also worked HSS and MME with computing and storage capability) power consumption.

1) *Small Cell Power Consumption*: According to the EARTH Project, the power consumption model of SeNB is formulated as:

$$P_b = \lambda_b \times (\alpha' P_{tb} + P_{b0}) \quad (10)$$

, where P_{tb} is the transmission power of SeNB which is related to the traffic load, α' is the increase coefficient and P_{b0} is the static power of SeNB. As we focus on the maximum capability of the network, all of the small cells in this paper are not put into a sleep mode.

2) *Gateway Power Consumption*: For the distributed resource management strategy, the gateway only works as the router to delivery the traffic from external network to the SeNBs, thus the power cost of gateway is composed of two parts: operation power of gateway P_c given in Table 3 in [10] and the backhaul power consumption P_{gbh_d} , which is modeled as microwave power consumption according to [11]:

$$P_{gbh_d} = \frac{\text{Throughput}_b}{100\text{Mbps}} \cdot 50W \quad (11)$$

, where Throughput_b is the overall throughput of SeNB in the coverage of LEO spot beam.

For the centralized network, the gateway power consumption will not only be the static power P_c , the backhaul power consumption P_{gbh_c} , but also the transmission power from the gateway to satellite to send back all the required traffic in U-plane of satellite, which are modeled as:

$$P_{gbh_c} = \frac{\text{Throughput}_b + SE_s \times W_s}{100\text{Mbps}} \cdot 50W \quad (12)$$

$$P_{gtx} = \frac{(2^{\text{Throughput}_s/W_s} - 1) \times kT_{\text{on_satellite}} W_g}{\frac{G_t' G_r' \lambda'^2}{(4\pi d)^2 L'}} \quad (13)$$

, where $SE_s \times W_s$ is sum of U-plane and C-plane throughput of LEO. $\text{Throughput}_s = (1 - O_{\text{verhead}_s}) \times W_s \times SE_s$ is the U-plane throughput of LEO. P_{gtx} is the uplink transmission power from the gateway to the satellite. W_g is the bandwidth of gateway and G_t' , G_r' , L' are the transmitter and receiver antenna gains, uplink atmosphere loss and rain attenuation respectively.

D. Energy Efficiency

The energy efficiency of the network is modeled as the throughput of U-plane of the network per watt consumed in the power grid. So the EE of DRMS and CRMS of hybrid C/U split network can be expressed as follows:

TABLE I
SIMULATION PARAMETERS.

	Parameter	Value	Parameter	Value
Satellite	$P_{ts} G_t (EIRP)$	54.4 dBW	W_s	30 MHz
	O_{verhead_s}	15 %	G_r	0 dB
	λ	137.3 mm	L	0 dB
	d	1000 km	$T_{\text{on_satellite}}$	26 dBK
Small cell	P_{tb}	0 ~ 4W	W_b	10MHz
	α'	16	P_{b0}	28.7 W
	$T_{\text{on_earth}}$	290 K	u	1
	T	0 dB	O_{verhead_b}	15 %
Gateway	λ'	50 mm	W_g	10 MHz
	G_t'	40 dB	G_r'	16 dB
	P_c	355 W	L'	0 dB

- EE of hybrid network with DRMS

$$EE_{DRMS} = \frac{\text{Throughput}_{DRMS}}{P_b + P_c + P_{gbh_d}} \quad (14)$$

- EE of hybrid network with CRMS

$$EE_{CRMS} = \frac{\text{Throughput}_{CRMS}}{P_b + P_c + P_{gbh_c} + P_{gtx}} \quad (15)$$

E. Coverage Probability

The coverage probability is defined as the probability that a randomly chosen user can achieve a target Signal-to-interference-plus-noise Ratio (SINR) T in U-plane. Based on the stochastic geometry knowledge, the coverage probability of two strategies can be obtained:

- Coverage Probability in hybrid network with DRMS

$$P_{\text{coverage_DRMS}} = \frac{1}{1 + \sqrt{T} \left(\frac{\pi}{2} - \arctan\left(\frac{1}{\sqrt{T}}\right) \right)} \quad (16)$$

- Coverage Probability in hybrid network with CRMS

$$\begin{aligned} P_{\text{coverage_CRMS}} &= P_{c_SeNBs} + P_{c_LEO} \\ &= E_r \{ P[SINR_b > T|r] P(r < \eta) \} \\ &\quad + E_r \{ P[SINR_s > T|r] P(r > \eta) \} \\ &= \int_0^{\pi \lambda_b} \sqrt{\frac{P_{tb} \theta (4\pi d)^2 L}{P_{ts} \lambda^2 G_t G_r}} e^{-v(1 + \sqrt{T}(\frac{\pi}{2} - \arctan(1/\sqrt{T})))} dv \\ &\quad + e^{-\pi \lambda_b \sqrt{\frac{P_{tb} \theta}{P_{ts} \lambda^2} \cdot \frac{(4\pi d)^2 L}{G_t G_r}}} 1 \left(\frac{P_{ts} G_t G_r \lambda^2}{(4\pi d)^2 L \sigma^2} > T \right) \end{aligned} \quad (17)$$

, which is the sum of the coverage probability of SeNB P_{c_SeNBs} and the coverage probability of LEO P_{c_LEO} . Here the function $1(A)$ denotes the indicator of event.

IV. NUMERICAL RESULTS

In the following, we use the default values in the Table I to illustrate the main results, where the key parameters in terrestrial network are based on the EARTH Project and the satellite parameters are obtained from [12]. For the uplink channel from gateway to satellite, the C-band 6GHz is assumed and 2m antenna is used at the gateway.

Figure 2 illustrates the spectral efficiency in the hybrid satellite terrestrial network. Under DRMS strategy, the spectral efficiency is independent with the density or the power of SeNB, because the received power and the interference both grow simultaneously in the interference limited network, as shown in Figure 2 (a) in black dash line. However, under the

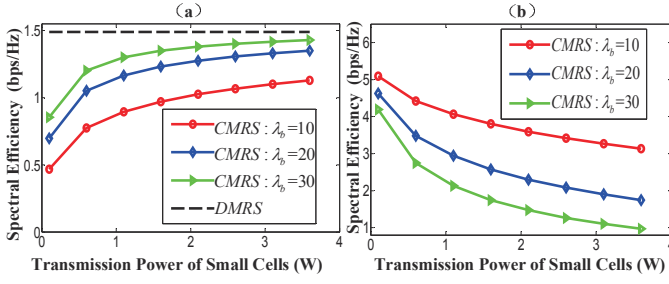


Fig. 2. Spectral Efficiency: (a) Relationship between SE of SeNB and transmission power of SeNB; (b) Relationship between SE of satellite and transmission power of SeNB.

CRMS scheme, the SE of SeNB grows with the increase of density λ_b and the transmission power P_{tb} of small cells, due to larger probability for UE to get access to SeNBs. On the contrary, the SE of satellite decreases with λ_b and P_{tb} as shown in Figure 2 (b).

The throughput of the hybrid network is one of the main indicators to compare two resource management schemes and we assume that the transmission power of small cell is 25dBm here. For the hybrid network with DRMS, the traffic in U-plane is routed to different small cells directly without the central control in the gateway. As illustrated in Figure 3, on account of the SE of small cells in DRMS holds stable, the throughput is directly proportional to the density of SeNBs λ_b . However, for the hybrid network with CRMS, the U-plane traffic will, under control of the gateway, choose to route to the satellite or the SeNBs and the parameter bias θ could be used to achieve higher throughput under this scheme. With small bias (e.g., $\theta = -165dB$), the advantage of satellite is quite obvious when the density of small cells is low, while resisting the UE to get access to SeNB when λ_b is large. On the contrary, if the bias is too large (e.g., $\theta = -125dB$), the benefits from the SeNBs can be enjoyed when the density of small cells is high, while failing to achieve higher throughput from satellite when λ_b is small.

The median value of bias $\theta = -145dB$ is more appropriate. The reason why the absolute value of θ is so small compare to $0dB$ is the fact that the satellite network is not an interference limited network. The distance from LEO to the earth is quite large, so that the received power from the satellite are much smaller than that from the SeNBs. However, even though the RSRP is smaller in the satellite link, the SINR could be larger than that in the terrestrial network. In addition, the channel parameters are simplified and the constant path-loss factor is reflected by bias θ here. It shows that, compared with network under DRMS, the hybrid network with proper bias factor under CRMS will achieve huge throughput gain (about 136%) in sparse networks (e.g., $\lambda_b = 5$) with only little loss (3%) in relatively dense networks ($\lambda_b = 25$).

Figure 4 shows the EE comparison between hybrid network with DRMS and CRMS strategies. It is obvious that the EE grows with the increase of density of small cells in DRMS network at first, resulting from the tradeoff between higher throughput and the static power consumption of the

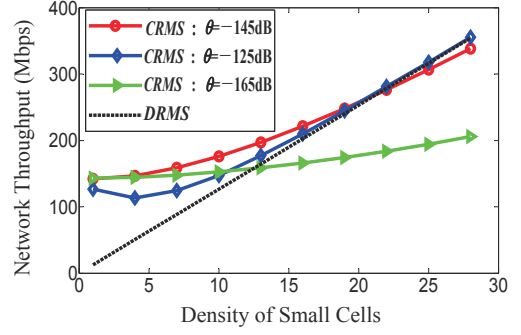


Fig. 3. Throughput comparison between DRMS and CRMS with various access bias θ .

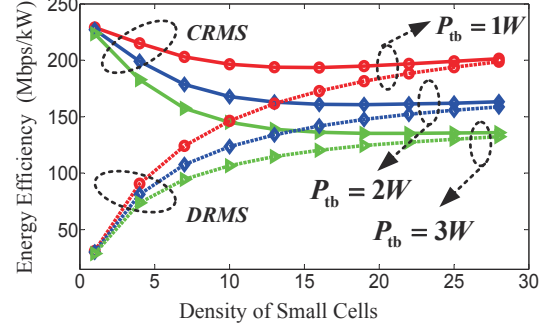


Fig. 4. Network EE comparison between DRMS and CRMS with multiple transmission power of SeNB.

gateway and SeNB, and then remains stable as both the power consumption and throughput vary linearly with the density of the SeNBs. For the hybrid network with CRMS, the results are totally different. The EE reaches quite a high value when the density of small cells is low benefiting from the large probability to get access to satellite and higher throughput from LEO. With the increase of density of the SeNBs, the EE shows a downward trend and finally remains constant with that under DRMS strategy. In addition, the probability of get access to the satellite and the power consumption are affected by transmission power of the SeNBs P_{tb} , so that the EE in both DRMS and CRMS network will decrease with the growth of P_{tb} . It is obvious that the network with CRMS strategy will achieve higher network EE than DRMS, especially in sparse networks (e.g., $\lambda_b = 5$) where the EE gain is nearly 60%.

In Figure 5, the U-plane coverage probability of the satellite and SeNBs under CRMS strategy is analyzed as a 3-D figure. The coverage performance is mainly relied on the satellite network when the density of small cells is low, so that most of the terminals get access to LEO and achieve higher SINR to maintain the higher coverage probability. On the contrary, the coverage probability is then provided by the SeNBs when the density of small cells λ_b is high. The transmission power of SeNB P_{tb} almost has no influence on the coverage performance when λ_b is small and the satellite is in the major role, but P_{tb} will help to increase the coverage performance for SeNBs when the λ_b becomes large.

Figure 6 compares the U-plane coverage probability under

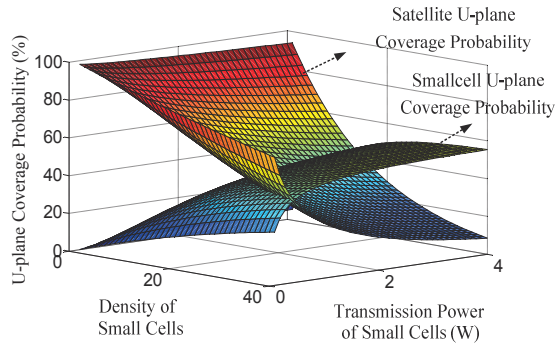


Fig. 5. U-plane coverage probability of satellite and SeNBs respectively under CRMS.

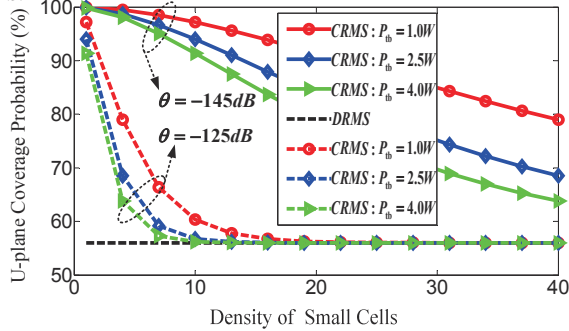


Fig. 6. U-plane coverage probability under DRMS and CRMS with different transmission power of SeNB and bias θ .

two strategies. It is shown that the U-plane coverage probability remains the same under certain outage threshold T for the hybrid network under DRMS strategy, which has nothing to do with the density λ_b or the transmission power P_{tb} of SeNB. This is because these two factors can not affect the SINR in the network. Furthermore, it is obvious that the U-plane coverage performance under CRMS strategy is much better than that under DRMS strategy as the satellite can achieve quite large SINR without the interference from SeNBs. In addition, the larger bias factor θ , λ_b and P_{tb} affect the probability to get access to satellite, resulting in lower coverage probability. The hybrid network with CRMS can achieve almost 77% and 57% coverage probability gain in sparse networks (e.g., $\lambda_b = 5$) and relatively dense networks (e.g., $\lambda_b = 25$) respectively than DRMS network.

In summary, by adapting proper access bias in hybrid networks with CRMS strategy, a higher throughput can be achieved and a higher EE and coverage probability can be realized by adjusting the transmission power configuration of the terrestrial network. Compared with DRMS network, the CRMS system can provide a more intelligent resource scheduling scheme as well as customized services. The parameters can be optimized in the future network under typical network topology and the density of small cells in CRMS strategy, to take both the advantage from satellite and terrestrial network.

V. CONCLUSION AND FUTURE WORK

In this paper, we focus on the hybrid satellite and terrestrial network with C/U-plane split, and propose two main resource

management schemes (CRMS and DRMS) to study the fundamental relationship between the network performance (SE, EE, throughput and coverage probability) and key parameters, including the transmission power and density of SeNBs, the static power consumption, gateway and the bias factor. It is shown that, compared with the hybrid network DRMS, the system with CRMS strategy to realize U-plane cooperation can achieve about 136% throughput gain, 60% EE gain, and nearly 77% coverage probability gain in ultra-sparse networks. Efficient resource management scheme is suggested for hybrid network in future 5G network. In future, the high throughput satellite in Ka or Ku band will be studied and the delay-coverage tradeoff in this hybrid network will be analyzed. In addition, broadcast of satellite with the intelligent cache in terrestrial network will be exploited to enhance the energy efficiency towards green 5G hybrid networks.

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