Multimed Tools Appl (2019) 78:8699–8710
https://doi.org/10.1007/s11042-018-6149-4

Wireless resource management mechanism with green communication for multimedia streaming

Yong Jiang [1]

Received: 19 March 2018 / Revised: 10 May 2018 / Accepted: 16 May 2018 /
Published online: 12 June 2018

Abstract In the face of massive parallel multimedia streaming and user access, multimedia servers are often in an overload state, resulting in the delay of service response and the low utilization of wireless resources, which makes it is difficult to satisfy the user experience quality. Aiming at the problems of low utilization rate of multimedia communication resources and large computing load of servers, this paper proposes a self management mechanism and architecture of wireless resources based on multimedia flow green communication. First, based on the combination of multimedia server, relay base station and user cluster, a multimedia green communication system architecture is built based on the comprehensive utilization rate of multimedia communication, and a cluster green communication control algorithm is proposed. Secondly, aiming at the dynamic service demand and asynchronous multimedia communication environment, aiming at ensuring the balance of resource allocation and accelerating the speed of resource allocation, we build a dynamic multimedia wireless resource architecture. Finally, the experimental results of statistics and analysis, from the server in different scale parallel multimedia streams under different scale delay, number of users relay network free resources proportion, user satisfaction, packet loss rate and other performance show that the proposed algorithm is effective and feasible.

Keywords Resource management · Green communication · Wireless control · Multimedia streaming

1 Introduction

With the widespread promotion of Internet multimedia applications and the rapid development of [12] and wireless communication technology [14], the demand for real-time multimedia services by mobile terminals such as mobile phones is increasing. Guo [4] is increasing.

✉ Yong Jiang
jiangyongls@sina.com

[1] Department of information technology, Jiangsu Union Technical Institute, Xuzhou, Jiangsu, China

However, the multimedia service is facing a series of problems in response to large-scale parallel service delay [15], unlimited resources uneven distribution of [7, 11] in low quality of user experience, so the academic and communication industry researchers carried out a series of research work, and achieved a series of achievements.

On the one hand, a new approach based on game theory to change rate, modulation and power in the game algorithm was proposed in article [1]. The authors of article [6] proposed a resource management system with transmission capacity for enhancing the performance of wireless mesh networks. The work of article [10] studied an enhanced radio resource management based MIH policies in heterogeneous wireless networks. Song B et al. [13] proposed a two-stage approach for task and resource management in multimedia cloud environment.

On the other hand, a key tool of common radio resource management technique had been designed by the author of article [9] to jointly manage the radio resources from different radio access technologies. The contributions of Castro A et al. [3] the proposal of an extended service management architecture based on Multi agent Systems able to integrate the fault diagnosis with other different service management functionalities. The resource scheduling for content dissemination in multimedia cloud was proposed by authors of article [8], which could increase the user satisfaction and decrease completion time of content dissemination.

The authors of article [16] investigated secure multimedia big data application in trust-assisted sensor cloud and proposed two types: one with a single trust value threshold), and another with multiple trust value thresholds. A qualitative analysis of electronic Human Resource Management was conducted by the author of article [2]. Y. Jin et al. proposed a QoS guaranteeing mechanism with the error control aware and the importance of ARQ Block with IEEE 802.16e protocol [5]. However, this research work ignored the problem of resource management in multimedia communication.

However, no in-depth study on the mobile resources for large-scale user equilibrium, communication network resource allocation and server large-scale computing problems, so this thesis studies the wireless resource management mechanism for independent multimedia streaming green communication.

2 Model of multimedia green communication system

The multimedia green communication system is based on the standard multimedia communication system, which is used to monitor and control the energy for reducing resource consumption and improving the utilization of resources. The multimedia server, the relay base station and the user cluster are combined, and the integrated energy utilization rate of multimedia communication is the main line, and its architecture is shown in Fig. 1. The multimedia green communication system mainly consists of three parts: the multimedia server cluster, the green communication module and the communication sub-net.

Here, the multimedia server cluster include the distributed parallel multimedia streaming servers. They deploy in different regions and connect with different green communication modules. The full duplex channel must be used in the communication sub network and the green communication module, which include the energy utilization rate collection and feed-back special channel. In addition, there are a large heterogeneous relay base station and a cluster of diverse user clusters in the communication sub-net. The user terminal of the user cluster is dominated by various types of smart phones. The energy report collection connects

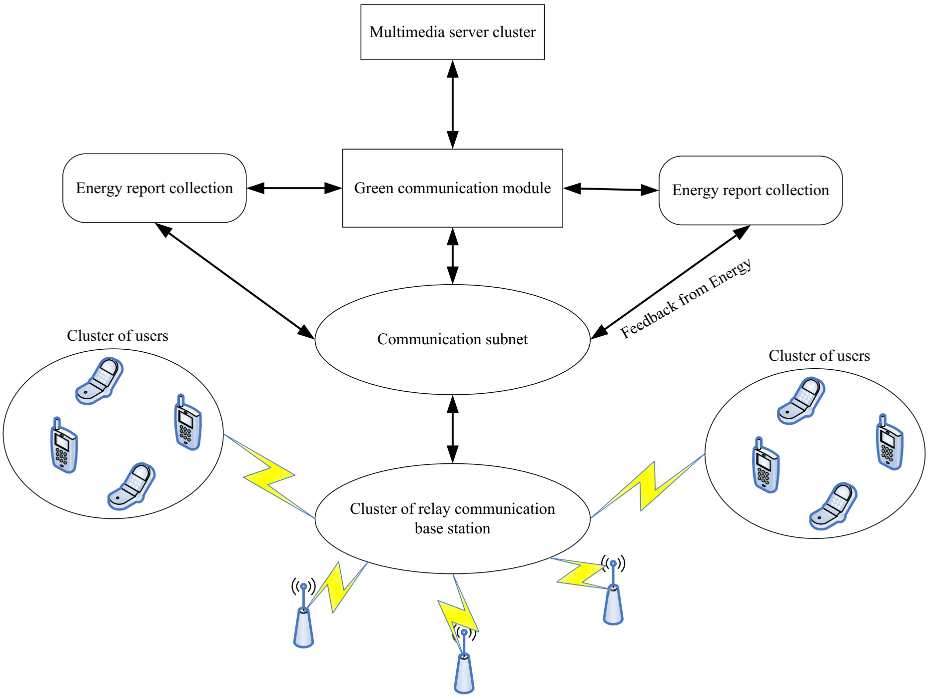

Fig. 1 Multimedia green communication system architecture

the green computing module and the communication sub-net, Its role is to report the energy utilization to the multimedia server cluster.

$$\begin{cases} \overline{U_n} = \sum_{i=1}^{|n-m|} C_i U_{n-i} \\ \overline{V_n} = \sum_{i=1}^{|n-m|} C_{n-i} \overline{U}_n \end{cases} \tag{1}$$

Among them, $\overline{U_n}$ $_{\text{denotes}}$ the mean of the application requirements of the N user is expressed. $\overline{V_n}$ denotes the resource status of the N relay base station. M represents the number of peer-to-peer data streams. Cn represents the weight of the first n green communication.

After the $\overline{U_n}$ and $\overline{U_n}$ are obtained by formula (1), the N relay base station is selected with $\sum_{l=1}^{n} \overline{U}_n \overline{V_n} > 1$, otherwise the next iteration will be carried out.

The relay cluster terminal is connected with the user cluster control point through the multimedia coding interface. Its role is to receive the multimedia data service request and the user terminal energy usage evaluation. The link can also be used for the identification and reorganization of the wireless channel and multimedia transmission channel, the related system information and paging information needed for cluster interaction control.

The green communication module is made up of a dedicated computer cluster, and the architecture and protocol stack are shown in Fig. 2. Among them, the competition module connects the service access point with the protocol stack. Specially, this module would activate the new round of service access point competition process through the peer interaction and control signaling of the protocol stack. At the same time, we classify the computers of the

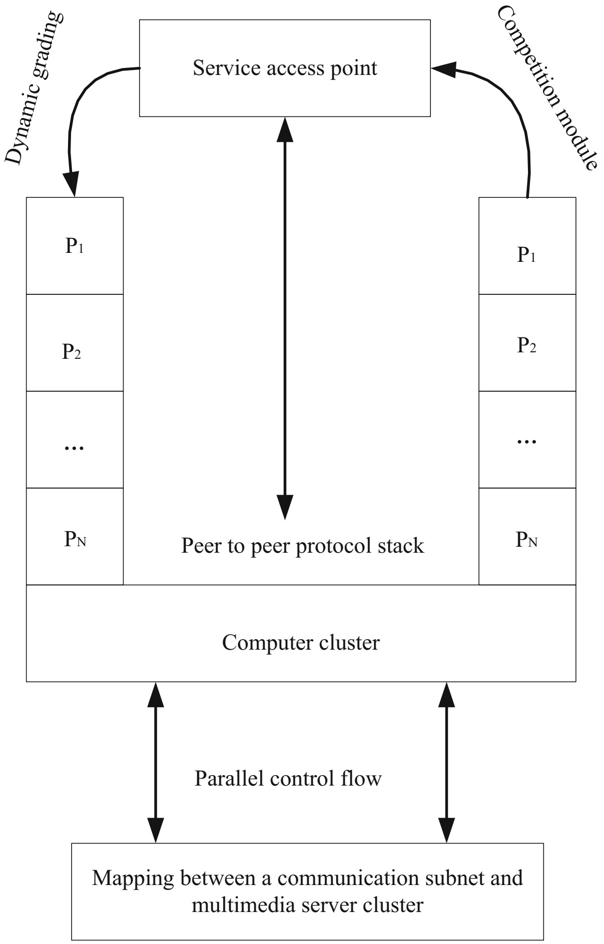

Fig. 2 Green communication module

green communication computer cluster with the service access points dynamically, also considering the multi stream parallel business scale and the protocol stack state. In order to load balanced cluster connection, the service access point not only has the basic function of communication with special computer, but also support cluster service related control signaling, cluster scheduling and paging message sending, cluster service communication network and multimedia server cluster. There are the mappings between multimedia wireless link parallel flow establishment, monitoring and evaluation etc. Besides, cluster green communication control point is not static assignment, but periodic or irregular internal competition allocation according to the size of multimedia flow and the size of user request. This is to avoid the problem of network performance degradation caused by poor state terminals, while giving full play to the advantages of excellent state terminals, avoiding resource waste and supporting the function of fault weakening.

The mapping function in Fig. 2 is shown as formula (2), in which the function represents a balanced evaluation method between the user's requirements and the communication sub-net in a two-dimensional space.

$$\begin{cases} \varphi(u,v) = \sum_{i=1;j=1}^{n;m} \varphi\left(u_{n-i}, v_{m-j}\right) \\ \varphi(x,y) = \sum_{k=1}^{|n-m|} \frac{C_{n-k} C_{m-k}}{nm} \sqrt{\iint \varphi(x,y) dxdy} \end{cases} \tag{2}$$

3 Autonomous management mechanism of multimedia wireless resources

In order to satisfy the diversity of user applications and dynamic service requirements, the different wireless access technologies and resource allocation schemes would be employed in multimedia communication. Based the above state, the radio resource management of real-time, accuracy and balance would be disturbed seriously, resulting in poor quality of user experience and network load distribution problem of polarization. In order to effectively improve the efficiency of resource management in multimedia service of large-scale heterogeneous wireless networks, we have refined the above problems into the following key issues.

(1) how to construct dynamic multimedia wireless resource architecture in dynamic service demand and asynchronous multimedia communication environment.
(2) how to ensure the balance of the distribution of the wireless multimedia service resources and speed up the convergence rate of the resource allocation;
(3) how to improve the autonomy of multimedia wireless resource management.

On the basis of the multimedia green communication system established in second section, with the perspective of green communication module, we built the multimedia wireless resource dynamic architecture shown in Fig. 3 by considering the diversity, dynamism and

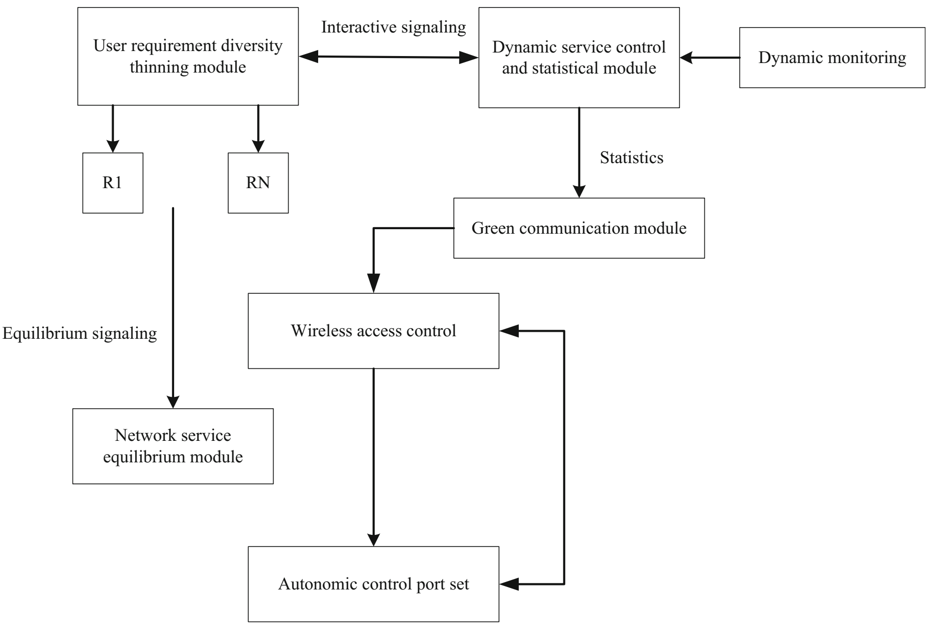

Fig. 3 Multimedia wireless resource dynamic architecture

heterogeneity. Among them, dynamic architecture is embodied in dynamic monitoring and dynamic service control and statistical modules. The module periodically exchanges information with the green communication module. The user diversity requirement is refined into a N subset. These subsets are used as the basis for network load balancing. There are two links between the wireless access control and the autonomous control port set. One links is used to transfer the user feedback of the wireless access state. The other is used to completing their interaction. In particular, the diversity of users' needs and the interaction between modules and dynamic service control and statistical modules is the core control flow in Fig. 3. The format is shown in Table 1. The parameter description of the signaling field defined in Table 1 is detailed in Table 2.

The autonomous management mechanism of multimedia wireless resources is based on the optimization goal defined by formula (3), and the algorithm pseudo code of Fig. 4 is used to manage resources independently.

$$\begin{cases} \min \sum\limits_{i=1}^{N} \varphi(u_i, d_i) \\ s.t. \sum\limits_{i=1;j=1}^{n;m} f_{ij}\left(\overline{\varphi_i}\right) \\ u_i \in U \quad d_i \in D \quad \overline{\varphi_i} = \dfrac{\sum\limits_{i=1}^{N} \varphi(u_i, d_i)}{N|n-m|} \end{cases} \tag{3}$$

Among them, U represents a subset of user diversity requirements, and D represents a set of dynamic service statistics, $\overline{\varphi_i}$ representing the independent management statistics and asynchronous means of multimedia wireless resources.

4 Performance evaluation and result analysis

In order to verify performance of the proposed radio resource management mechanism for multimedia stream green communications (WRMG), such as the performance of the server and relay network source management performance and user experience, we designed a set of experiments, which verified the above performance in different scale parallel server multimedia stream under the delay, number of users under different scale relay the proportion of idle resources, network user satisfaction and packet loss rate performance. The above performance

Table 1 Interaction signaling composition

Field	Definition
Interaction source	The initiator of interactive signaling
Interactive type	The purpose of the interaction
Interaction signaling length	The size of the signaling
Dynamic service state	The dynamic changes in the service
Interactive purpose	The destination of interactive signaling
Interaction priority	A differentiated service
User requirements subdivision	The diversity of user needs
Network statistics and green computing	Green computing scheme based on statistical updating

Table 2 Important parameters for interactive signaling

Parameters	Definition
IER_SRC	Private port numbers from autonomous control port centralization
IER_TY	Independent definition of type based on port number
IER_LEN	Signaling size from IER_SRC
DS_S	Values from the dynamic monitoring module
IER_DES	Private port numbers from autonomous control port centralization
IER_PR	Independent definition of priority according to IER_SRC
UR_DT	The user requirement subdivision vector R
NS_GC	The interaction of the autonomous control port number for the green communication module and the wireless access control

```
Algorithm name: AmmR(U, D, S);
Input:
  U//Diversity subdivision of user requirements
  D//Dynamic service set
  S//Autonomic control port set
  PT//Threshold value of autonomous priority control
Output:
  C//Weight of green communication
  Re//Selected relay base station cluster
  ET//Resource equilibrium weight

Algorithm AmmR(U,D,S){
  Update protocol stack;
  Competition access point;
  Initialization of parallel control flow;
  Initialization of U;
  Dynamic monitoring of D;
  Initialization of S, PT;
 If(IER_SRC==1)
   Obtain the value of IER_DES;
   While(IER_TY)
    {
      For(i=1, j=1; n,m){
         φ(u_{n-i}, v_{m-j})
      }
    }
  else{
    If(IER_PR>PT)
      Analyze the value of IER_LEN, NS_GC;
      Update the value of DS_S;
      return C, Re, ET;
  }
    else{
      Update PT;
      AmmR(U, D, S);
  }
}
```

Fig. 4 An autonomous management algorithm for multimedia wireless resources

Table 3 Experimental environment

Parameter	Value
Server number	10
Server kernel number	4 core
Server hard disk storage space	2 TB
Relay base station number	50
Parallel multimedia stream number	[1,10]
User mobile phone model	nova 2s
Server CPU master frequency	1.9GHz
Server memory	4GB DDR4
Server CPU model	Xeon E5-2609 v3
Relay base station MAC protocol	IEEE 802.11g
Number of users	[5,14]
Interference signal duration	[1, 10]ms

is compared with ones of the multimedia transmission protocol proposed in reference [5] as WMAP-16.

The definition of experimental index:

(1) the delay of the server in the parallel multimedia stream of different sizes: with the increase of parallel multimedia stream, the maximum delay of the server side to the user's demand.
(2) the proportion of idle resources in relay networks under different scales of users: as the number of users increases, the total surplus idle resources of relay networks occupy the proportion of total resources.
(3) packet loss rate: in the end to end communication process from the server side to the user's mobile terminal, the loss of data packets is in the proportion of the total transmission packets.
(4) user satisfaction: the user's actual satisfaction on the video at the mobile terminal is divided into 5 levels, detailed in Table 4.

Tables 3 and 4 gives the setting of the experimental environment and parameters.

On the one hand, we statistically analyzed the real-time performance of the proposed algorithm and the efficiency of network resource management in the face of different scale parallel multimedia traffic and user scale, as shown in Figs. 5 and 6. Figure 5 shows the delay of the server in parallel multimedia streams of different sizes. With the increase of parallel multimedia traffic, the resource consumption of servers on multimedia request listener channel

Table 4 User satisfaction rating

Level	Definition
1	There are serious discarding and carton
1.5	The loss of packet is serious, and the number of pause is few
2	A certain packet loss and poor quality of the picture
2.5	The sound is incompatible with the picture
3	The quality of the picture is good and the sound is consistent with the picture, but there is a certain pause
4	The best user experience

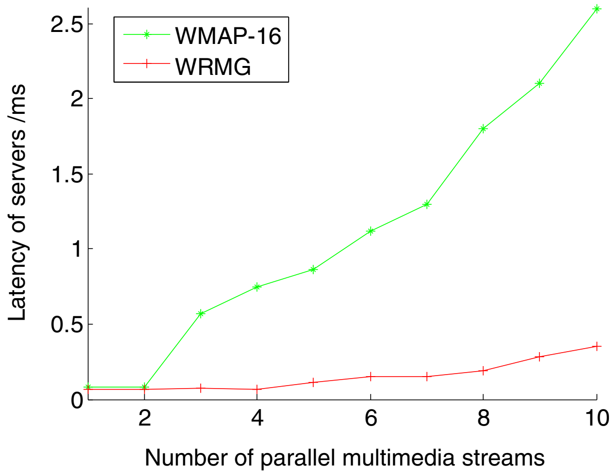

Fig. 5 Latency of servers in parallel multimedia streams of different sizes

is increasing, increasing the response delay to new multimedia cases. This delay will continue to spread with the creation of multimedia stream, the reading and reconfiguration of multimedia data, so that the real time experience of the user is seriously affected. However, from Fig. 5, we can see that the proposed WRMG algorithm is divided into multimedia server cluster, green communication module and communication sub-net through the multimedia green communication system. At the same time, the multimedia server cluster is composed of distributed parallel multimedia streaming servers deployed in different regions and connected by green communication modules. Especially, compared with WMAP-16, the energy report collection of the proposed algorithm connects the green computing module and the communication sub-net, and reports the energy utilization to the multimedia server cluster. The above control processes can equalize the overload of multimedia server in the communication sub-net. These processes

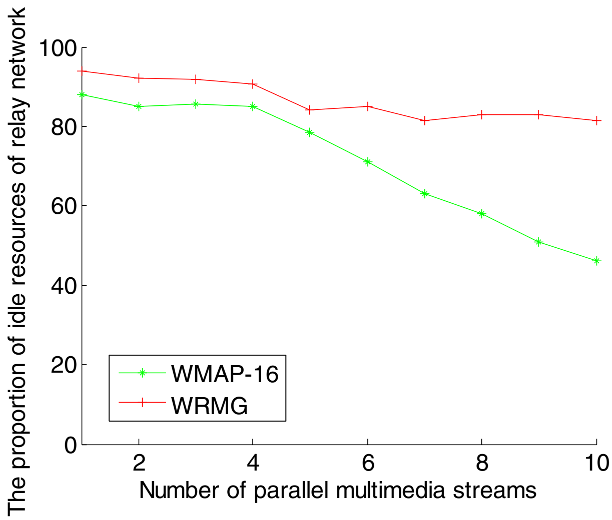

Fig. 6 The proportion of idle resources of relay network under different scale of users

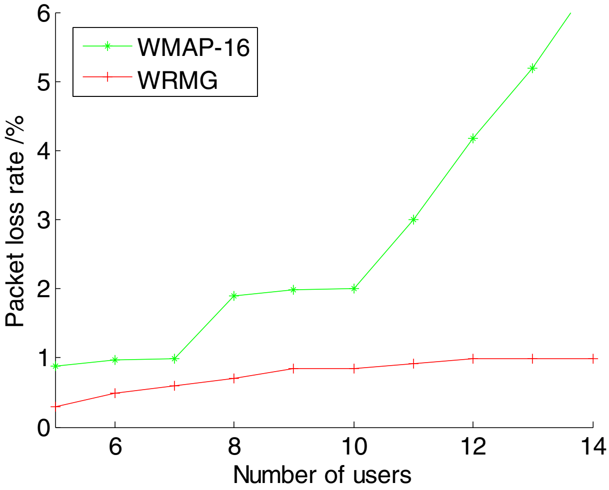

Fig. 7 Packet loss rate

can also enable the server to maintain real-time performance in the case of large-scale parallel multimedia streaming. Similarly, the proposed algorithm can efficiently cope with the radio resource allocation and balancing problem of relay networks under different scale users. According to the energy report, we collect resource information and integrate resources in real time, which effectively improves the resource utilization rate. See Fig. 6.

The experience and performance of the user side are detailed in Figs. 7 and 8. The proposed algorithm is based on the green communication module and reconstructs the multimedia wireless resource dynamic architecture from diversity, dynamics and heterogeneity. Dynamic monitoring and dynamic service control and statistical experiment multimedia architecture are updated dynamically. In particular, compared with WMAP-16, the proposed algorithm refines the user diversity requirement for network load balancing. Among them, wireless access control and autonomous control port set can not only feed back the wireless access state, but

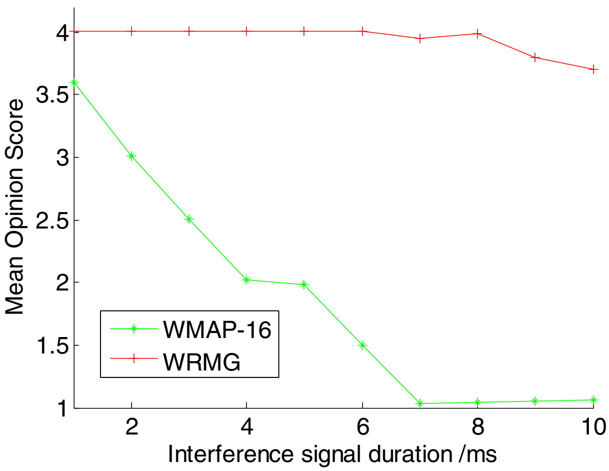

Fig. 8 Mean Opinion Score

also realize the independent interaction. In particular, the diversity of user needs and the interaction between modules and dynamic service control and statistical module can effectively reduce packet loss rate and improve user satisfaction.

5 Conclusions

For resolving the delay and multimedia server overload problems in massive parallel multimedia streaming and user access, a wireless multimedia communication independent green resources management mechanism and its architecture were proposed in order to short service response delay and improve the utilization rate of wireless resources, which could ensure the quality of the multimedia mobile user experience. On the one hand, the multimedia real-time service system is divided into multimedia server, relay base station and user cluster. The multimedia green communication system architecture and its green communication control algorithm are designed to optimize the comprehensive energy utilization of multimedia communication. On the other hand, in order to adapt to the dynamic service requirements and asynchronous multimedia communication environment, a dynamic multimedia wireless resource architecture is proposed. The architecture can effectively balance the wireless multimedia service resources and quickly converge the resource allocation algorithm. We use the methods of mathematical analysis and experimental statistics to compare the proposed algorithms in terms of real time, reliability and effectiveness, respectively. The results show that compared with the QoS guarantee mechanism of document [5], the proposed algorithm has obvious advantages in terms of server response delay, relay network idle resource ratio, user satisfaction and packet loss rate.

Acknowledgements This work is supported in part by Jiangsu Province Qing Lan Project.

References

1. Aliaskari M, Shahzadi A (2017) A game theoretic approach to joint resource management in wireless ad hoc networks[C]. International symposium on telecommunications. IEEE, pp 6–11
2. Arjomandy D (2016) Social media integration in electronic human resource management: development of a social eHRM framework[J]. Canadian Journal of Administrative Sciences 33(2):108–123
3. Castro A, Sedano AA, García FJ et al (2018) Application of a multimedia service and resource management architecture for fault diagnosis[J]. Sensors 18(1):68
4. Guo L (2017) An embedded multimedia communication terminal based on DSP+FPGA[J]. Multimed Tools Appl 76(16):1–13
5. Jin Y, Bai GW (2013) A guarantee mechanism of QoS diversity based on error control aware and ARQ block importance in WiMAX networks[J]. J Inf Comput Sci 10(8):2269–2278
6. Köbel C, García WB, Habermann J (2017) A resource management system for transmission capacity enhancement in wireless mesh networks[J]. Ing Desarro 34(2):370–396
7. Li S, Zhu G, Lin S et al (2017) Cross-layer resource management in software defined ultra dense wireless networks[C]. International conference on mobile ad-hoc and sensor networks. IEEE, pp 412–416
8. Li C, Zhu L, Liu Y et al (2017) Resource scheduling approach for multimedia cloud content management[J]. J Supercomput 73(2):1–23
9. Lopez-Benitez M, Gozalvez J (2011) Common radio resource management algorithms for multimedia heterogeneous wireless networks[J]. IEEE Trans Mob Comput 10(9):1201–1213
10. Omheni N, Gharsallah A, Zarai F (2017) An enhanced radio resource management based MIH policies in heterogeneous wireless networks[J]. Telecommun Syst 12:1–16

11. Sheng M, Wang Y, Li J et al (2017) Toward a flexible and reconfigurable broadband satellite network: resource management architecture and strategies[J]. IEEE Wirel Commun 24(4):127–133
12. Sivaprakash C, Pauline A (2017) Configuring linux system for internet protocol based multimedia communication network[J]. Indian J Sci Technol 10(7):1–6
13. Song B, Hassan MM, Alamri A et al (2016) A two-stage approach for task and resource management in multimedia cloud environment[J]. Computing 98(1–2):119–145
14. Yang Q, Wang H, Dohler M et al (2017) Guest editorial multimedia communication in the internet of things[J]. IEEE Internet Things 4(2):484–486
15. Yu J, Wong WC (2017) A network resource management framework for wireless mesh networks[J]. Wirel Pers Commun 95(3):1–25
16. Zhu C, Shu L, Leung VCM et al (2017) Secure multimedia big data in trust-assisted sensor-cloud for smart city[J]. IEEE Commun Mag 55(12):24–30

JIANG Yong was born in 1977. He received the M.S. degree from China University of Mining and Technology in 2009. Now he is a professor at Jiangsu Union Technical Institute. His research interests include computer network technology and database technology, etc.