TELKOMNIKA, Vol.15, No.4, December 2017, pp. 1666~1676
ISSN: 1693-6930, accredited **A** by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v15i4.6686

Selective Green Device Discovery for Device to Device Communication

Bhaskara Narottama*[1], Arfianto Fahmi[2], Rina Pudji Astuti[3], Desti Madya Saputri[4], Nur Andini[5], Hurianti Vidyaningtyas[6], Patricius Evander Christy[7], Obed Rhesa Ludwiniananda[8], Furry Rachmawati[9]
Telecommunication Engineering Program, School of Electrical Engineering, Telkom University
Bandung, Jawa Barat 40257, Indonesia
*Corresponding author, e-mail: bhaskaranarottama@gmail.com[1], {arfiantof[2], rinapudjiastuti[3], destimadyasaputri[4], nurandini[5], huriantividya[6]}@telkomuniversity.ac.id, {evander.christy[7], obedrhesa[8], furryrachma[9]}@gmail.com

Abstract

The D2D communication is expected to improve devices' energy-efficiency, which has become a major requirement of the future wireless network. Before the D2D communication can be performed, the device discovery between devices must be done. The previous works usually only assumed one mode of device discovery, i.e. either use network-assisted (with network supervision) or independent (without network supervision) device. Therefore, we propose a selective device discovery for device-to-device (D2D) communication that can utilize both device discovery modes and maintain devices' energy-efficiency. Different from previous works, our proposed method selects the best device discovery mode to get the best energy-efficiency. Moreover, to further improve the energy-efficiency, our proposed method also deployed in D2D cluster with multiple cluster heads. The proposed method selects the most suitable mode using thresholds (cluster energy consumption and new device acceptance) and cluster energy expectation. Our experiment result indicates that the proposed method provides lowest energy consumption per new accepted device while compared with schemes with full network-assisted and independent device discovery in low numbers of new device arrival (for the number of new devices arrival=1~3).

***Keywords**: device-to-device communication, next generation wireless network, green communication, device discovery*

1. Introduction

Due to the explosion of the mobile service and user demand [1], the mobile network is expected to be highly congested in the near future [2]. To cope with this problem, device-to-device (D2D) communication offers direct communication between devices in proximity, allowing the user plane traffic to be exchanged, without burdening the network [3]. Furthermore, the D2D communication, together with Internet of Things (IoT) and small cell access is also proposed as an upcoming architectural revolution in 5G communication [3]. Therefore, D2D communication will play a major role in the next generation wireless network.

As one of promising future wireless network technologies, D2D communication is expected to take resource efficiency into consideration. Two resource constraints that can be pointed out are the spectral resource (which already developed in cellular communication using methods such as Mean Greedy algorithm [4], Promethee method [5], fractional power control considerations [6], or adaptive resource allocation [7], increase the efectiveness of antenna radiation [8, 9], and the energy resource in devices' battery.

In this paper, we will focus on the D2D capability to enhance energy efficiency. One popular approach to reducing the energy consumption in the D2D communication is by forming clusters of the devices in the cell [8-10]. In each cluster, the cluster head (CH) receives the data content from the base station (BS) and re-transfer it to its cluster member (CM) [8, 9]. By utilizing this method, the number of long-range communication links which consumes more energy can be decreased [10, 11].

Received June 26, 2017; Revised August 28, 2017; Accepted November 5, 2017

Device discovery, which is devices recognition process in the proximity, is an important factor in D2D communication. To satisfy the Proximity Service requirements [12, 13], both device discovery and communication process are the main enablers in D2D features [12]. Moreover, before any services are given, information requested or data exchanged, the devices must know its proximity devices [14]. Therefore, device discovery is recognized as the initial process in the D2D communication, that is, the first important step before any form of D2D communication can be formed [15, 16]. Moreover, device discovery can also be used for other promising D2D features, such as measurement of channel state information (CSI) and cross-channel state information (C-CSI) [17]. Due to its important role in the whole D2D scenario, device discovery is expected to be energy-efficient [14, 18, 19].

Because of its data-distributing nature, the CH may suffer higher energy consumption compared to the CMs [20]. Thus, to tackle unfairness in CH energy consumption, a multi-CH method, i.e. cluster head rotation method, is proposed by the authors to improve the fairness in energy consumption [20]. To utilize the cluster head rotation method in device discovery, device discovery schemes for the cluster head rotation method is proposed in [19]. There are two schemes that presented: the first scheme is eNB-assisted device discovery, and the second scheme is the independent device discovery [19]. The first method exploits BS assistance to detect new devices while the other avoid the BS supervision by independently recognizing the new device [19].

Due to the usage of different modes of D2D communication, selection method to select different D2D modes are needed to adapt to different conditions. There are several works that presented various selective modes for D2D. In [21], the proposed selection of different D2D resource allocation mode is presented. In [22], Floating Band D2D is proposed to select between in-band and out-band D2D communication. In [22], an adaptive mode for D2D in bursty traffic condition is proposed. The adaptive mode assigns best D2D mode based on traffic load and channel occupation time [22]. In [23], a distance-based method to select between the cellular mode and the direct D2D mode is proposed.

However, as the best of our knowledge, the selection procedure for device discovery that considers energy consumption is still underdeveloped. Nevertheless, D2D communication will better meet users' demand if it can be deployed with or without network support. There is a need to develop a selection mechanism to select best modes that can satisfy energy-efficiency, as mentioned in the vision of ultra-dense next generation wireless network [24]. Previous works usually more focused on either network-assisted [15,25] or independent device discovery [14, 26, 27].

The contributions of our work can be presented as follows. First, we propose a selective green device discovery method, which is a threshold-aware approach to select the best device discovery mode based on cluster's previous energy consumption. Based on several parameters and condition, during the time period, the method may change its nature from eNB-assisted to independent and vice versa. Therefore, the proposed adaptive approaches are expected to take both the advantages of the network-assisted and independent device discovery. Second, the proposed method is implemented in a multi-CH scenario using the cluster head rotation method. Third, we conducted simulations to examine the performance of the proposed method.

The rest of this paper is organized as follows. Section II explains the system model that is being used. In Section III, different modes of device discovery in D2D are defined. In Section IV, the full scope of the proposed method is presented. The results are presented and discussed in Section V. Finally, the conclusion of this paper is drawn in Section VI.

2. System Model and Formulation

In this work, an LTE-A single cell area with an outdoor dense environment is assumed. A single BS is located at the center of the cell. The orthogonal frequency division multiple access (OFDMA) in the downlink (DL) is assumed for radio access [28]. All D2D devices are capable of communicating in both short range (SR) link for inter-device communication and long range (LR) link in the BS-device communication [28]. The devices which act as CHs is transferring the data content to its respective CM. The parameters and simulation assumptions of this work, which is inspired from [11, 20, 22] are presented in Table 1.

Table 1. Simulation Parameters and Assumptions

Parameter	Value
Cell diameter	500 m
Maximum distance between D2D peers (d)	0.05 km
Number CH per cluster	5
Initial number of devices per cluster $X_{c,t}$	10
Assumed discovery message size S_S	50 Kb
Threshold constant γ_E	1.2
Threshold constant γ_R	0.2
Number of new devices to join the cluster ($Y_{c,t}$)	1~10
New device v battery level C_v	$[unif(10,95)]\% \times 2900$ mAh
Device battery threshold $C_{threshold}$	$20\% \times 2900$ mAh
Rx power on LR link $P_{Rx,lk}$	1.8 Joule/s [31]
Tx power on SR link $P_{Tx,k}$	1.425 Joule/s [31]
Rx power on SR link $P_{Rx,kj}$	0.925 Joule/s [31]
Pathloss (BS-device)	128.1 + $37.6\log_{10}(d[km])$ [25]
Pathloss (device-device)	140 + $40\log_{10}(d[km])$ [25]

The D2D communication in this work is assumed as data content transfer through short-link communication between CHs and CMs [11]. The devices are assumed to be spread randomly in the cell area with uniform distribution. All devices are assumed to have similar maximum battery capacity (2900 mAh) and sufficient battery level for performing D2D communication (at least 10% of battery capacity). Moreover, all devices are also capable of forming clusters and can act either CH or CM.

Finally, the energy efficiency of the proposed method is measured as the average energy consumption for discovering a new device. Inspired from [18], we assume that energy efficiency is defined as the size of distributed data content per energy consumed. Therefore, the energy efficiency of a D2D session s of the cluster c can be expressed as

$$EC_{disc,s,c} = \frac{E_{disc,s,c}}{\sum_i n_{i,s,c}} \quad (1)$$

with $E_{disc,s,c}$ is the device discovery energy consumption and $n_{i,s,c}$ is the number of accepted new devices of d a D2D session s of the cluster c.

3. Device Discovery Modes

As described in [15] there are four basic steps in the discovery process. First, in “discovery request step”, the new device asks permission to announce its discovery signals [15]. Second, in “information step”, the network informs monitoring devices about the new device and assigned resource [15]. Third, the discovery signals are transmitted [15]. Finally, in “report match” step, monitoring devices report the network about the discovery of new device [15].

In this work, the network-assisted device discovery is assumed to provide full network assistance and supervision. As presented in Figure 2, the model steps in [15] (Proximity Service discovery of 3GPP [29]) are adapted for network-assisted device discovery to meet the multi-CH D2D clustering scenario our previous work [19]. The PC5 radio interface is employed for inter-device communication [15, 29]. First, the new device sends its discovery request to the network via the PC3 radio interface. Second, the network informs devices in the cluster about the new devices and assigned spectral resource via the PC3 radio interface. Third, the new device transmits the discovery signals to existing cluster devices via the PC5 radio interface. Fourth, the cluster devices report the discovery match to the network via the PC3 radio interface.

On the other hand, for the independent device discovery, CHs is tasked to take network roles in device discovery. As presented in Figure 3, the model steps in [17] (Proximity Service discovery of 3GPP [29]) are modified for independent device discovery to meet the multi-CH D2D clustering scenario in our previous work [19]. The PC5 radio interface is also utilized for inter-device communication [15, 29]. In step 1.a, the new device sends its discovery request to CH via the PC5 radio interface. The CH informs acceptance of the new device to the network via the PC3 radio interface in step 1.b. In step 2.a, the network informs resource allocation to CHs via the PC3 radio interface. The CH forwards information about the new device and assigned the spectral resource to CMs via the PC5 radio interface. In step 3, the new device transmits the discovery signals to existing cluster devices via the PC5 radio interface. In step 4, the CMs report the discovery match to the CH via the PC5 radio interface.

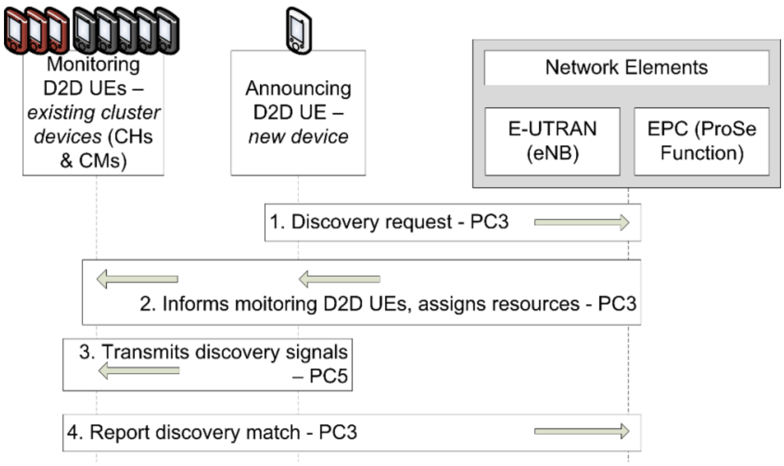

Figure 2. Network-assisted discovery mode [21, 17, 33]

The independent-device discovery allows the CH to take the responsibility in the process of device discovery [19]. However, in this work, due to its compliance to the inband D2D (LTE-A), it is assumed that the network still taking roles for resource assignment (which resulting in step 1.b and 2.a) [19].

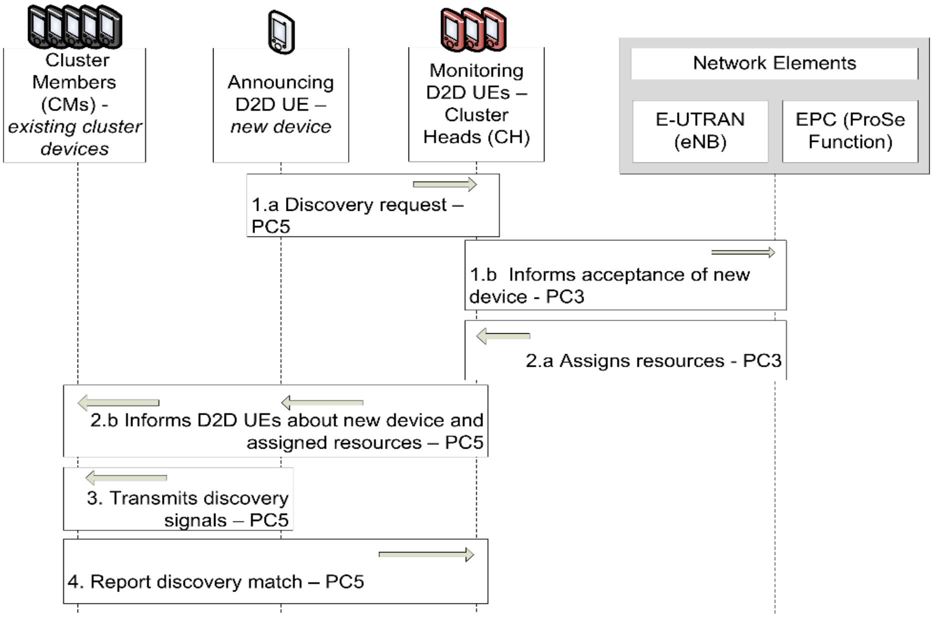

Figure 3. Independent discovery mode [21, 17, 33]

Therefore, we formulate device discovery energy consumption in this work as follows. On the one hand, inspired from [11,19,28,30], the cluster energy consumption for network-assisted device discovery can be calculated as

$$E_{disc,assist,c,m} = \sum_{n_i}\left(\sum_{n_k}\frac{S_S.P_{Rx,lk,m}}{R_{lk}} + \sum_{n_k}\frac{S_S.P_{Rx,ik,m}}{R_{ik}} + \sum_{n_k}\frac{S_S.P_{Tx,kl,m}}{R_{kl}}\right) \quad (2)$$

where n_i is the new device that selected to join to the cluster in a particular round m of cluster head rotation, S_S is the discovery content, n_k indicates CH and CM, and n_l indicates BS. The first part indicates Step 2, the second part indicates Step 3, and the third part indicates Step 4 from Figure 2. Additionally, inspired from [11,19,28,30], the energy consumption of the new device for network-assisted device discovery can be defined as

$$E_{disc,assist,i,m} = \sum_{n_i}\left(\frac{S_S.P_{Rx,il,m}}{R_{il}} + \frac{S_S.P_{Tx,li,m}}{R_{li}} + \sum_{n_k}\frac{S_S.P_{Tx,ik,m}}{R_{ik}}\right) \tag{3}$$

where the first part indicates Step 1, the second part indicates Step 2, and the third part indicates Step 3 from Figure 2. On the other hand, the cluster energy consumption for independent device discovery can be calculated as

$$E_{disc,ind,c,m} = E_{disc,ind,CH,m} + E_{disc,ind,CM,m}. \tag{4}$$

The CH energy consumption (denoted as $E_{disc,ind,CH,m}$), inspired from [11,19,28,30], can be calculated as

$$E_{disc,ind,CH,m} = \sum_{n_h}\left(\sum_{n_k}\frac{S_S.P_{Rx,lk,m}}{R_{lk}}\right) + \sum_{n_i}\left(\sum_{n_k}\frac{{S_S}/{N_k}.P_{Tx,kl,m}}{R_{kl}} + \sum_{n_k}\frac{S_S.P_{Rx,lk,m}}{R_{lk}} + \sum_{n_j}\frac{S_S.P_{Tx,kj,m}}{R_{kj}} + \sum_{n_j}\frac{S_S.P_{Rx,jk,m}}{R_{jk}}\right) \tag{5}$$

where n_h indicates all new devices, n_i indicates only selected new device, n_j indicates CM, n_k indicates CH, and n_l indicates BS. The first part indicates Step 1.a, the second part indicates Step 1.b, the third part indicates Step 2.a, the fourth part indicates Step 2.b, and the fifth part indicates Step 4 from Figure 3. The CM energy consumption (denoted as $E_{disc,ind,CM,m}$), inspired from [11,19,28,30], can be calculated as

$$E_{disc,ind,CM,m} = \sum_{n_i}\left(\sum_{n_j}\frac{S_S.P_{Rx,kj,m}}{R_{kj}} + \sum_{n_j}\frac{S_S.P_{Rx,ij,m}}{R_{ij}} + \sum_{n_j}\frac{S_S.P_{Tx,jk,m}}{R_{jk}}\right) \tag{6}$$

where the first part indicates Step 2.b, the second part indicates Step 3, and the third part indicates Step 4 from Figure 3. Additionally, inspired from [11,19,28,30], the energy consumption of the new device for independent device discovery can be defined as

$$E_{disc,ind,i,m} = \sum_{n_i}\left(\sum_{n_k}\frac{S_S.P_{Tx,ik,m}}{R_{ik}} + \sum_{n_k}\frac{S_S.P_{Rx,ki,m}}{R_{ki}} + \sum_{n_k}\frac{S_S.P_{Tx,ij,m}}{R_{ij}}\right) \tag{7}$$

where the first part indicates Step 1.a, the second part indicates Step 2.b, and the third part indicates Step 3 from Figure 3.

4. Proposed Method

The proposed selective method is assumed to be deployed in massive device scenario with outdoor ultra-dense network (UDN) condition. In this condition, the device discovery will be frequently performed. Thus, the deployment of energy-efficient device discovery is crucial. The D2D devices also work alongside cellular (LTE-A) devices, although has their own dedicated spectral resource. Additionally, the devices are assumed to be static during the D2D communication. We assume a future UDN scenario, where each device can utilize cellular and D2D communication. However, in this work, we only focus on D2D communication deployment in each device. The data content, which is content that several users has interests in, triggers the initiation of D2D communication as shown in Figure 4. The data content is also assumed to be transferred via file transfer protocol (FTP). The data content can be defined as video data or other multimedia contents for multicast and broadcast multimedia service (MBMS) [18].

Additionally, the devices can freely form a cluster to distribute data content. Moreover, the multi-CH D2D data transfer, i.e. cluster head rotation method, is utilized. The cluster head rotation, which is a further enhancement of the D2D clustering method, enables multiple CHs to distribute data content sequentially. The cluster head rotation also contains a selection mechanism to select content-distributing CHs.

In Figure 4, based on [18], the D2D framework which implemented in this work is presented. First, D2D communication is assumed to be initiated by devices' common interest of a data content [28,31]. Second, we assume to use both network-assisted and independent D2D that utilize licensed spectrum [18]. Third, we assume both *a priori* and *a posteriori* discovery. Accordingly, new devices can join the cluster after and before a particular data transfer in the round m. Because of the utilization of clustering (for cluster head rotation method), we assume both long and short range link in this work [18, 31]. Long range link is used to communicate between BS and CH. Short range link is used to communicate between CH and CMs.

Moreover, dedicated resource and static devices (no mobility of devices) are assumed for D2D devices [18]. Furthermore, there is no link adaptation that utilized for D2D communication in this work [18]. Next, fixed transmit power is assumed in this work [18]. Finally, for data distribution in D2D communication, multi-CH method (cluster head rotation method [20]) is deployed [18]. In this work, this process (from the D2D initiation until the cluster head rotation) is regarded as one D2D session.

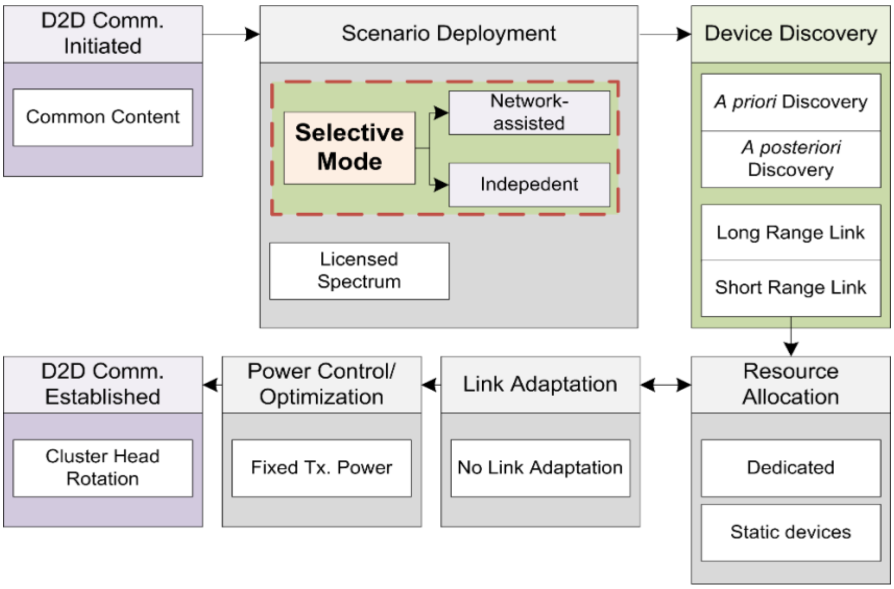

Figure 4. Implementation framework of D2D communication

In this paper, our objective is to propose an energy-efficient selective method that can both utilize network-assisted and independent device discovery. The process is based on the adaptive method for bursty traffic in [22]. However, the method in [22] is aimed to adapting the D2D resource model according to delay traffic in bursty traffic model scenario. Departing from [22], our method considers D2D cluster energy-efficiency as a constraint to select the status of network support (independent or network-assisted) in device discovery. Therefore, we propose the addition of a selection function in the D2D implementation framework.

In Figure 5, the proposed selection process for the device discovery mode is presented. The process can be further described as follows. First, the previous device discovery mode $X_{k,t-1}$ is identified. Next, the threshold of energy consumption $E_{threshold}$ is calculated and compared with previous energy consumption $E_{k,t-1}$. Moreover, the expected energy consumption $E[E_c]$ is calculated. The result is used to determine which device discovery mode that can produce least energy consumption. Finally, the device discovery mode for the next session $X_{k,t}$ is determined.

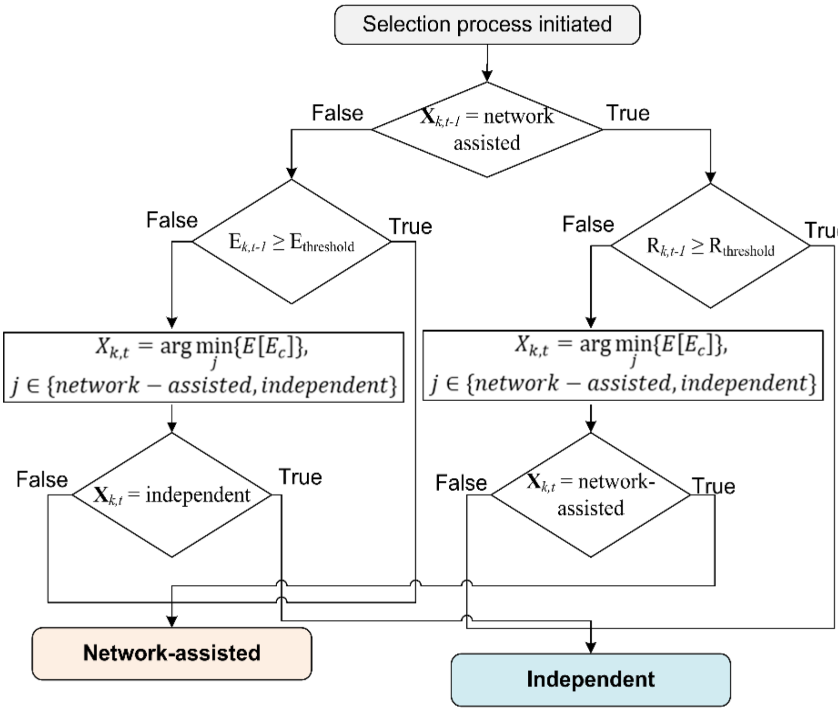

Figure 5. Selection process of device discovery mode

As presented in the Figure 5, thresholds of cluster energy consumption and rejected devices are utilized. The energy consumption threshold can be expressed as

$$E_{threshold,t} = \gamma_E E_{c,t-2} \quad (8)$$

where $E_{c,t-2}$ is energy consumption in cluster c at time $t-2$ and γ_E is threshold variable for energy consumption. Moreover, the threshold of rejected devices can be defined as

$$R_{threshold,t} = \gamma_R Y_{c,t} \quad (9)$$

where $Y_{c,t}$ is new devices that coming to join the cluster c at the present time t and γ_R is threshold variable for the rejected devices.Furthermore, the selection of mode with minimum expected energy consumption, which is based on minimum delay selection in [22], can be expressed as

$$X_{k,t} = \arg\min_j\{E[E_c]\}, j \in \{network - assisted, independent\} \quad (10)$$

where $E[E_c]$ and j indicates the expectation of cluster energy consumption and the selection prior to the expectation of cluster energy consumption.

The proposed method is expected to handle the dynamic of cluster device energy consumption and the possibility of battery drain in massive devices scenario. The expected cluster energy consumption $E[E_c]$ is intended to ensure the cluster achieves most efficient energy consumption from both device discovery modes. As presented in Figure 2, the device discovery and data transfer procedure are deployed. In the simulation, we assume that there is no condition change for following device discovery and data transfer procedure.

5. Results and Discussion

In Figure 6, the device discovery energy consumption of the cluster per accepted new device is presented. In the figure, we can examine the energy consumed for accepting a new device to join the cluster. For all scenarios, multi-CH clustering with the number of CHs = 5 is deployed. The number of initial device in the cluster is 10. According to our result, the cluster spends 0.0215 J in average to accept a new device for the proposed method. For the fully independent discovery, the cluster spends 0.0230 J in average to accept a new device. The cluster spends 0.0217 J in average to accept a new device for the proposed method for the fully network-assisted discovery. Additionally, the result shows that the proposed selective method has the best performance (lowest device discovery energy consumption per new accepted device) for low number of new device arrival (for the number of new devices arrival = 1 ~ 3). For number of new devices arrival $Y_{c,t} = 4 \sim 10$, the energy consumption of the proposed method is lower than independent mode only.

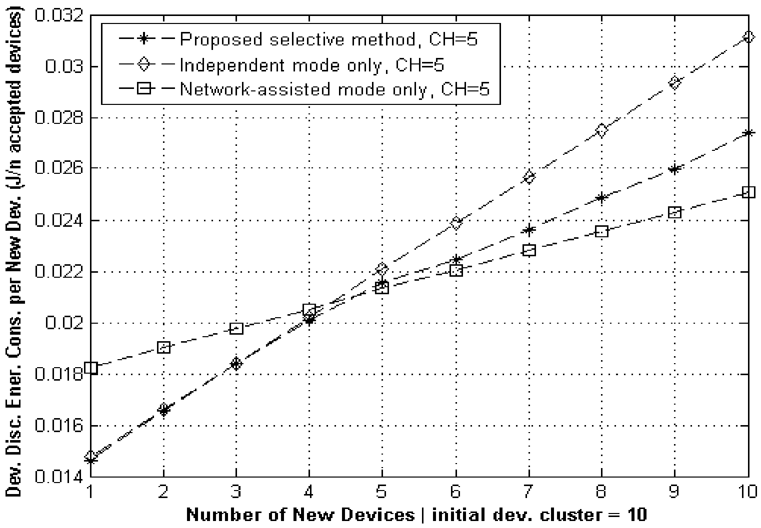

Figure 6. Device discovery energy consumption per accepted new device

In Figure 7, the ratio of selected by the selected device discovery mode is presented. In the figure, the portion of both network-assisted and independent mode is presented. According to our result, the independent mode is selected more compared to the network assisted mode. Using simulation parameters and assumptions as presented in Table 1, the independent mode was selected in 62% of data transmit session on average. On the other hand, the network-assisted mode was selected in 38% of data transmit session on average.

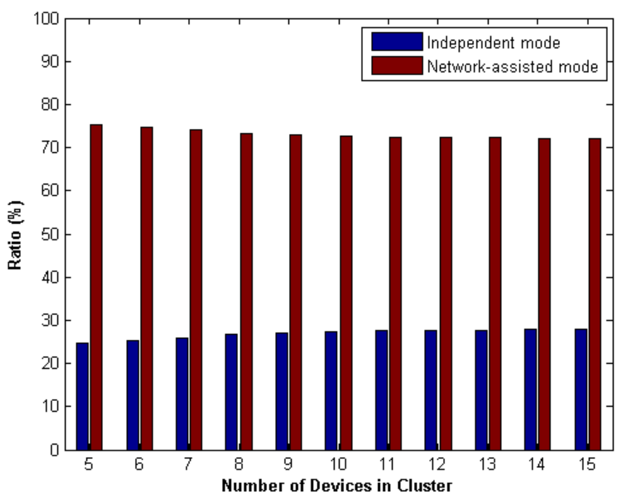

Figure 7. Ratio of device discovery modes

In Figure 8, the ratio of new devices acceptance is presented. In the figure, the portion of accepted new devices is compared with rejected new devices. According to our result, average new device acceptance ratio is 89%. In the proposed method, new device acceptance is determined by battery level. Therefore, in this simulation, battery level of new device v battery level (denoted by C_v) is a critical factor in device acceptance. Moreover, the result shows that there is no significant difference for every addition of device per cluster. We observe that this due to the fact that battery level C_v is used as the acceptance criteria.

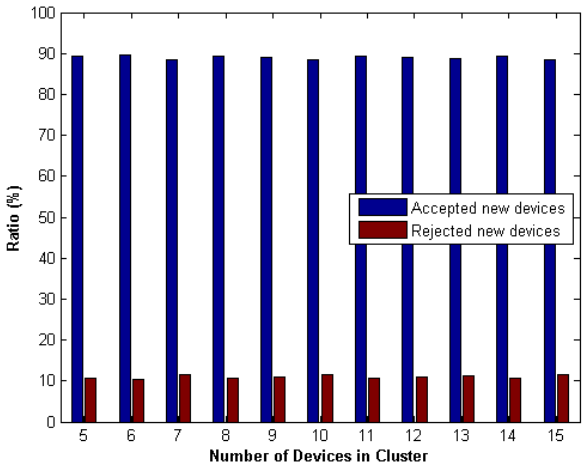

Figure 8. New devices acceptance

6. Conclusion

In this paper, an energy-efficient selective method of device discovery for D2D communication is proposed. The proposed method is able to meet the research objective by providing a selection to utilize network-assisted and independent device discovery. A multi-CHs D2D method for content distribution, i.e. cluster head rotation method, is also implemented in this work. According to the simulation result, the proposed method proved to have decent energy efficiency compared with a scenario that only deploy network-assisted or independent device discovery. For accepting new device, compared to fully independent and fully network-assisted discovery, the proposed method has lowest device discovery energy consumption (compared to fully independent and fully network-assisted discovery) in low numbers of new device arrival (for the number of new devices arrival = 1 ~ 3).

For future works, a selection mechanism to select the degree of network support in network-assisted device discovery will enhance the selection process. Deployment of indoor scenario within a small coverage area, an effort to comply with ultra dense network consideration, will also be considered. The complexity reduction for selection method will also be considered.

Acknowledgement

This work is supported by Telkom University under Penelitian Dana Internal (PDI) research grant.

References

[1] Cisco. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020. 2016.
[2] B Zhang, Y Li, D Jin, Z Han. Network Science Approach for Device Discovery in Mobile Device-to-Device Communications. *Vehicular Technology, IEEE Transactions*. 2015; 99: 1-15.
[3] A Gupta, R Jha. A Survey of 5G Network: Architecture and Emerging Technologies. *Access, IEEE*. 2015; 3: 1206-1232.

[4] A Fahmi, M Asvial, D Gunawan. Improved Performance of Mean Greedy Algorithm for Chunk Allocation in SC-FDMA Uplink Systems using Joint-User and Chunk-Based Allocation. *Journal of ICT Research and Applications*. 2013: 59-81.
[5] A Fahmi, M Asvial, D Gunawan. Combined-order Algorithm using Promethee Method Approach and Analytic Hierarchy Decision for Chunk Allocation in LTE Uplink Systems. *International Journal of Communication Networks and Information Security (IJCNIS)*. 2013: 39-47.
[6] A Fahmi, M Asvial, D Gunawan. *Uplink resource allocation algorithms with fractional power control as power constraints for OFDMA system*. TENCON 2011 - 2011 IEEE Region 10 Conference. Bali. 2011.
[7] Z Liu, Y Shen, Z Yu, F Qin, Q Chen. Adaptive Resource Allocation Algorithm in Wireless Access Network. *TELKOMNIKA Telecommunication, Computing, Electronics and Control*. 2016; 14(3): 887-893.
[8] P Rocca, AF Morabito. Optimal Synthesis of Reconfigurable Planar Arrays with Simplified Architectures for Monopulse Radar Applications. *IEEE Transactions on Antennas and Propagation*. 2015; 63(3): 1048-1058.
[9] T Isernia, A Massa, AF Morabito, P Rocca. *On the optimal synthesis of phase-only reconfigurable antenna arrays*. Proceedings of the 5th European Conference on Antennas and Propagation (EUCAP). Rome. 2011: 2074-2077.
[10] B Narottama, A Fahmi, B Syihabuddin. *Impact of Number of Devices and Data Rate Variation in Clustering Method on Device-to-Device Communication*. Wireless and Mobile (APWiMob), 2015 IEEE Asia Pacific Conference. 2015: 233-238.
[11] E Yaacoub, H Ghazzai, MS Alouini, AA Dayya. *Achieving Energy Efficiency in LTE with Joint D2D Communications and Green Networking Techniques*. Wireless Communications and Mobile Computing Conference (IWCMC), 2013 9th International. 2013: 270-275.
[12] 3GPP. 3rd Generation Partnership Project. Technical Specification Group SA. Feasibility Study for Proximity Services (ProSe) (Release 12). TR 22.803 V1.0.0. 2012.
[13] Y Peng, Q Gao, S Sun, ZY Xiu. *Discovery of device-device proximity: Physical layer design for D2D discovery*. Communications in China - Workshops (CIC/ICCC), 2013 IEEE/CIC International Conference on. Xi'an. 2013.
[14] PK Huang, E Qi, M Park, A Stephens. Energy efficient and scalable device-to-device discovery protocol with fast discovery. PK Huang, E Qi, Minyoung P, A Stephens. New Orleans, LA. 2013.
[15] NK Pratas, P Popovski. *Network-Assisted Device-to-Device (D2D) Direct Proximity Discovery with Underlay Communication*. 2015 IEEE Global Communications Conference (GLOBECOM). San Diego. 2015.
[16] J Hong, S Park, S Choi. *Neighbor device-assisted beacon collision detection scheme for D2D discovery*. Information and Communication Technology Convergence (ICTC). International Conference. Busan. 2014.
[17] Z Liu, Y Li, Z Yu, Y Shen. Efficient D2D Discovery Scheme for Channel Measurement of Interference Alignment. *TELKOMNIKA Telecommunication, Computing, Electronics and Control*. 2016; 14(2): 548-554.
[18] S Mumtaz, H Lundqvist, KMS Huq, J Rodriguez, A Radwan. Smart Direct-LTE communication: An energy saving perspective. *Ad Hoc Networks*. 2013; 13: 296–311.
[19] B Narottama, A Fahmi, B Syihabuddin, PE Christy, OR Ludwiniananda. Device Discovery Schemes for Energy-efficient Cluster Head Rotation in D2D. *TELKOMNIKA Telecommunication, Computing, Electronics and Control*. 2017; 15(1): 203-211.
[20] B Narottama, A Fahmi, B Syihabuddin, AJ Isa. *Cluster Head Rotation: A Proposed Method for Energy Efficiency in D2D Communication*. Communication, Networks and Satellite (COMNETSAT), 2015 IEEE International Conference. 2015: 98-102,10-12.
[21] K Akkarajitsakul, P Phunchongharn, E Hossain, VK Bhargava. *Mode selection for energy-efficient D2D communications in LTE-advanced networks: A coalitional game approach*. Communication Systems (ICCS), IEEE International Conference on. Singapore. 2012.
[22] J Kim, S Kim, J Bang, D Hong. Adaptive Mode Selection in D2D Communications Considering the Bursty Traffic Model. *IEEE Communications Letters*. 99: 1-1.
[23] ZY Yang, SM Cheng, YJ Wang. *Mode selection for device-to-device communications with Voronoi tessellation*. 2nd International Conference on Intelligent Green Building and Smart Grid (IGBSG). Prague. 2016.
[24] A Osseiran, F Boccardi, V Braun, K Kusume, P Marsch, M Maternia, O Queseth, M Schellmann, H Schotten, H Taoka, H Tullberg, MA Uusitalo, B Timus, M Fallgren. Scenarios for the 5G Mobile and Wireless Communications: the Vision of the METIS Project.
[25] G Fodor, E Dahlman, G Mildh, S Parkvall, N Reider, G Miklós, Z Turányi. Design aspects of network assisted device-to-device communications. *IEEE Communications Magazine*. 2012; 50(3): 170-177.
[26] B Han, J Li, A Srinivasan. On the Energy Efficiency of Device Discovery in Mobile Opportunistic Networks: A Systematic Approach. *IEEE Transactions on Mobile Computing*. 2015; 14(4): 786-799.

[27] C Lee, A Helal, N Desai, V Verma, B Arslan. Konark: A system and protocols for device independent, peer-to-peer discovery and delivery of mobile services. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*. 2003; 33(6): 682-696.
[28] E Yaacoub, H Ghazzai, MS Alouini, AA Dayya. On the impact of D2D traffic offloading on energy efficiency in green LTE-A HetNets. *Wireless Communications and Mobile Computing*. 2015; 15(6): 1089–1105.
[29] 3GPP. TS 23.303 - proximity-based services (ProSe); stage 2. tech. rep., 3GPP. 2014.
[30] F Francois, OH Abdelrahman, E Gelenbe. *Impact of Signaling Storms on Energy Consumption and Latency of LTE User Equipment*. High Performance Computing and Communications (HPCC), 2015 IEEE 7th International Symposium on Cyberspace Safety and Security (CSS), 2015 IEEE 12th International Conferen on Embedded Software and Systems (ICESS). 2015: 1248-1255.
[31] P Mach, Z Becvar, T Vanek. n-Band Device-to-Device Communication in OFDMA Cellular Networks: A Survey and Challenges. *IEEE Communications Surveys & Tutorials*. 2015; 17(4): 1885-1922.