Enhanced Resource-efficient Class-based Flow Mobility Support in PMIPv6 Domain

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Abstract

Flow mobility is an emerging technology to support flexible network selection for an application flow and to spread concentrated load over another acceptable access. Recently, several drafts and proposals related to flow mobility have been being handled in the Internet Engineering Task Force (IETF) and 3rd Generation Partnership Project (3GPP), but mobility handling per individual flow leads to signaling overhead and power consumption issues because individual flow always wants the best connected service, with all available network interfaces within its command. Power-saving communication is becoming a worldwide issue in the mobile communication field. To make resource-efficient flow mobility, we propose a enhanced class-based flow mobility (CFM) mechanism. Through the performance analysis and results, we confirm that a CFM mechanism is superior to individual flow mobility (IFM) mechanism in terms of signaling overhead, packet delivery overhead, and power consumption costs.

Keywords: Proxy Mobile IPv6, PMIPv6, flow mobility, class-based flow mobility

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1. Introduction

Multi-interface on mobile devices, which allows them to connect to heterogeneous networks simultaneously, is becoming increasingly common [1]. In such an environment, the flow mobility that controls individual application flows from one interface to another even when the mobile node (MN) does not physically switch its network interface is becoming a critical issue in the research field of next generation wireless networks. Flow mobility enables the mobile users to facilitate the dynamic interface selection and to balance overloaded data traffic in networks appropriately for network operators [2]. For these reasons, the Internet Engineering Task Force (IETF) and 3rd Generation Partnership Project (3GPP) are now actively driving flow mobility issues. Several studies have been completed [3] - [6].

Q. Wang et al. and Loureiro et al. presented architectures for QoS-aware flow mobility, which distribute specific application flows based on either the perspective of the user or the network by employing policy entity [3] [4]. Although they are regarded as a solution to flow mobility, they have some limitations. They require the MN to be modifed to involve it in the mobility management protocol stack because it is client-based mobility management. Also, the MN must register the user's preference with the policy entity in advance.

To cover these limitations, Trung et al. and Bernarods et al. presented the network-based flow mobility over proxy mobile IPv6 (PMIPv6) that is considered the next-generation IP mobility protocol by several standard bodies due to its network-based effective mobility performance [7]. It iseffective for data offloading from a network perspective without requiring any signaling precedure at the MN, allowing the localized mobility anchor (LMA) to distribute application flows to proper mobile access gateways (MAG) on the network's decision [5] [6].

However, all proposals that are either client-based or network-based mobility management have several drawbacks because they only focus on an individual flow's hand-over. First, they can easily bring about signaling overhead that enables all flows to have the best connected network. Second, they can quickly run out of battery power because they preferentially consider flow performance with all the available network interfaces.

In this paper, we propose an enhanced class-based flow mobility (CFM) mechanism by classifying the application flows into groups and performing group-based flow handling to overcome these drawbacks of the individual flow mobility mechanisms (IFM). To support our scheme, we present a hybrid flow classification method and network selection algorithm. Thus, they can help hand off specific application flows to target access networks based on network parameters (traffic load, network delay, and bandwidth). Through the performance analysis, we confirm that CFM is more resource-efficient than IFM in terms of signaling overhead costs, packet delivery costs, and power consumption costs.

This paper is organized as follows. In Section 3, we propose the CFM mechanism. Section 4 evaluates a performance of IFM and CFM mechanism based on an analytical model and presents the numerical results. In Section 5, we offer a conclusion.

2. Class-based Flow Mobility Scheme

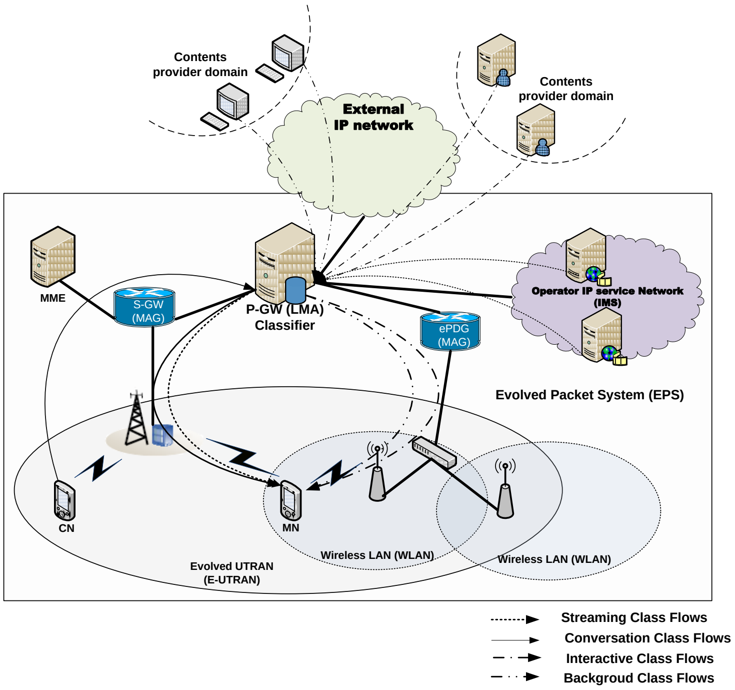

Fig. 1. Reference network model for class-based flow mobility

3.1 Requirements for Supporting Flow Mobility in PMIPv6

The PMIPv6 provides network-based mobility management to MNs that are connected to a PMIPv6 domain, introducing two new functional entities, LMA and MAG. The MAG is the entity detecting MN's attachmenet and provides IP connectivity. The LMA assigns one or more home network prefixes (HNPs) to the MN and is the topological anchor for all traffic belonging to the MN. The PMIPv6 allows MNs to connect to the network through multiple interfaces for simultaneous access. The MN can send packets simultaneously to the PMIPv6 domain over multiple interfaces. In such environment, to support PMIPv6-based flow mobility, two issues should be resolved.

First, an HNP is assigned to one interface at a time because PMIPv6 employs a per-MN prefix model. Therefore, when flow mobility occurs, some flows are moved to a new interface while others are transmitted via the old interface. To keep the sessions, the HNP should be assigned to multiple interfaces simultaneously. To solve the issue, a logical interface-based approach is proposed as one option to hide the changes at the physical interfaces from the IP layer [8]. Second, the PMIPv6 does not support flow-based routing because the LMA performs an HNP-based packet routing. To make packets route at the flow-based level, an extended LMA binding cache entry (BCE) or flow binding cache entry (FBE) is required [5] [6]. By applying these solutions, the flow mobility can provide dynamic network selection and better network experience for end users.

3.2 Classification Method for Grouping Application Flows

The CFM maximizes the user's performance and minimizes signaling overhead and power consumption at the MN. As depcited in **Fig. 1**, the CFM classifies and groups application flows based on their service class type and then forwards them to the proper access network.

Table 1. The characteristics and examples of class types.

Traffic class	**Characteristics**	**Example of the application**
Conversational class	- Preserve time relationship between information entities of the stream. - Conversational patter (stringent and low delay).	Voice
Streaming class	- Moderate delay and variation.	Streaming video
Interactive class	- Request-response pattern. - Preserve payload content. - Moderate delay.	Web browsing
Background class	-Destination is not expecting the data within a certain time. - Preserve payload content.	Background download of e-mails

To classify application flows according to service class type, a LMA must act as a classifier. According to [9], all application flows can be categorized into four classes: conversational, streaming, interactive, and background classes, based on how delay-sensitive an application is. Generally, the conversational class is the most sensitive, while background is the least sensitive. Conversational and streaming classes are intended for real-time and delay-sensitive flow. Conversational class has stricter and lower delay requirements, but streaming class require moderate delay. Interactive and background classes are not intended for transfer delay. Interactive class follows a request-response pattern, and background class is that in which the destination is not expecting the data within a certain time and the content of the flows will be transparently transferred with low bit error rate. **Table 1** shows the characteristics of each class in detail.

In the 3GPP, the IP multimedia subsystem (IMS) is defined, which is an overlay subsystem over the 3GPP core network to support IP multimedia services including voice, video, audio, and text transmissions [10]. The IP multimedia services are provided after a negotiation procedure by session initiation protocol (SIP) and session description protocol (SDP). Thus, they can be classified by QoS parameters within SDP.

Such classification methods for Internet traffic and IMS traffic in the classifier (i.e., LMA) are divided into header-based and payload-based methods. Recent services are frequently running on non-standard ports, so the header-based classification method that checks the packet header is difficult to classify correctly. On the other hand, the payload-based classification method that checks the entire protocol payload requires a lot of computational power and leads to significant overhead [11]. Additionally, most streaming and multimedia application flows from IMS are controlled by SIP or RTSP control protocol. Thus, such application flows cannot be analyzed and classified by traditional methods that are port-based because these applications use dynamically allocated port numbers for video and audio after exchanging control protocols [12]. After negotiation, those application flows (e.g., video and audio) are transferred based on information within the control protocol. For this reason, we present a new flow classification method to support our proposed scheme (see **Fig. 2**). Operation is as follows.

(1) Upon receiving the packets for application flows at the LMA, the LMA checks the flow ID by looking at FBE. Note that in order to support flow-based forwarding, all packets are examined by the header-based method and then forwarded to the proper MAG.

(2) If there is a flow ID for the received application flow, the LMA will check the class ID as described in (3) step. Otherwise, this packet is defined as the first packet for the application flow. Thus, this packet is classified into one of two categories:

(2.1) if this packet is multimedia service flows such as streaming or conferencing, the LMA determines whether it is a control packet or not. In control packet case, the LMA will extract dynamic session information from the control packet and then determine the flow ID and class ID. In a different case, this packet will be examined by the payload-based method and then the LMA will determine the flow ID and class ID.

(2.2) if this packet is not multimedia service flows, the LMA will examine the packet by the payload-based method and then determine the flow ID and class ID.

(3) In this step, the LMA checks the class ID if the FBE includes a flow ID for received application flow. If there is a class ID for received application flow, the LMA will forward this flow by looking at FBE to proper MAG. Otherwise, the LMA performs step 2.2.

(4) From the above procedure, the grouped application flows destined to MN will be forwarded to the proper MAG.

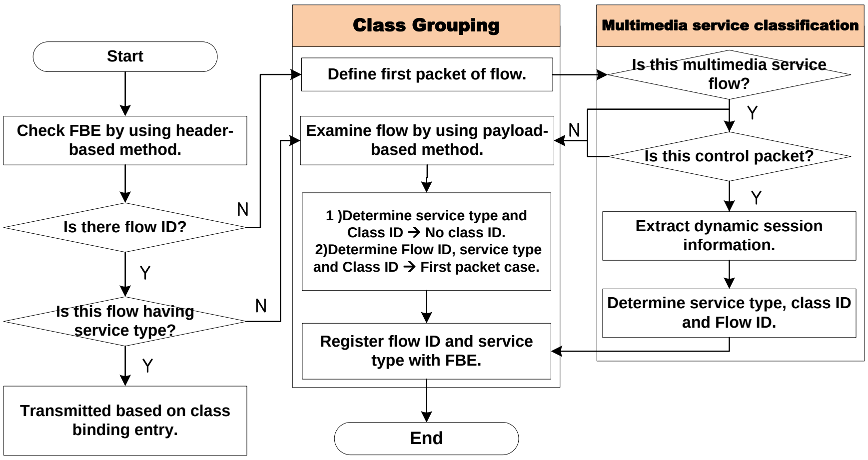

Fig. 2. Proposed new classification algorithm for class-based flow mobility

3.3 Network Selection Algorithm to Move Grouped Application Flows

The IFM focuses on individual application flow requirements and distributes this flow based on only its requirements. On the other hand, CFM focuses on class and allows flows to be moved at the same time. For this reason, it could not fulfill individual flow requirements. To ensure efficient flow handover based on class, dynamic flow handover is required, and suitable network selection is also needed. For CFM, vertical handover network selection is required since MN attaches to different networks (e.g., 3G and WLAN). J. Lee et al. proposed single service vertical handover algorithms by considering the network parameter, such as data rate or packet loss rate, to fulfill user's satisfaction, but this does not consider the user's multi services [13]. F. Zhu et al. proposed vertical handover algorithms for multi services to maximize the benefit of handover for both the user and the network [14]. However, they only focus on individual flow handover but do not consider grouped multi flows. Therefore, we propose handover decision algorithms for grouped multiple flows to suport our CFM scheme as shown in **Fig. 3**. This algorithm shows dynamic flow handover that considers user preferences and network parameters such as bandwidth (BW), load factor (LF), and network delay (ND). Also, several binding entry information is needed on the LMA to facilitate class-based flow forwarding; therefore, a binding cache entry (BCE) extension is required, and we extend the flow binding cache entry (FBE). The group ID is stored at the FBE, which consists of FID, service type, group ID, and group activation information as shown in **Fig 4.**

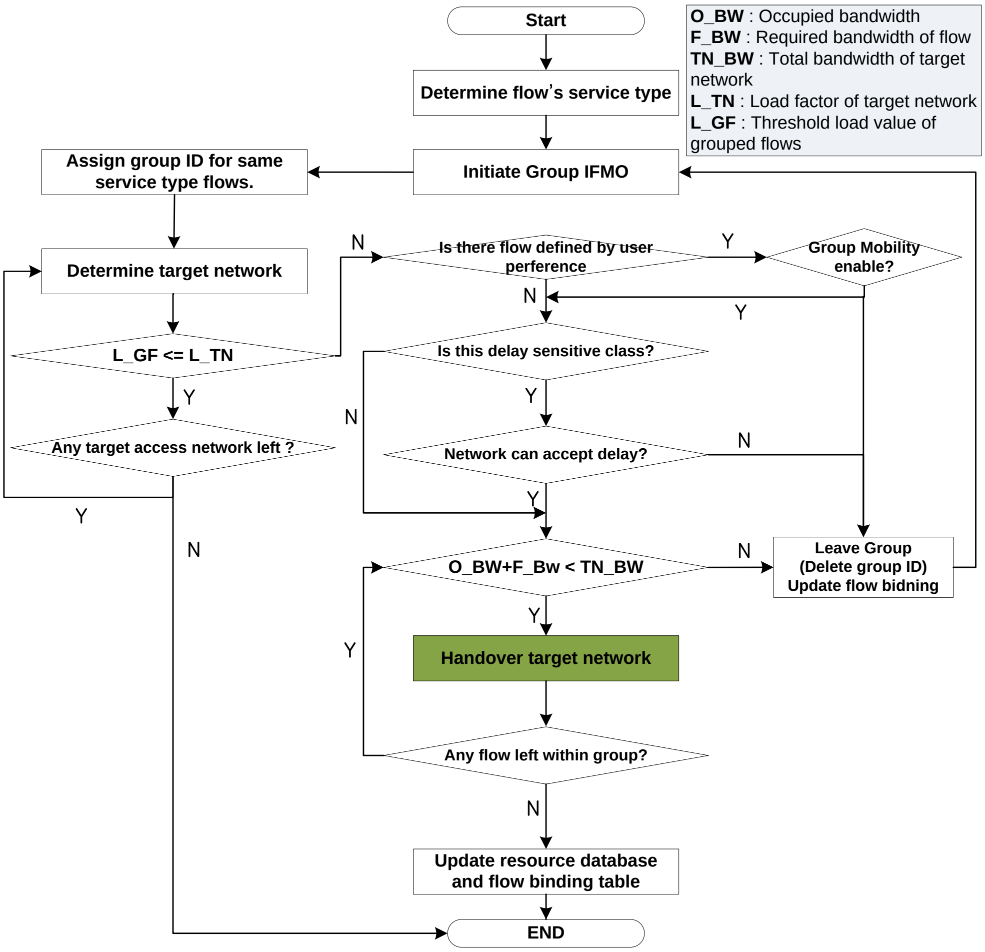

Fig. 3. Proposed handover decision algorithm for class-based flow mobility

It is assumed that an MN may conduct multiple application flows, and they are classified. When the CFM is initiated, grouped application flows are chosen based on class, and the choice mechanism is out of scope. Selected application flows are assigned to the same group ID and the available load factor is checked for target access network to decide whether to hand off.

The flow handover should be treated differently in terms of user preference and delay sensitive flow. Since the user does not want to hand off flows within the same class, those flows must not be moved to the target network. Also, since conversational or streaming flows

Extended Flow Binding Entry

FID	Service Type	Group ID	Group Activation/Inactivation
10	BG	1	Active
20	BG	1	Active
30	BG	1	Active
40	BG	2	Active
50	BG	2	Active

Fig. 4. Extended flow binding cache entry for class-based flow mobility

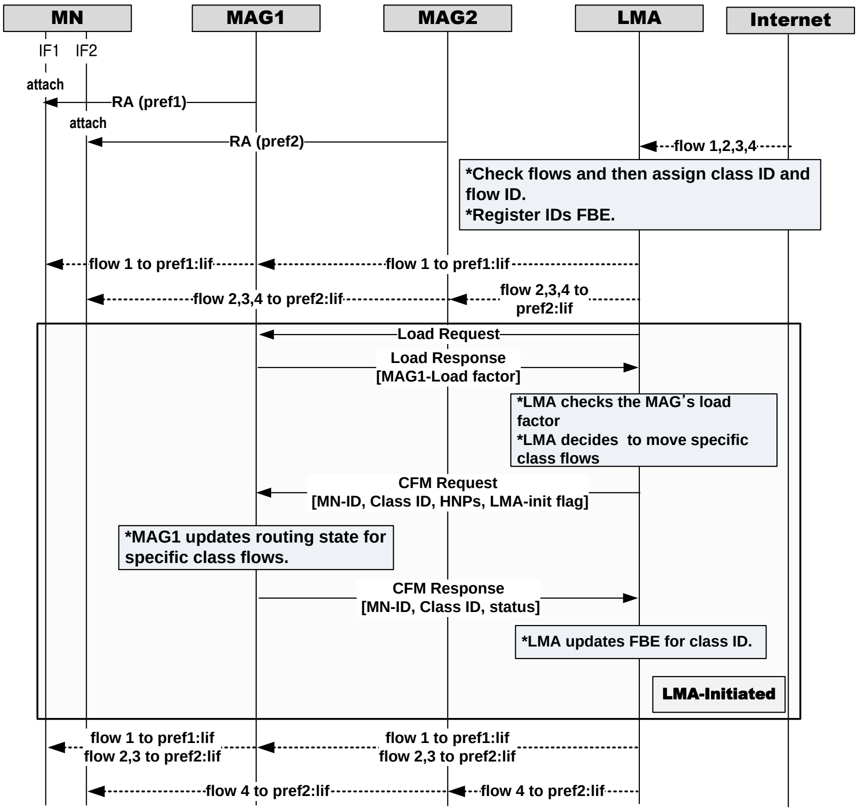

Fig. 5. Protocol procedure of LMA-initiated class-based flow mobility

must guarantee their delay requirements, the target network's delay parameter should be considered. After that, the network entity checks available BW at the target network by considering occupied bandwidth and required bandwidth. If the sum of occupied bandwidth and required bandwidth is less than the total bandwidth of target network, this flow can be moved to the target network, but if there is no available BW to accept the flow, it can be moved to the target network and deleted from the group.

The application flows that cannot be moved to the target network remain at the current access network by removing their group IDs. However, these flows also join the group by assigning new group IDs when the next CFM is performed. As a result, grouped application flows can be moved to the target access network or not by controlling their group IDs.

3.4 Protocol Procedure for Proposed CFM

Fig. 5 and **Fig. 6** show the sequence of message flows used for CFM. While the MN is connected to MAG1 and is about to be connected to MAG2 sequentially, the CFM can be initiated by MAG-initiated or LMA-initiated. Either the MAG or LMA may initiate CFM after MN predefines its preference by using L2 signaling or router solicitation (RS). The MAGs receiving preference information forward them to LMA by sending proxy binding update (PBU) for either MAG or LMA to make flow a handover decision based on it.

Assuming that MN uses flow 1, 2, 3, and 4, and that both flows 2 and 3 belong to the same class, when LMA initiate CFM, it sends a load request message to the target MAG (MAG1) to know the load factor of MAG1. Actually, the load request/response messages are derived from

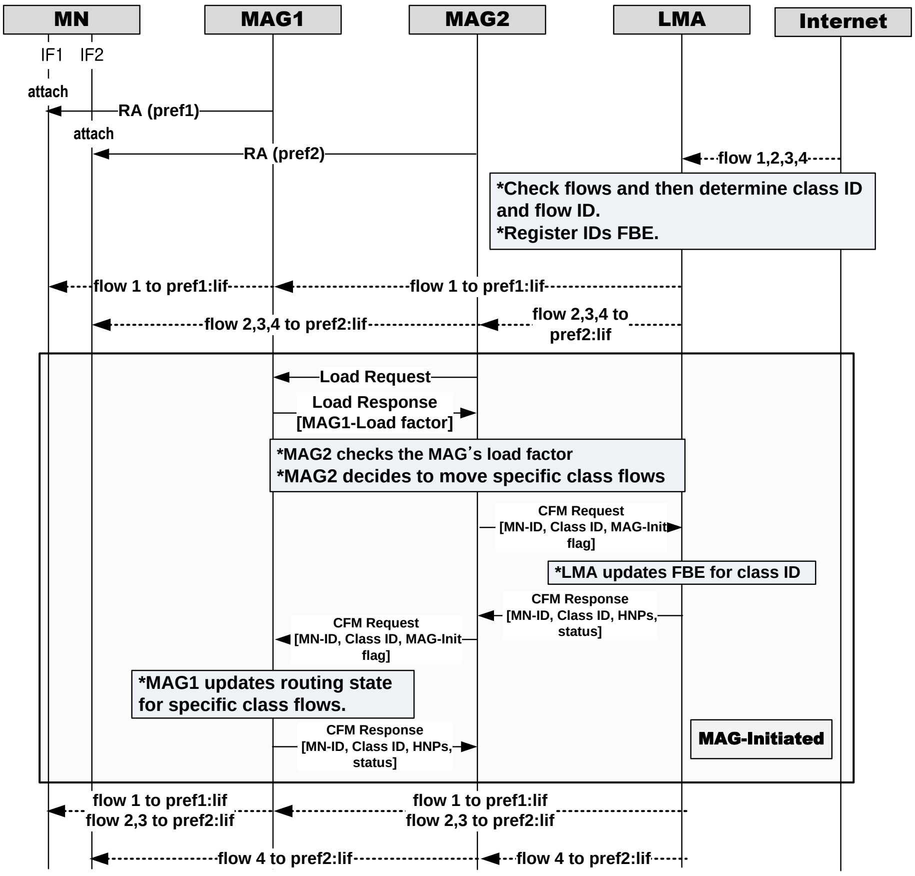

Fig. 6. Protocol procedure of MAG-initiated class-based flow mobility

an extended heartbeat signaling message [15], which is originally used to detect whether the other end is still reachable in the PMIPv6 domain. Upon receiving the load request message at the MAG1, the MAG1 responds with a load response message containing its load factor. Once LMA receives the load response message, it determines if MAG1 can accept all of the same class flows. If MAG1 can accept all of the same class flows, the LMA sends a CFM request message containing MN-ID, Group ID, HNPs, and LMA-init flag to MAG1 to update routing states for flows having the same class. Finally, the LMA have the same class flows to move MAG1 based on the proposed network selection algorithm and then updates FBE for the specific group ID.

When MAG2 initiates CFM by detecting congestion or a bottleneck, it sends a load request to the target MAG (MAG1) by MAG-to-MAG signaling to check available load for grouped applications (i.e., MAG-Initiated case).

If MAG1 can accept grouped application flows, after MAG1 sends a load response containing its load factor, the MAG2 sends a CFM request message containing MN-ID, group ID, and MAG-init flag to LMA. Once the LMA receives this message, it updates BCE for the selected service type and sends the CFM response message to MAG1 to update its routing state. As a result, the LMA hands off the same class flows based on proposed algorithm like LMA-initiated. In IFM, no service disruption period occurrs during the flow handover procedure, unlike normal handover because MN is connected to and uses two MAGs simultaneously. In the case of IFM, when several flows belonging to MN want to be moved, signaling occurs according to the number of flows. Thus, CFM ensures that signaling overhead is minimized by handing off at the same time.

4. Performance Analysis and Numerical Results

This section presents a performance analysis of the CFM and the IFM mechanisms. In this paper, we only consider [5] naming TIFM as IFM mecahsnisms to compare with CFM. For ease of analytical modeling, we assume that the network is always able to admit all flows and that the bandwidth required for individual flows within the same class is equal. Under these assumptions, we analyze signaling overhead costs, packet delivery costs, and power consumption of two mechanisms. We also offer the numerical results by comparing their performances.

4.1 System Model

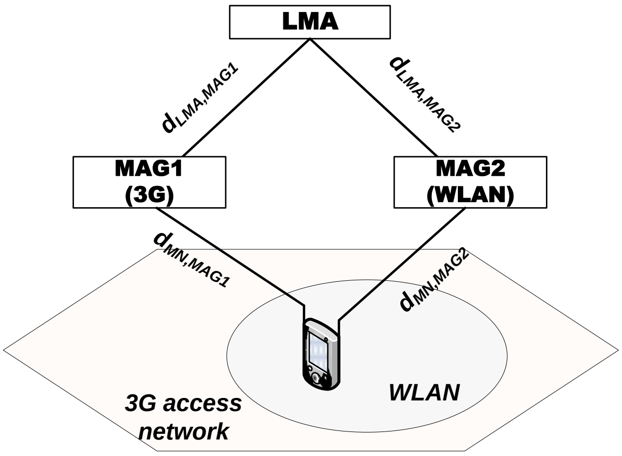

Fig. 7. Network topology for performance analysis

Fig. 7 illustrates the network model for the performance analysis. It is assumed that there are two access networks of different data rates. The hexagon represents a 3G access network, while the circle represents 802.11 wireless LANs. To handle the effects of the flow mobility procedure among two overlapped networks, only the mobile users within the overlapping areas are considered. The $d_{x\text{-}y}$ denotes the hop distance between two network entities, x and y, assuming that 3G access network consists of N cells and that all cells have hexgon shapes with size S. In addition, each MN moves at an average velocity of v; the session arrival process to the MN follows a Poisson distribution; and the residence time that the MN stays are follows and exponential distribution. Thus, we define μ_s and λ_s as the cell-crossing rates for which the MN keeps its residence in the same domain and at the same session arrival rate. From these, we obtain the average number of movements, $E(N_s)$, and express it as follows [16]:

$$E(N_s) = \mu_s / \lambda_s. \tag{1}$$

$$\mu_s = 2 \cdot v / \sqrt{\pi \cdot S} \cdot (\sqrt{N} - 1) / \sqrt{N}. \tag{2}$$

4.3 Signaling Cost

As shown in Eqs. (3) and (4), the SCz denotes signaling costs to conduct the flow mobility operation of z scheme. It can be calculated as the sum of load signaling messages and flow information registration signaling messages considering MN's movement because it is mainly related to the mobility properties of the MN. There is no signaling over air because all signaling messages for FMO are exchanged between MAG and LMA.

$$SC_{CFM} = E(N_s) \cdot (C_{Load\_request} + C_{Load\_response} + C_{CFMreq} + C_{CFMres}), \tag{3}$$

$$SC_{TIFM} = N_{Flow} E(N_s) \cdot (C_{CFMreq} + C_{CFMres}), \tag{4}$$

where N_{Flow} is the number of application flows to be distributed in IFM. In the case of LMA-initiated CFM, since CFM is performed by LMA, the load request/response and CFM request/response messages are only exchanged between LMA and MAG. The signaling cost of LMA-initiated CFM is expressed by:

$$\begin{aligned} C_{Load\_request} &= \alpha \cdot (d_{MAG1,LMA} \cdot L_{Load\_request}) + (d_{MAG1,LMA} - 1) \cdot P_R + P_{LMA,} \\ C_{Load\_response} &= \alpha \cdot (d_{LMA,MAG1} \cdot L_{Load\_response}) + (d_{LMA,MAG1} - 1) \cdot P_R + P_{MAG}, \end{aligned} \tag{5}$$

$$\begin{aligned} C_{CFM\_request} &= \alpha \cdot (d_{MAG1,LMA} \cdot L_{CFM\_request}) + (d_{MAG1,LMA} - 1) \cdot P_R + P_{LMA}, \\ C_{CFM\_response} &= \alpha \cdot (d_{LMA,MAG1} \cdot L_{CFM\_response}) + (d_{LMA,MAG1} - 1) \cdot P_R + P_{MAG}, \end{aligned} \tag{6}$$

In the case of MAG-initiated, since the MAG decides to move grouped flows and checks available target MAG by sending MAG-to-MAG signaling, the signaling cost is different from LMA-initiated. The load request/response messages are exchanged between MAGs, but CFM request/response messages are only exchanged between LMA and MAG. The signaling cost of MAG-initiated CFM is calculated by:

$$\begin{aligned} C_{Load\_request} &= \alpha \cdot (d_{MAG1,MAG2} \cdot L_{Load\_request}) + (d_{MAG1,MAG2} - 1) \cdot P_R + P_{LMA}, \\ C_{Load\_resonse} &= \alpha \cdot (d_{MAG2,MAG1} \cdot L_{Load\_response}) + (d_{MAG2,MAG1} - 1) \cdot P_R + P_{MAG}, \end{aligned} \tag{7}$$

$$\begin{aligned} C_{CFM\_request} &= \alpha \cdot (d_{MAG2,LMA} \cdot L_{CFM\_request}) + (d_{MAG2,LMA} - 1) \cdot P_R + P_{LMA} + P_{MAG}, \\ C_{CFM\_response} &= \alpha \cdot (d_{LMA,MAG1} \cdot L_{CFM\_response}) + (d_{LMA,MAG1} - 1) \cdot P_R + P_{MAG} + P_{LMA}, \end{aligned} \tag{8}$$

where α and L_m are the unit transmission cost over wired link and the amount of the signaling message, respectively. P_R is the routing processing cost between routers, while P_{LMA} and P_{MAG} denote the processing cost required in LMA and MAG.

4.4 Packet Delivery Cost

As shown in Eq. (9), the PC_z denotes packet delivery cost of z scheme. We define PC_i as BW usage incurred by flows via interface i. The n is the maximum number of interfaces at the MN. In the case of flow mobility, because flows belonging to MN use multiple access networks simultaneously, unlike a normal handover case, we consider multiple access networks. The PC_z is expressed by:

$$PC_z = \sum_{i=1}^{i=n} PC_i, \tag{9}$$

$$PC_i = \sum_{s=1}^{m} PN_i \cdot P_s + \sum_{s=1}^{m} PM_i \cdot PS_s, \tag{10}$$

where PN_i and PM_i represent the packet transmission cost for interface *i* over wired and wirless, respectively, which means the cost between LMA and MAG and MAG and MN. PS_s represents the data packet size for application flow *s*. Also, *m* represents the number of application flows.

$$PN_i = \tau_i \cdot P_s \cdot d_{LMA,MAGi} + P_{MAGi}, \tag{11}$$

$$PM_i = \kappa_i \cdot P_s \cdot d_{MAGi,MN} + P_{MN}, \tag{12}$$

where τi and κ_i are the unit transmission cost for *i* interface over wired link and wireless link, respectively.

4.6 Power Consumption Cost

The power consumption cost is defined as the amount of power consumed in MN. It is dependent on cell paging, scanning, beacon operation, time of data communication, and the amount of data being received (or sent) by a particular type of application. It is computed using the sum of the time of data communication and amount of data. It can be expressed by the following:

$$P = r_d \cdot d + r_t \cdot t + c. \tag{13}$$

Here, r_d and *d* refer to the power consumption rate for data and the amount of data, respectively. r_t and *t* are the power consumption per unit time and the transaction time, respectively, and *P* and *c* refer to the total power consumption cost to receive *d* amount of data. In the case of video streaming, the power consumption cost can be expressed by an equation (14) derived from [17]. On the other hand, in the case of FTP-downloads such as background, service is expressed by equation (15) derived from [17].

$$P = t \cdot [r_t + R_{req} \cdot r_d] + c, \tag{14}$$

$$P = d \cdot [\frac{r_t}{R_{cur}} + \cdot r_d] + c, \tag{15}$$

where R_{req} and R_{cur} are the data rate required by the specific session and current avaiable data rate.

4.6 Numerical Results

We employ parameter values used in the literature [17] [18] as shown in **Table 2** and **Table 3**. To analyze performance, we assume some requirements. First, the MN has four application flows, of which, flows A, B, and C are the background service class and flow D is the streaming service class. Second, the length of each flow and the threshold value of traffic load for each flow are different. Third, four application flows are forwarded to MN via 3G access network, and then specific flows will be distributed to WLAN according to the value of the traffic load at the 3G access network.

Figs. 8 shows the signaling overhead cost as MN's velocity increases and the session arrival rate to MN. The result shows that IFM increases proportionally to the number of flows, but the cost of CFM is lower than IFM because the flows are grouped within the same class and moved to the target network at the same time regardless of the number of flows.

Table 2. Parameters used for numerical results

Parameters	Values	Parameters	Values	Parameters	Values
S, N	314, 30	P_R, P_{LMA}, P_{MAG}	8, 24, 12	L_{signal}	100
λ_s, μ_s	10, 0.01	n, m	2, 4	τ, k	10, 20
$d_{MAG,LMA}$	20	$d_{MAG,MAG}$	15	$d_{MAG,MN}$	2
Data rate of App. A	2	Data length of App. A	20	Load threshold of App. A	0.4
Data rate of App. B	3	Data length of App. B	60	Load threshold of App. B	0.5
Data rate of App. C	4	Data length of App. C	120	Load threshold of App. C	0.7
Data rate of App. D	5	Data length of App. D	250	Load threshold of App. D	0.3

Table 3. Power consumption in 3G/WLAN interfaces

Mode	Parameters		
	r_t (W)	r_d (J/Kbyte)	idle (W)
3G	0.45	0.0008	0.082
WLAN	0.9	4.12E-04	0.74

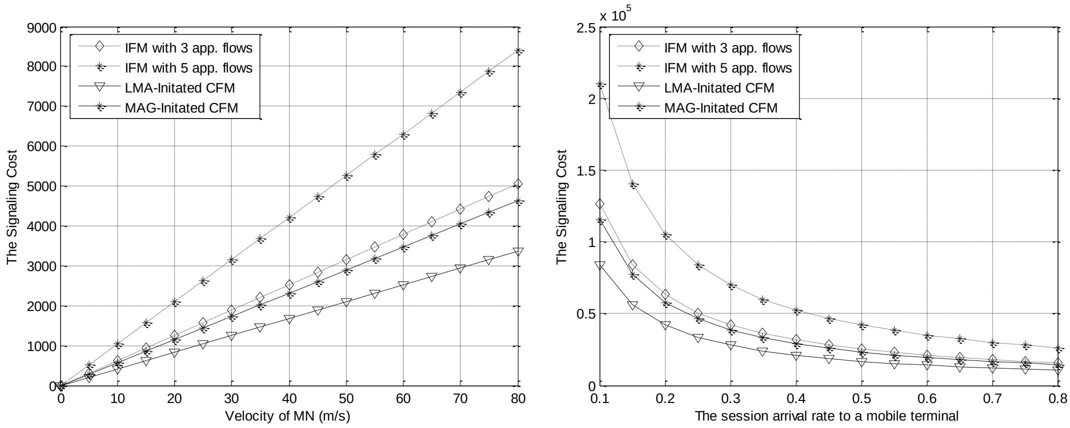

Fig. 8. Signaling cost as MN's velocity and session arrival rate increases

Fig. 9 shows the packet delivery cost of the IFM and CFM as traffic load increases at the 3G access network. In the case of 3G only, the packet delivery cost increases continuously due to the increased traffic load at the 3G access network. Actually, we observe this when the traffic load increases at the 3G access network, since when blocking probablity at the 3G access network increases, the packet delivery cost is higher than for other mechanisms. In the case of IFM, compared to CFM, the packet delivery cost is reduced when the traffic load value is 0.3. In the region from 0.4 to 0.65, the IFM is lower than CFM because some application flows are distributed to WLAN due to increased traffic load at the 3G access network. However, in the region from 0.7, CFM is lower than IFM because three grouped application flows are distributed to WLAN at the same time. Thus, we observe that when the 3G access network has a higher traffic load value, the proposed CFM is more efficient.

Fig. 10 shows the power consumption cost at the MN as the traffic load at the 3G access network increases. In the region from 0.1 to 0.25, both IFM and CFM show the same result values because no application flows are moved to WLAN. In the region from 0.3 to 0.5, the

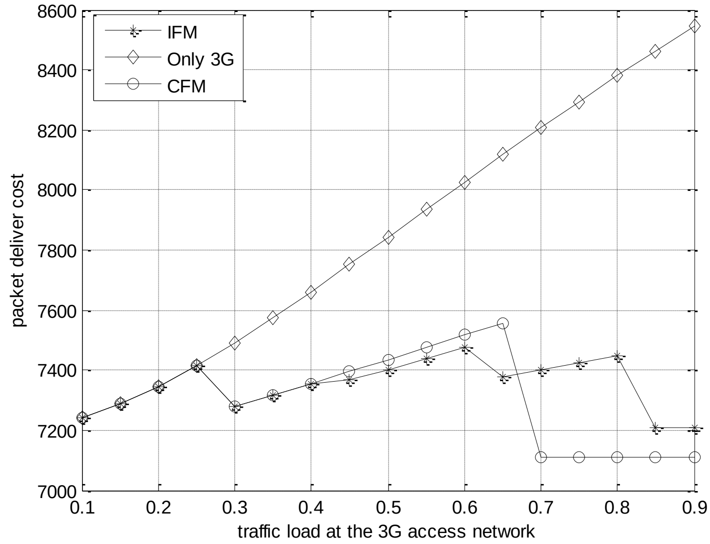

Fig. 9. Packet delivery cost as traffic load increases at the 3G access network

result shows that the both IFM and CFM increase because flow D is moved to WLAN, but in the case IFM, the cost is a little lower than CFM because flow A is also moved to WLAN. In the region from 0.5 to 0.8, the result shows that the CFM is lower than IFM because all applications are moved to WLAN, while flow B and flow C are maintained at the 3G access network in the case of IFM.

Fig.11 shows the power consumption cost at the MN as time increases. We also analyze three cases: 3G only, IFM, and CFM cases. Supposing that the traffic load increases every 30 seconds at the 3G access network, the result shows that the proposed CFM is more energy-efficient than IFM because the CFM uses the WLAN interface later than IFM.

From these results using simple cases, we confirm that the CFM can avoid unnecessary signaling overhead on the network side and also reduce power consumption on the host side.

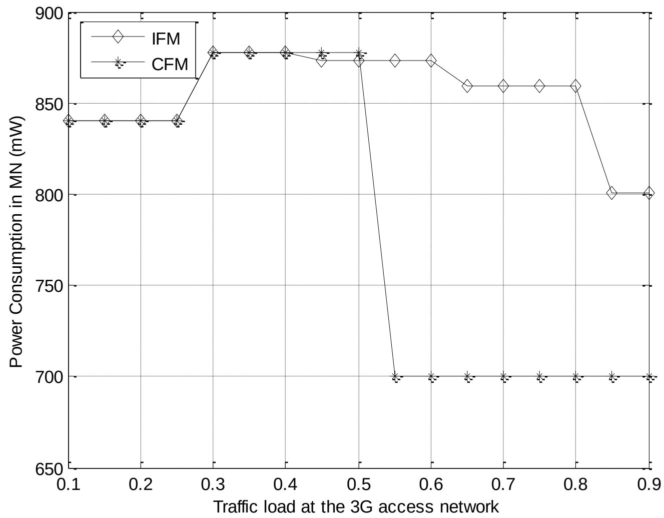

Fig. 10. Power consumption cost at the MN as the traffic load increases at the 3G access network

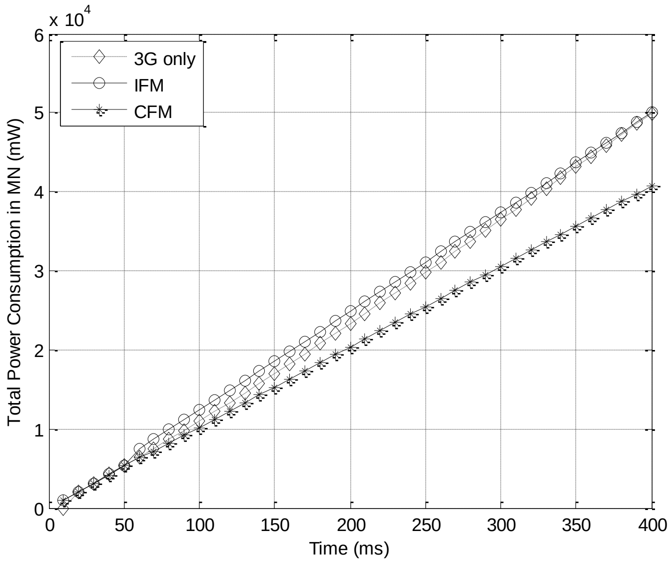

Fig. 11. Power consumption cost at the MN as the time increases

5. Conclusion

In a multihoming environment, the flow mobility is an effective mobility technique that can provide flexible network selection per application flow for mobile users and allow mobile operators to balance data traffic by distributing specific application flows. However, individual flow mobility schemes introduced in IETF and 3GPP bring about signaling overhead and power consumption issues due to prioritizing the performance of individual flow. To solve these issues, we propose a CFM mechanism, which classifies the application flows into groups and performs group-based flow handover. Also, we present a new classification algorithm and handover decision algoithm to support our scheme. Through the performance analysis based on proposed algorithm, we confirm that the CFM mechanism is more resource-efficient than the IFM mechanism in terms of signaling overhead, packet delivery overhead, and power consumption costs.

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