IEEE Infocom 2016 Poster Presentation

Using typing pattern to save energy: adaptive notification mechanism in MIM APPs

Y. Pan, S. Li, X. Xia, Z. Li, Z. Yang, Y. Zhang, J. Li, M. Wei, J. Zhang
Computer Science, Northwestern Polytechnical University, Xian, China
Email: {panyan, jinchenxia, ljw, wmfei, zhangjingyu}@mail.nwpu.edu.cn,
{lishining, lizhigang, zyang, zhangyu}@nwpu.edu.cn

***Abstract*—Typing notification of instant messaging APPs improves user experience during online chatting. However, frequent notification leads to high energy consumption of mobile devices. In this paper, we study the trade-off between the frequency of typing notifications for user experience and communication energy saving of mobile device. We propose adaptive typing notification mechanisms, which exploit user's typing pattern and the current network conditions to adjust notification intervals. Simulation results demonstrate the proposed schemes can significantly save energy while improving user experience.**

I. Introduction

Typing notification of Mobile Instant Messaging (MIM) APPs during online chatting improves user experience. However, notification packets increase the time user equipment (UE) stays in radio powered state and consume more the so-called *tail energy* [1], increasing the energy consumption. MIM APPs with typing notification consume 60%-100% more communication energy than those without the function [2], [3].

When sender (S) types, APP sends notification periodically to receiver (R). The APP informs R "S is typing" till it receives a message. Different APPs have different mechanisms (i.e., notification intervals, ranging from hundreds of milliseconds to tens of seconds). To the best of our knowledge, we are the first to study the tradeoff between energy consumption and user experience of MIM APPs with typing notification.

In this paper, we present typing pattern based (TP-based) mechanisms to improve user experience and reduce energy consumption in MIM APPs with typing notification. We define a metric, named ***N**otification **P**redication **G**ap* (NPG) to measure user experience. This is the first work to define a metric to measure user experience of typing notifications. We get the mechanisms by Genetic Algorithm (GA) [4] instead of exhausted method. Simulation results show that ***TP-based mechanisms saves communication energy without damaging user experience in both 3G and Wi-Fi networks***.

II. Typing Pattern and Problem Formulation

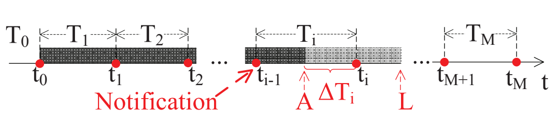

Fig. 1: Typing message with periodic notifications

As Fig. 1 shows, S starts to type and sends the first notification at $t_0 = 0$. The longest typing time of all messages is t_M. A mechanism is represented as $T_i(>0, i = 1, 2, \cdots, M$, and $T_0 = 0)$. The i_{th} notification sent at t_i $(= \sum_{n=0}^{n=i} T_n)$ means: during T_{i+1}, S continues to type or sends a message. Dark and grey part $(0-L)$ on the time axis means S's expecting typing time. Dark part $(0-A)$ is the actual typing process until an interruption happens at A, as S interrupts typing suddenly or one of users' devices disconnects to server.

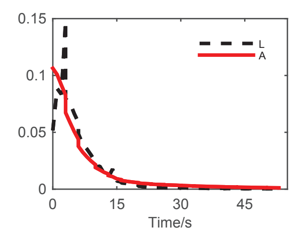

Fig. 2: Normalised distributions of inputting time (L) and interruption time (A)

The distributions of L and A shown in Fig. 2 are called user typing pattern (TP) and represented as $L_{ra}(t)$ and $A_{ra}(t)$, respectively. $X_{ra}(t)$ $(X = L$ or $A)$ is the probability X equals t. If interruption happens at A, no message will be sent but the prompt displays till t_i. We define the delay R knows the interruption happens as $\Delta T_i = t_i - A$. The expected value is:

$$E(\Delta T) = \sum_{i=0}^{M-1} \int_{t_i}^{t_{i+1}} A_{ra}(t) \cdot (t_{i+1} - t) dt, \qquad (1)$$

we call E(ΔT) ***N**otification **P**redication **G**ap* (NPG) and use it to measure user experience. Consider the mechanism of sending notification only when S starts to type (BM2 in Tab. I): If interruption happens, ΔT_i is "infinite" and R is informed S is typing a long message, which results bad user experience.

Without loss of generality, we assume networks have two states: active for packets transferring and sleep for energy saving. The expected communication energy is:

$$E(E) = p_a \cdot \sum_{i=1}^{M} \int_{t_{i-1}}^{t_i} L_{ra}(t) \cdot min(T_i, T_{tail}) dt + \\ p_a \cdot T_{tail} + p_s \cdot \sum_{i=1}^{M} (\int_{t_{i-1}}^{t_i} L_{ra}(t) \cdot max(0, t_{i+1} - t) dt), \qquad (2)$$

where p_a and p_s are the power levels of active state and sleep state, respectively, and T_{tail} is *tail time*.

978-1-4673-9955-5/16/$31.00 ©2016 IEEE

$E(E)$ and $E(\Delta T)$ contradict with each other. To align them, we adopt linear combination form to define an objective, user cost (UC):

$$UC = \alpha_E \cdot \left(\frac{E(E)}{E(E^{BM2})} - 1 \right) + \alpha_T \cdot \frac{E(\Delta T)}{E(\Delta T^{BM2})}, \quad (3)$$

where $E(E^{BM2})$ and $E(\Delta T^{BM2})$ are the energy and NPG of BM2 to normalise the corresponding values of any mechanism to [0,1]; The real numbers α_E and α_T are two parameters to assign different weights to energy and NPG, with $0 \leqslant \alpha_E \leqslant 1$, $0 \leqslant \alpha_T \leqslant 1$ and $\alpha_E + \alpha_T = 1$.

In continuous space, minimising UC with the constraints of Eq. (1) to (3) could not be solved, because T_i has infinite number of possible values. So we discrete t_M by N, length of one time-slot is t_M/N. T_i consists of limited number of time-slots. Limited by space, we do not present discrete forms of Eq. (1) and (2). The number of all possible mechanisms is 2^N. Then we use GA [4] to search approximate solutions.

TABLE I: Different notification mechanisms

Mechanism	***Intervals: $T_i(s)$***
Wechat	0.2s for the first 10s
Viber	4,6,8,12,16,22
Whatsapp	Random value between 2 and 4
BM1	2,4,8,16,32
BM2	54
TP-based(3G)	6.2,8.5,8.5,7.7,9.2,10,3.1
TP-based(Wi-Fi)	3.1,3.9,3.9,3.9,3.1,3.9,3.1,3.9,3.1, 4.6,4.6,3.1,3.9,2.3,3.1

III. Performance Evaluation

We collect 142,338 instant messages of 25 volunteers from Feb. 2013 to Oct. 2015. Each message consists of time-stamp, content and sender's name. We assume the typing time of a message is linear to its length and experimentally obtain a constant typing speed of 0.77s per Chinese word. We set 0.77s as the length of a time-slot. 99% of the messages are shorter than 70 words, so we set $N = 70$, and $t_M = 70 \cdot 0.77 \approx 54$s. T_{tail} is 4s of 3G [5] and 0.2s of Wi-Fi[1]. p_a and p_s are normalised as 1 and 0, respectively. The interruption probability depends on network condition and users' behaviour. We assume it is constant on unit time and greater than 0. So we get the normalized distribution of A as Fig. 2. Mechanisms of some main stream MIM APPs are listed in Tab. I.

Figure 3 demonstrates how energy and NPG change with different α_E in 3G and Wi-Fi[2]. Within the region near 0.38 in 3G and 0.44 in Wi-Fi, both energy and NPG stay relatively low. We thus pick up the mechanisms, named TP-based in Tab. I, for the remaining evaluations. Figure 4 shows energy and NPG of different mechanisms in different networks.

TP-based mechanism achieves communication energy savings of 16%∼25% without damaging user experience in 3G network, and achieves communication energy saving of 12%∼62% as well as improves user experience in Wi-Fi network. In Tab. I, T_is for 3G are longer than T_is for Wi-Fi, because T_{tail} for 3G is longer, leading longer NPG in 3G as shown in Fig.4(a). In Wi-Fi, NPG of TP-based mechanism is 1.8s, 0.3s longer than Whatsapp. In 3G, NPG of TP-based mechanism (2.9s) is longer, but still shorter than Wechat.

[1] 0.2s is replaced by a time-slot ($0.77s$) during simulation.

[2] 3G without Fast Dormancy and LTE are not considered because of their long $T_{tail}(>10s)$. Increasing T_i does not save energy effectively.

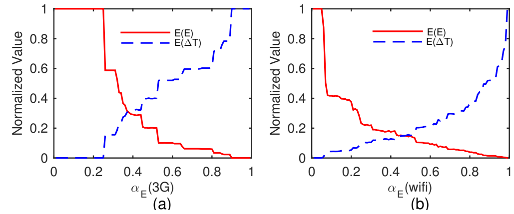

Fig. 3: Impacts of α_E on Energy and NPG

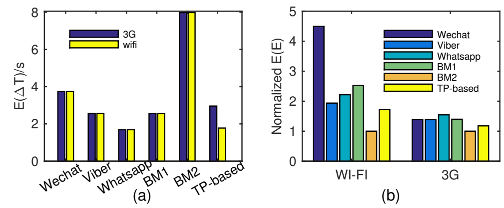

Fig. 4: NPG and energy of different mechanisms

IV. Conclusions and Future Work

In this poster, we are the first to define a novel metric to measure user experience of MIM APPs with typing notification. To improve user experience and reduce energy consumption of UE, we present a TP-based framework to adjust notification intervals of MIM APPs. In future work, we would like to fully consider the interaction between S and R and different TPs of different users, which helps to reduce more packets, thus saving more energy.

Acknowledgment

This work was supported by National Key Technologies R&D Program of China Grant No. 2014BAH14F01, National S&T Major Project of China Grant No. 2012ZX03005007, National NSF of China Grant No. 61402372 and Fundamental Research Funds for the Central Universities Grant No. 3102014JSJ0003.

References

[1] N. Balasubramanian et al. Energy consumption in mobile phones: a measurement study and implications for network applications. In *Proc. ACM SIGCOMM*, 2009.

[2] L. Zhang et al. Characterizing instant messaging apps on smartphones. In *Proc. Springer PAM*, 2015.

[3] E. Vergara et al. When mice consume like elephants: instant messaging applications. In *Proc. ACM e-Energy*, 2014.

[4] A. Chipperfield et al. The matlab genetic algorithm toolbox. In *IET Applied control techniques using MATLAB*, 1995.

[5] F. Dormancy. Fast dormancy best practices. *GSM association, network efficiency task force*, 2010.