

Single Button HEMS Printer for Tangible On-Demand Delivery of Smart Home Information

Shigeru Owada
Sony Computer Science Laboratories, Inc.
Tokyo, Japan
sowd@acm.org

Masahiro Karaki, Hiroshi Inazu,
Ryousuke Tachikawa, Masahiko Goto
CRESTEC Inc. Tokyo, Japan
{m-karaki|h-inazu|r-tachikawa|m-goto}@crestec.co.jp

Abstract—We propose a HEMS Printer that prints smart home-related information on small pieces of paper on demand. Triggered by entrance door motion, demand-response signals, or error signals from home appliances, it prints electricity saving information, upcoming schedules, coupons of nearby stores (to encourage “cool sharing”), maps of repair shops, and so on. Our device is essentially a portable thermal printer with one LED illuminated button. The LED blinks when some information is ready. Pressing the button prints a slip of paper similar to a receipt. The main advantages of our system is its simplicity, portability and disposability of the paper, and low mental burden.

Keywords— User Interface; Home appliances; Home Energy Management System; Demand Response

I. BACKGROUND

The market for zero-energy homes (ZEH) is growing. ZEH have better thermal insulation, and are usually equipped with a smart meter, a solar panel, and storage batteries. Those devices are controlled by Home Energy Management System (HEMS). HEMS gathers environmental information from sensors or online services, and controls network-connected home appliances. Logging and visualization of lifelog data, calculating electricity fees, communicating with cloud services, and delivering necessary information to the user are also roles of HEMS.

Most HEMS interact with the user through smartphones or a wall-attached or desk-mounted tailored HEMS panel. The former provides a convenient and seamless user experience for those who are already smartphone users. On the other hand, non-smartphone users may run into a technical barrier with the smartphone-based user interface. In Japan, the ratio of smartphone users is still 65% of the entire population [1]. A wall-attached or standalone HEMS panel provides a somewhat optimized user interface to the user, while it often supports a limited portion of HEMS services.

II. OUR SYSTEM

We propose the HEMS printer, which is a portable thermal printer with a single LED-illuminated button (Fig.1). The LED blinks when some information is ready to be printed. Pressing the button while the LED is blinking prints the information on receipt-like rolled paper. In some cases (when a home appliance needs repairing, in our proposed use cases described later), printing is automatically performed without pressing the button.

III. USE CASES

We propose three distinct use cases where this device is useful (though these are not the only cases): the Demand Response (DR) case, outgoing/return case, and troubleshooting case. We describe these cases as follows.

A. Demand Response case

Traditionally, power is controlled only by power suppliers. On the other hand, Demand Response (DR) is a shift of paradigm to change consumer electricity usage from the demand side. OpenADR [2] or ECHONET Lite [3] are technologies which deliver DR signals and change electricity usage patterns. While automatic electricity usage control is efficient, it can cause critical consequences because electricity consumption may be connected to important or even vital activities. Therefore, DR is not only achieved by automated control, but also by more gentle encouragement to change human activities such as dynamic change of electricity prices, incentive-based coupons [4], or the ‘cool/warm sharing’ approach [5]. The latter approach pushes people to go out (with home devices switched off) and participate in social events or spend time and money in tie-in stores. These sort of activities are already promoted by public organizations as a campaign, without technical support. Fig.2 is an example print-out of our system during this event. It contains information about electricity price changes and shop coupons.



Fig.1 The HEMS Printer



Fig.2 DR. Example

B. Outgoing-Return cases

There is a broad range of research trials and products about how and when to deliver information to the user [6,7]. Basically, the timing should be when they are not concentrating, and not in the middle of executing tasks. The timing of going out from or returning home obviously satisfy these requirements. We set an acceleration sensor and a human body detector on the home entrance door to detect these events (Fig.3).



Fig.3 Door sensor

Power usage history
 現状電気料金 ¥11,250 / 目標電気料金 ¥15,000

Power saving advice
 エネルギーの方が少ない
 ・食器洗い乾燥機はまとめて洗い
 ・お風呂のお湯の量を今までの80%
 ・お風呂には一着に入るようにしてみてください。熱いお風呂が好きなら先に、ぬるめのお風呂が好きなら後に
 ・入浴の目安は、寝る1時間前に38~40度のぬるめのお湯に20~30分くらい浸かると質のよい睡眠が得られます

Schedule
 明日の予定
 10:30 : ヨガ教室 @ ヨガ
 15:00 : お茶 with ママ友

Visitors
 11:12 : ヤマ川 急便
 12:35 : 近所の鈴木さん

Fig.5 Return case

Power saving achievements
 25%
 あなたの今月、大幅に節電。この調子でください。

Coupons
 今日のお得なクーポン
 使うお店 | 穴クレストストア 三田店
 東京都港区芝 4-2-3
 電話 03-5442-4555
 鶏肉全品 10%引き

Transportation
 ★★この付近の運行情報★★
 唐木線
 2015年1月28日
 唐木線は、除雪作業のため、早朝（日明け）～16時00分頃まで、森野原～日町駅間で運休となります。バスによる代行輸送は行いません。
 稲津線 お知らせ
 2015年1月28日4時2分 配信
 稲津線は、除雪作業のため、明日（29日）12時40分頃～15時00分頃まで、小園～木更駅間の上下線の一部列車が運休となります。

Coupon
 交換用部品全品
 本日のみ レジにて 5% 引き
 2015年1月28日発行

Fig.4 Outgoing case

In the outgoing case, the printer prints the progress ratio of the monthly power saving goal, traffic information, as well as coupons of nearby stores (Fig.4).

In the case of returning home, the printer also prints the progress of the power saving goal with advice for improvement, schedule of the next day, and visitor list while the house was vacant (Fig.5.)

C. Troubleshooting case

An advantage of HEMS is that it is usually possible to gather more information about connected devices than before. For example, ECHONET Lite has accessibility to the manufacturer ID, manufacturing date, standardized but customizable error code definition, and so on. Traditionally, when a device needs repairing, the user has to look for the instruction manual and find where the problem is, and, if necessary, look for a nearby support station by themselves. Although online manuals are becoming popular these days, the

user still has to actively find the file on the internet. Smart homes can automate this process.

The HEMS printer catches error signals sent from connected devices and generates support information. In this scenario, the printer automatically prints without pressing the button because HEMS concluded that user interaction is required for the device to be repaired. In other words, the system gave up on self-repairing.

The example print-out is shown in Fig.6. It shows what is broken and what the user should do. It also shows a map of a nearby support station or a store where the user can buy replacement parts. To urge people to quickly repair the device, a time-limited coupon is also added.

IV. IMPLEMENTATION AND LIMITATIONS

We use a Star Micronics SM-S210i mobile printer and its Android SDK as part of our system. We also used a LightBlue Bean board to control the on-printer button. The printer and the button is BLE-connected to the backend server called 'Kadecot' running on an Android device [3]. Since the Android device is used only as a server platform, the user does not have to directly interact with it. The server recognizes home appliance networks through ECHONET Lite, DLNA, and so on.

The power saving goal is set to 5% less than the previous month's real value. This may not be realistic when the climate is extreme.

Some portions of the proposed scenario are not fully implemented. For example, managing real coupons requires the cooperation of ad agencies or at least nearby tie-in stores. It is our future work.

V. CONCLUSION

We propose a HEMS printer that communicates with home network devices and prints related information on small pieces of paper. The main advantages of our system are its simplicity, portability and disposability of the paper, and low mental burden. A demonstration video is available on YouTube: <http://bit.ly/1tmholl> (with Japanese subtitles)

Parts to be repaired
 の電球が切れています。下記の交換部品の購入をおすすめします。
 CREST ELECTRIC 製
 シーリングランプ交換ランプ
 型番 : CR-ECO0130L

Map to the shop
 東京都港区芝 4-2-3
 電話 03-5442-4555

Coupon
 交換用部品全品
 本日のみ レジにて 5% 引き
 2015年1月28日発行

Fig.6 Troubleshooting case

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