NNEPS: Network-Updated E-Paper Signage with Reduced Standby Power Consumption

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***Abstract*—Electronic Paper Signage (EPS) is used in various ways, such as at bus stops and in menu lists. One type of EPS is a network-updated EPS that updates content via the Internet. In the network update type EPS, a management computer consumes power constantly while awaiting contents. Therefore, a feature of the electronic paper (e-paper), namely, that it does not require standby power, cannot be utilized. To solve this problem, we proposed a network-updated EPS system that reduces power consumption during standby communication. We developed a prototype of the proposed EPS system and evaluated its power consumption.**

Keywords-Electronic Paper, Signage, Power Saving.

I. INTRODUCTION

Electronic Paper Signage (EPS) is a type of digital signage. EPS is a signage specialized in displaying still images using an electronic paper display. Electronic paper displays are characterized by low power consumption because they can retain the screen without consuming power after updating the screen. EPS is being used for floor guides [1] and information boards in office buildings [2].

One type of EPS is a network-updated EPS that updates content via the Internet [3]. Network-updated EPSs are used at bus stops and at certain types of bulletin boards [3]. In the network-updated EPS, the computer that controls the e-paper consumes power constantly while waiting for contents. Therefore, an important characteristic of the e-paper, namely, that it does not require standby power, cannot be utilized. To solve this problem, we propose a network-updated EPS that reduces power consumption during standby. The rest of the paper is structured as follows. In Section II, we present the related work. In Section III, we describe the proposed method. Section IV describes the system configuration and Section V the implementation. In Section VI we conduct the assessment of the power reduction. Finally, we conclude in Section VII.

II. RELATED WORK

Tobias *et al.* [4] have developed a prototype and investigated the performance of an information display device that combines photovoltaics, a low-power wireless protocol, and an electronic paper display. Their results showed that low-resolution e-paper displays can achieve numerous screen updates with very limited energy.

Yang *et al.* [5] proposed two different power supply methods for e-paper: in-situ triboelectric and wireless power supply within 30 cm. They showed that each method can successfully update the screen and drive the e-paper without using batteries or power supply modules.

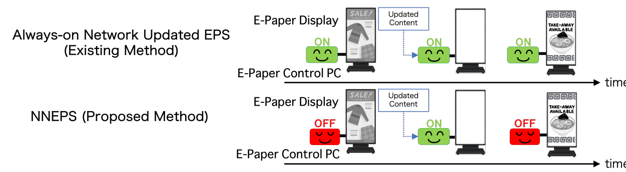

Figure 1. Comparison of the existing and proposed methods.

III. PROPOSED METHOD

In this study, a network-updated EPS is converted to a normally-off to save power. Normally-off [6] is the concept of turning off the power when a system is not in use.

The network-updated EPS waits for updated content sent via the Internet. The control PC built into the EPS is responsible for the process of receiving and displaying content on the e-paper display. In existing network-updated EPSs, he control PC is always running and consuming power. Conversely, in the proposed method, the control PC is turned off. When updating content, the control PC is activated upon receiving a notification. When the update of the e-paper display is completed, the control PC is turned off. In this way, the control PC spends less time in the startup state, thereby reducing power consumption. We named the system that realizes EPS with normally-off network electronic paper signage Normally-off Network Electronic Paper Signage (NNEPS). Figure 1 shows a comparison of the NNEPS with the existing network-updated EPS.

IV. SYSTEM CONFIGURATION

The NNEPS is composed of an e-paper, an e-paper control PC, and a power control plug. The electronic paper is the display part. The e-paper control PC performs processing related to e-paper updates. The power control plug stands by with the communication function turned on and turns the power supply to the e-paper control PC on and off as needed for screen updates, thereby enabling the EPS to achieve normally-off.

V. IMPLEMENTATION

Figure 2 shows the NNEPS. The NNEPS implements a power control plug using a microcontroller and relay module.

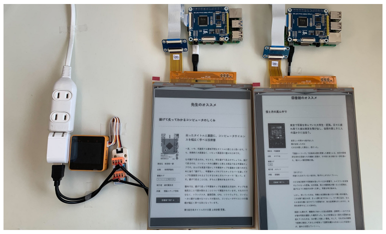

Figure 2. A picture of the NNEPS.

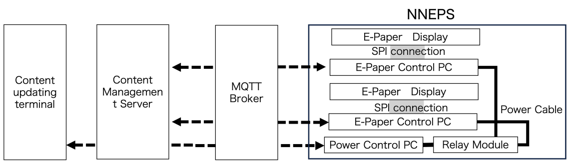

Figure 3. Configuration chart of the NNEPS System

The M5Stack Core2 for AWS (Amazon Web Services) was used as the micro-controller that controlled the relay modules. The M5Stack implements firmware that turns the relay module on and off in response to notifications via MQTT (Message Queuing Telemetry Transport).

Figure 3 shows the system configuration of the NNEPS. Multiple EPSs can be connected using relay modules to manage power on/off status.

VI. Assessment of Power Reduction

In order to compare the power consumption resulting from different screen update control flows, experiments will be conducted using the same hardware, and no comparison will be made with existing solutions We conducted an experiment to evaluate the power consumption of the NNEPS and that of the existing network-updated EPS. Each system was prepared, and the power consumption of each system was measured using a watt checker. The power consumption of NNEPS is the sum of the power consumed by the e-paper control PC and the power supply control PC. The NNEPS measured power for two different cases, one with one EPS connected to the relay module and the other with two EPSs connected to the relay module. The NNEPS with one EPS connected to the relay module is designated as NNEPS-1, and the NNEPS with two EPS connected to the relay module is designated as NNEPS-2 (Figure 4). The frequency of screen refreshes was set to once every five minutes, and power consumption was measured for one hour.

Figure 5 shows the results of the evaluation experiment. The power consumption was 1.88 Wh for the existing method in which the e-paper control PC was always active, and 1.25 Wh for NNEPS-1. Under these conditions, the proposed method, NNEPS-1, reduced the amount of electricity by about 33% compared to the existing method. The value for NNEPS-2 was 2.81 Wh, which is more than twice the value for NNEPS-1. This result is considered an implementation convenience.

When multiple EPSs are controlled by the NNEPS, screen updates are performed one by one, so the time required for the

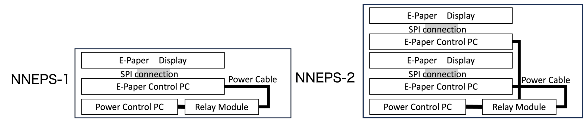

Figure 4. Configuration diagram of NNEPS-1 and NNEPS-2.

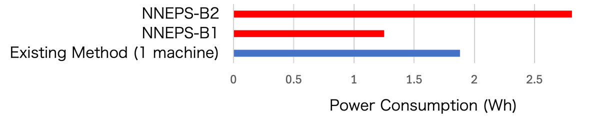

Figure 5. Power consumption comparison between existing and proposed methods.

screen update process increases with the number of connected units. NNEPS-1 completes the screen update process in an average of 85 seconds, but when two EPSs are connected, the process takes an average of 108 seconds. In the case of NNEPS-2, both e-paper control PCs are turned off when the screen update process of the EPS to be updated later is completed. Therefore, the power consumption of both of the two e-paper control PCs increased due to the longer startup time, and is considered to be more than twice as much as when one of the PCs is connected.

VII. Conclusion

NNEPS reduces the number of PCs that are always on standby for communication, it is more effective the more EPSs there are. In this implementation, a maximum of two EPSs could be connected, but screen update processing could not be performed in parallel, resulting in unnecessary power consumption. In the future, we will work on implementation to increase the number of EPSs controlled by NNEPS and aim to compare with existing products.

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References

[1] CREA Co., *Office building guide - crea co., ltd. | world's largest 42-inch electronic paper signage*, https://www.crea2007.co.jp/pr/20230211c/, retrieved: Sep. 2024, (online).

[2] TintTech, *Wired & wireless epaper digital signage - tinttech*, https://tinttech.io/, [retrieved: Sep., 2024], (online).

[3] Alpha Japan, *E paper signage*, https://www.a-japan.co.jp/epd/eps.html, [retrieved: Sep., 2024], (online).

[4] T. Grosse-Puppendahl *et al.*, "Exploring the design space for energy-harvesting situated displays," UIST '16, pp. 41–48, 2016. DOI: 10.1145/2984511.2984513.

[5] Y. Bo-Ru *et al.*, "Battery-free charging methods for driving e-paper devices," in *Proceedings of the International Display Workshops*, 2020, p. 751.

[6] T. Nakada, T. Shimizu, and H. Nakamura, "Normally-off computing for IoT systems," in *2015 International SoC Design Conference (ISOCC)*, 2015, pp. 147–148. DOI: 10.1109/ISOCC.2015.7401761.