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Sleepy Devices

A Goal Document for a Master's Thesis Work

By

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1. Introduction

In a network of connected cameras where not all cameras are always needed there are possibilities of saving energy. As energy prices continue to increase and with the impact that energy consumption has on the climate, the need to explore these possibilities also increase. This can be done by prototyping some methods of reducing energy when one or several cameras are not in use.

2. Background and Motivation

Based on an early reading of articles, other researchers in this field have utilized technologies such as network proxies and Wake-on-LAN (WoL) to optimize power usage in diverse scenarios. The findings from these papers show promising benefits of using these approaches, specifically in terms of power consumption, such as in Cebeci et al.'s implementation with BitTorrent [2] or in a PC network by Riccardi et al. [5]. However, we propose there remains research to be made in comparison of the benefits of these techniques in contrast to each other. The goal of the project is to contribute to this area of knowledge by practical implementation and energy consumption comparison of several approaches in a specific network environment.

3. Project Aims and Main Challenges

Based on an early reading of articles, other researchers in this field have utilized technologies such as network proxies and Wake-on-LAN (WoL) to optimize power usage in diverse scenarios. The findings from these papers show promising benefits of using these approaches, specifically in terms of power consumption, such as in Cebeci et al.'s implementation with BitTorrent [2] or in a PC network by Riccardi et al. [5]. However, we propose there remains research to be done in comparison of the benefits of these techniques in contrast to each other. The goal of the project is to contribute to this area of knowledge by practical implementation and energy consumption comparison of several approaches in a specific network environment.

4. Approach and Methodology

This project will be built upon previous knowledge; therefore, the first step will be going through earlier research in the area. Based upon that research, different implementations shall be specified alongside already formulated solutions from Axis. After one or several proposed solutions have been found, the next step is implementing those in a single network environment of specific Axis, or Axis-related products.

Some already proposed solutions from Axis include the following:

- Keep one camera online, waking the other cameras through the network.
- A separate low-power proxy brings cameras online through WoL commands.
- Physically daisy-chain the cameras together, keeping the first camera online controlling the others.
- Allow a computer running video management software (VMS) to remotely wake up cameras.

After implementing the prototypes we found most fitting, we will need to evaluate them based on a set of metrics. Currently the preliminary choice of metrics is:

- Time until camera wakes up (latency).
- Energy consumption when camera is powered on.
- Energy consumption when camera is in low-power mode, if applicable.
- Energy consumption when camera is powered off.
- Solution energy consumption, e.g. from a low-power proxy or VMS.

Based on the metrics above, we can then build a model of the energy consumption that can be applied on other networks of devices and in different use cases. We will also evaluate the accuracy and reliability of our models by doing actual energy measurements and comparing the values.

With the formalized model, a comparison between the different prototypes can be done alongside any practical advantages or disadvantages of each solution. The final evaluation aims to determine which solution that was found most suitable for the scenario.

5. Previous work

Back-ground knowledge and experiences can be found among the professors and PhD students at the department of Electrical Engineering and Information Technology, specifically the Secure and Networked Systems Division. Additionally, the team at Axis can offer practical experience of working with the system.

Pant and Deep describe the process of implementing a low-power proxy with WoL-capabilities [4]. An implementation of utilizing green proxies with BitTorrent has been made which shows the benefits of the technique by Cebeci et al. [2]. An overview of low power proxying in a network environment which illustrates the concept clearly can be found in an article by Nordman and Christensen [3]. In the article by Aagela et al., an implementation of a low-power proxy used to turn on and off a remote drone significantly improved power optimization [1]. WoL used in a network of PCs during nighttime to ensure that they only run when

needed showed that it is possible to reduce energy consumption in the article by Riccardi et al. [5].

6. Advancements and Outcome

Verification of the theoretical knowledge will be shown by real-world experiment where we will implement our prototypes on a network of cameras. Through this we will hopefully find a prototype that reduces energy consumption by a significant margin in the given scenario, that can hopefully be implemented on a larger scale. Furthermore, our work can bring further knowledge to this area of research and help future projects by providing them with the results of our experiments and research alongside a formalized model to evaluate similar scenarios.

7. Resources

We will have access to workstations at Axis so that we can work with their camera software system as well as a network of cameras that we can experiment on and implement our prototypes. Additionally, we will be able to directly measure the energy consumption of the network of cameras with electrical measuring instruments.

8. References

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[4] Millie. Pant, Kusum. Deep, and SpringerLink (Online service). *Proceedings of the Third International Conference on Soft Computing for Problem Solving*. Advances in Intelligent Systems and Computing,. Springer India:, New Delhi :, 2014.

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