Using Mobile Networks to Allow Longer and Deeper CPE Sleep

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I. Research goal and context

Internet access networks represent 27% percent of ICT electricity consumption, and therefore, about 1% percent of global electricity consumption. Within the access network, the customer premise equipment (CPE) is the biggest consumption hotspot, representing 0.6% percent of the global energy consumption [1]. CPEs are unused and idle most of the day, often with a high idle power consumption.

To reduce CPE power consumption, sleep modes are a widely recognized area of research. Sleep modes are already standardized in PON ITU standards at the Optical Network Unit (ONU) level, where several sleep mechanisms exist and are commanded by the Optical Line Terminal (OLT). We are interested in the cyclic sleep mode mechanism, which is defined as the ability to power off the ONU transmitter and receiver for short periods with a periodic wake-up to check the link status [2].

Regarding Wi-Fi, some access point (AP) power-saving features have been addressed in IEEE 802.11 Working Group [3]; however, the majority of the research effort has focused on reducing the consumption of battery-powered client devices. Although some research has focused on implementing AP sleep modes, the number of studies remains relatively low, and no effective AP sleep mode has yet been standardized. That said, the Target Wake Time (TWT) protocol in IEEE standards seems to be a good candidate for implementing periodic sleep in APs. TWT signaling enables clients and APs to negotiate communication intervals, allowing clients to sleep between service periods. Using this framework, an AP could enter a light sleep state between service periods [3].

AP periodic sleep is a good start, but latency constraints and the need to regularly broadcast beacon frames prevent the AP from entering a deep sleep. Researchers typically focus on switching off only the Wi-Fi radio interfaces, leaving the CPU on, which greatly limits power savings. In this work, we propose a novel Wake-on-LAN framework that enables AP deep sleep while limiting latency for clients with dual mobile/Wi-Fi connectivity, such as smartphones.

II. Contribution

Our proposed approach is to turn off the APs and reboot them using the mobile network for wake-on-LAN. As illustrated in Fig. 1 (a), we propose sending a wake-up notification to the AP via the mobile network and the downstream fixed

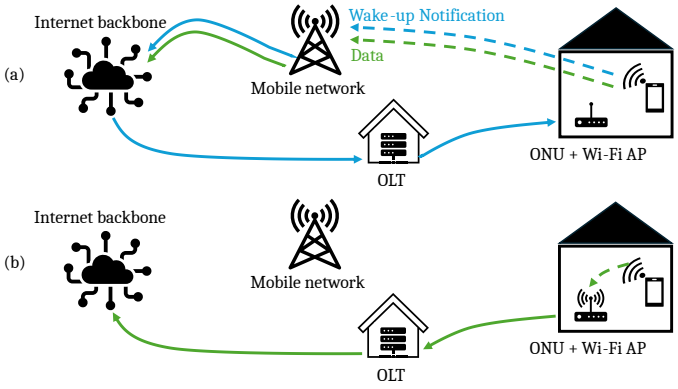

Fig. 1. Wifi AP Wake-up on LAN using mobile network.

access network. Simultaneously, the client can begin transmitting data using the mobile network. The same applies if the client is to receive downlink data, which would be sent via the mobile network while the AP boots up. Once the AP is fully booted, the client device can switch to Wi-Fi connectivity to exchange data (Fig. 1 (b)).

The first objective of this work is to develop a decision criterion based on the user arrival rate to determine whether it is beneficial for the AP to turn off. The second objective is to assess potential energy savings under various usage profiles. Then compare them to the following scenarios: a scenario in which both the ONU and the radio interface of the Wi-Fi AP periodically sleep, assuming TWT signaling is used, and the baseline scenario in which no sleep mode is applied.

Preliminary results indicate that our strategy could save about one third of the energy compared to the periodical sleep strategy and two-thirds of the energy compared to the baseline scenario.

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References

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