

(i.e., IEEE 802.15.4) module to wake up periodically to check whether there is any downstream packet arrival notification arrives or not.

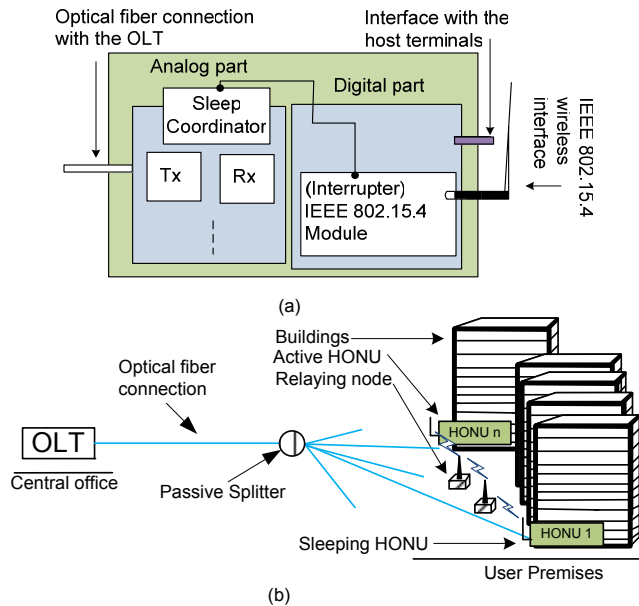


Figure 2. (a) Functional block diagram of a HOUN. (b) HONU deployment scenario in a customer premises.

We assume that at a given time at least one of the HOUNs is in active mode under the OLT. The OLT needs to notify a HONU on downstream packet arrival. Hence, even if there is no incoming downstream traffic, OLT invokes one of the HOUNs to stay in active mode. As a result, the OLT can reach any Interrupter and make a HONU's analog part active on packet arrival. Furthermore, we assume that in the customer premises all the Interrupters can communicate among themselves through their wireless interfaces. Figure 2 (b) states a scenario where OLT requests the HONU 1 to be waked up through the HONU n, which is in active mode.

As the number of PON hosts is exponentially increasing, there would not be much distance between two HOUNs (e.g., the distance can be two consecutive buildings in an urban area). Then PON operators should deploy an IEEE 802.15.4 network that allows the interconnection of the different HOUNs satisfying reliability and delay requirements. We consider that all these Interrupters and the intermediate relaying nodes sleep and wakeup synchronously. When a new packet arrives for a sleeping HONU, the OLT notifies the Interrupter of that HONU through any active HONU. After getting the notification from the OLT, the Interrupter of that HONU invokes the sleep coordinator. Sleep coordinator makes the analog part of the sleeping HONU active. Figure 3 states how HONU's ONU module switches to Active state. After being active, that ONU module synchronizes with the OLT's downstream clock and then start receiving the packets.

3. INITIAL RESULTS AND DISCUSSION

We perform some initial analysis in order to compute the energy saved when a PON network utilizes the proposed HOUNs instead of the standard one. Figure 3 depicts that while an ONU of a 10 G Ethernet PON consumes 10 W, the Interrupters of our HOUNs just need to use 30 mw [3] in the listening state. Then we roughly estimate that in a PON network with 32 ONUs our solution saves 450 kW/day. Then, assuming an average kW price of 0.15\$, our solution would save 67.5\$ per day. If we extend that saving to a complete year, the saving per OLT and year goes up to \$25000. Then, in case an operator decides to widely deploy PON technology in a big and dense city (e.g. Seoul) thousands of OLTs would be required, and our solution would reduce electricity bill in millions of dollars. Besides, as all the HOUNs are reachable from the OLT, downstream packets experience reduced amount of delay. Future work will present this idea in more detailed.

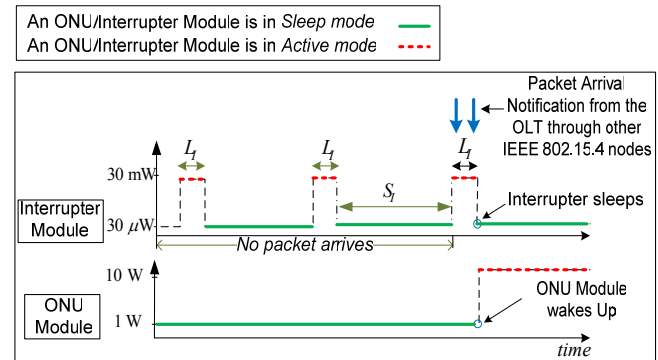


Figure 3. Proposed periodic listening procedure for an interrupter and on packet arrival wake up procedure for an ONU module.

4. REFERENCES

- [1] R. Kubo, J.-i. Kani, H. Ujikawa, T. Sakamoto, Y. Fujimoto, N. Yoshimoto, H. Hadama, "Study and Demonstration of Sleep and Adaptive Link Rate Control Mechanisms for Energy Efficient 10G-EPON," *Journal of Optical Communications and Networking*, IEEE/OSA, vol.2, pp.716-729, Sep. 2010.
- [2] Z. Jingjing, N. Ansari, "Toward energy-efficient 1G-EPON and 10G-EPON with sleep-aware MAC control and scheduling," *IEEE Communications Magazine*, vol.49, pp.s33-s38, February 2011.
- [3] Dong-Hoon Cho, Jung-Hoon Song, Ki-Jun Han, "An Adaptive Energy Saving Mechanism for the IEEE 802.15.4 LR-WPAN, Wireless Algorithms, Systems, and Applications. Lecture Notes in Computer Science. Springer, Berlin, 2006.