Towards energy efficient data intensive computing using IEEE 802.3az

Dimitar Pavlov, Joris Soeurt, Paola Grosso, Zhiming Zhao, Karel van der Veldt, Hao Zhu, Cees de Laat
System and Network Engineering Group, University of Amsterdam

Motivations and Research Question
The huge network traffic generated by data-intensive apps consumes large amounts of energy. This brings up a problem of optimizing energy efficiency of networking equipment. There are technologies to achieve this:
1. Dynamically power off unused switch ports.
2. Adjust transmission power based on cable length.
3. Turn active ports into sleep during periods of inactivity.

The third one above is used in the 802.3az protocol, which reduces energy consumption in the network without performance degradation, but implementation differs between vendors.

Moreover, the amount of energy saved depends on the network traffic patterns.

Therefore, the research question is how to model the energy characteristics of data-intensive computing in order to save energy based on the investigation of the energy behavior of 802.3az devices in a real network situation.

Power Budget Calculator
The goal of modelling is to:
- Estimate the energy consumption generated by the data transmission.
- Understand the impact of changes to the scenarios: e.g. adding new nodes.
- Optimize based on scenario: e.g. determine best number of used nodes or reduce the transmission speed.

According to the parameters of data-intensive tasks and the energy profiling in the energy efficient Ethernet (EEE) environment, we can model the energy consumption of data transmissions.

We developed a Power Budget Calculator, which contains two basic model: Task-based Estimate and Data-based Estimate.

Task-based Estimate
Estimate the total energy usage of the switch for a particular task as a function of the number of used ports on a switch. Throughput \( \lambda \) is fixed.

\[
E_t = P \cdot T_{	ext{on}} = P \cdot (T_{	ext{on}} / n + (n-1) \cdot C)
\]

Data-based Estimate
Calculate the energy usage of a single port based on the available energy profile for a particular switch at a particular transmission speed (throughput).

The amount of data is fixed.

\[
E_i = P \cdot (s \cdot T) = (P \cdot s) \cdot (T) \cdot N
\]

Both need the energy profiling of the EEE.

IEEE 802.3az
The IEEE 802.3az protocol turns active links to a low power model when no traffic exists; it refreshes in a interval to detect coming traffic and wakes up.

Experiments of Energy Characteristics
- Energy vs. Throughput

Use Cases of the Power Budget Calculator
Optimize the scenarios: determine the execution parameters

Conclusion
EEE is effective in reducing the energy consumption of TCP traffic. The amount of energy saved varies depending on vendor. The inter-frame time interval influences the energy consumption of running the data intensive application. Research directions:
- Set a suitable and stable interval.
- Buffer application request to increase idle time.

Future Work
The future version of the Calculator should be free of unrealistic assumptions and incorporated into our scheduler. The Calculator will be included in the ongoing energy knowledge base system, which exposes measurement data and supports prediction of energy characteristics.

References:

* The current prototype Power Budget Calculator implementation is available at https://github.com/uppercluster-efficiency.