# *Towards energy efficient data intensive computing using IEEE 802.3az*

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## 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[1,2] 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.

* The current prototype *Power Budget Calculator* implementation is avail- able at https://github.com/zupper/cluster-efficiency.

### 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.

$$E_t = P * T_{total} = P * (T_{single} / n + (n-1) * C)$$

### Data-based Estimate

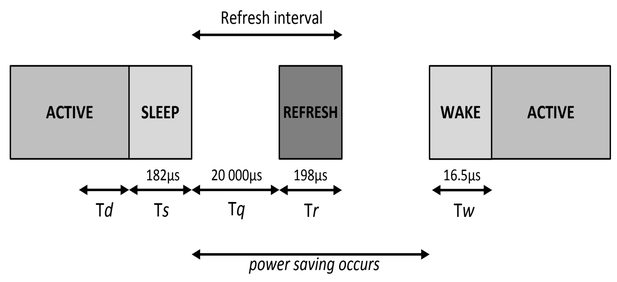
Calculate the energy usage of a single port based on the available energy profile for a particular switch at a particular transmission speed (throughput).
The amount of data is fixed.

$$E_d = P_{total} * T = (P_{single}(\lambda) * N) * T$$

Both need the energy profiling of the EEE.

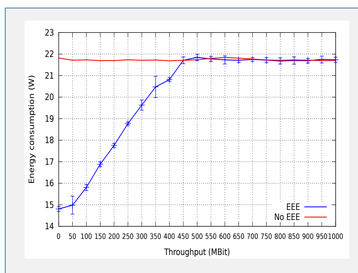
## IEEE 802.3az

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.

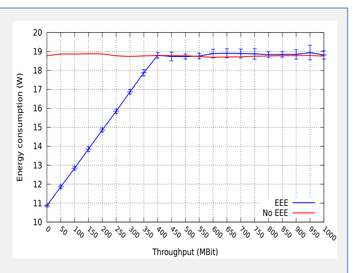



## Experiments of Energy Characteristics

- Energy vs. Throughput



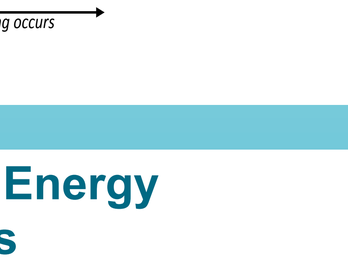

TCP, 1000BASE-T
Huawei S1728GWR-4P.




TCP, 1000BASE-T Cisco
SG300-28

Both switches show a linear increase in power consumption.

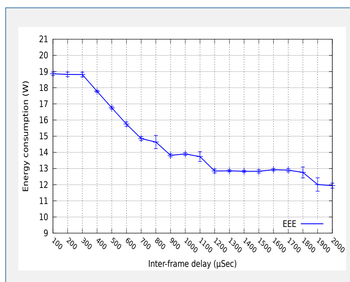

UDP, 1000BASE-T
Huawei S1728GWR-4P.



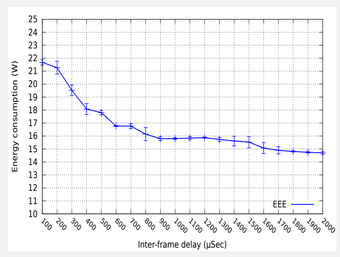

UDP, 1000BASE-T
Cisco SG300-28

Both switches always consume maximum energy, regardless of throughput.

- Energy vs. Inter-frame delay (TCP, 1000Mbit)




Frame Pattern,
Huawei S1728GWR-4P.

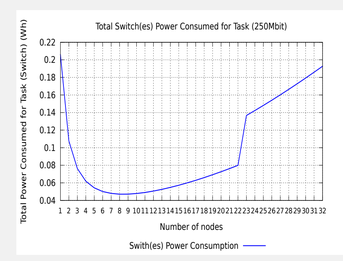



Frame Pattern
Cisco SG300-28

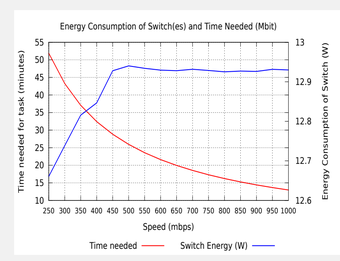
The Huawei device starts saving energy at smaller inter-frame delay values than the Cisco device.

## Use Cases of the Power Budget Calculator

Optimize the scenarios: determine the execution parameters




Task-based estimate: determine the number of nodes




Data-based estimate: determine the transmission speed

## 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[3].
The Calculator will be included in the ongoing energy knowledge base system[4], which exposes measurement data and supports prediction of energy characteristics.

References:

1. LAN/MAN Standards Committee of the IEEE Computer Society. IEEE Std 802.3az-2010 (Amendment to IEEE Std 802.3-2008). 2010.
2. P. Reviriego, J. Maestro, J. Hernaandndez and D.Larrabeiti. Burst transmission for energy-efficient ethernet. *Internet Computing, IEEE,* 14(4):50 –57, July-Aug. 2010.
3. Z. Zhao, P. Grosso, J. van der Ham, R. Koning, and C. de Laat. An agent based network resource planner for workflow applications. *International Journal of Multiagent and Grid Systems*, 7/6:187–202, 2011.
4. H. Zhu, K. van der Veldt, P. Grosso, Z. Zhao, X. Liao and C. de Laat. *GreenCom2012, IEEE*, Nov. 2012.

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