ITU Kaleidoscope 2013
Building Sustainable Communities

Solar-Powered Cell Phone Access Point for Cell Phone Users in Emerging Regions

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Outline

- Introduction & research purpose
- Analysis of AP surplus power for cell phone charging
- Energy conservation of servers for web-based information services
- Conclusion

Introduction

- Low-cost energy delivery can expand ICT services into emerging regions
  - Solar-powered cellular network draws attention
  - Cell phones are easy for local people to handle
- However, charging expenses are still expensive for cell-phone users
  - In Uganda…
    - GNI per person is $510
    - Average expense per charging is $0.20 !!

Research Purpose

1. Feasibility study on distribution of electricity of solar-powered access point (AP) to cell phone users
   - Surplus power of a 60W AP meets electricity demand for charging by 9.3% of the user population in the model area

2. Energy conservation of servers used for electricity distribution
   - Energy-proportional low-power server cluster can save energy compared with conventional management policy under low load

Cellular Network in Rural Areas

Village Phone Program (Grameen Bank)

Extend micro-loan for the purchase of a Village Phone Operator (VPO) start- up kit

which includes a handset, antenna, solar charger, shared phone software, and airtime.

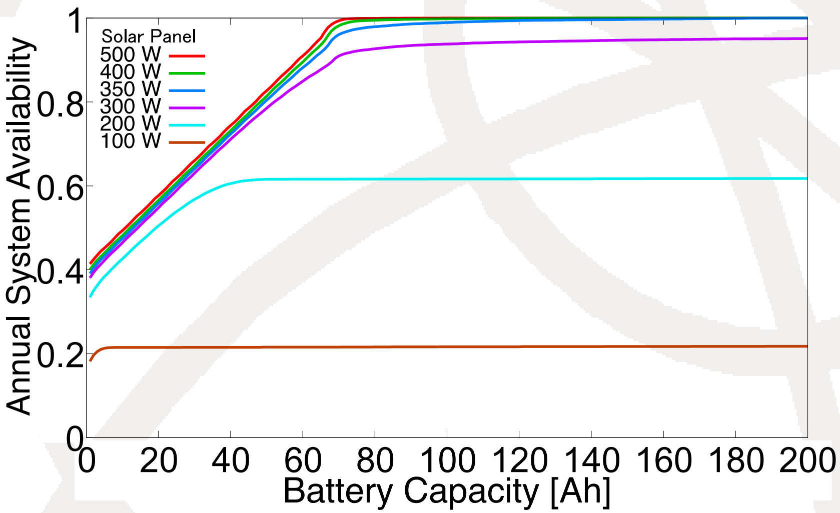
(IFC, The Village Phone Program)

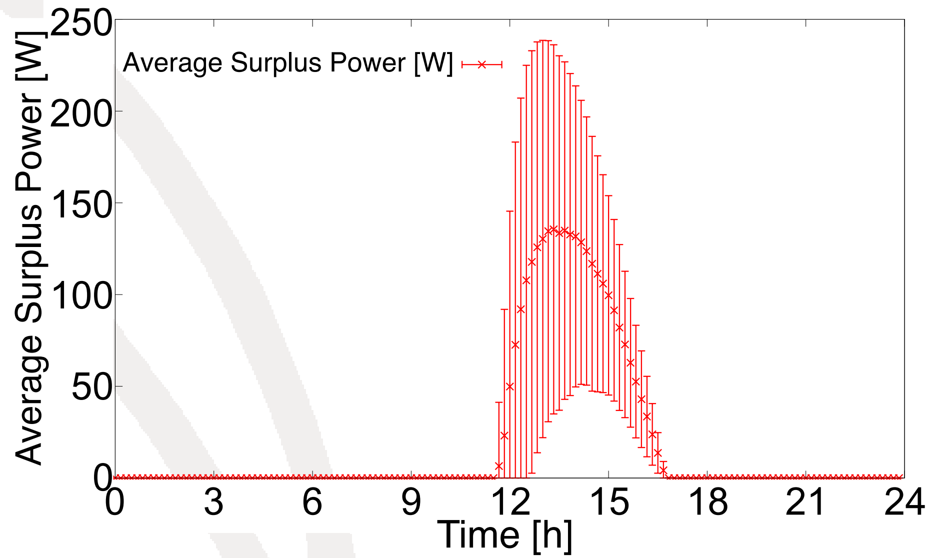
OpenBTS

- Open source software that works like a GSM Base Station (BTS)

1. Surplus power of AP with OpenBTS

- Assume 60W power consumption





Assuming 99% availability
-Solar module : 400W
-Battery : 92Ah

Average surplus power
449Wh/day
(Standard deviation=229Wh/day)

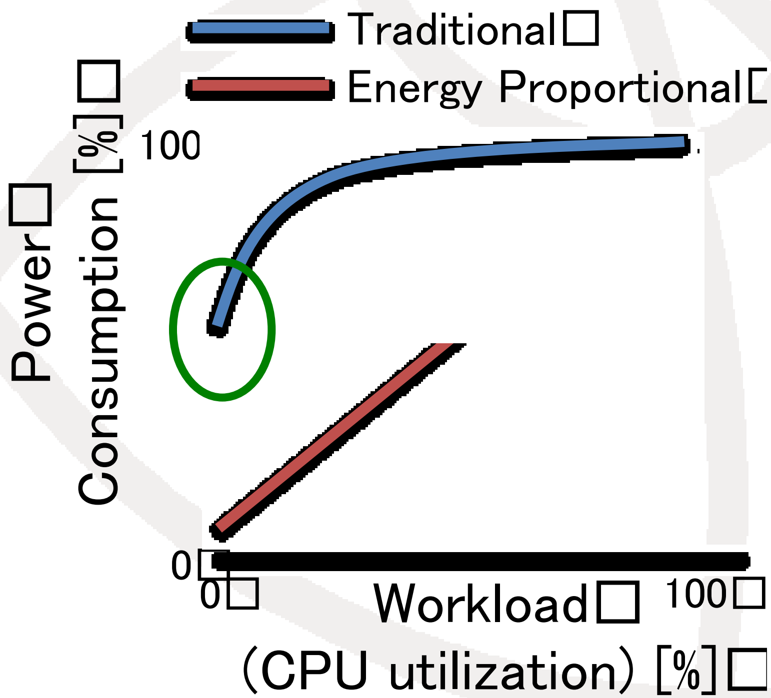
Power Consumption of charging cell phones & Summary

- Average Power consumption 4096 Wh/day
  - 50.3 (Coverage area of AP) [km^2]
  - X 1 (Cell-phone ownership)
  - X 0.44 (Market share of the provider)
  - X 2.96 (Capacity of a phone battery) [Wh]
  - X 0.375 (Charging frequency) [/day/people]
  - X 167 (Average population density in Uganda)[people]

- Assuming charging efficiency is 0.85, 9.3% (= 449/4096*0.85) of users can use surplus power to charge their cell phones

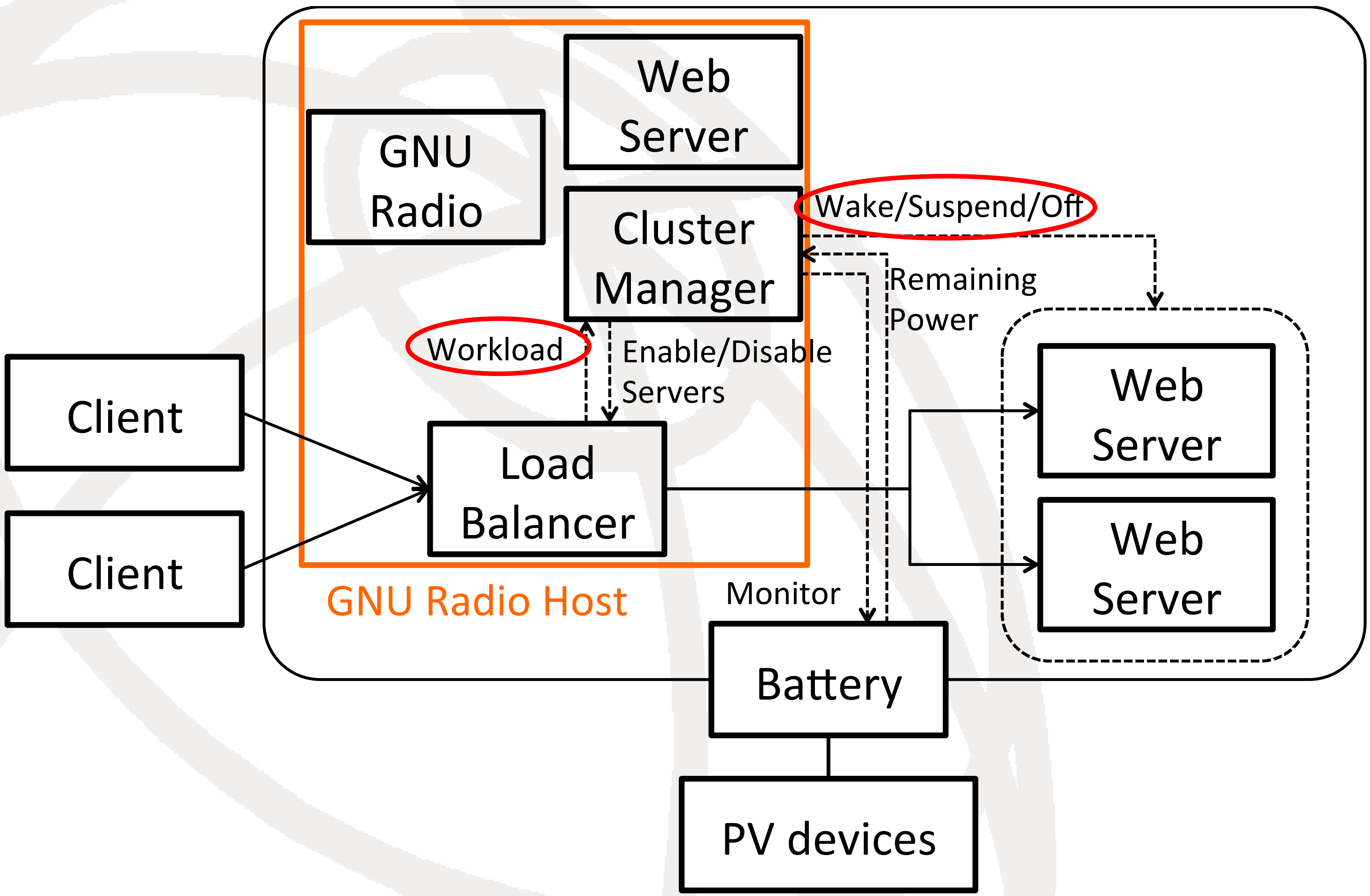
2. Energy Conservation of Servers

- For Web-based graphical information
- High power consumption in low load
  → Energy proportional



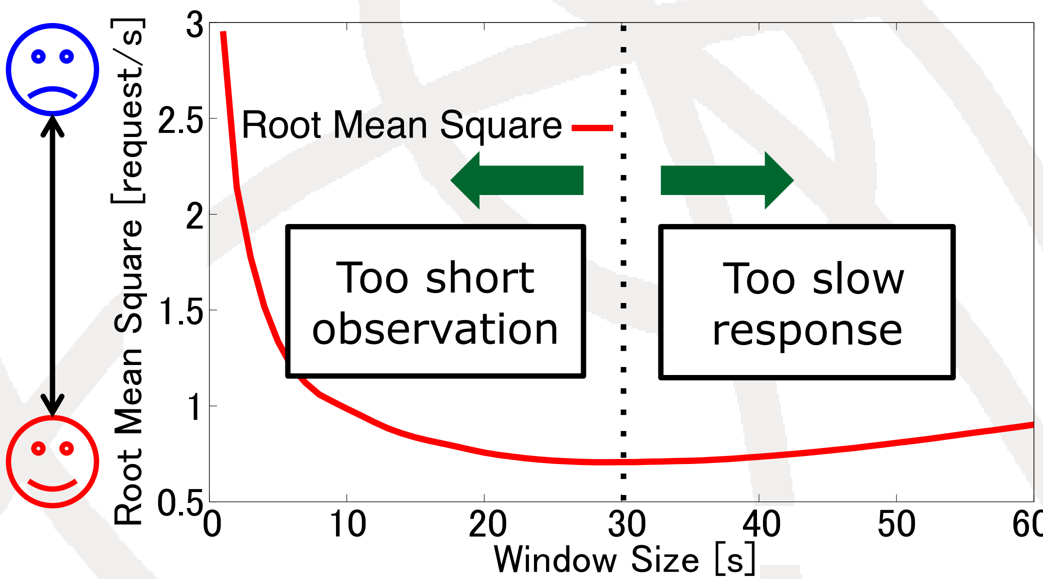
- How?
  - Cluster with low-power servers
  - Adjust the number of active servers according to workload

Architecture Overview



Workload Prediction

- Moving Window Average [1]
  Average of the request rates in the last *n* seconds



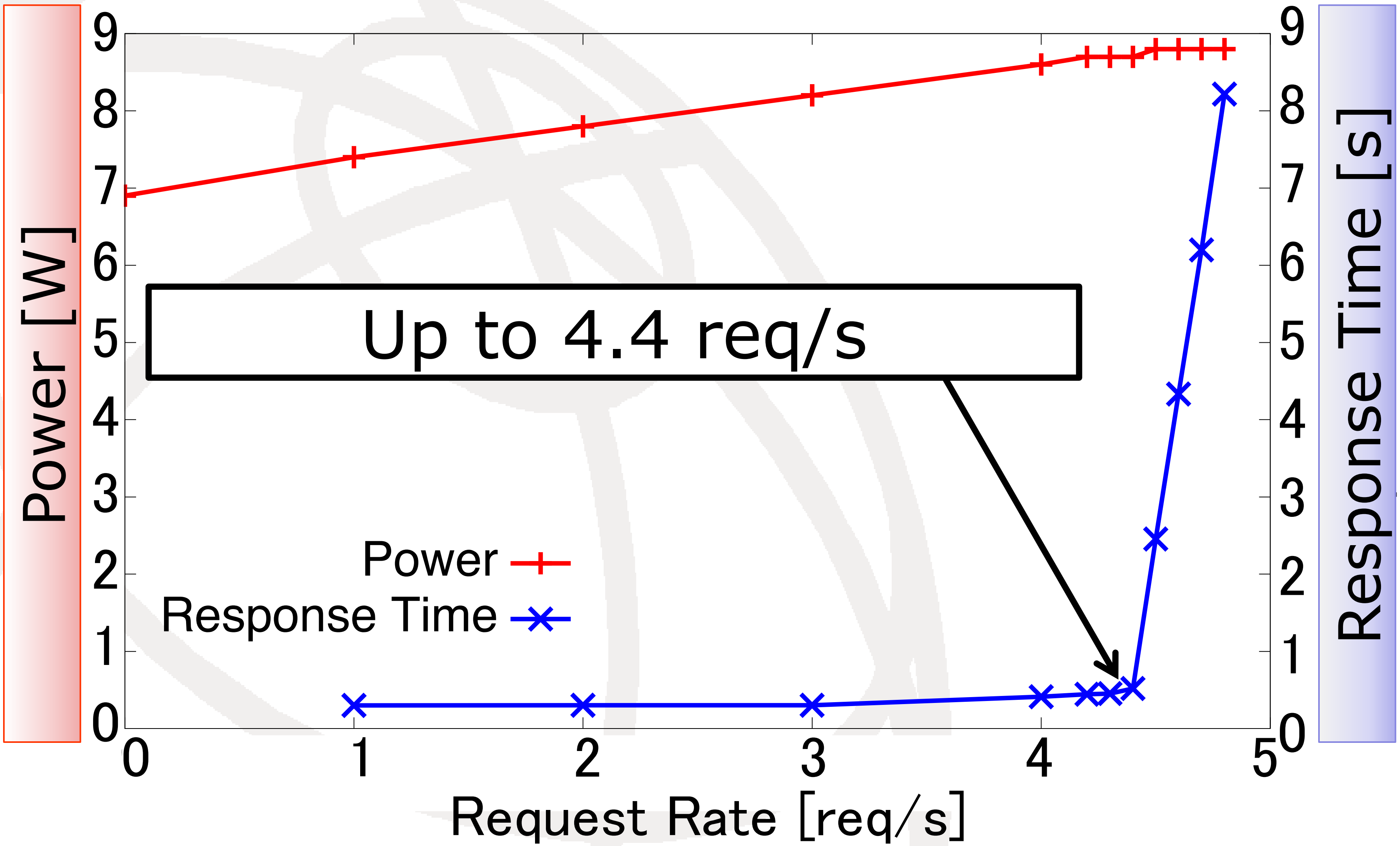
λ=0～15 req/s for 600 sec

n = 30

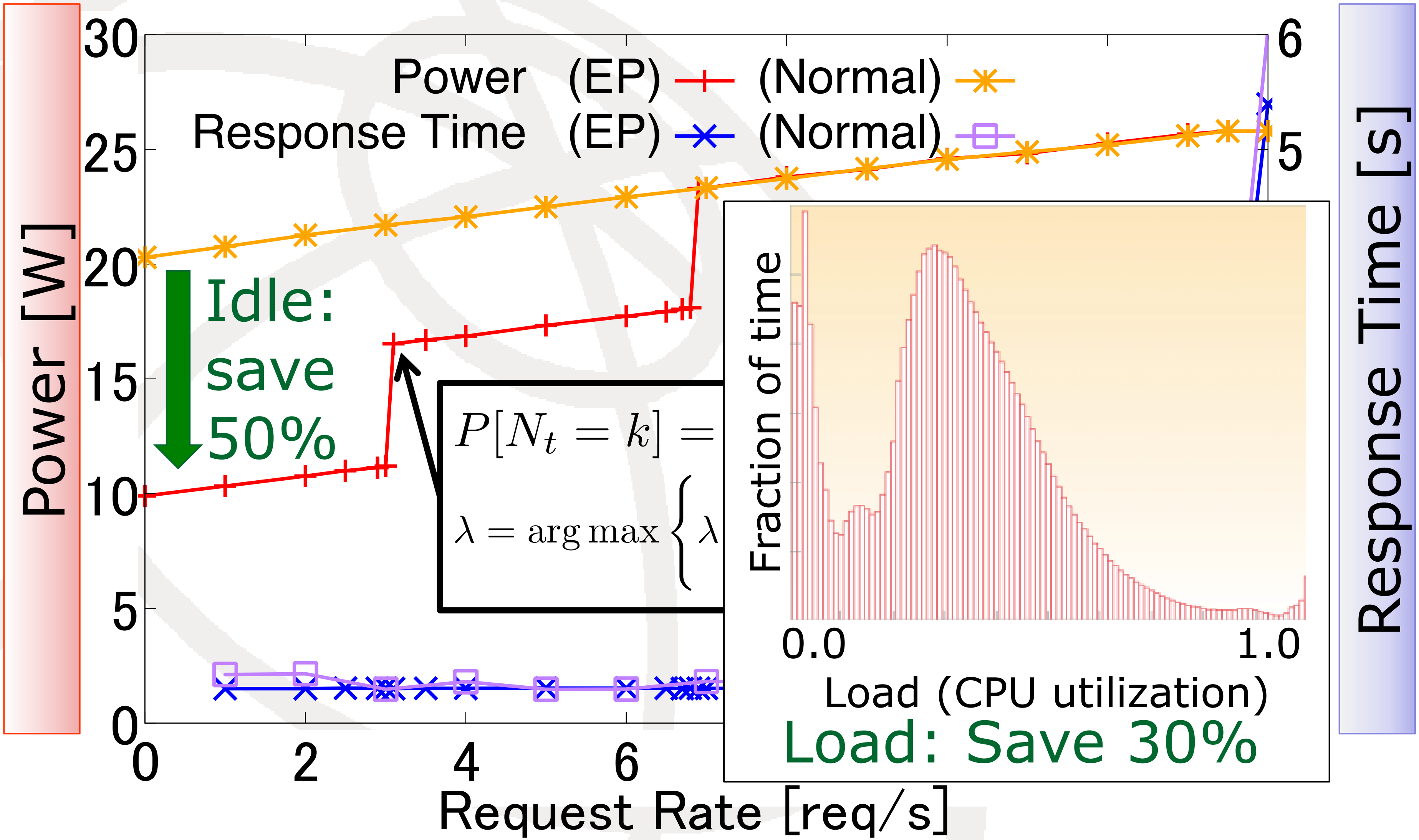
- Compare with thresholds determined from CDF of Poisson distribution

[1] A. Krioukov et al., "NapSAC: Design and Implementation of a Power-Proportional Web Cluster," SIGCOMM Computer Communication Review, vol.41, pp.102–108, Jan. 2011.

Experiment Result 1
Unit Test



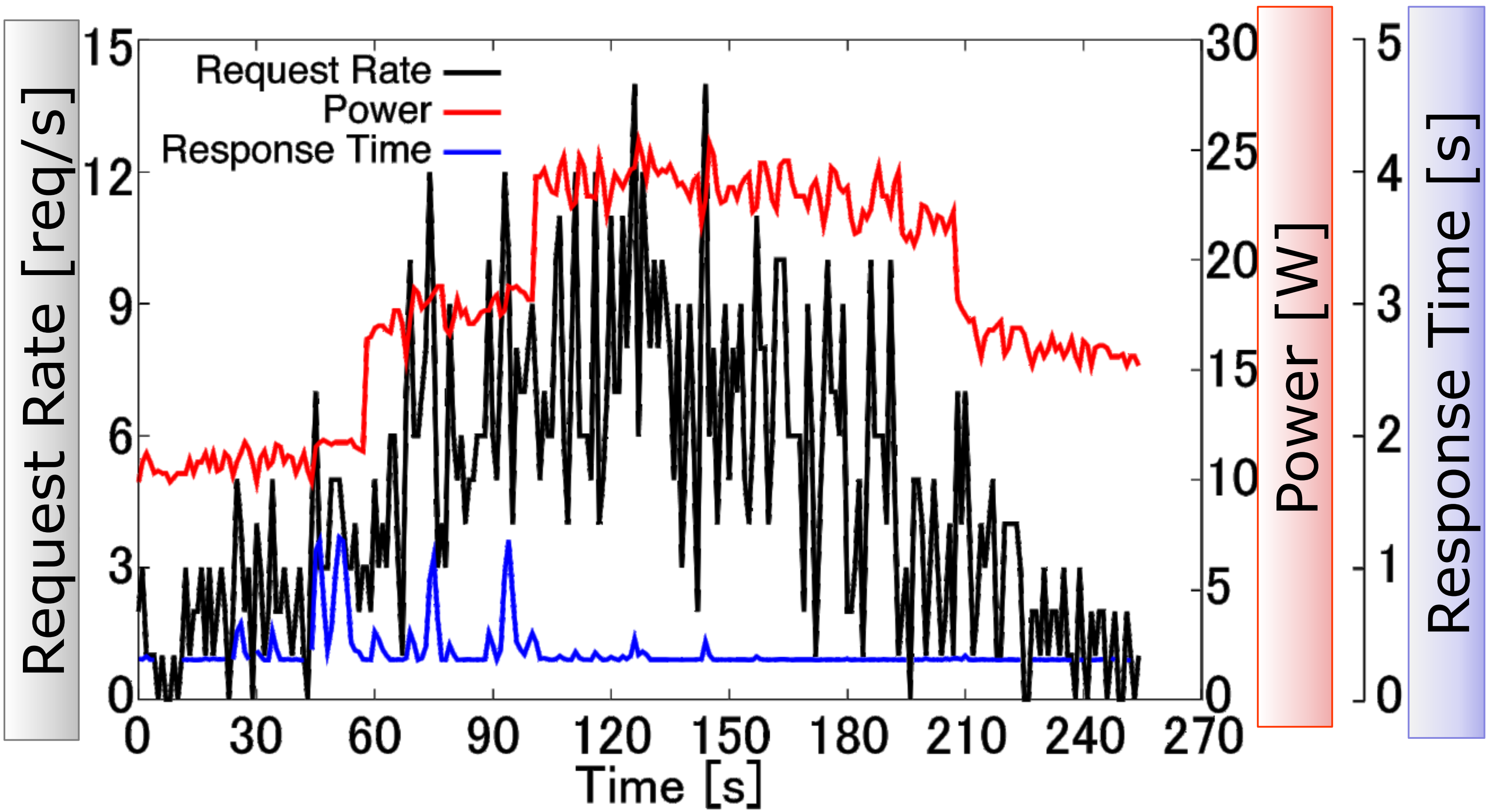
Experiment Result 2
Energy Proportional vs. Normal



L. Barroso and U. Hölzle, “The Case for Energy-Proportional Computing,” 2007

Experiment Result 3
Poisson Traffic

- Average arrival rate λ rises/falls by 1 req/s every 15 seconds



Conclusion

- Purpose:
  - To solve high charging expenses in emerging regions by electricity distribution from APs
  - Energy conservation of servers that support electricity distribution of APs
- Surplus power of an 60W AP can be used for charging of 9.3% of users
- Energy-proportional operation saves wasted energy in low load