AN ADVANCED ENERGY EFFICIENT RACK SERVER DESIGN WITH DISTRIBUTED BATTERY SUBSYSTEM

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OUTLINE

1. Why distributed BBS(Li-ion)
2. Key technologies & project progress
3. Architecture & design
4. BBS vs UPS
5. Test data analysis
6. Future plan & summary

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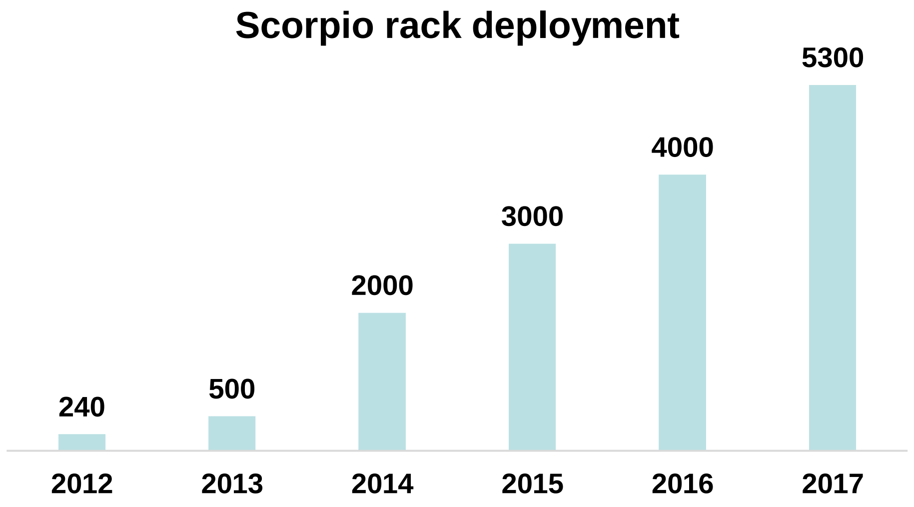
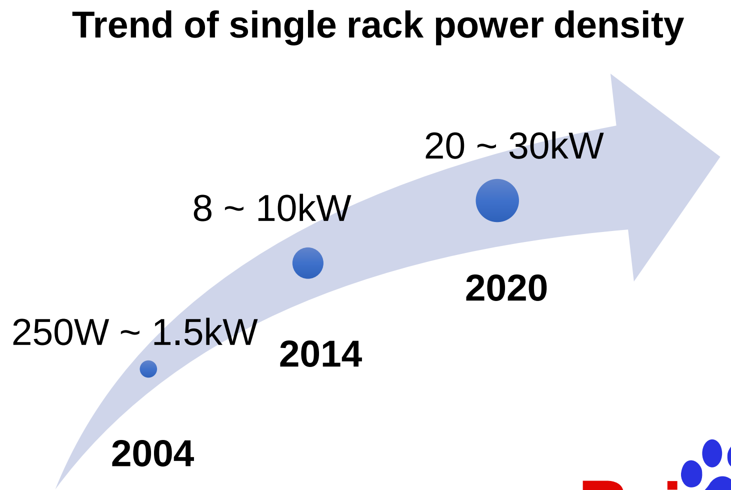
SCORPIO RACK DEVELOPMENT IN CHINA

Overall Deployment

15000 racks

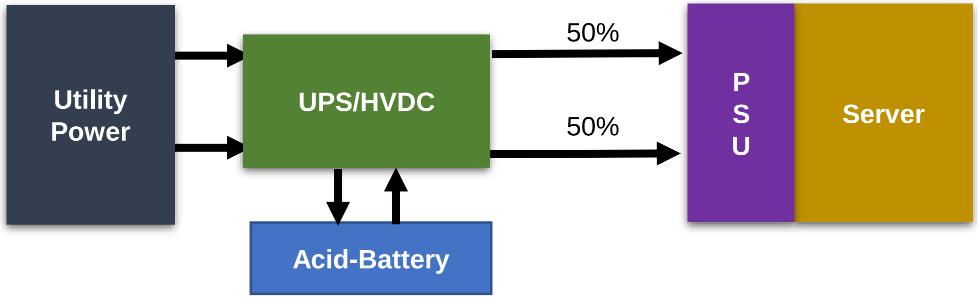
15 billion CNY





J. G. Koomey, Growth in Data Center Electricity Use 2005 to 2010, Oakland CA: Analytics Press, 2011

DISADVANTAGES OF CURRENT SYSTEM POWER ARCHITECTURE



Traditional UPS power architecture

UPS room

Acid-battery room

High power loss	High power density	Deployment unscalable	Maintenance inconvenient
Efficiency 88%~92%	Power Peak Draw Problem	Real estate waste	Environmentally Unfriendly
↓	↓	↓	↓
12V power architecture	Providing extra power	Distributed deployment	Li-ion battery

12V distributed backup battery (Li-ion) subsystem (BBS)

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KEY TECHNOLOGIES & PROJECT PROGRESS

1. Cell selection

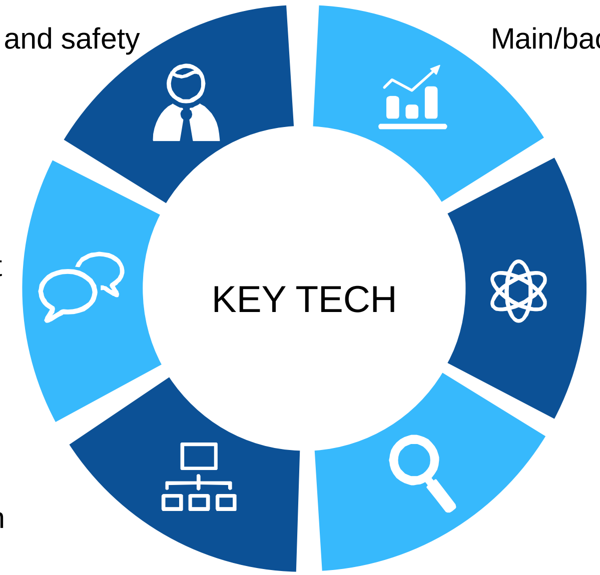
Power, energy, lifecycle and safety

2. Power architecture

All 12V architecture, independent charge/discharge circuit

3. Automatic M&O

Without manual operation



4. Fast switching

Main/backup power fast switching

5. Battery protection

Charge/discharge cut-off voltage, current, temperature

6. Fault alarm

Detect and deal with faults in time

2015
feasibility analysis & system design

2016 Q1~Q3
specification & EVT & DVT

2016 Q4
PVT & dozen of racks deployed in Baidu YQ

2017
dozens of racks deployed

2018
hundreds of racks to be deployed

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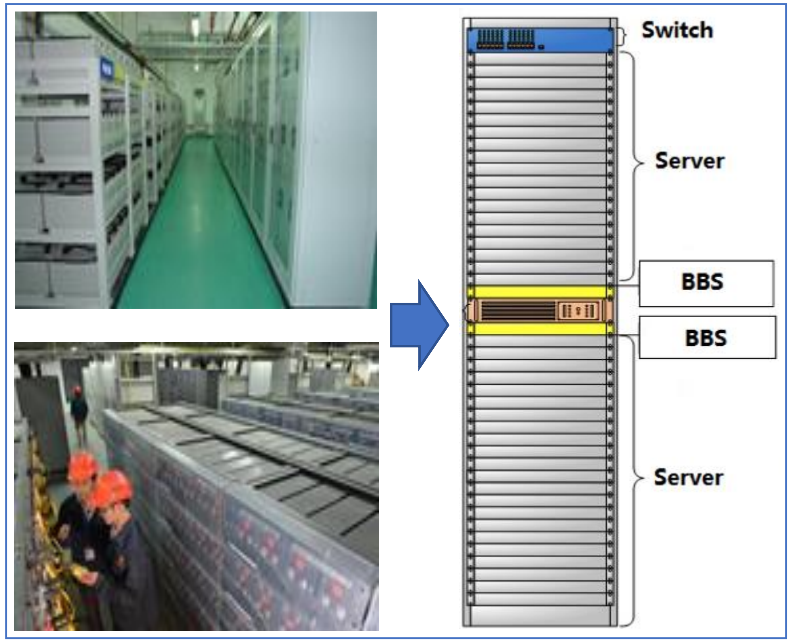
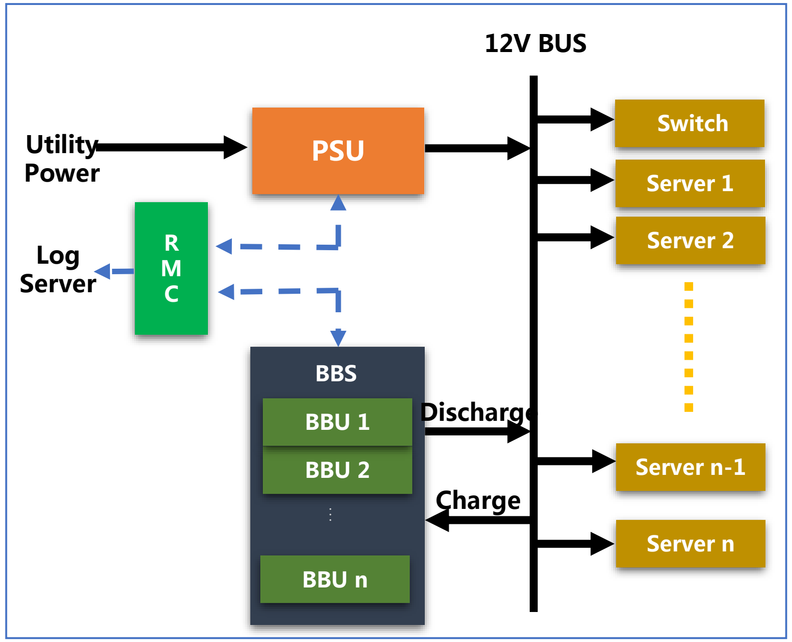
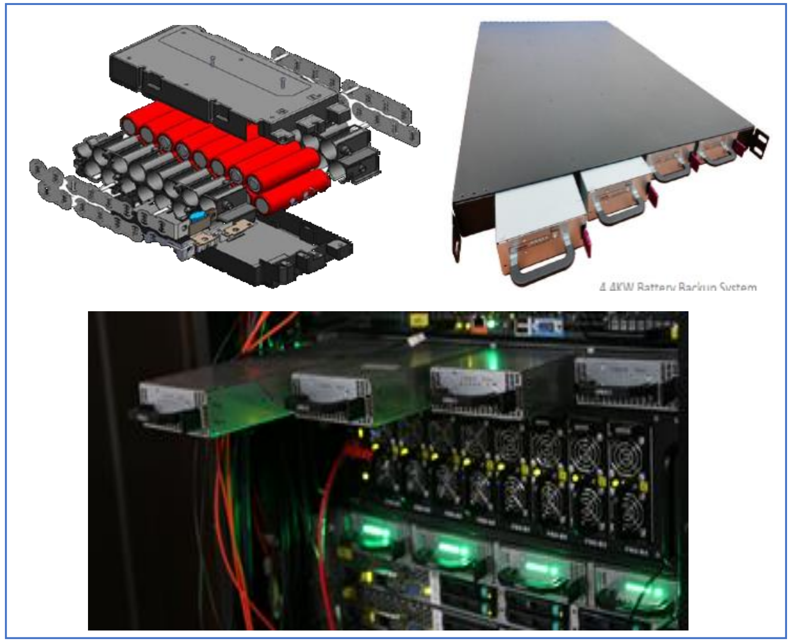
SYSTEM POWER ARCHITECTURE WITH BBS



distributed deployment, data center → rack

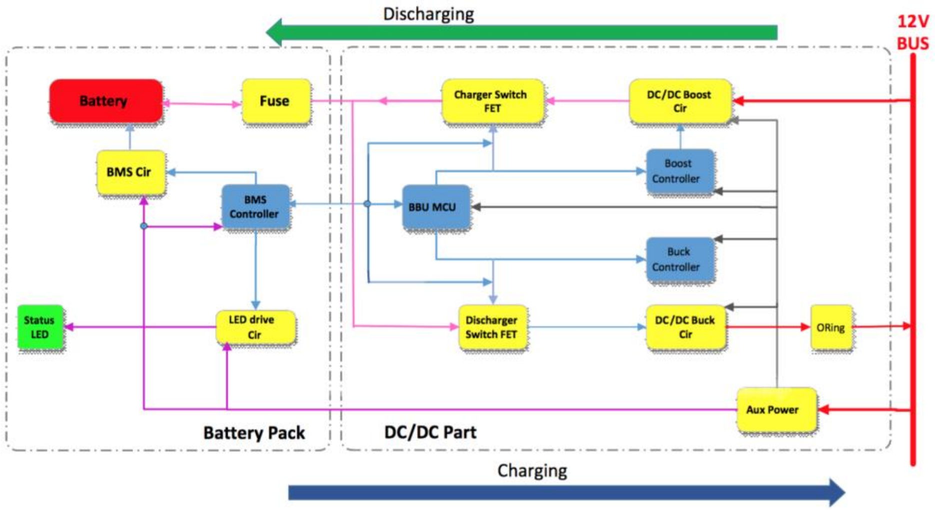


12V architecture, backup on DC side

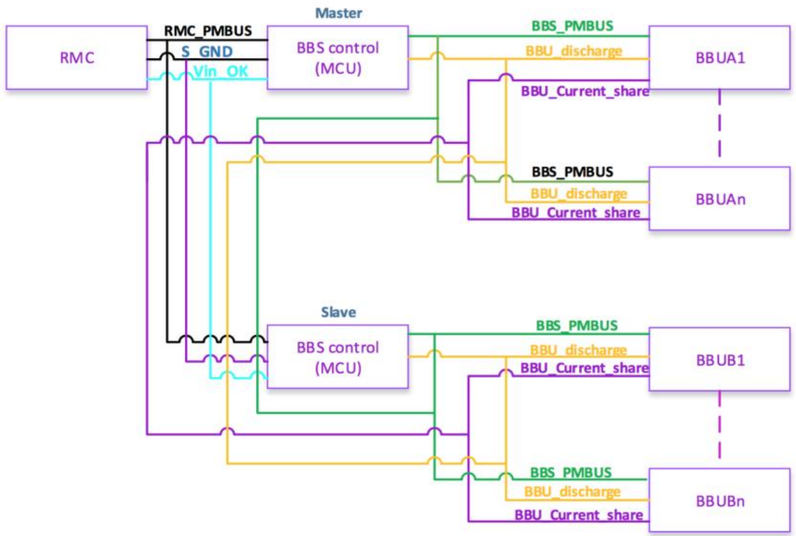


18650 Li-ion battery as energy storage unit

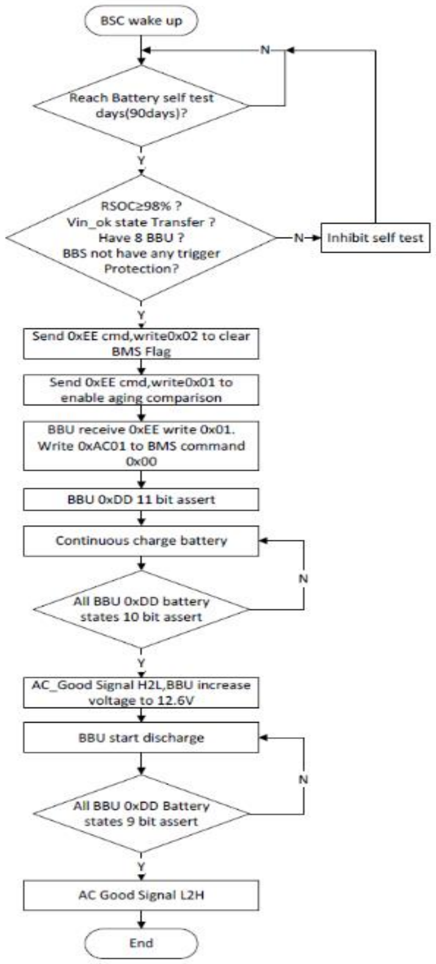
BBS SUBSYSTEM ARCHITECTURE & DESIGN



BBS hardware design diagram



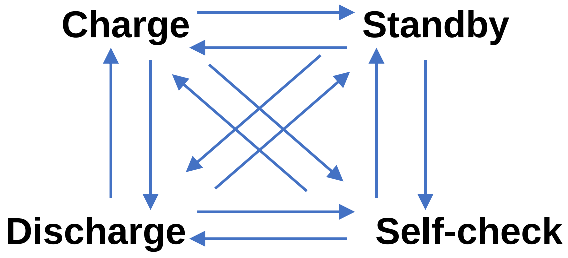
BBS management architecture diagram



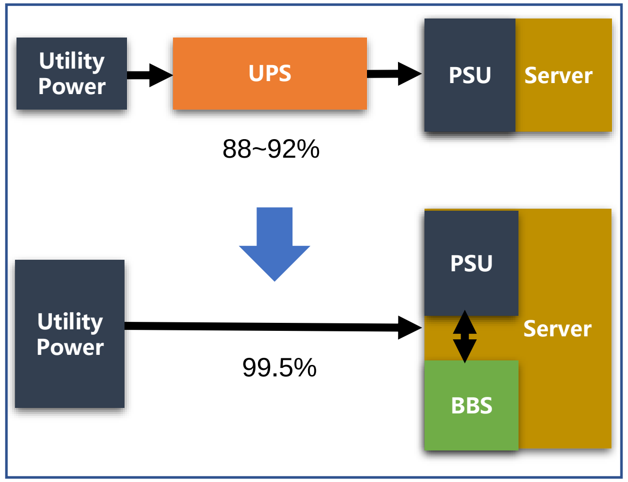
Self Check Process

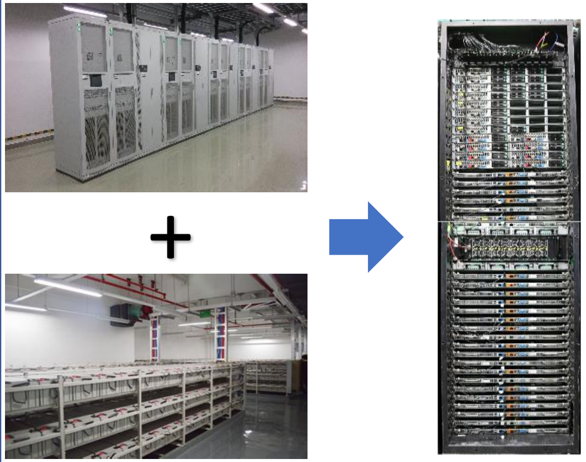
Automatically

1. check battery state of health (SoH)
2. judge whether self-check conditions are met
3. release 30% electricity when conditions are met
4. restore to charging state after discharging finished



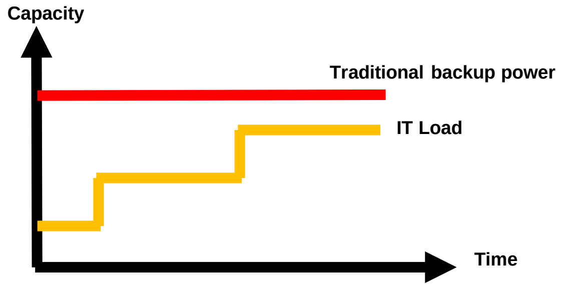
DISTRIBUTED BBS VS UPS +ACID-BATTERY





regular dust cleaning
capacitor replacement
regular battery inspection
manual charge/discharge test

On-line monitoring via BMS
Automatic self-check
Hot plug, online replacement



Deployed with racks, saving one-time investment

Efficiency
↑ 10%

Real Estate
↓ 25%

Automatic
M&O

On-demand
Deployment

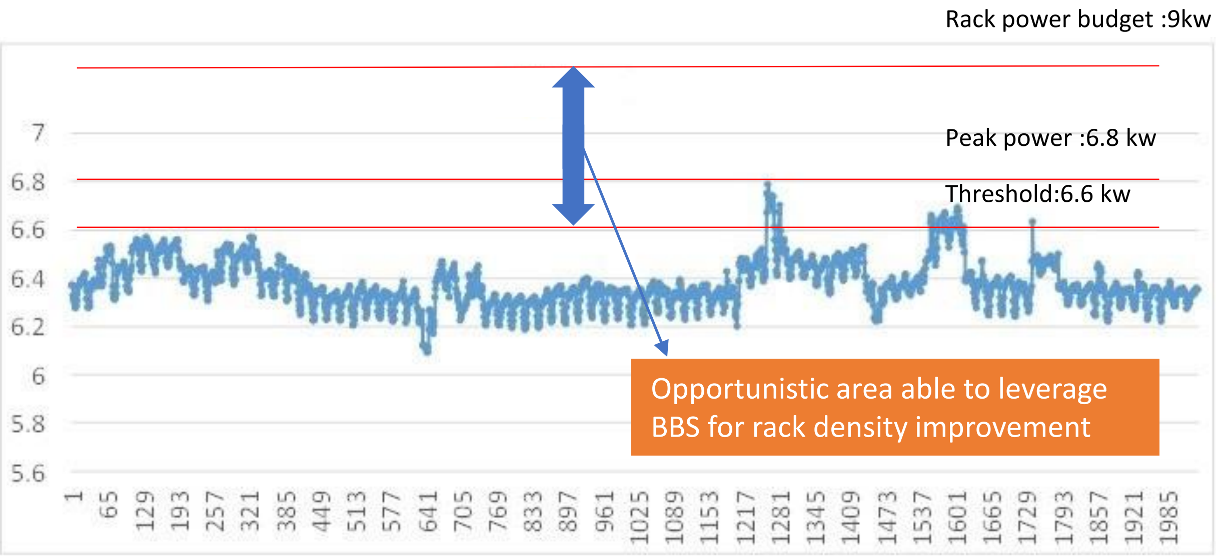
TEST DATA ANALYSIS FOR POWER PEAK DRAW PROBLEM

Power density increase

Power peak draw problem

- **Dynamical power capping**
- **Workload balancing placement** — performance↓
- **Battery backup system** — extra power

Workload power characteristics based energy efficient design methodology



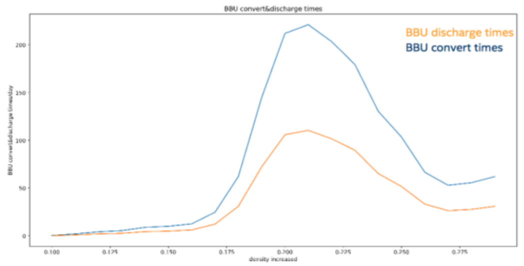
rack power consumption with workload A

BBS functionality on power peak draw problem addressing:

- able to save 2.4 kW power budget per rack
- no compromising performance

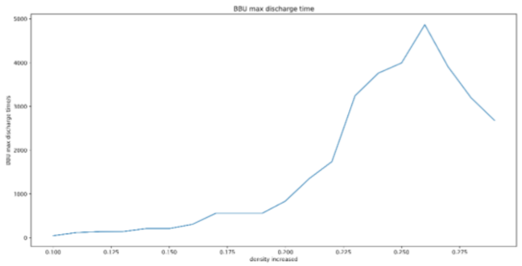
TEST DATA ANALYSIS FOR POWER PEAK DRAW PROBLEM

BBU convert/discharge frequency with density increased. (15% BBU available)



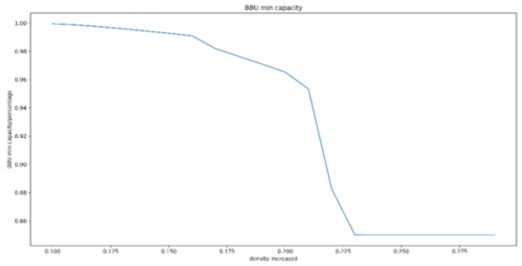
increase_per	bbu_convert
0.1	0.454554
0.11	2.090946
0.12	4.272804
0.13	5.545554
0.14	9.000161
0.15	10.09109
0.16	12.63659
0.17	24.81863
0.18	62.09202
0.19	144.8208
0.2	212.0947
0.21	221.1858
0.22	203.5491
0.23	179.5487
0.24	130.6387
0.25	103.5473
0.26	66.63756
0.27	53.00095
0.28	55.72827
0.29	62.09202

Max discharge time with density increased(15% BBU available)



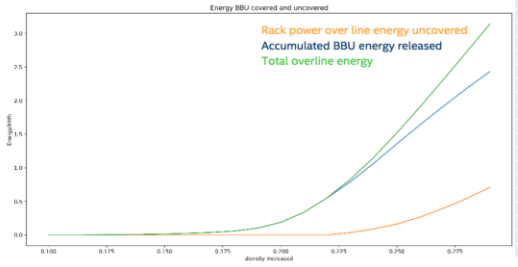
increase_per	max_discharge_time/s
0.1	45
0.11	117
0.12	139
0.13	140
0.14	209
0.15	209
0.16	306
0.17	559
0.18	559
0.19	559
0.2	837
0.21	1342
0.22	1739
0.23	3249
0.24	3762
0.25	3995
0.26	4869
0.27	3908
0.28	3190
0.29	2680

BBU min capacity with density increased(15% BBU available)



increase_per	min_available/kwh
0.1	2.198973333
0.11	2.197255083
0.12	2.194292
0.13	2.191207306
0.14	2.187661278
0.15	2.184057917
0.16	2.180073222
0.17	2.160179194
0.18	2.148159833
0.19	2.136140472
0.2	2.123648889
0.21	2.097496194
0.22	1.941788422
0.23	1.870229789
0.24	1.870041822
0.25	1.870048183
0.26	1.870000022
0.27	1.870004639
0.28	1.870023889
0.29	1.870066994

Over line energy BBU can cover with density increased. (15% BBU available)



increase_per	Accumulated_energy_released_per_day/kwh
0.1	0.000131669
0.11	0.000632549
0.12	0.002033572
0.13	0.004901608
0.14	0.009318944
0.15	0.01584195
0.16	0.024734998
0.17	0.037849962
0.18	0.058645155
0.19	0.102629275
0.2	0.187972554
0.21	0.338343135
0.22	0.554267561
0.23	0.792406229
0.24	1.066785839
0.25	1.356939045
0.26	1.641947915
0.27	1.914552587
0.28	2.179805779
0.29	2.431336374

Preliminary findings:

- BBU can support rack power density increase 15% without significant influence on battery life and capacity.

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FUTURE PLAN

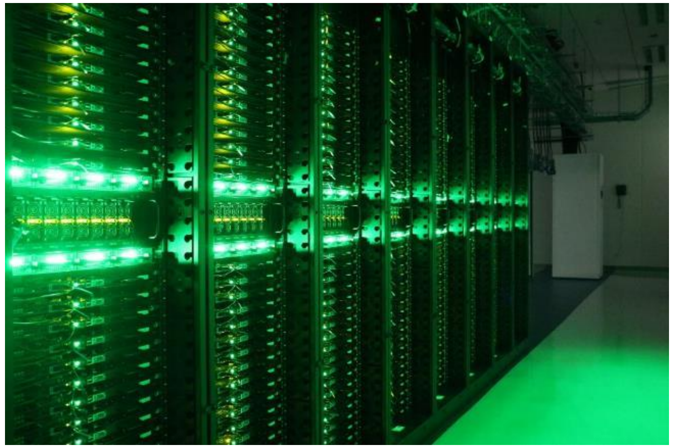
Algorithm optimization	• Optimize BBS control algorithm/policy based on multiple dimensional factors modeling
Improve data sizing	• Implement machine learning tech for further research
Explore TCO benefits	• Consider draw power from utility to BBS during off-peak and use BBS energy during on-peak

SUMMARY

Introduce an advanced energy efficient server design with distributed Li-battery system

- proves functionality of BBS solution for **power peak draw problem**
- achieves below benefits over traditional UPS power architecture

1st in China	On-demand deployment	Efficiency ↑ 10%	Real Estate ↓ 25%	Automatic M&O



Baidu deployed rack server with distributed BBS

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Thanks