ABCI
AI Bridging Cloud Infrastructure

Opportunities of ML-based data analytics in ABCI

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INTRODUCTION OF ABCI SYSTEM

ABCI: Open Innovation Platform for advancing AI Research & Deployment

AIST Booth #2409

0.550 EFlops(FP16), 37.2 PFlops(FP64)
19.88 PFlops(Peak), Ranked #7 in Top500
14.423 GFlops/W, Ranked #4 in Green500
ImageNet training in 224 seconds (world record)

Chips
(GPU, CPU)

Tesla V100

Xeon Skylake-SP

Compute Node
(4GPUs, 2CPUs)

PRIMERGY
CX2570 M4

Node Chassis
(2 Compute Nodes)

PRIMERGY
CX400 M4

Rack
(17 Chassis)

System
(32 Racks)

1088 Compute Nodes
4352 GPUs

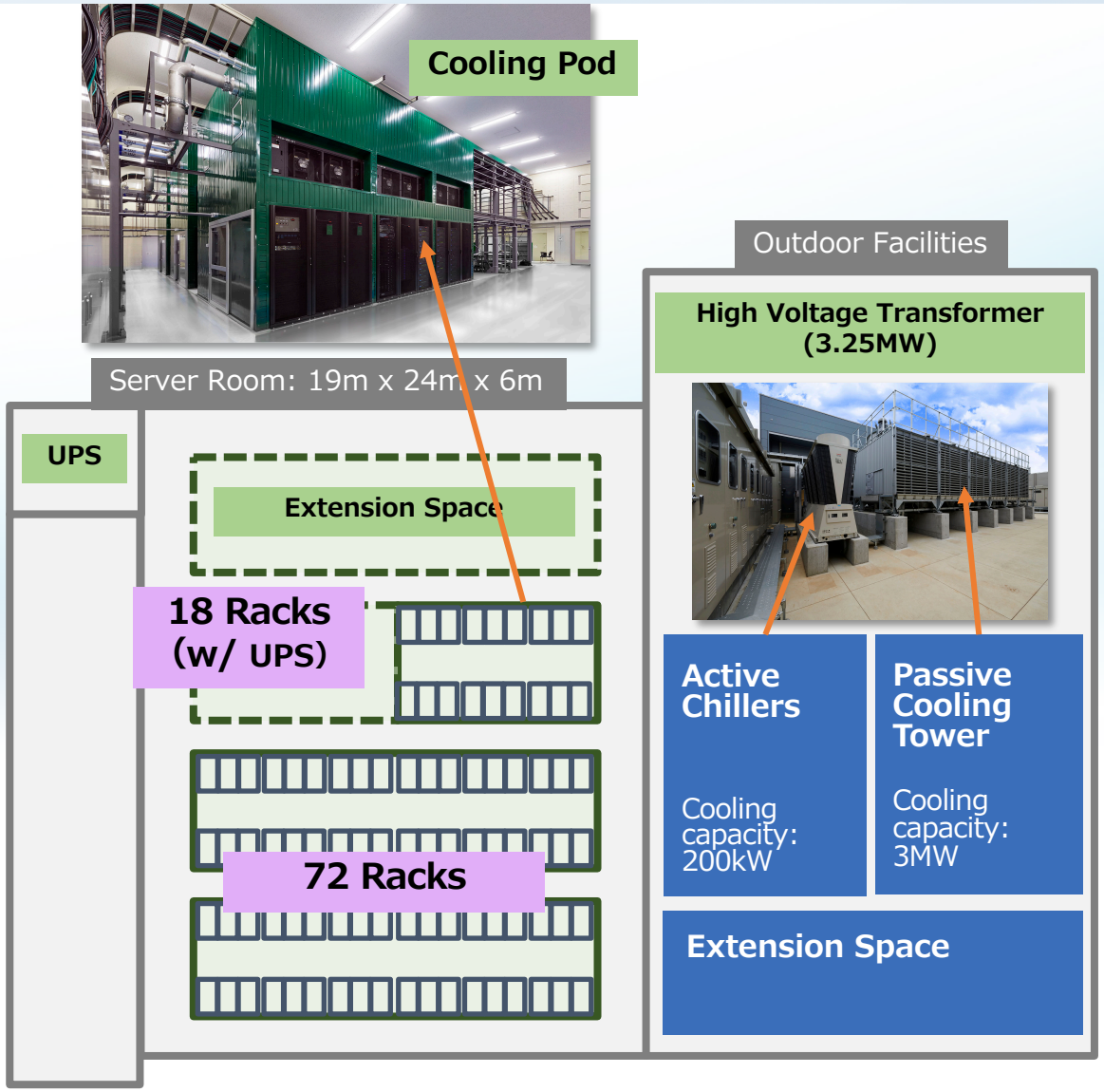
GPU:	CPU:				
7.8 TFlops(FP64)	1.53 TFlops(FP64)	34.2 TFlops(FP64)	68.5 PFlops(FP64)	1.16 PFlops(FP64)	37.2 PFlops(FP64)
125 TFlops(FP16)	3.07 TFlops(FP32)	506 TFlops(FP16)	1.01 PFlops(FP16)	17.2 PFlops(FP16)	0.55 EFlops(FP16)

ABCI achieves ultra-dense packaged rack

	AAIC	TSUBAME3.0	ABCI	Summit	TPU 3.0 Pod
Organization	AIST	TokyoTech	AIST	ORNL	Google
Start of operation	2017	2017	2018	2018	2018
Number of nodes	50	540	1088	4608	unknown
Throughput Processor (TP)	NVIDIA Tesla P100	NVIDIA Tesla P100	NVIDIA Tesla V100	NVIDIA Tesla V100	TPU 3.0
Number of TP	400	2160	4352	27648	unknown
Theoretical Perf. (FP64)	2.2 PF	12.2 PF	37.2 PF	200 PF	unknown
Theoretical Perf. (DL)	8.6 PF	47.2 PF	550 PF	3.3 EF	100 PF / Pod
TOP500*	287	19	5	1	unknown
GREEN500*	7	6	8	5	unknown
#Nodes / Rack	6	36	34	16	unknown
#GPU / Rack	48	144	136	96	unknown
kW / Rack	22 kW	64.8 kW	67.33 kW	45-55 kW (est.)	unknown
DL Perf. / Rack	0.9 PF	3.1 PF	17 PF	12 PF	12.5 PF (100 PF / 8 rack)

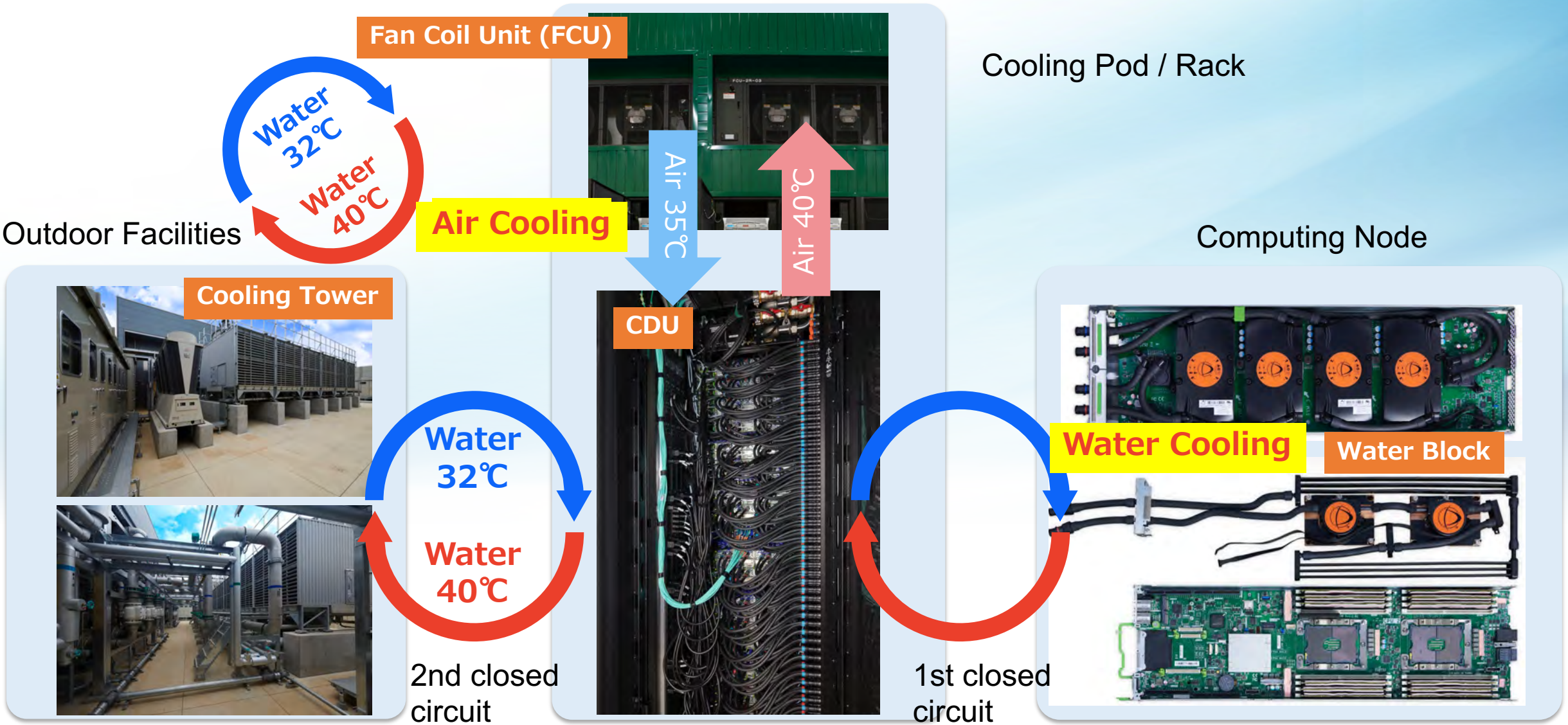
*June 2018

AI Datacenter
"Commoditizing supercomputer cooling technologies to Cloud (70kW/rack)"



- **Single floor, cost effective building**
- **Hard concrete floor 2t/m² weight tolerance for racks and cooling pods**
- **Number of Racks**
  - Initial: 90 (ABCI uses 41 racks)
  - Max: 144
- **Power capacity: 3.25 MW**
  - ABCI uses 2.3MW max
- **Cooling capacity: 3.2MW**
  - 70kW/rack: 60kW water + 10kW air

Free cooling with hybrid air/water cooling system



Optimizing AI data center operation using ML

Develop a framework for optimizing the operation of AI data center by self-adapting ML/DL technologies

World leading supercomputing systems for big data / AI

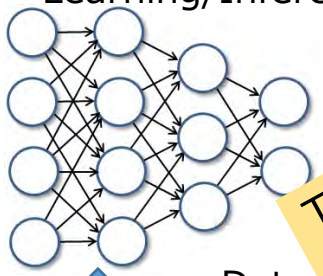
TSUBAME 3.0

ABCI

- Reduce power consumption
- Improve resource utilization
- Reduce HW maintenance fee using failure prediction

Data-driven operation

Learning/Inference

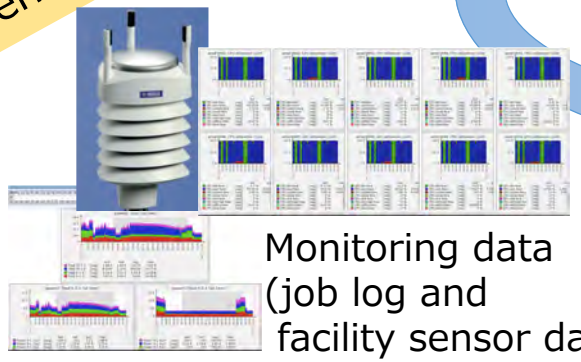


Train and apply parameters for improving the operation

Data analytics

Data for learning

Data center generates huge amount of sensor data

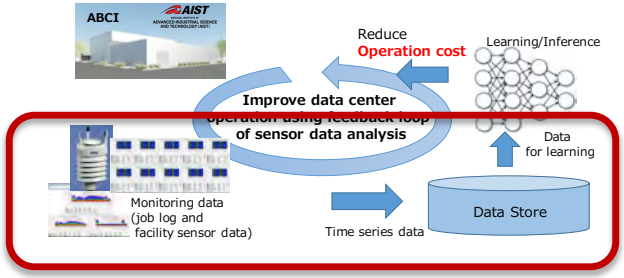


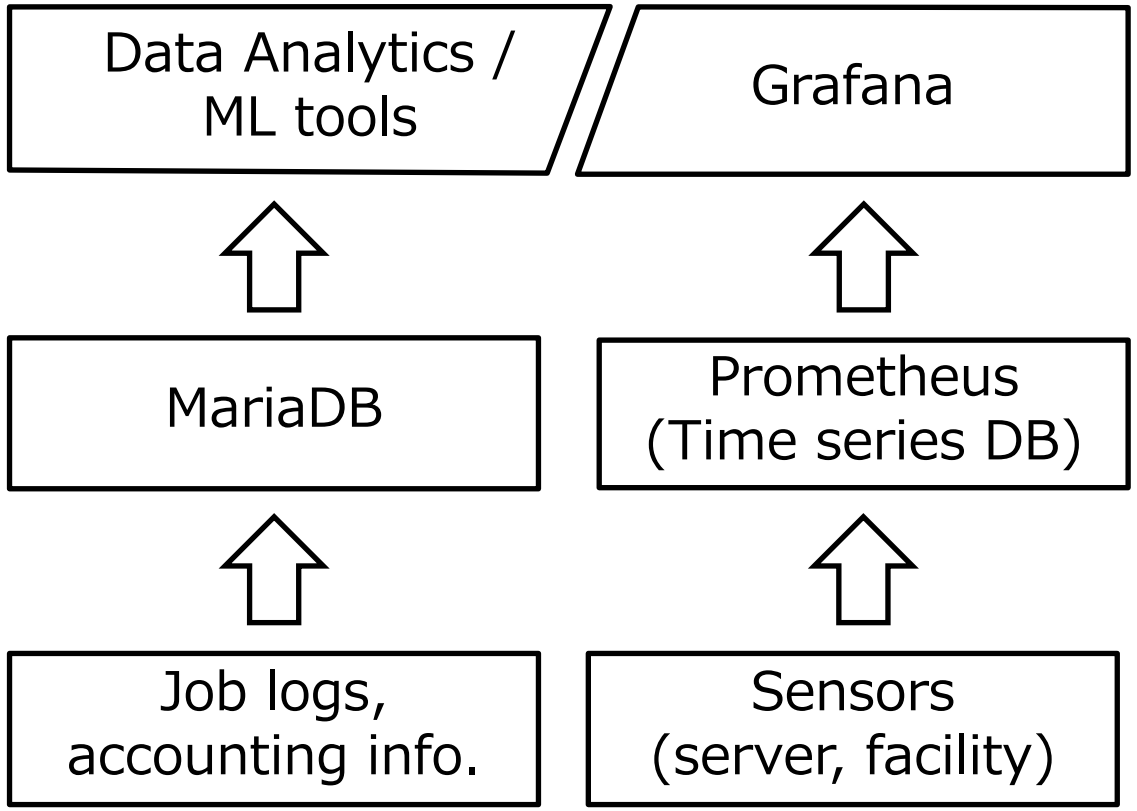
Monitoring

Monitoring data (job log and facility sensor data)

Data Store

Monitoring mechanism



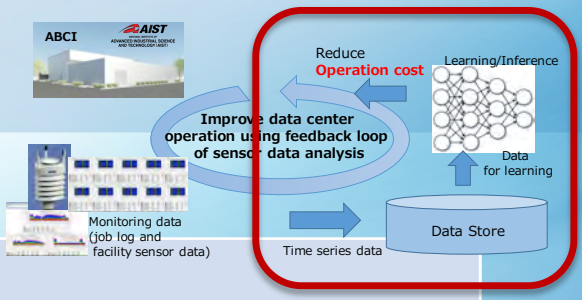


ABCI Facility Monitoring through Grafana

Collecting sensor data

Location	#items	Sampling rate	Sensors
Server	873	1 min.~1 hour	CPU/GPU usage, memory usage, I/O usage, temperature, power consumption, etc
IB/Ethernet Switch	6245	1 min.~1 hour	
Job scheduler	26	-	Job ID, account ID, group ID, job type, resource type, walltime, application info., etc
AI data center	408	1 sec.	Temperature (hot/cold aisle), rack inlet air temperature, humidity, power consumption
			FCU inlet/outlet temperature, power consumption, status
			Water temperature, volume of water flow, power consumption of pump, status, CDU
Site	8	1 min.	Temperature, humidity, wind speed/direction, rainfall

ABCI Software Stack



Software

Operating System	CentOS, RHEL
Job Scheduler	Univa Grid Engine
Container Engine	Docker, Singularity
MPI	OpenMPI, MVAPICH2, Intel MPI
Development tools	Intel Parallel Studio XE Cluster Edition, PGI Professional Edition, NVIDIA CUDA SDK, GCC, Python, Ruby, R, Java, Scala, Perl
Deep Learning	Caffe, Caffe2, TensorFlow, Theano, Torch, PyTorch, CNTK, MXnet, Chainer, Keras, etc.
Big Data Processing	Hadoop, Spark

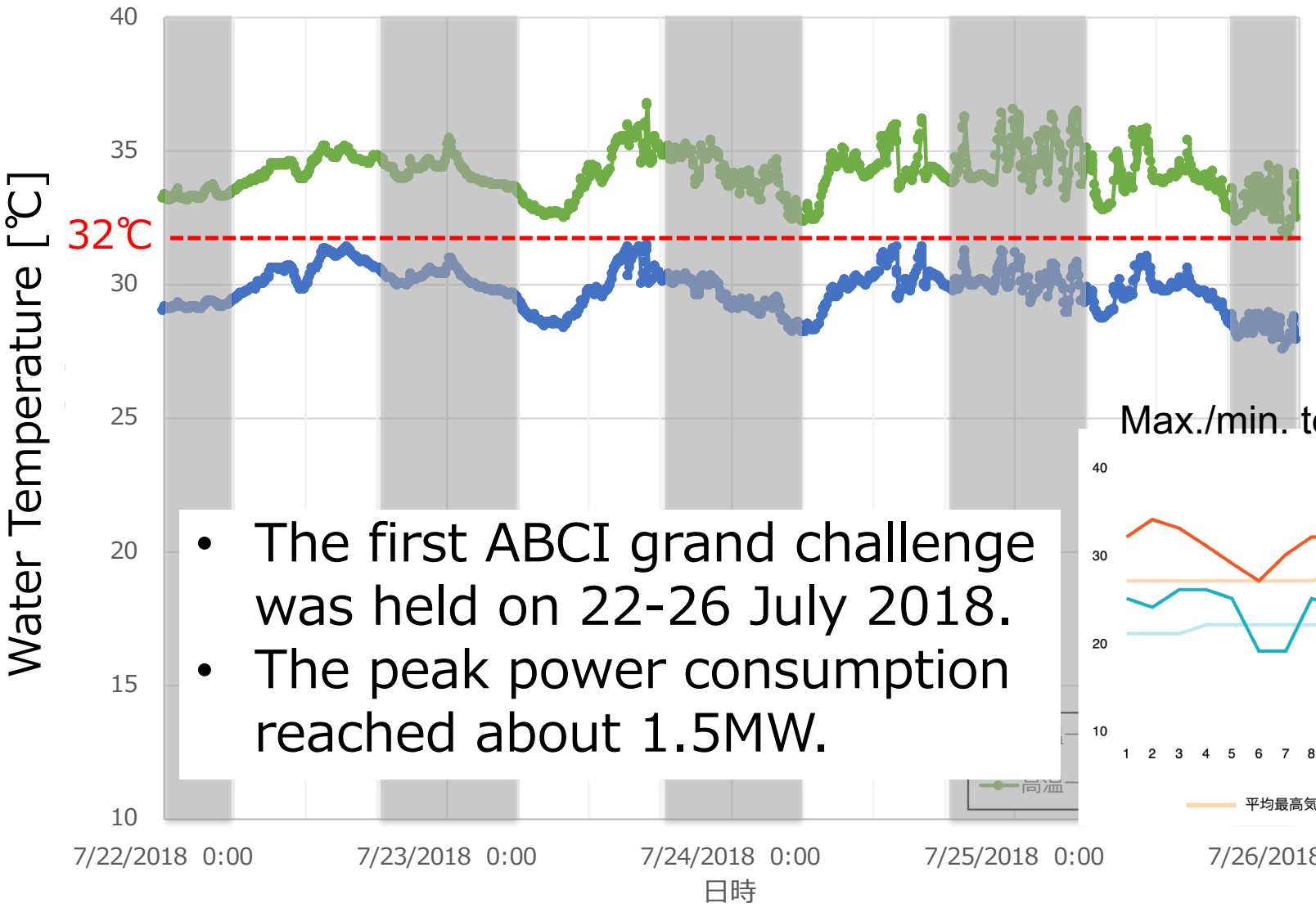
Container support

- Containers enable users to instantly try the state-of-the-art software developed in AI community
- ABCI supports two container technologies
  - **Docker**, having a large user community
  - **Singularity**, recently accepted HPC community
- ABCI provides various single-node/distributed deep learning framework container images optimized to achieve high performance on ABCI

Use Case 1:

EFFICIENT FACILITY CONTROL

100% free cooling is possible in high summer

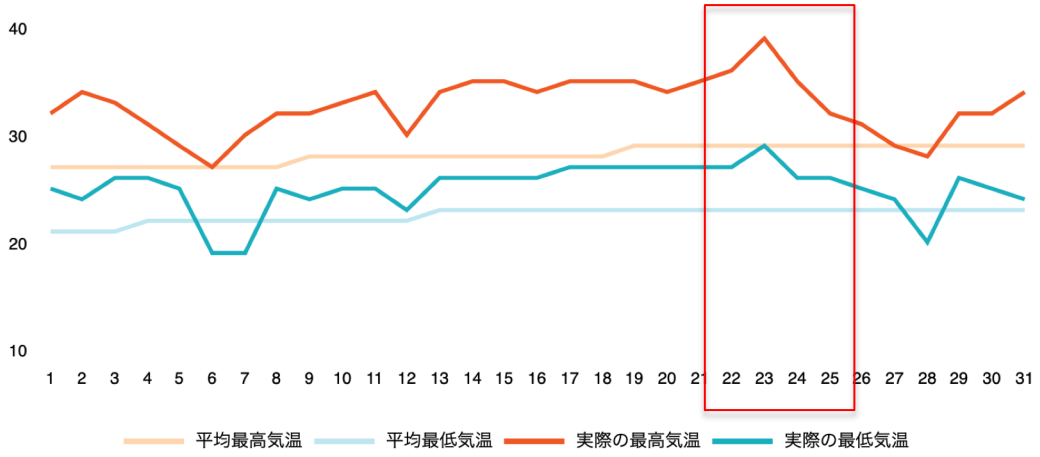


Cooling Water (From ABCI): <40℃

Cooling Water (To ABCI): <32℃

- The first ABCI grand challenge was held on 22-26 July 2018.
- The peak power consumption reached about 1.5MW.

Max./min. temperature in Kashiwa in July 2018



Use case 1: More efficient and smarter facility control

- Cooling towers cannot so quickly adjust the water temperature with server load fluctuation.
  - The longer water circuit loop, the slower response.
  - In some HPC/data centers, it might be serious.
- There is a chance of applying ML to improve utilization.
  - Workload prediction is enable to generate cooler water before coming heavy workload. That means...
  - Job scheduler executes more jobs under temperature constraint
  - GPU/CPU runs more higher frequency.

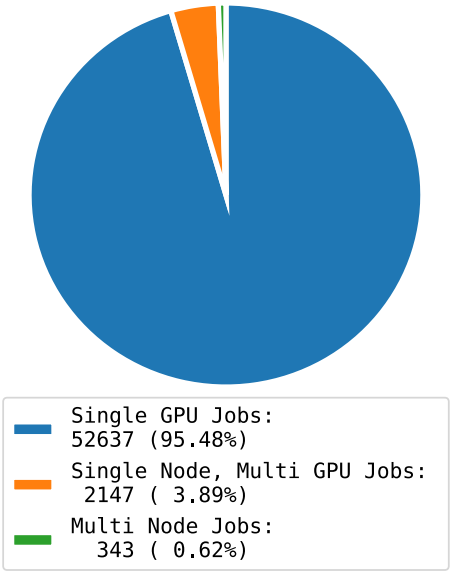
Use case 2:

EFFICIENT JOB SCHEDULING

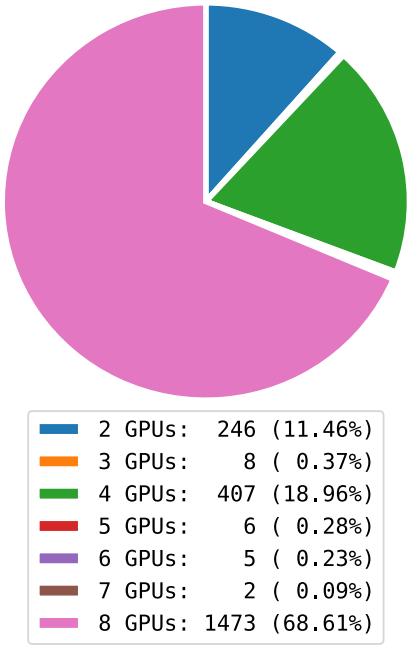
Preliminary data analysis for efficient deep learning job scheduling in AAIC (prototype system of ABCI)

- Analyze 55,127 jobs submitted on AAIC from 07/14/2017 to 12/31/2017
- 95% jobs are Single GPU jobs and WRA is too low, 0.103 on average.

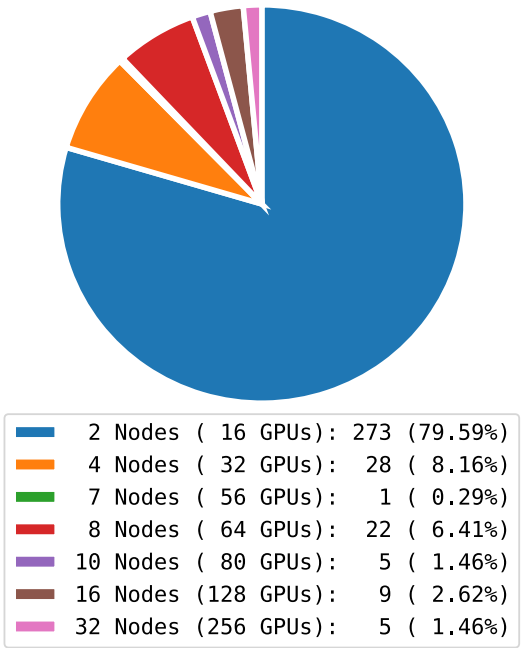
1 GPU/ Multi GPU / Multi Node Jobs



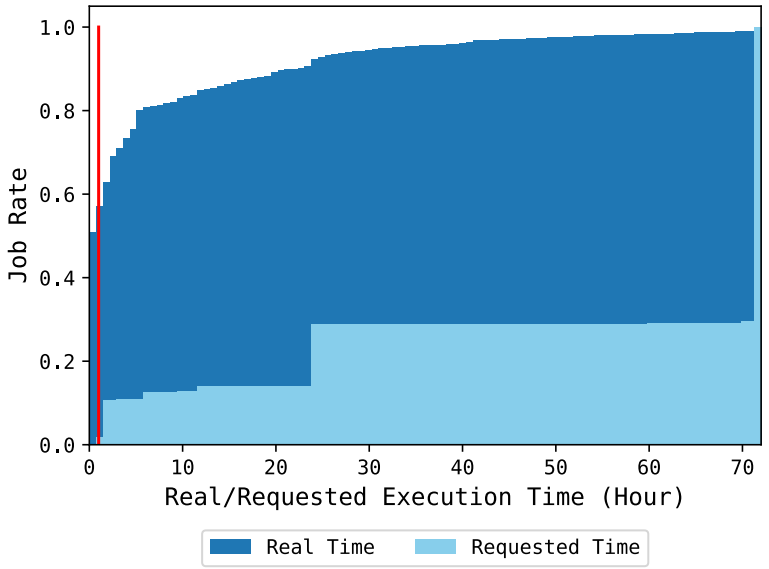
1 Node, Multi GPU Jobs



Multi Node Jobs



Walltime Request Accuracy (WRA)

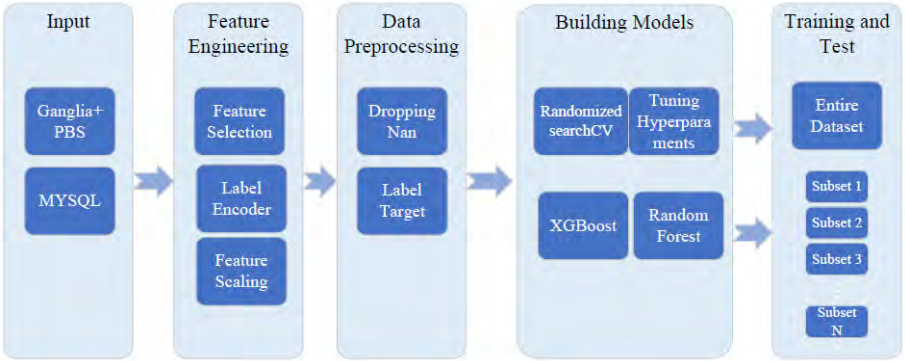


$$WRA_i = \frac{Walltime_i}{Walltime_Request_i}$$

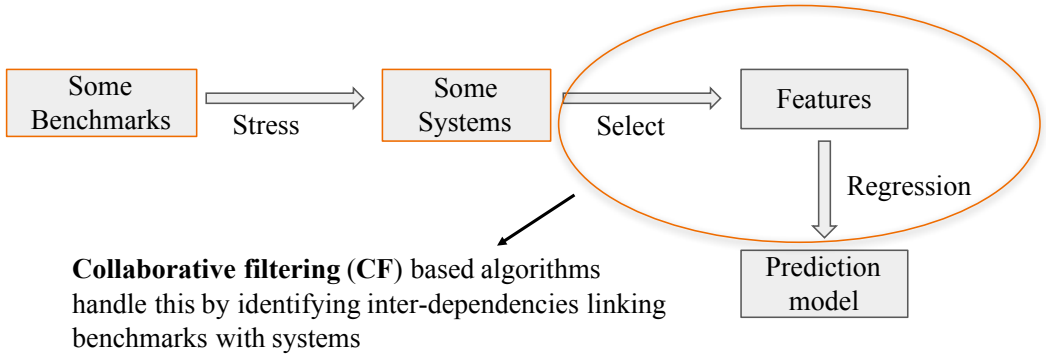
Use case 2: Efficient job scheduling

- Predicting job execution time and user incentive design to improve WRA are important for efficient job scheduling

Machine Learning Predictions for Underestimation of Job Runtime on HPC System [Guo2018]



Predicting Performance Using Collaborative Filtering [Salaria2018]



Use case 2: Efficient job scheduling

- Future work: Job scripts contains important information including package dependencies, program parameters, container image, which will greatly affect the efficiency and execution time of jobs.
  - E.g., Use CNN to process job scripts [Wyatt2018]

Thank you for your attention!

More Information is available!
https://abci.ai/

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