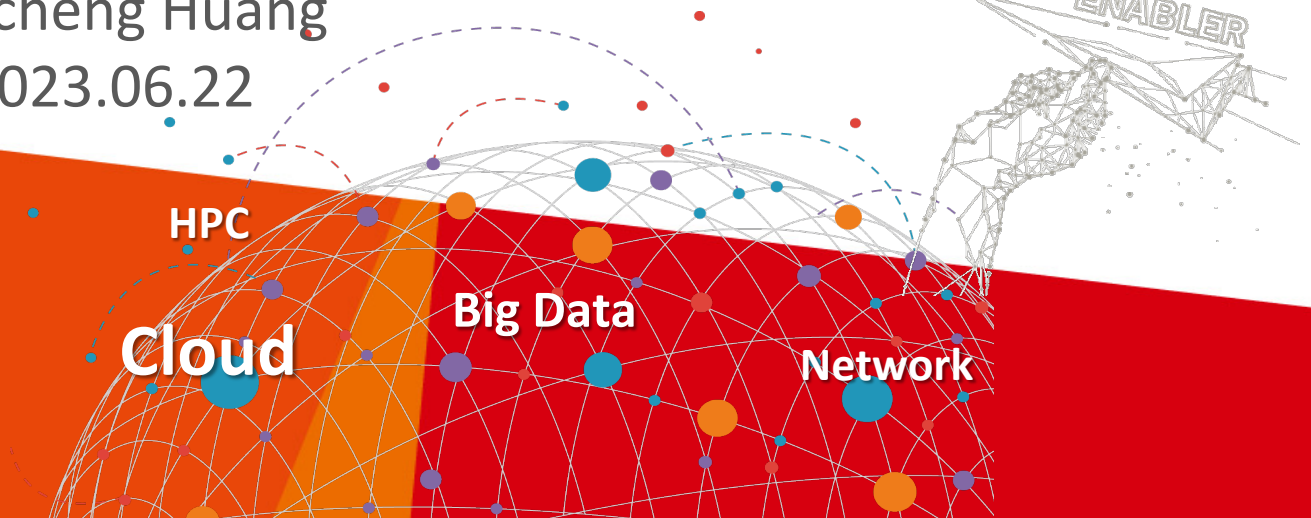
NARLabs
National Applied Research Laboratories
National Center for High-performance Computing

PRAGMA 39
Jakarta, Indonesia

Efforts toward "zero emission"

Weicheng Huang
2023.06.22

Commitment · Passion · Innovation



Tiered Service Architecture of NCHC

Application Development Platform

PaaS

Platform As A Service (PaaS)

DAS | Render Farm | AIOT | Block Chain | VR/AR

Data Service Platform

DaaS

Data As A Service (DaaS)

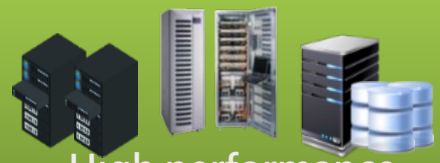
LIONS Bio info Platform | Civil IOT Taiwan | Data/Model Market | Taiwan Data Cube

Cloud Infrastructure and Network Service

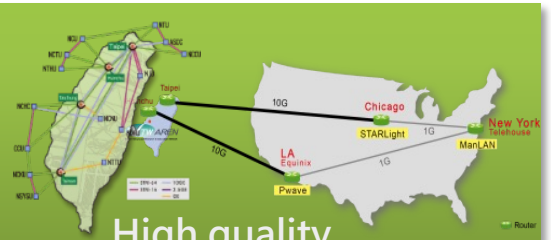
IaaS

Infrastructure As A Service (IaaS)

High performance computers
Big data analysis clusters



High performance storage equipment



High quality academic research network

Cyber Security

- Intelligence information analysis
- Cyber Defense Exercise Platform
- Privacy Enhancement Technologies
- Quantum Computing

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Power Saving Attempts

- ❖ Effectiveness of Power Consumption
- ❖ Promoting the Utilization of Computing Facility

- Power Usage Effectiveness (PUE) improvement
- Server hibernation
- Optimization of Job Queues Configuration

- Never a major power consumer
- Every effort counts

PaaS

Application of AIOT Platform

- Data Service
- AI Framework
- Dashboard
- SAS Composer

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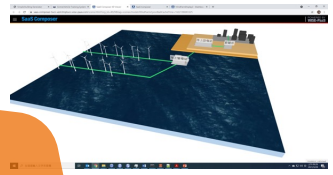
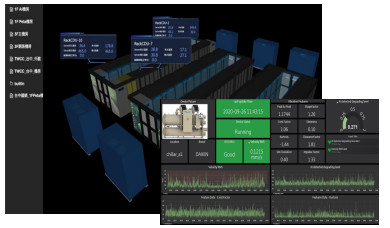
video analysis

offshore wind



Machine Room



Infrastructure monitoring of synchrotron radiation lab.

PM2.5
w/*international partners*

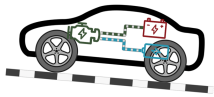
Development

Application

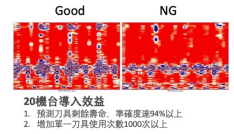
AIOT

collaboration

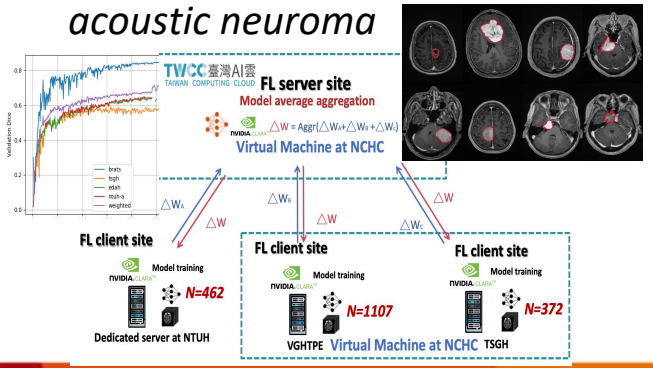
electric subsystem of Electric car



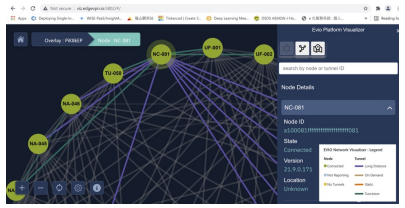
AI enhanced production line



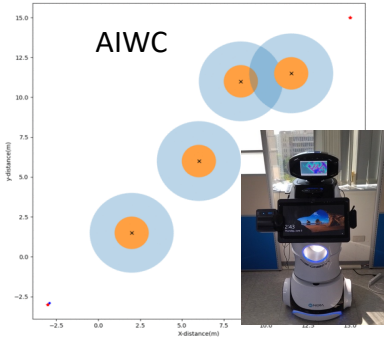
Federated Learning acoustic neuroma



R-Pi4 Cloud



navigation of Robots



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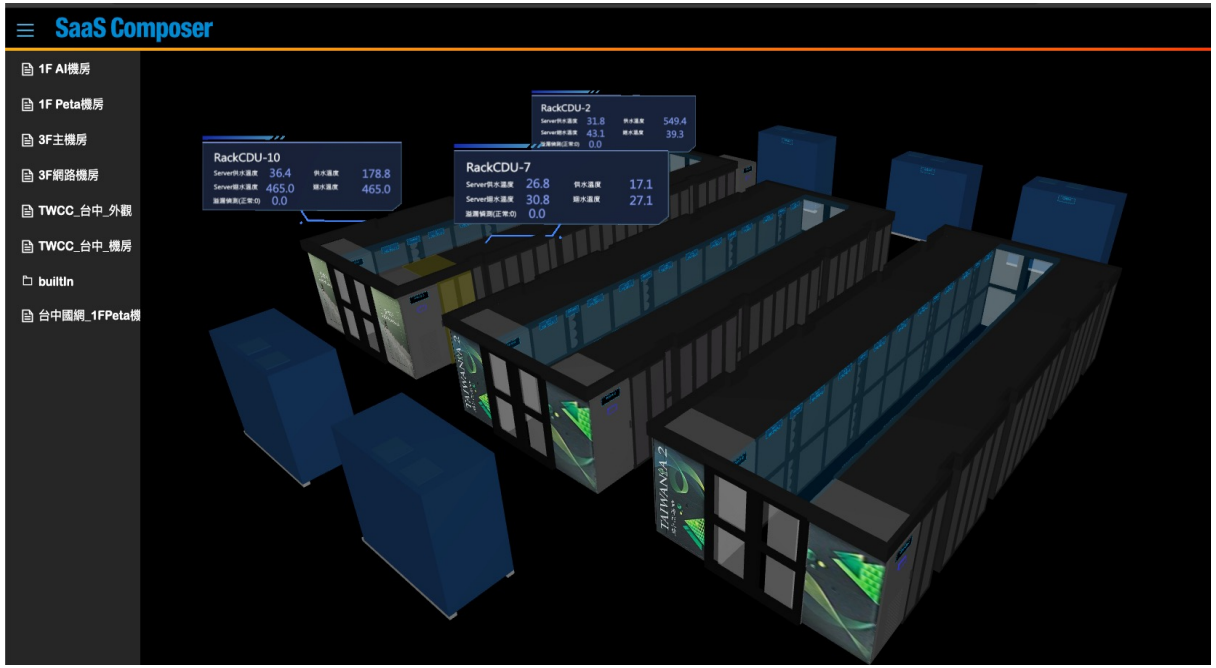
better than nothing – “legacy” machine room

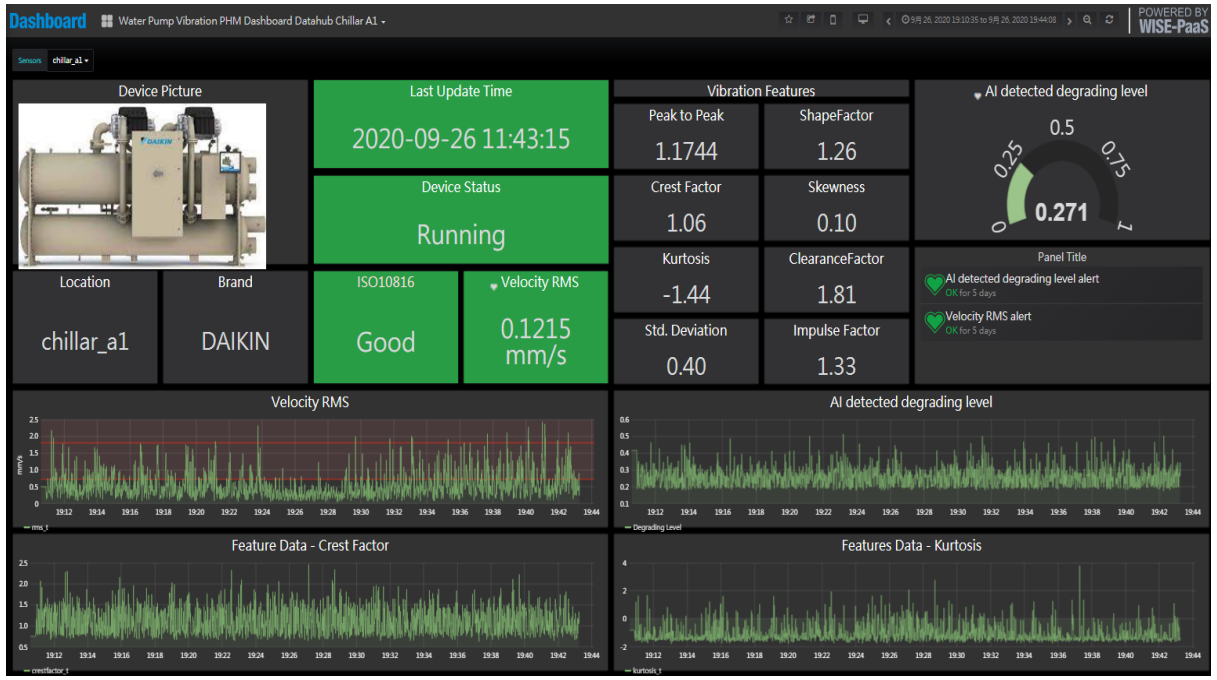
PUE IMPROVEMENT

AIOT Platform Monitoring MR



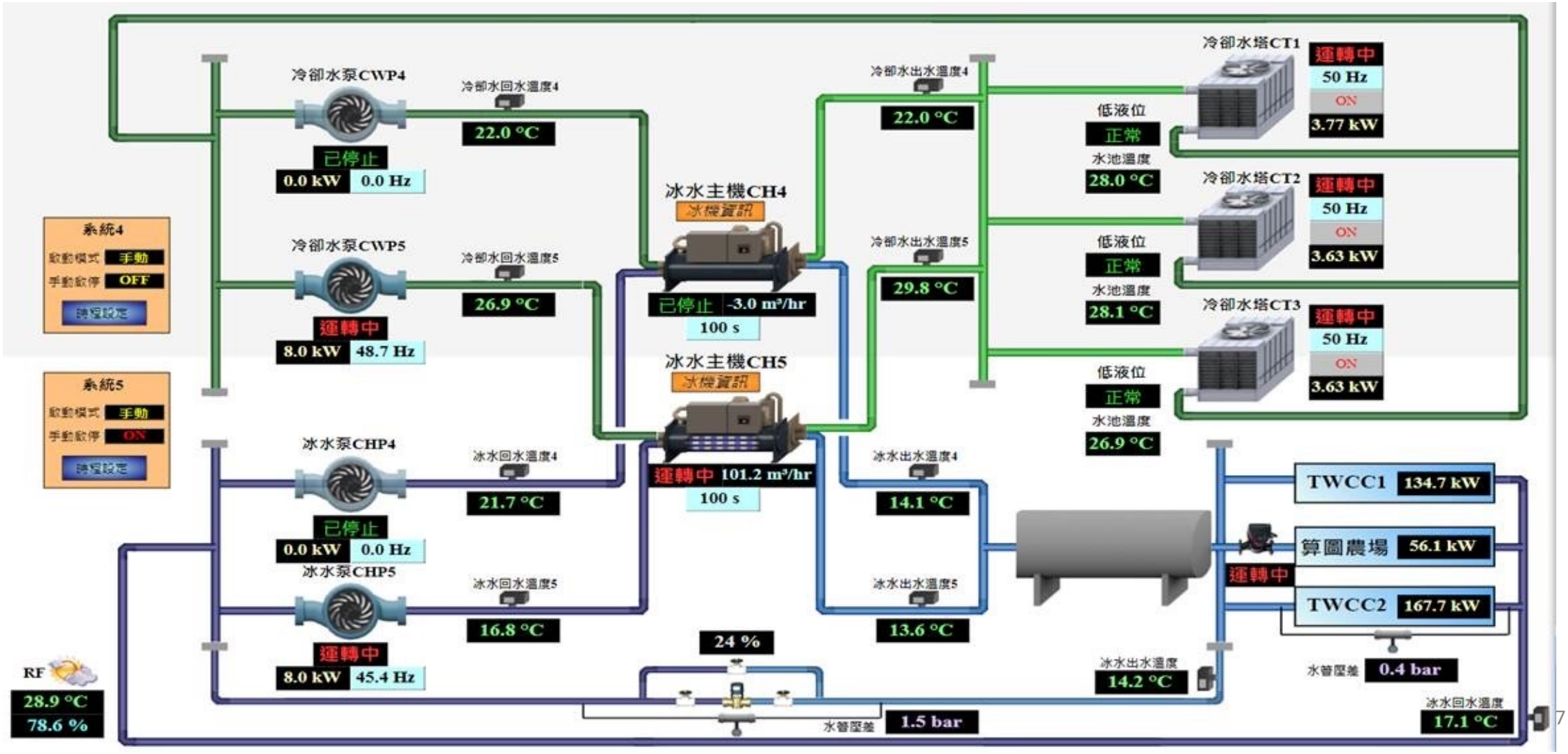
Environmental Monitor of Machine Room

Chiller Monitoring



Infrastructure of Machine Room

Used for training features selection



Data Preprocessing

COP = Coefficient of Performance = energy efficiency ratio = refrigeration_capacity@full load(watts)/electrical input power (watts)

- data investigated(features), 1/2

table name	description
tag Drivers.ModbusTcpNetwork.BTU.PROGRAM.RF_CH5_COP	chiller_5_COP
tag Drivers.ModbusTcpNetwork.BTU.PROGRAM.RF_CH5_KW	chiller_5_Refrigerating capacity
tag Drivers.ModbusTcpNetwork.BTU.RF_CH5_BTU.points.FLOW	chiller_5_ice water flow
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CHRT	chiller_5_ice water back water temperature
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CHST	chiller_5_ice water send water temperature
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CHST_SP	chiller_5_ice water temperature set point
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CH_DP	chiller_5_ice water pressure difference
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CWRT	chiller_5_cooling water back water temperature
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CWST	chiller_5_cooling water send water temperature
tag Drivers.ModbusTcpNetwork.CH.CH5.points.CW_DP	chiller_5_cooling water pressure difference
tag Drivers.ModbusTcpNetwork.CH.CH5.points.H_P	chiller_5_high pressure
tag Drivers.ModbusTcpNetwork.CH.CH5.points.KW	chiller_5_power consumption
tag Drivers.ModbusTcpNetwork.CH.CH5.points.L_P	chiller_5_low pressure
tag Drivers.ModbusTcpNetwork.INV.CT1_INV.points.HZ	cooling tower_1_fan frequency
tag Drivers.ModbusTcpNetwork.INV.CT1_INV.points.KW	cooling tower_1_fan power consumption
tag Drivers.ModbusTcpNetwork.INV.CT2_INV.points.HZ	cooling tower_2_fan frequency
tag Drivers.ModbusTcpNetwork.INV.CT2_INV.points.KW	cooling tower_2_fan power consumption
tag Drivers.ModbusTcpNetwork.INV.CT3_INV.points.HZ	cooling tower_3_fan frequency
tag Drivers.ModbusTcpNetwork.INV.CT3_INV.points.KW	cooling tower_3_fan power consumption
tag Drivers.ModbusTcpNetwork.PUMP.CHP5_INV.points.HZ_F	ice water pump_5_frequency
tag Drivers.ModbusTcpNetwork.PUMP.CHP5_INV.points.KW	ice water pump_5_power consumption
tag Drivers.ModbusTcpNetwork.PUMP.CWP5_INV.points.HZ_F	cooling water pump_5_frequency
tag Drivers.ModbusTcpNetwork.PUMP.CWP5_INV.points.KW	cooling water pump_5_power consumption

Data Preprocessing

- data investigated(features), 2/2

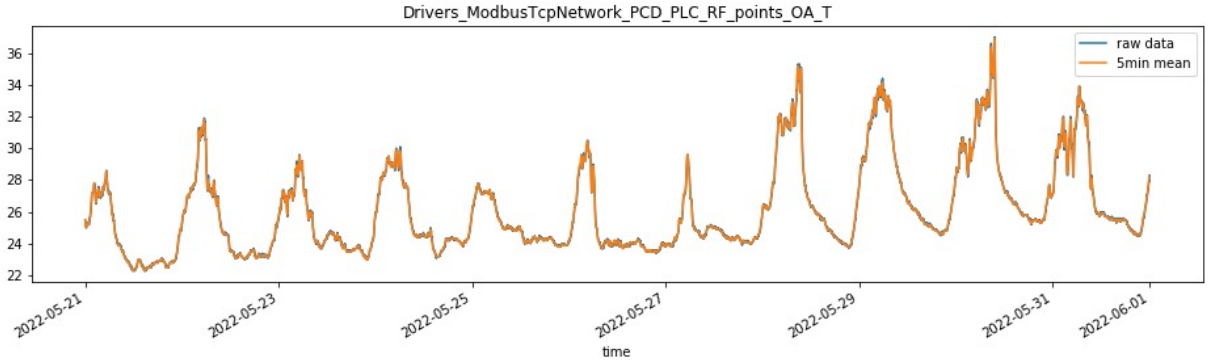
table name	description
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.AI_PIT	TWCC2_IT electricity consumption
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.AI_PM	TWCC2_facility electricity consumption
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.FARM_PIT	rendering farm_IT electricity consumption
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.FARM_PM	rendering farm_facility electricity consumption
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.TWCC_PIT	TWCC1_IT electricity consumption
Drivers.AbstractMqttDriverNetwork.AbstractMqttDriverDevice.points.PUE.TWCC_PM	TWCC1_facility electricity consumption
Drivers.ModbusTcpNetwork.PCD.PLC_RF.points.OA_RH	ambient humidity
Drivers.ModbusTcpNetwork.PCD.PLC_RF.points.OA_T	ambient temperature (dry bulb)

table name	description
Drivers.ModbusTcpNetwork.PCD.PLC_3F_XDP.points.$33F_AI_CHST	Cold Tank send water temperature
Drivers.ModbusTcpNetwork.PCD.PLC_3F_XDP.points.$33F_AI_CHRT	total back water temperature
Drivers.ModbusTcpNetwork.INROW.INROW3_SUPPLY_AIR_TEMP	rendering farm env. temperature
Drivers.ModbusTcpNetwork.TRH.$33F_TRH.points.$33F_TRH13_T	TWCC1 env. temperature
Drivers.ModbusTcpNetwork.TRH.$33F_TRH.points.$33F_TRH14_T	TWCC2 env. temperature

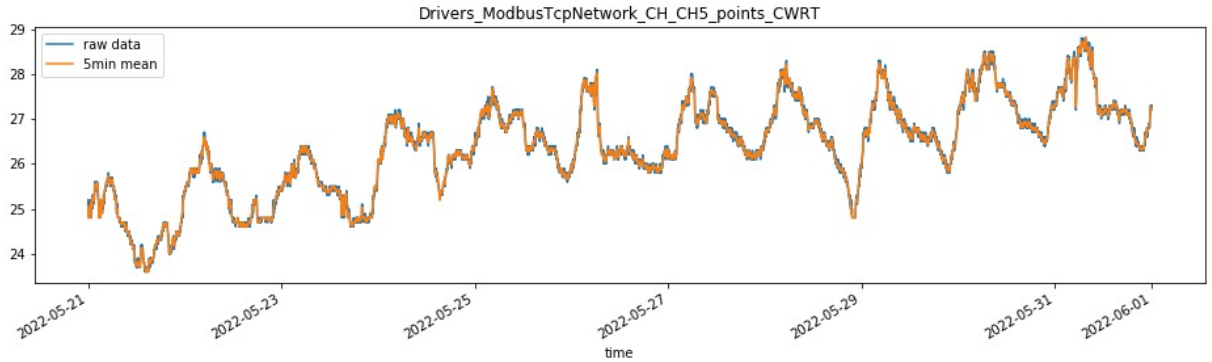
TWCC1/TWCC2 & rendering farm are computers
IT electricity = the electricity used by the computer itself
facility electricity = misc. electricity used to support the computer

Sample of Data

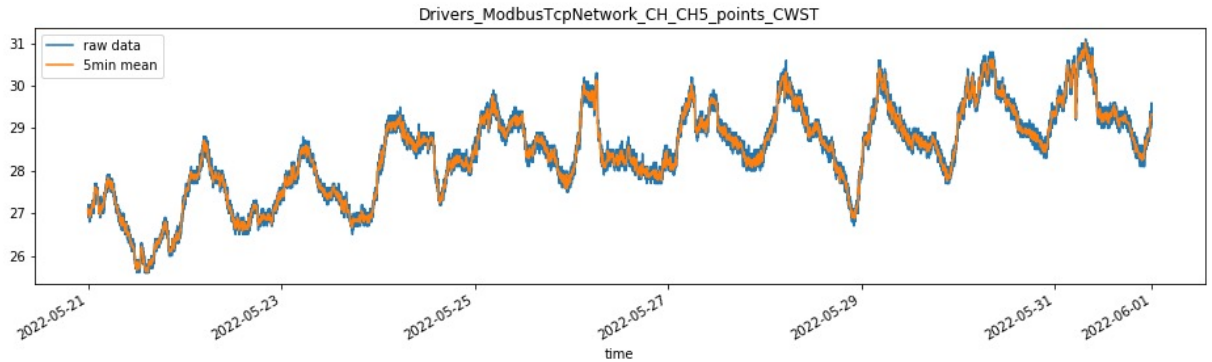
external Temperature



water temp. of chiller : return from MR

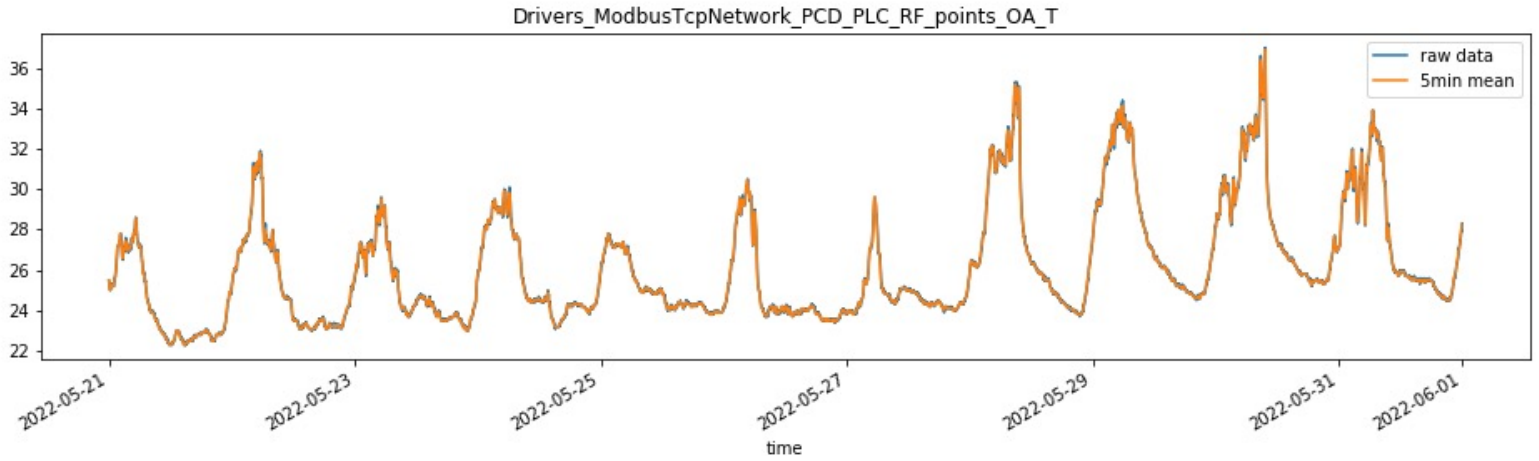


water temp. of chiller : fed to MR

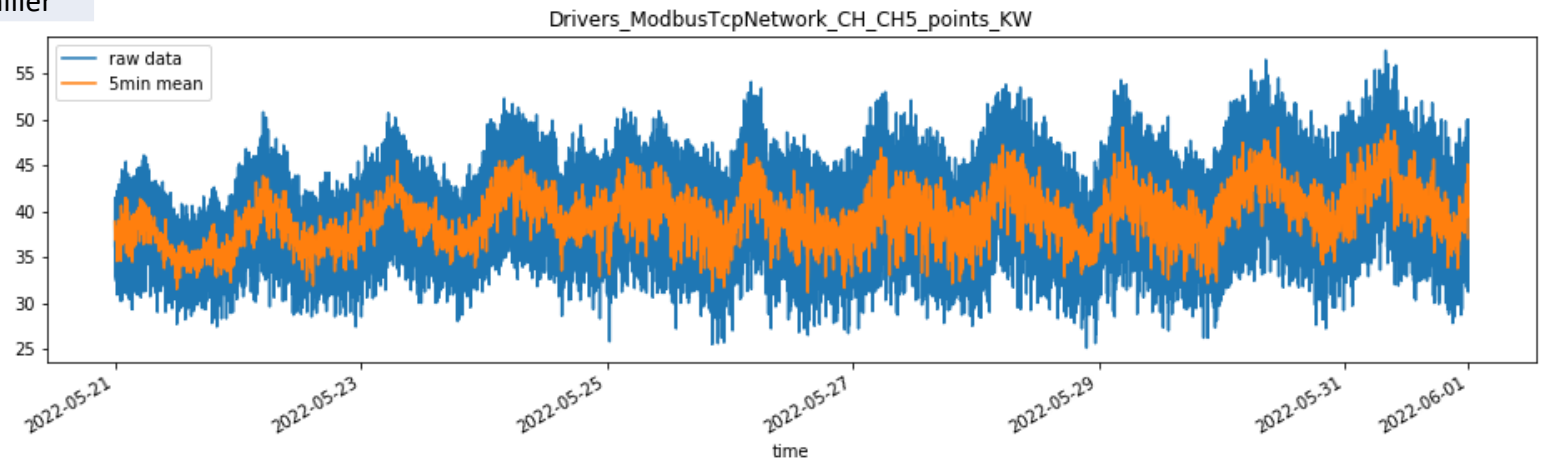


Sample of Data

external Temperature



power consumption of chiller



ML model training – model selections

- MLP
- RNN
- LSTM
- RF & XGBoost
- Auto-AI via commercial software (ARIMA)

Initial Results

Random Forest PUE

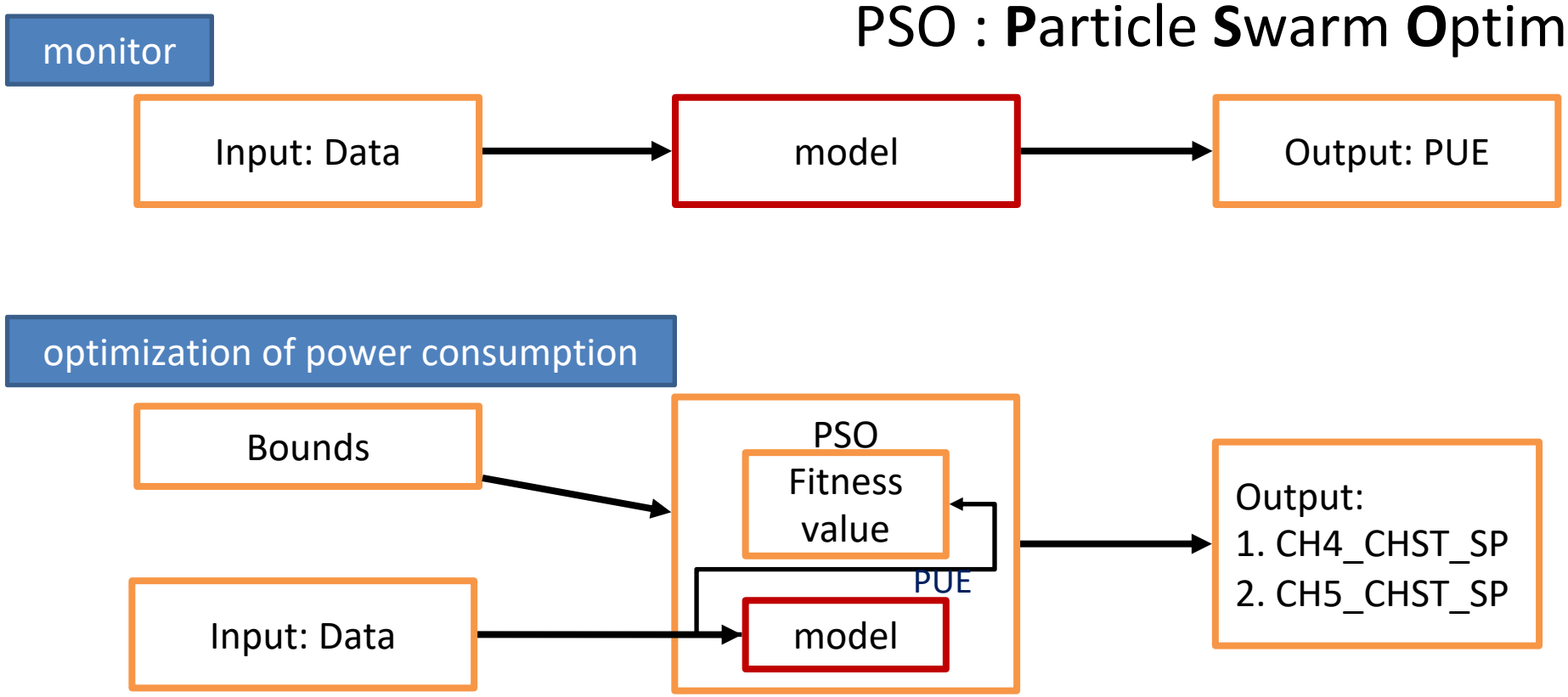
XGBoost PUE

ML algorithm	R2_score	dataset
LSTM	0.568	11 days/5min
RF	0.9405	1 yr/5min
XGboost	0.9427	1 yr/5min
AutoAI(ARIMA)	0.560	1 yr/1hr

PUE optimization procedure – PSO

- currently, use on chiller only

PSO : **P**article **S**warm **O**ptimization



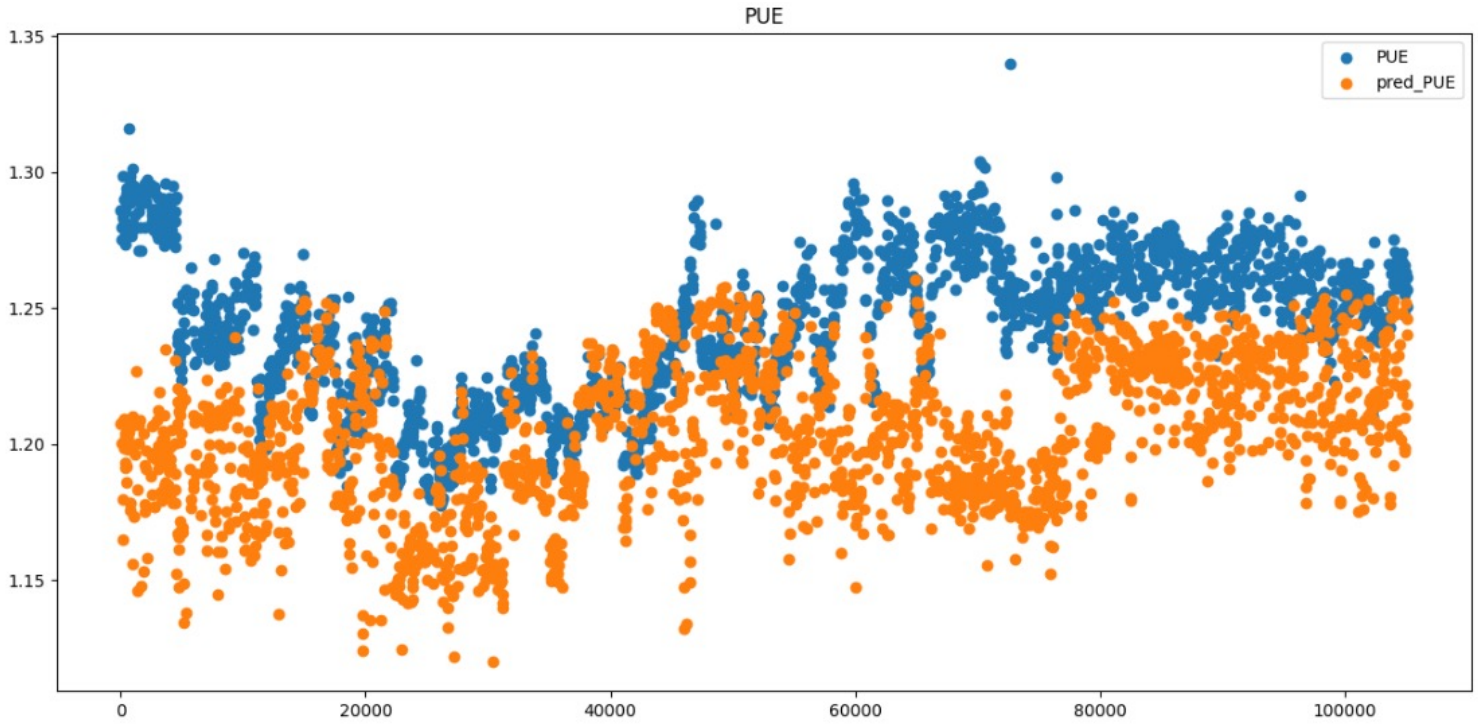
CH4_CHST_SP : ice water temperature set point of chiller 4
CH5_CHST_SP : ice water temperature set point of chiller 5

Chiller Temperature Adjustment via PSO

- Components adjusted
  - Chiller water temp. fed into the MR
  - Power consumption of water tower
  - Frequence of turbine of water tower

Prdicted Power Saving : 3.208%

$$power\ saving = \frac{PUE_{real} - PUE_{pso}}{PUE_{real}}$$



ML algorithm	R2_score	Dataset
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AutoAI(ARIMA)	0.560	1 yr/1hr

Implementation is yet to be decided

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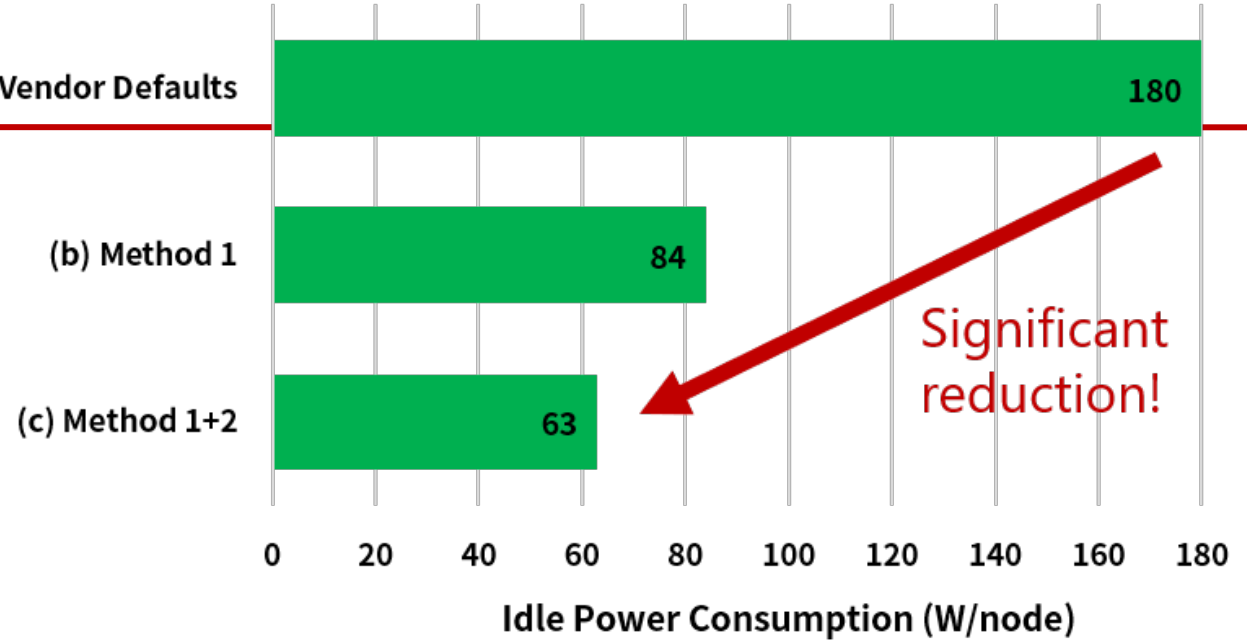
utilize the build-in features

HIBERNATION

Server Hibernation



- Taiwania 3
  - Utilization : ~ 75%
    - Seasonal fluctuation of loading
    - CPU @ turbo frequency – full speed
- BIOS configuration tuning
  - c-state enabled
    - vendor-supplied BIOS defaults : raw performance w/C-states disabled
  - BIOS prioritization modified
    - efficiency PPW, instead of raw performance.
- System sleep enabling
  - RAID controller kernel driver fixed
    - prevent the system sleep
  - Suspend-to-idle (ACPI S0) sleep state become available
    - Awaken on demand with help from the Slurm scheduler

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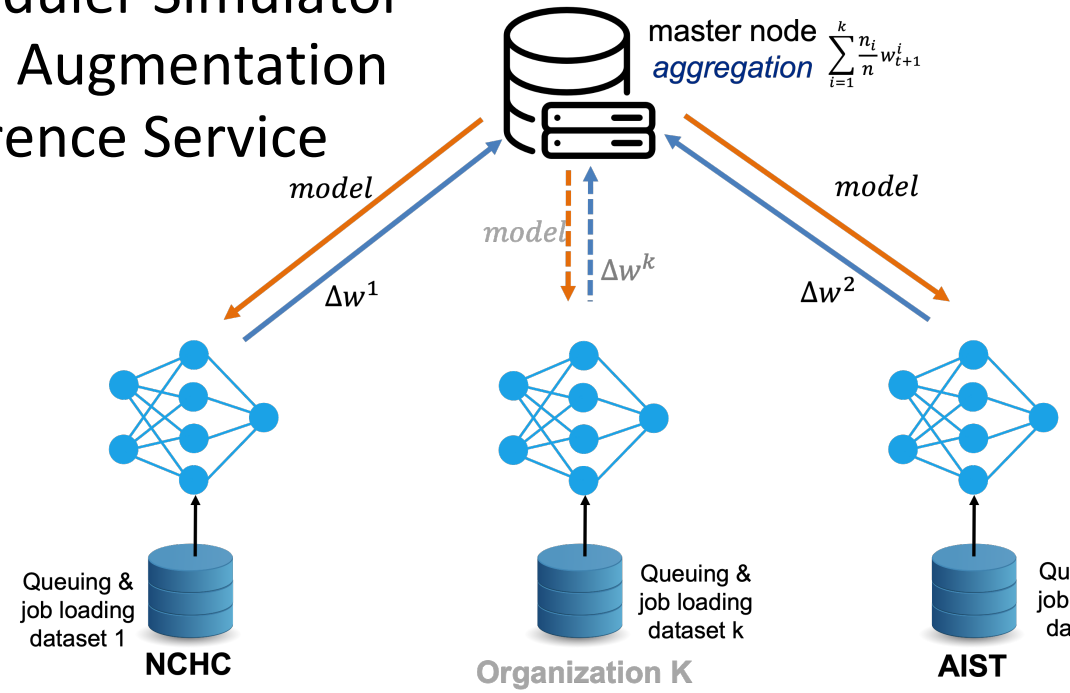
the other way around – utilization of computing resource

OPTIMIZATION OF JOB QUEUES CONFIGURATION

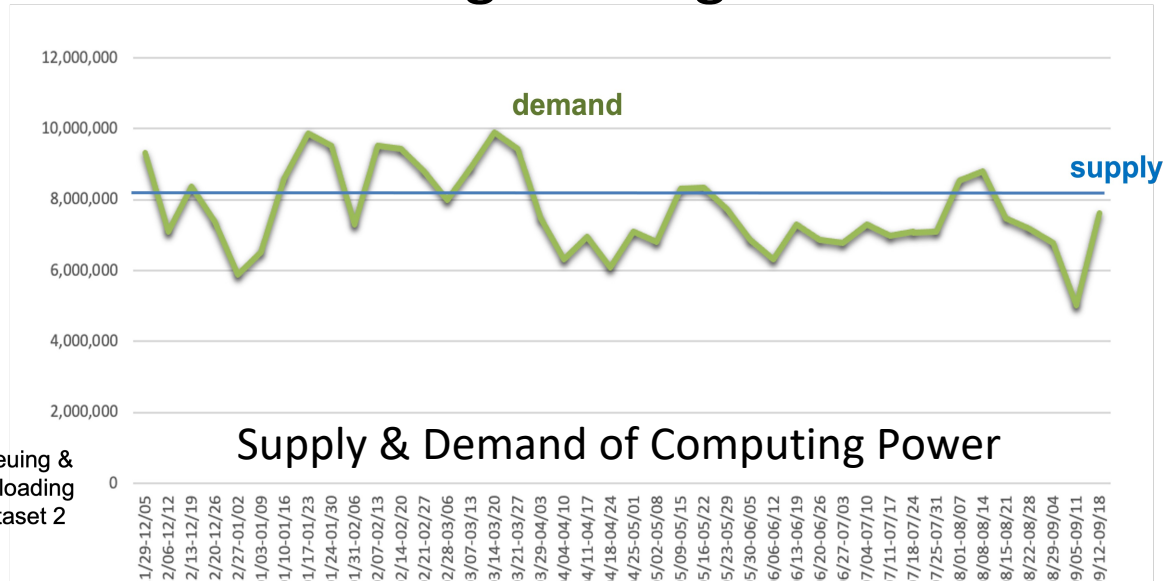
International Federated Learning Platform – AI-enhanced Queues configuration for Supercomputer

Purpose of platform：remedy of difficulty in data sharing

- Technology involved
  - Machine Learning
  - Federated Learning framework
  - Normalization of data
  - Scheduler Simulator
  - Data Augmentation
  - Inference Service



- Application – not limited to…
  - Optimization of HPC queues
  - ML across organizations w/o actual data sharing
  - Sensitive data
  - Data too large to migrate



Call for Participation