ENI PoC #11: Intelligent Energy Management of DC

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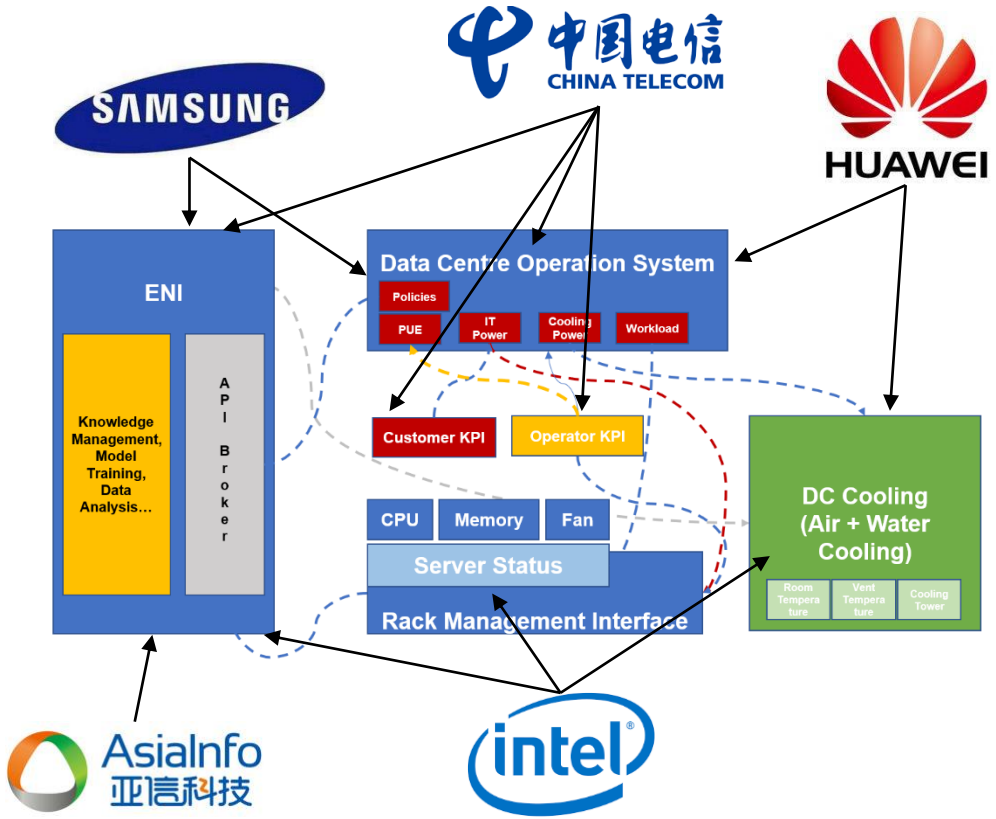
PoC member, tasks and goals

Host/Team Leader:

中国电信 CHINA TELECOM

Team members:

intel HUAWEI SAMSUNG AsiaInfo 亚信科技



- ✓ **PoC Project Goal #1:** DC profile analysis. Demonstrate the use of AI-based methods to analyze energy related data, e.g. DC dynamic environment and IT workload data etc..
- ✓ **PoC Project Goal #2:** Policy-based, model-driven DC Energy Management. Demonstrate the use of AI algorithms to enable policy-based and model-driven energy management..

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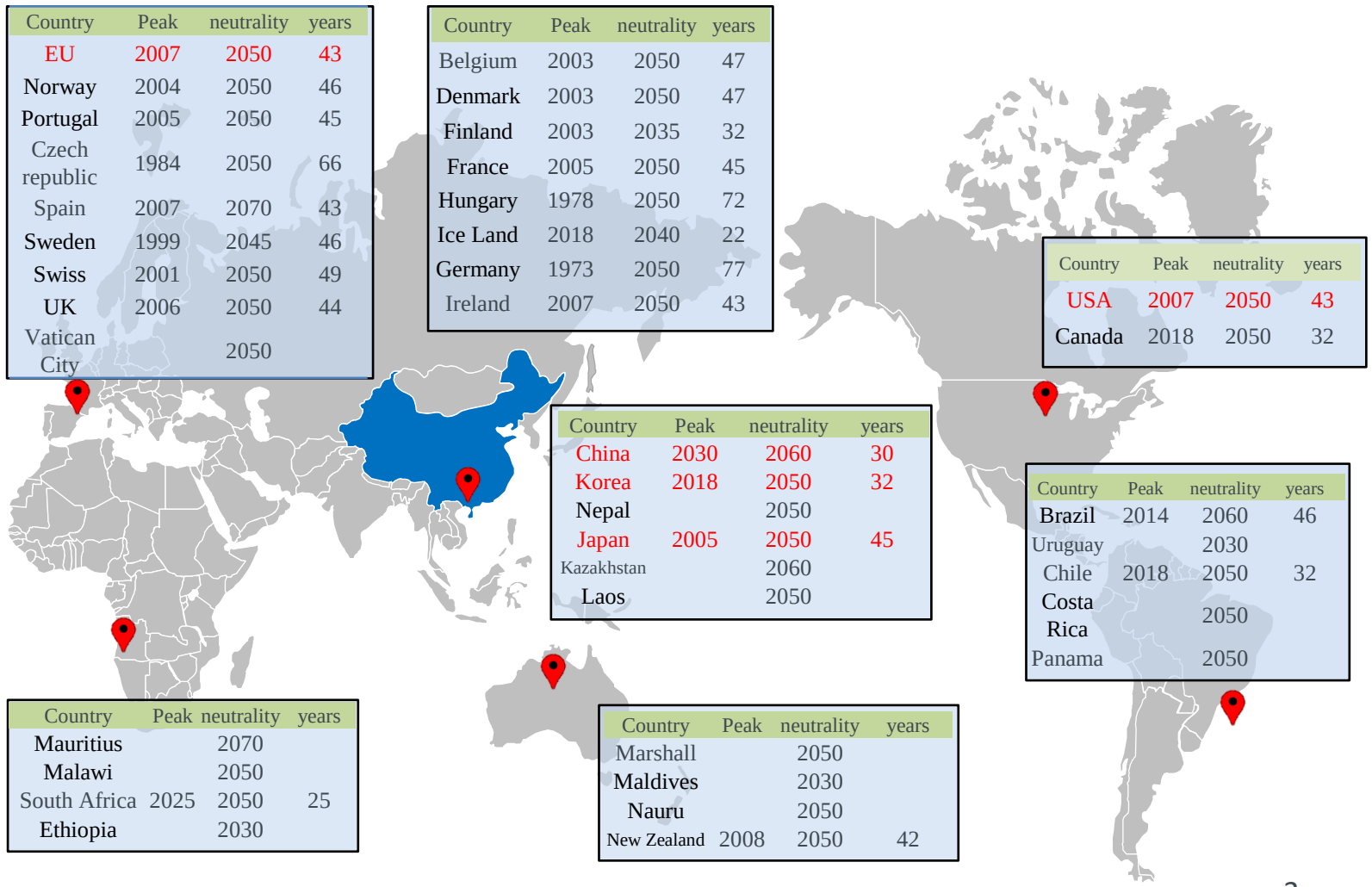
PoC Motivations: globally, many countries promised to zero carbon emissions (ZCM) by 2050

Currently, data centers around the world consume about 200TWh of electricity per year, accounting for about 1% of global electricity consumption. It is expected that data centers around the world will consume 20% of global electricity by 2025.

In order to actively deal with global climate change, 30 countries have started the process of moving towards ZCM and decided to ZCM before 2050. It is imperative for global DC to save energy and reduce emissions.

Industries are heavy on electricity bills. The space for traditional energy saving method is limited, whicn cannot match the energy saving demands for diversified business ecology towards 5G. Hence, intelligent energy saving of DC plays an overall and key role.



Country	Peak	neutrality	years
EU	2007	2050	43
Norway	2004	2050	46
Portugal	2005	2050	45
Czech republic	1984	2050	66
Spain	2007	2070	43
Sweden	1999	2045	46
Swiss	2001	2050	49
UK	2006	2050	44
Vatican City		2050	

Country	Peak	neutrality	years
Belgium	2003	2050	47
Denmark	2003	2050	47
Finland	2003	2035	32
France	2005	2050	45
Hungary	1978	2050	72
Ice Land	2018	2040	22
Germany	1973	2050	77
Ireland	2007	2050	43

Country	Peak	neutrality	years
USA	2007	2050	43
Canada	2018	2050	32

Country	Peak	neutrality	years
China	2030	2060	30
Korea	2018	2050	32
Nepal		2050	
Japan	2005	2050	45
Kazakhstan		2060	
Laos		2050	

Country	Peak	neutrality	years
Brazil	2014	2060	46
Uruguay		2030	
Chile	2018	2050	32
Costa Rica		2050	
Panama		2050	

Country	Peak	neutrality	years
Mauritius		2070	
Malawi		2050	
South Africa	2025	2050	25
Ethiopia		2030	

Country	Peak	neutrality	years
Marshall		2050	
Maldives		2030	
Nauru		2050	
New Zealand	2008	2050	42

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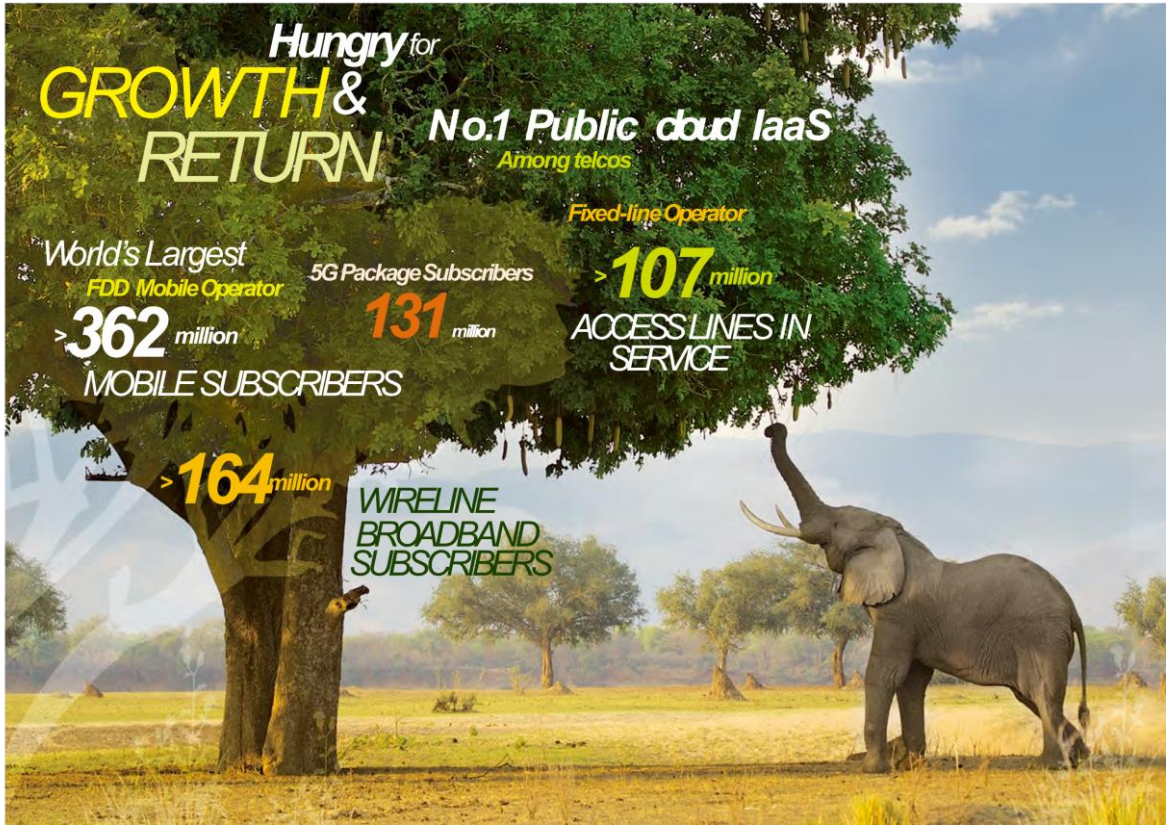
China Telecom IDC

- Largest service provider in China
- Mainstream internet ecosystem support

Connecting over 300 cities

- IDC Site: 700+ (large scale)
- Rack No.: 420K+
- Bandwidth: 300T+

China Telecom Facts*:



*Data taken from Deloitte 2020 China Telecom annual report

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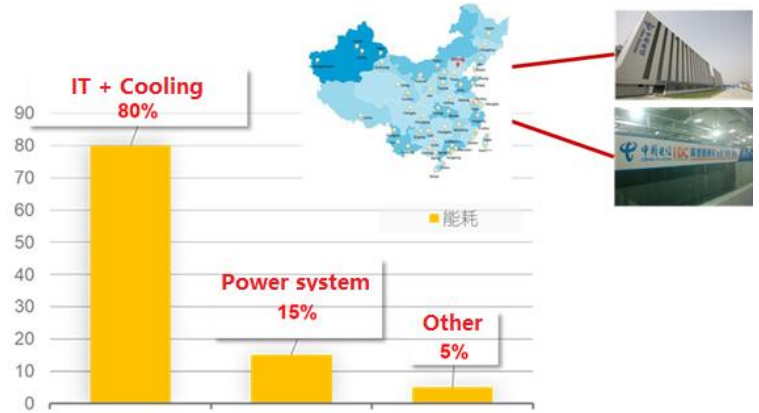
Traditional IDC power saving reached ceiling

Challenges

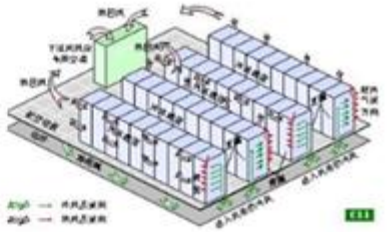
- High energy consumption
- IT load(50%), cooling(30%+), lighting etc.
- 5G edge DC number increasing

Traditional IDC power saving

- CFD optimization
- Temperature tunning
- Power off low load equipment
- Electricity bill discount
- Natural cooling



Temperature Tunning



CFD

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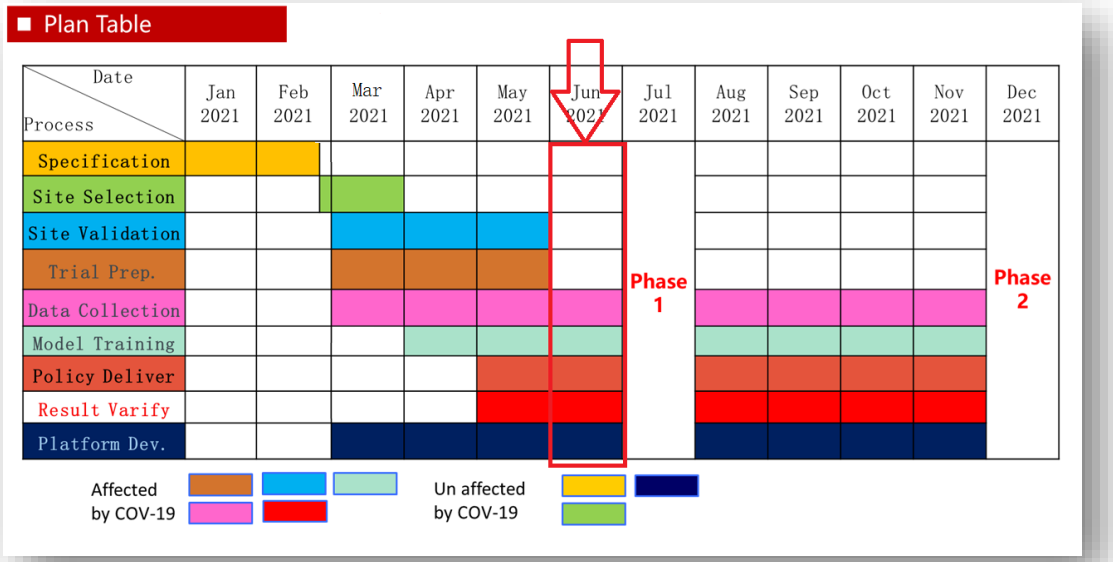
2021 Task Plan



IDC Energy Management Platform online (V3)

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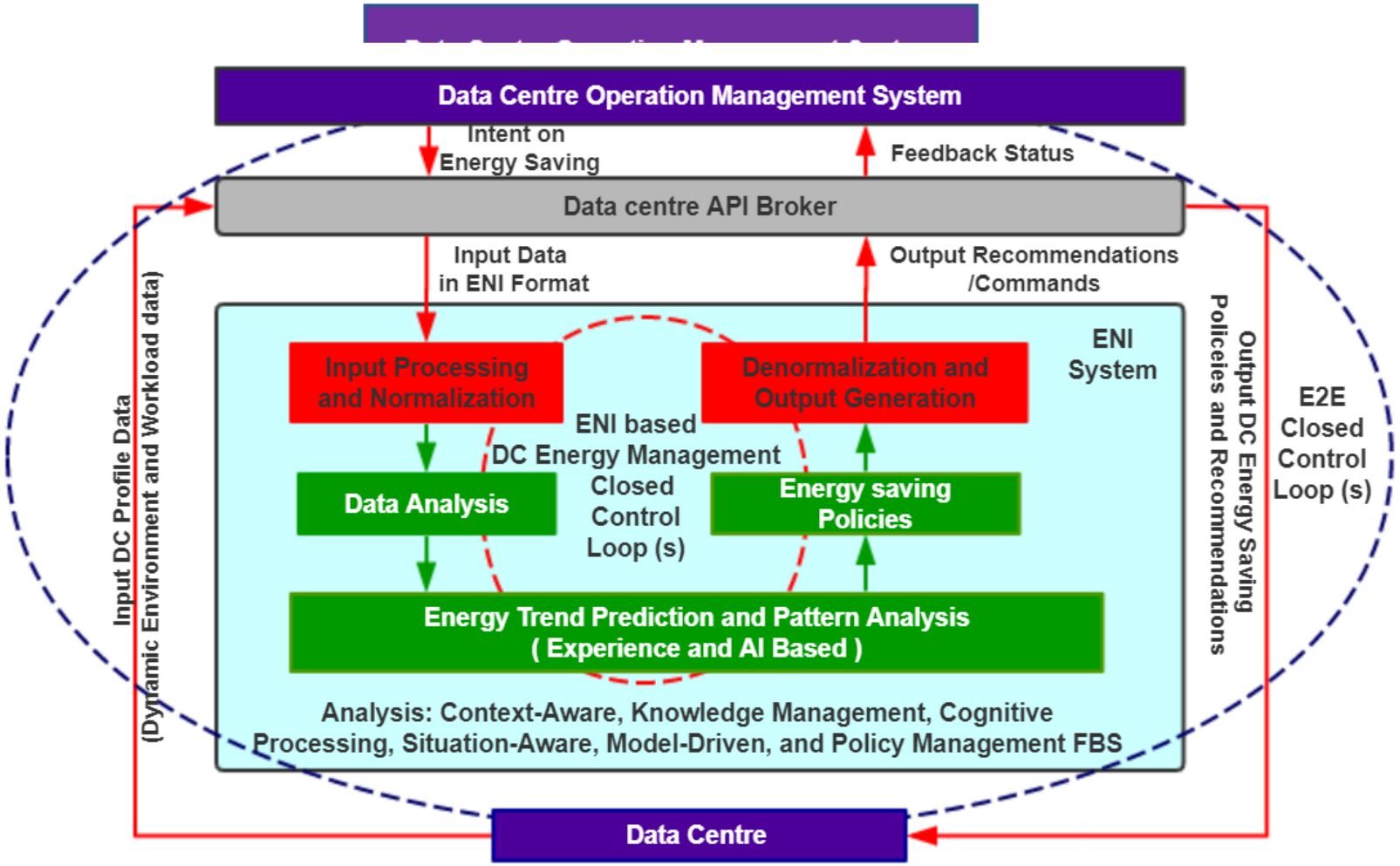
Reference to ENI Architecture



Energy-saving cloud system

Cloud
- Massive data analysis
- Policy generation
- Policy management...

Edge
- Policy execution
- Context-Aware
- Feedback status...

End
- Data Ingestion

(Such as DC sensor data)...

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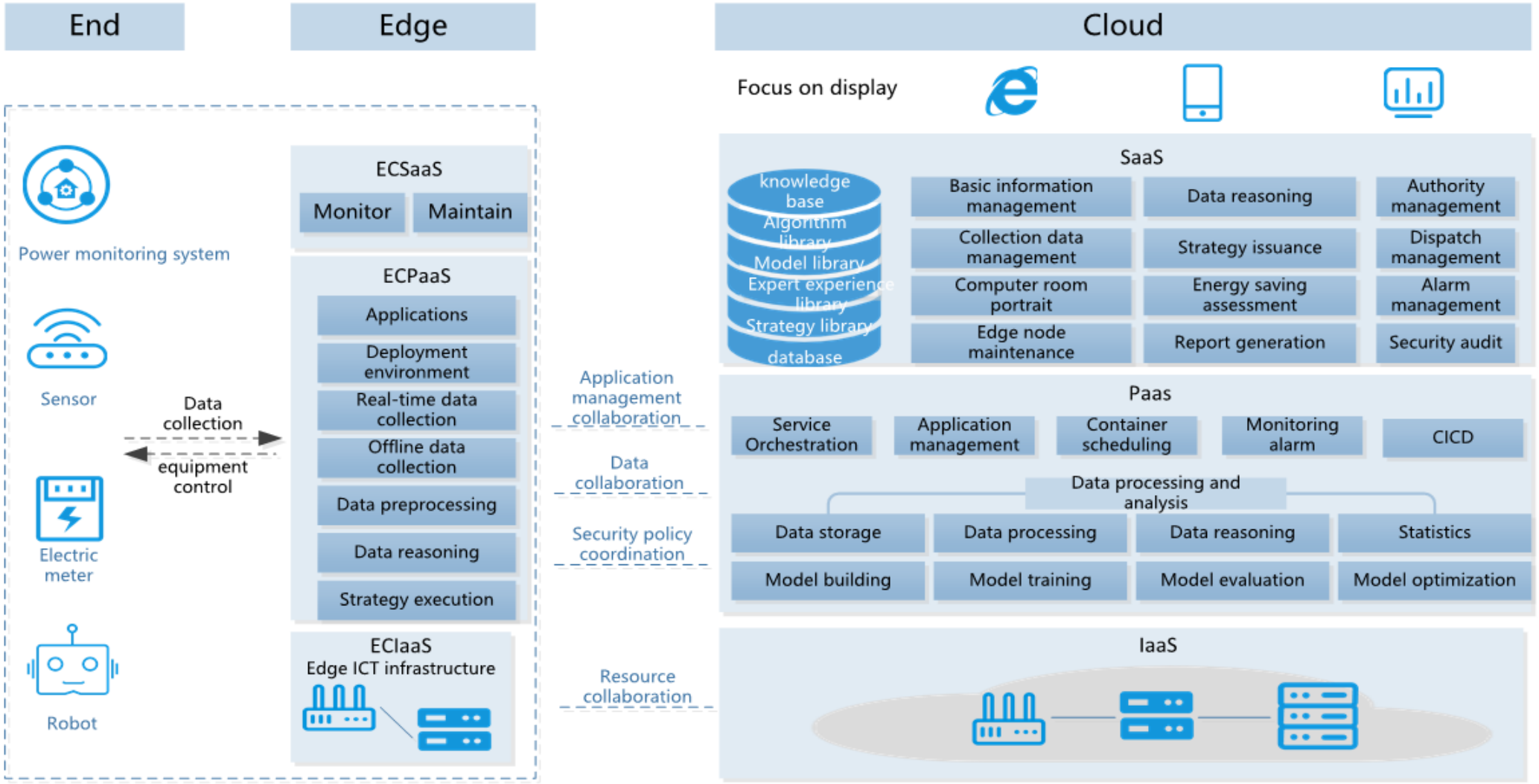
Architecture of PoC System



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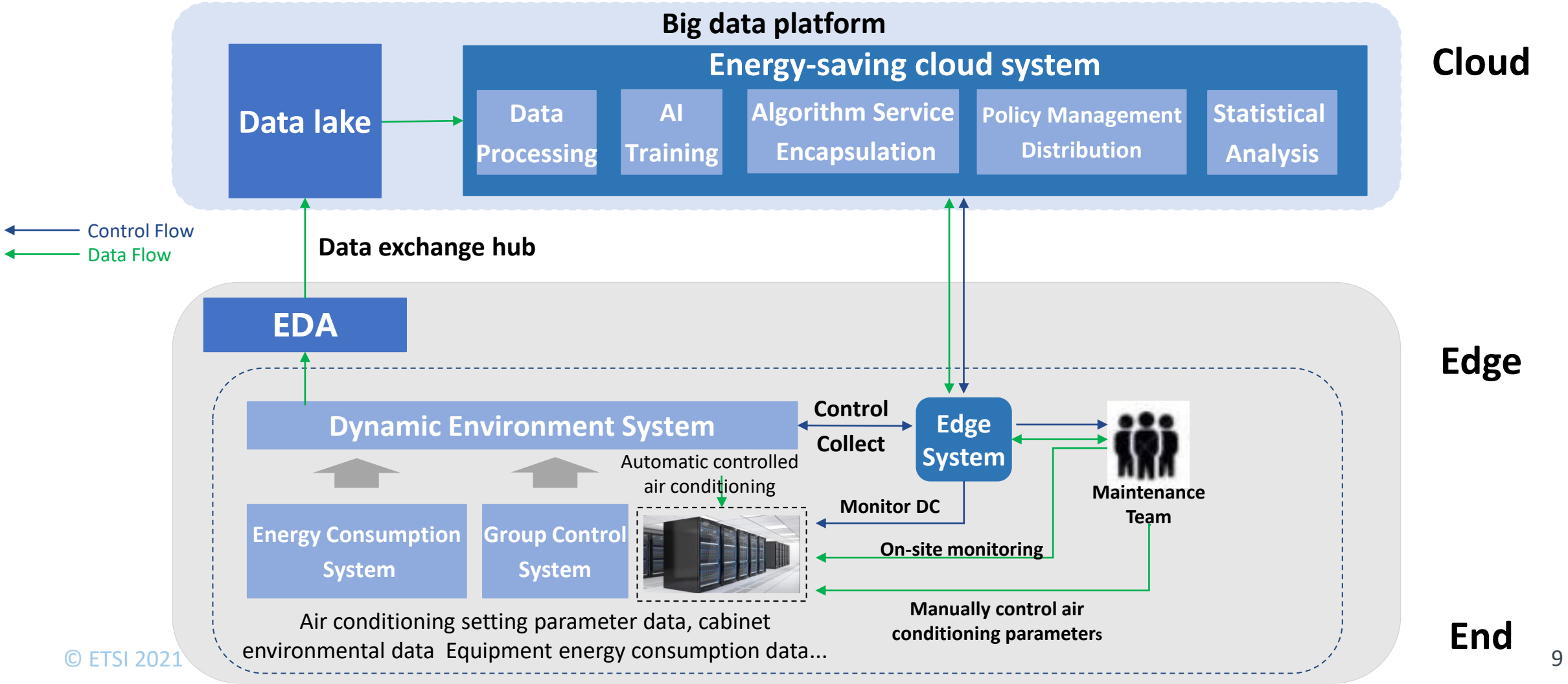
Control Flow of PoC System



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Test Report from CAICT 中国信通院

NO.	Test Object	Test Result	Date
1	PUE before system launch	1.373	2020.4.29
2	PUE after system launch	1.352	2020.4.30

A list of the tested equipment and the test contents

Equipment name: DC energy saving platform

	Test item	Measured item	Qualified item	Unqualified item
Test content：				
1、Cloud platform	8	8	8	0
2、Edge system	4	4	4	0
3、Data processing and synchronization	3	3	3	0
Total	15	15	15	0

100%qualified

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PoC System Logic

Step 1

- Basic data of IDC room
- Temperature Data
- Real-time data of the cabinet
- Real-time data of air conditioning
- Equipment parameter data

→ Transformation of IDC → Data Collection & Uploading

Step 2


Data analysis & presentation


Release Policy


Cloud&Edge collaborative processing


Automatic Control

a) Deploy the cloud system
b) Deploy the Edge system
c) Joint debugging and testing of the Cloud & Edge system
d) Joint debugging and testing of the Cloud & IDC system

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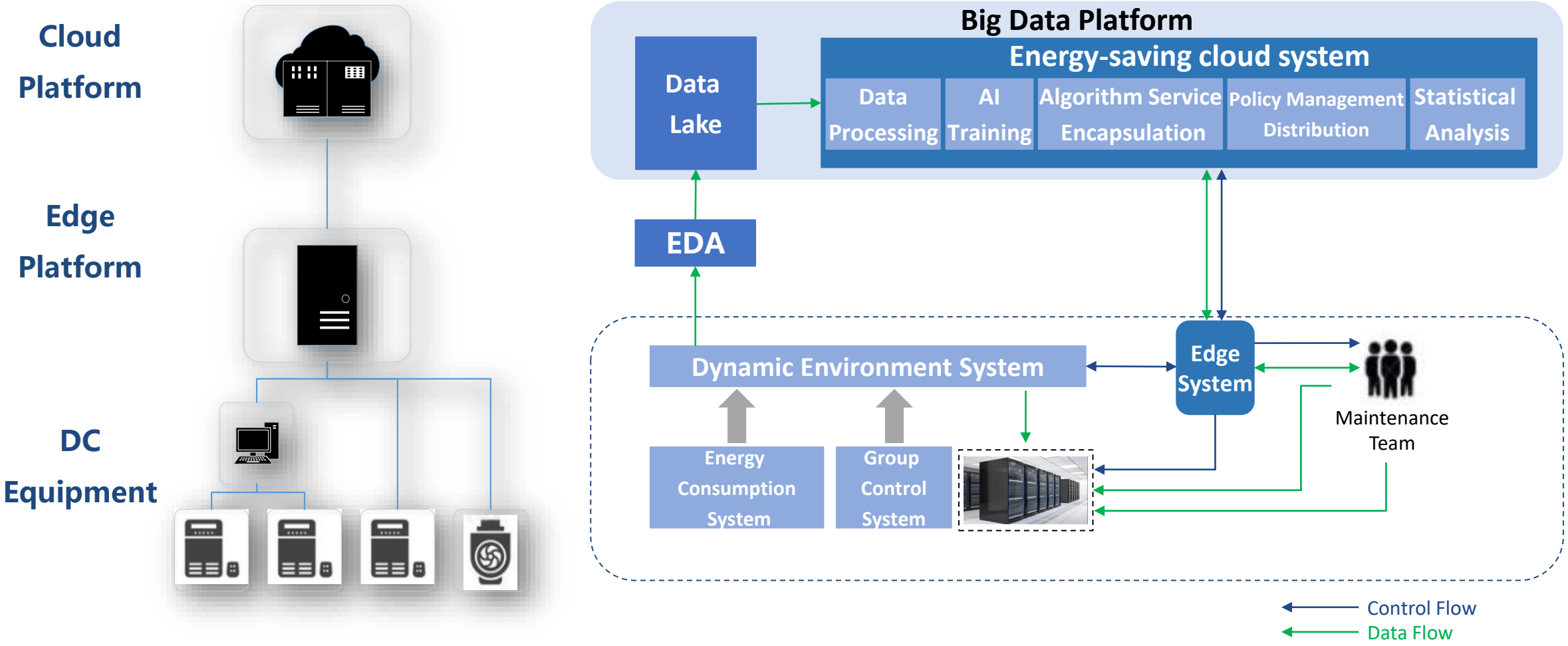
Data Flow of PoC System



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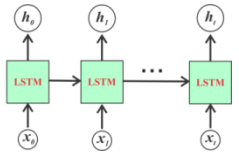
AI modeling process

Cleaning

Data Cleaning

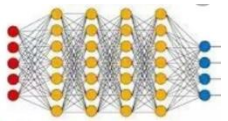
Data Annotations

Modeling



LightBGM

LSTM



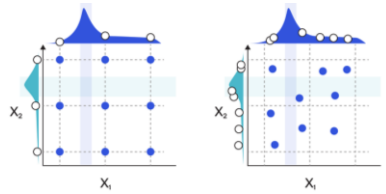
DNN

• • •

Training

Super Parameter Tuning

Cross Validation



dmlc XGBoost + scikit learn

Deployment

Model Test

Deployment Model

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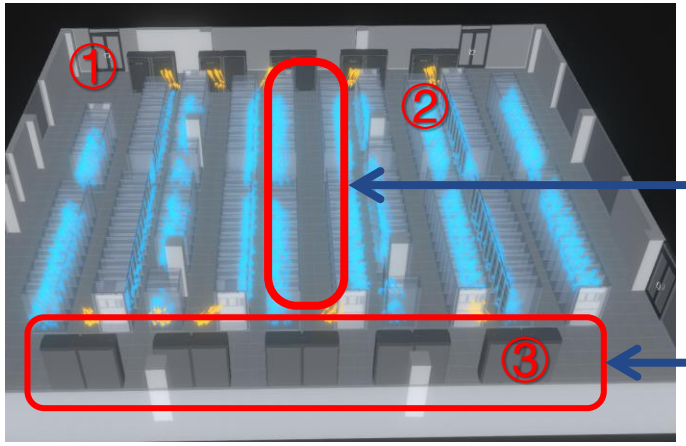
AI Energy Saving Overview

Room



Water Chilling Unit

Data

① Static Data
② Cabinet Data
③ Air Conditioning Data
④ Unit Data(water-cooled)

Algorithm Model

- Prediction model of cabinet air outlet temperature
- Computer room heat balance model
- Power consumption/refrigeration capacity prediction model

Control Policy

- ✓ Air Supply Control: adjust the opening of the air outlet floor and the air outlet temperature to improve energy-saving efficiency.
- ✓ Air Conditioning Control: adjust the air conditioning switch and PID parameters to reduce energy consumption.
- ✓ Water-cooled unit control: adjust the operating parameters of the water-cooled unit to reduce energy consumption,

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Examples of AI algorithm models

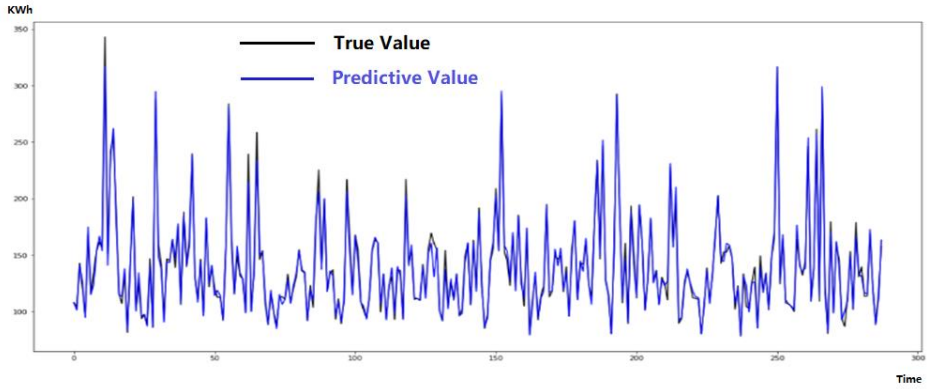
Prediction Model for Water-cooled IDC Power Consumption

Input

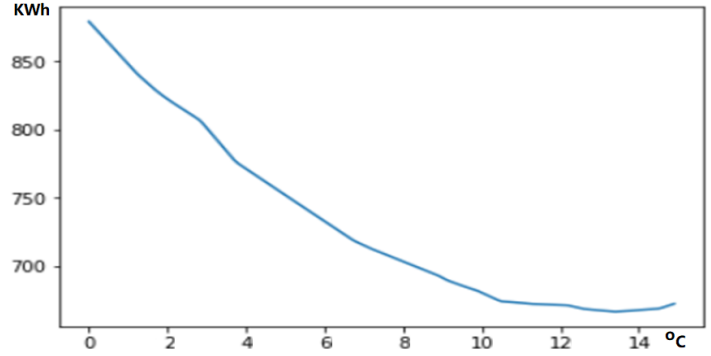
① Chilled water supply pressure
② Frozen return water flow
③ Chilled water supply temperature
④ Frozen return water temperature
⑤ Outdoor temperature
⑥ Outdoor humidity

Output

✓ Water cooling unit power



Fitting Results of the Main Engine Power Consumption Test Set



The relationship curve between the main air conditioning engine power consumption (vertical axis) and the chilled water temperature (horizontal axis) with constant parameters

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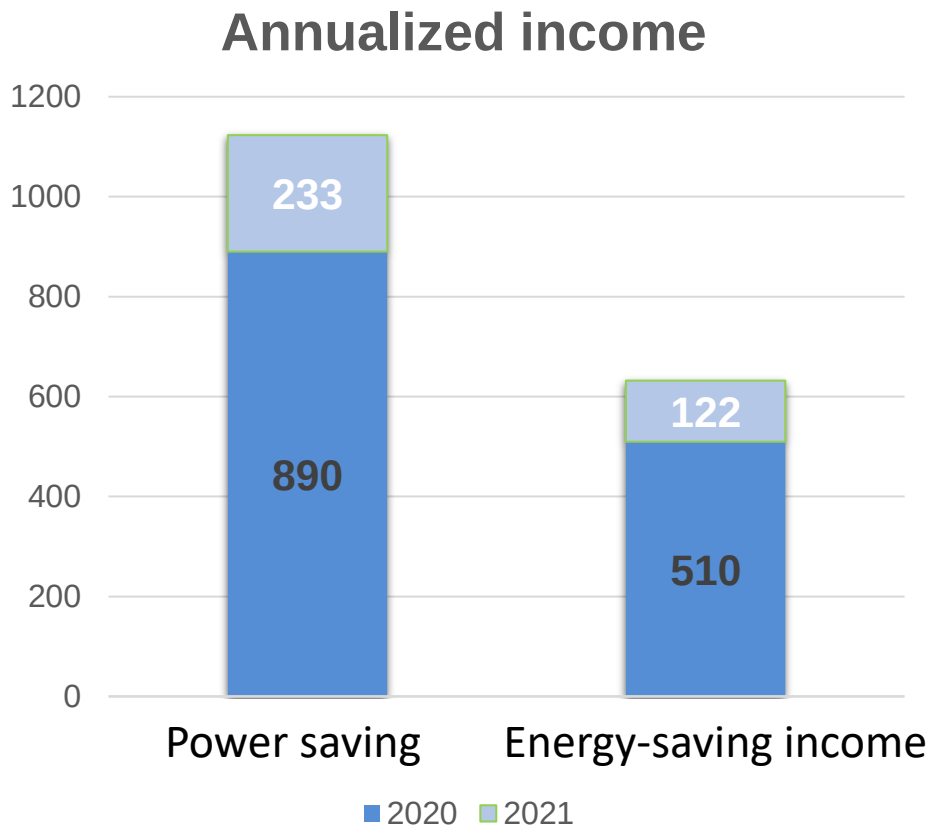
Calculation method of power saving

PUE = Total Facility Power of IDC/ IT equipment energy consumption

= (IT equipment energy consumption + Air conditioning refrigeration energy consumption) / IT equipment energy consumption

Power Saving = Air conditioning refrigeration power consumption in non-energy saving state – Air conditioning refrigeration power consumption in energy-saving state

Practical Effect of Poc Project



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Use Case on AI Policy

Brief Intro

Based on phase I results, the remaining 11 DC room of building 2, the PID value adjusted based on cold aisle temperature, change end air-con that below 23 degree, thus increase room temperature

- **data:** 2021.4.23 to 6.6.T0 2021.6.7to6.9T1;
- **No.of Room:** 11个 network DC;
- **Fan Motor Adjusted:**101;
- **Temp. Adjusted** 25;
- **Power Off Air Condition** 6

AI based policy settings

	Fan Power Range						Temperature		Air Con Off
Original	40%-80%						22℃±1℃		
New	40%-60%	50%-70%	40%-70%	50%-80%	60%-80%	70%-80%	24℃±1℃	25℃±1℃	
Value Changed	25	59	1	6	1	2	18	6	6
Room 1-1	3	5					4	2	
Room 1-2	3	3	1	1			2	2	1
Room 1-3	3	6				2	1	1	
Room 1-4	4	2		1	1		1		2
Room 1-5	4	6					3	1	
Room 1-6	1	8		1			2		
Room 1-7		12					2		
Room 1-8		8					1		
Room 1-9	2	3		3					3
Room 1-10	4	1					2		
Room 1-11	1	5							
Total	25	59	1	6	1	2	18	6	6

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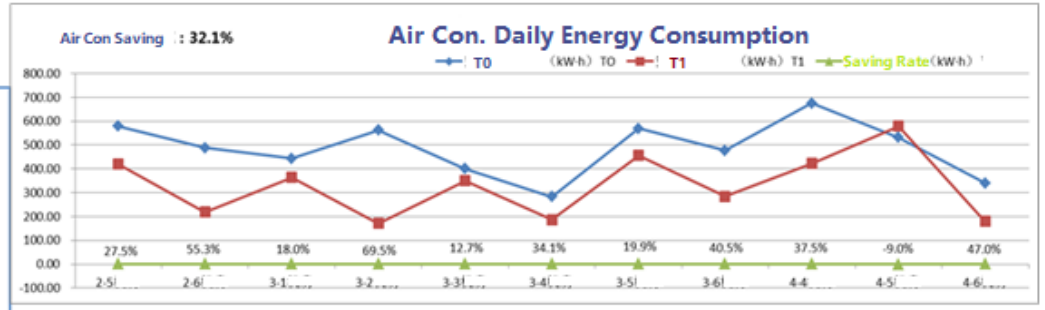
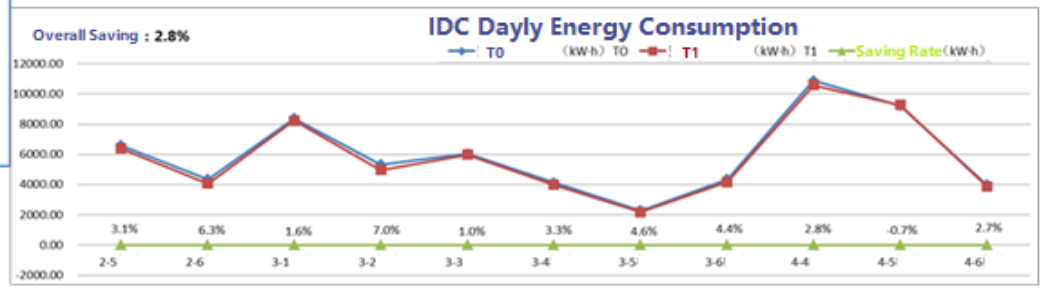
Use Case on AI Policy

Phase II Results

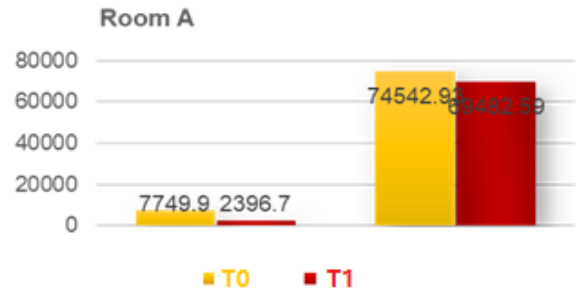
Applying AI policy to IDC for 14 days:

- End Air Condition Energy Saving Rate **32.1%;**
- DC Room Energy Saving Rate**2.8%;**
- 14 days Electricity Saving **25070.71kW; Year forecast 65.36 Million kWh**
- 14 days Electricity Bill saving**13788.89 RMB; Year forecast 35.95 Million RMB** (0.55RMB/kWh) ;

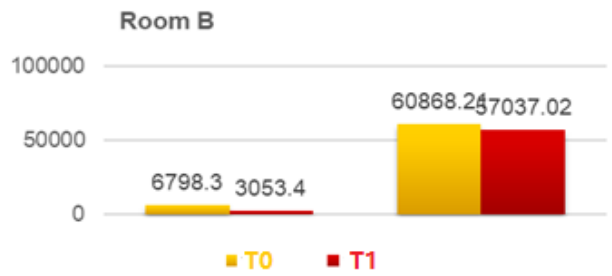




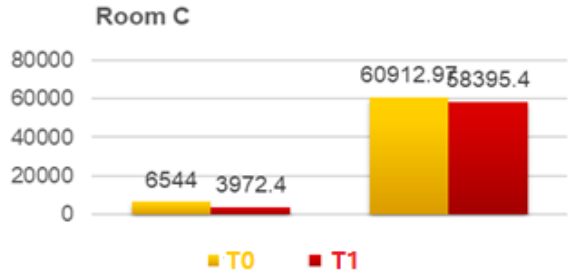
Highest Saving achieved:



Room A saving **69.07%**, overall **6.79%**



Room B saving **55.09%**, Overal **6.29%**



Room C saving **39.3%**, overall **4.13%**

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Use Case on AI Policy

Brief Intro

Based on basic data, temperature data, real-time data of the cabinet, real-time data of air conditioning, change the equipment setting

- **data:** T0-2021.6.15 to 6.22
  T1-2021.6.25 to 6.30;
- **Fan Motor Adjusted:** 5;
- **Temp. Adjusted:** 27;
- **Power Off Air Condition:** 0

Comparison of effect before and after Policy Implementation

Room 2-3	2020/6/22	2020/6/23	2020/6/24	2020/6/25	2020/6/26	2020/6/27	2020/6/28	2020/6/29	2020/6/30
Room 2-3 Line A	655.9	649.2	654.1	658.5	642.2	671.5	654.3	653.3	654
	648.8	646.1	648.9	653.5	639	664.5	648.6	648	648.9
Room 2-3 Line B	508.9	505.8	508.2	509.2	502.9	515.4	504.5	504.7	507.8
	521.6	518.3	521	521.5	515.7	526.9	516	516.4	520.1
Room 2-3 Line C	659.6	665.7	660.9	660.7	665.4	658.6	659.5	660.2	661
	595.2	605.9	597.4	596.7	606.5	591.1	597.2	594.3	597.5
Room 2-3 Line D	308.5	496.1	403.5	408.1	493.2	327.2	407.2	410.9	408.4
	320.1	486.9	396.6	397.3	482.2	322.4	411.6	401.8	403.9
Room 2-3 Line E	434.1	434.4	433.5	433.1	432.8	438.2	433.4	433.1	432.3
	439.4	439.4	438.6	438.3	437.3	443.9	438.5	438.2	437.4
Room 2-3 Line F	364	363.8	363.8	365.6	361	373.5	366.8	365.6	365.9
	350.1	349.4	349.9	351.7	346.5	359.9	353	351.6	351.9
Room 2-3 Line G	200.6	191	195.3	193.9	190.3	196.8	193.2	194.6	194.8
	438.2	452.2	445.8	445.4	446.9	446.9	445.7	447.3	447.7
Total IT Equipment Power Consumption	6445	6804.2	6617.5	6633.5	6761.9	6536.8	6629.5	6620	6631.6
Total Air Conditioner Energy Consumption	535	509	416	365	384	376	386	388	396
Policy Execution Time									
PUE	1.08	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.06
PUE before executing the policy	1.08								
Saving electricity quantity			123.33	175.63	167.10	156.75	154.31	151.53	144.48
Refrigeration energy saving rate	30.33%								
Total energy saving rate	2.25%								

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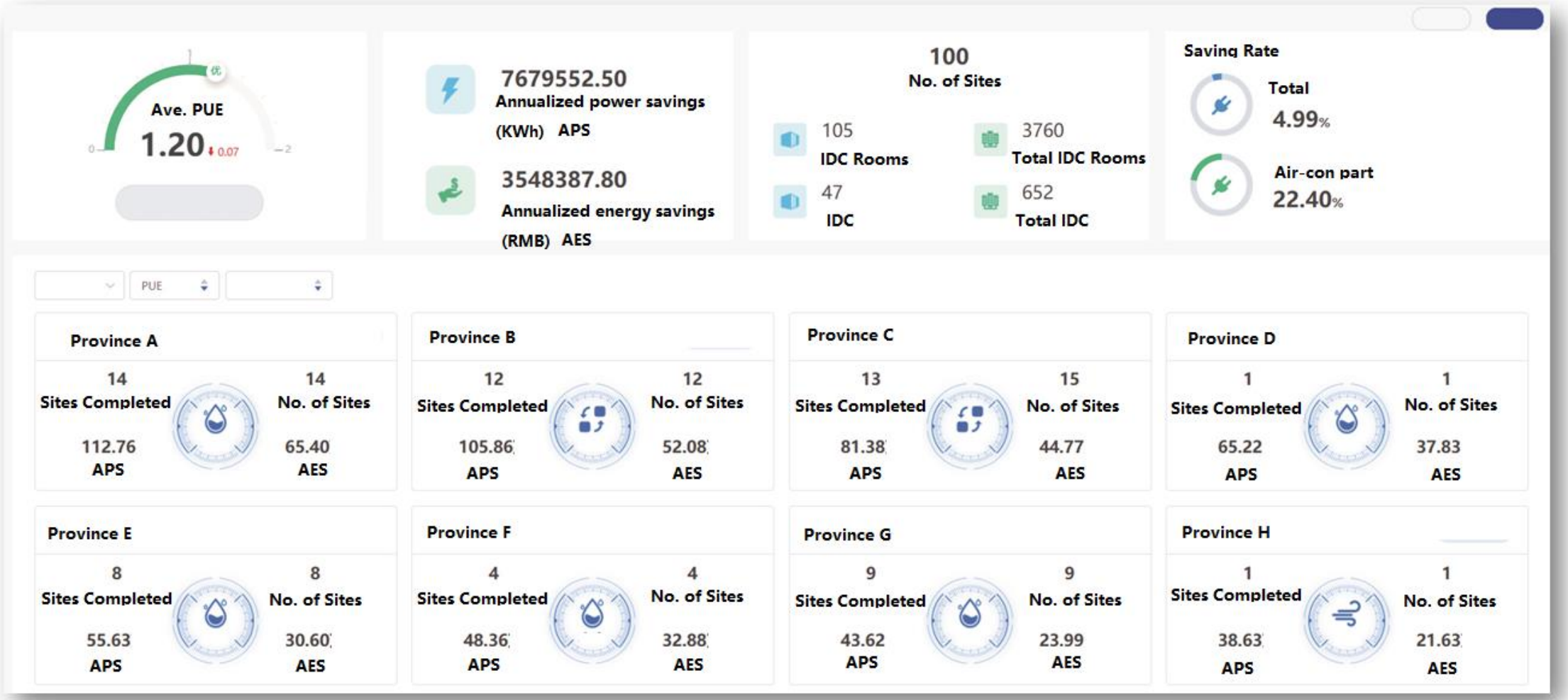
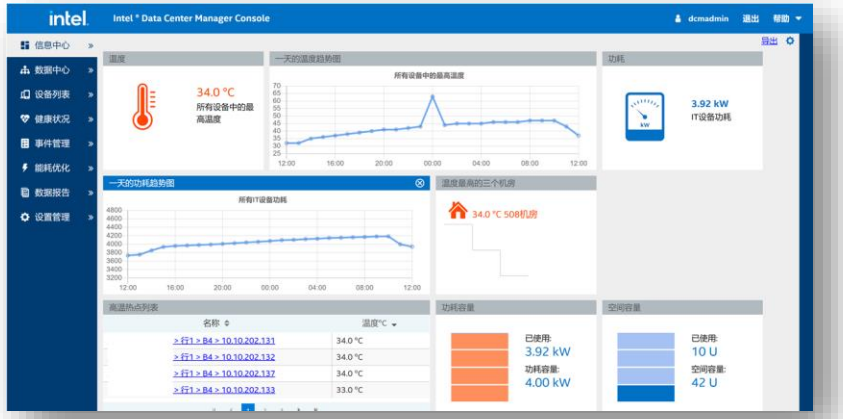
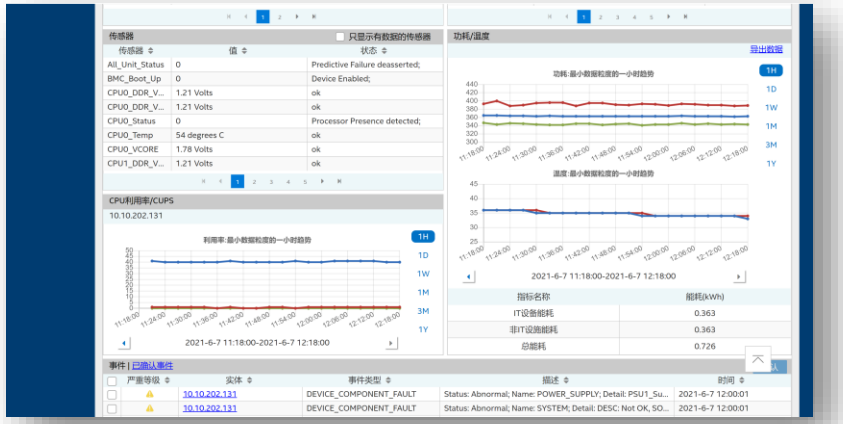
Poc#11 Achievement Display



Intel DCM – IT load analysis



Intel DCM software installed in CT lab, and IT load information can be obtained



IT load and server status (e.g. CPU frequency etc.) can be analyzed on a defined frequency

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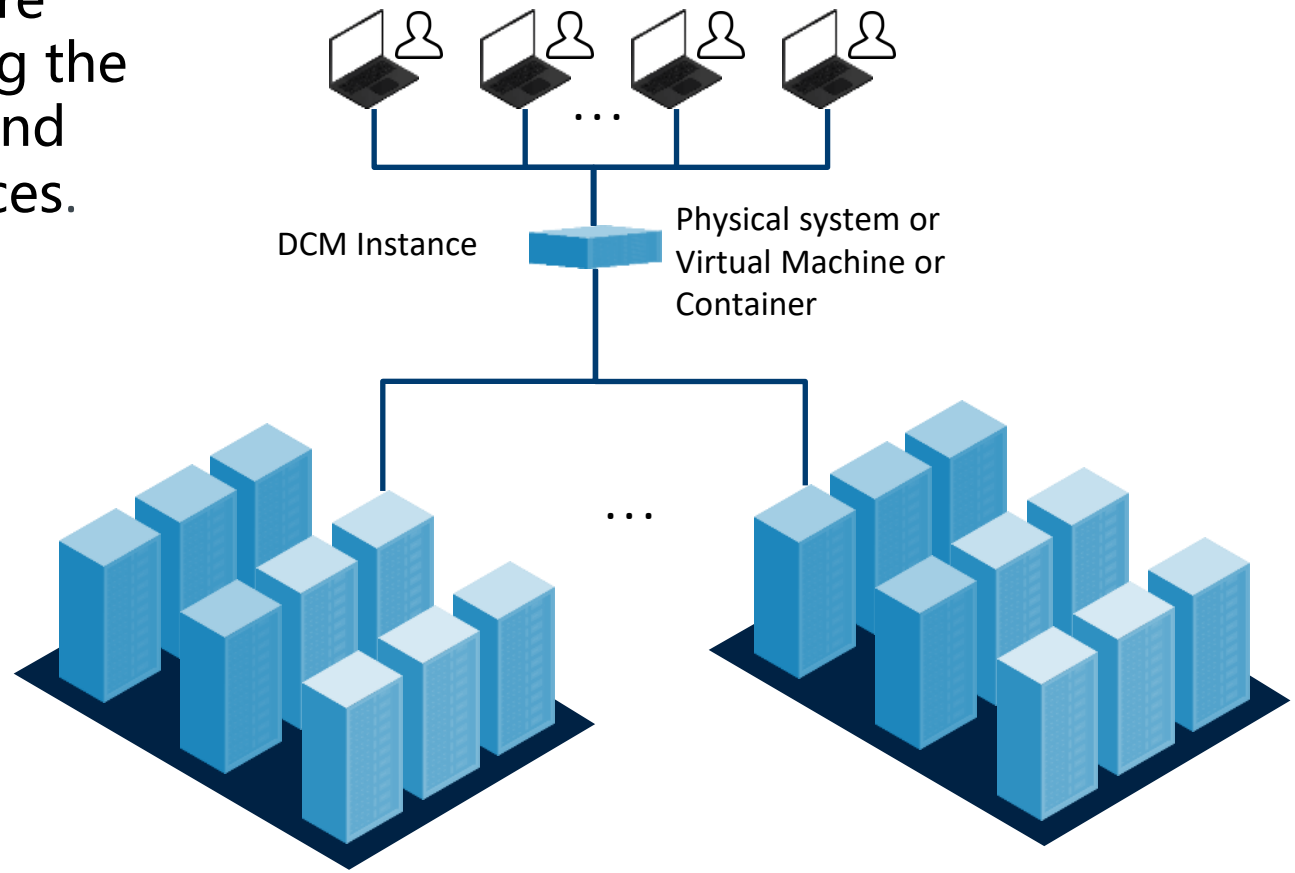
Intel® DCM Overview

- Intel® DCM is an out-of-band software solution for monitoring and managing the inventory, utilization, health, power, and thermals of servers and other IT devices.

- Intel DCM reduces data center total cost of ownership (TCO) by:
  - Improving inventory & asset management
  - Increasing data center reliability
  - Simplifying maintenance
  - Optimizing power & cooling efficiency
  - Maximizing compute density
  - Reducing downtime



DCM Instance, devices being monitored, and users are on the same network

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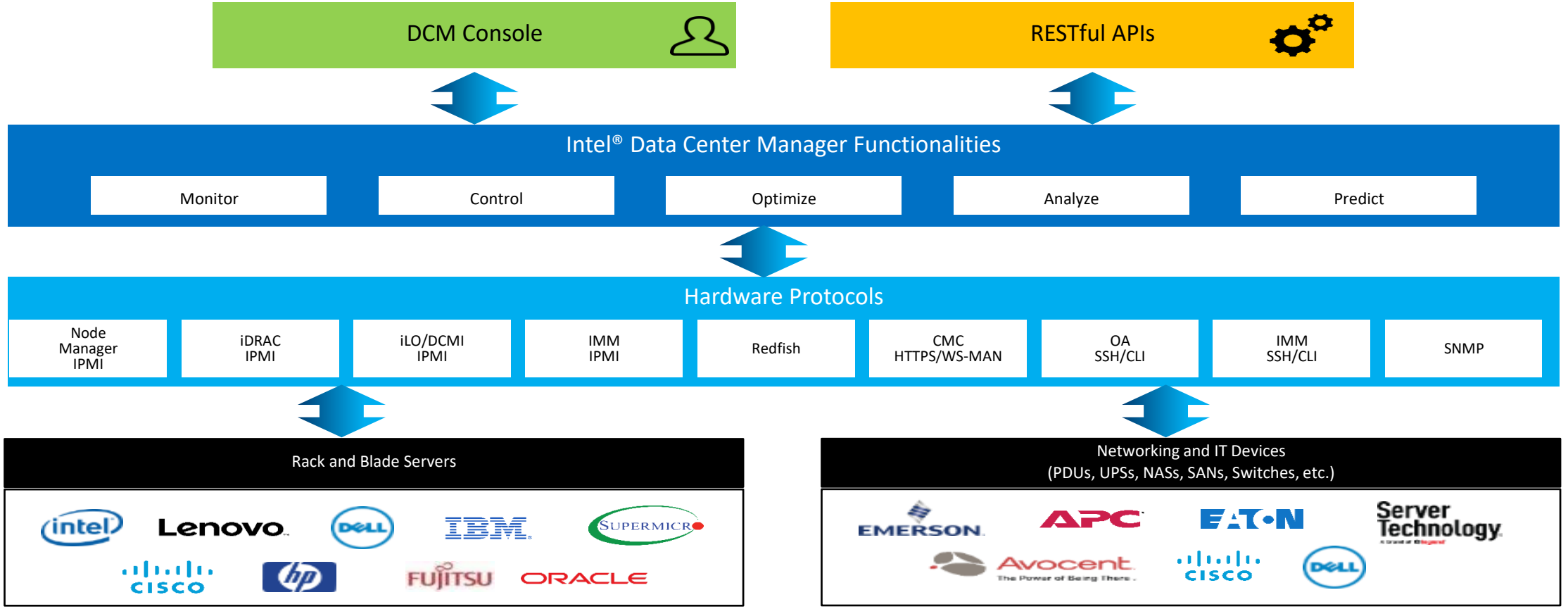
Intel® DCM Software Architecture



Scales to 10Ks of nodes

IPMI = Intelligent Platform Management Interface
IMM = Integrated Management Module
SNMP = Simple Network Management Protocol
WS-MAN = Web Services-Management

iDRAC = Integrated Dell Remote Access Controller
CMC = Chassis Management Controller
CLI = Command Line Interface
DCMI = Data Center Manageability Interface

iLO = Integrated Lights-out
OA = Onboard Administrator
SSH = Secure Shell

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Intel® DCM Use Cases

Capacity Planning

- Where to place devices
- Optimizing rack density
- Keeping up and forecasting power, space, and processing demands

Infrastructure and Asset Management

- Discovering and tracking assets
- Knowing details of available systems
- Building visual layouts and maps
- Aggregating info for the entire infrastructure

Utilization Monitoring

- Monitoring utilization
- Identifying unused devices
- Application & workload optimization
- Network monitoring

Health Monitoring

- Realtime issue detection
- Locating hotspots
- Predicting health issues
- Reliable & customizable alerts

Manageability

- Remote control
- Identifying component issues
- Updating firmware
- Provisioning systems

Energy Consumption

- Over-provisioning power and cooling
- Granular thermal mapping
- Monitoring energy use per device
- Power Capping

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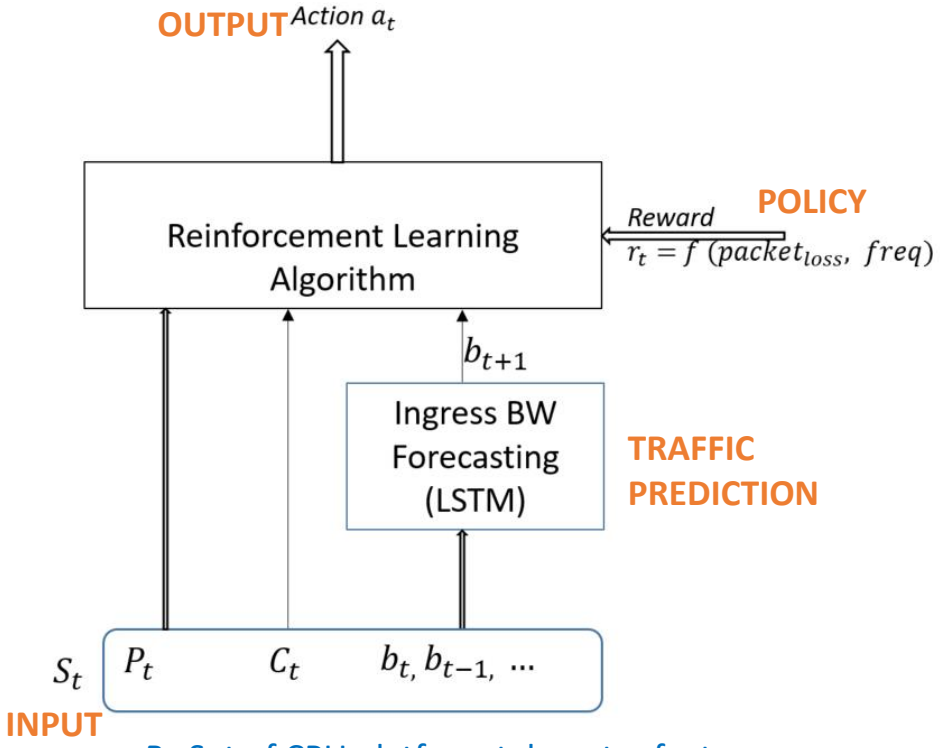
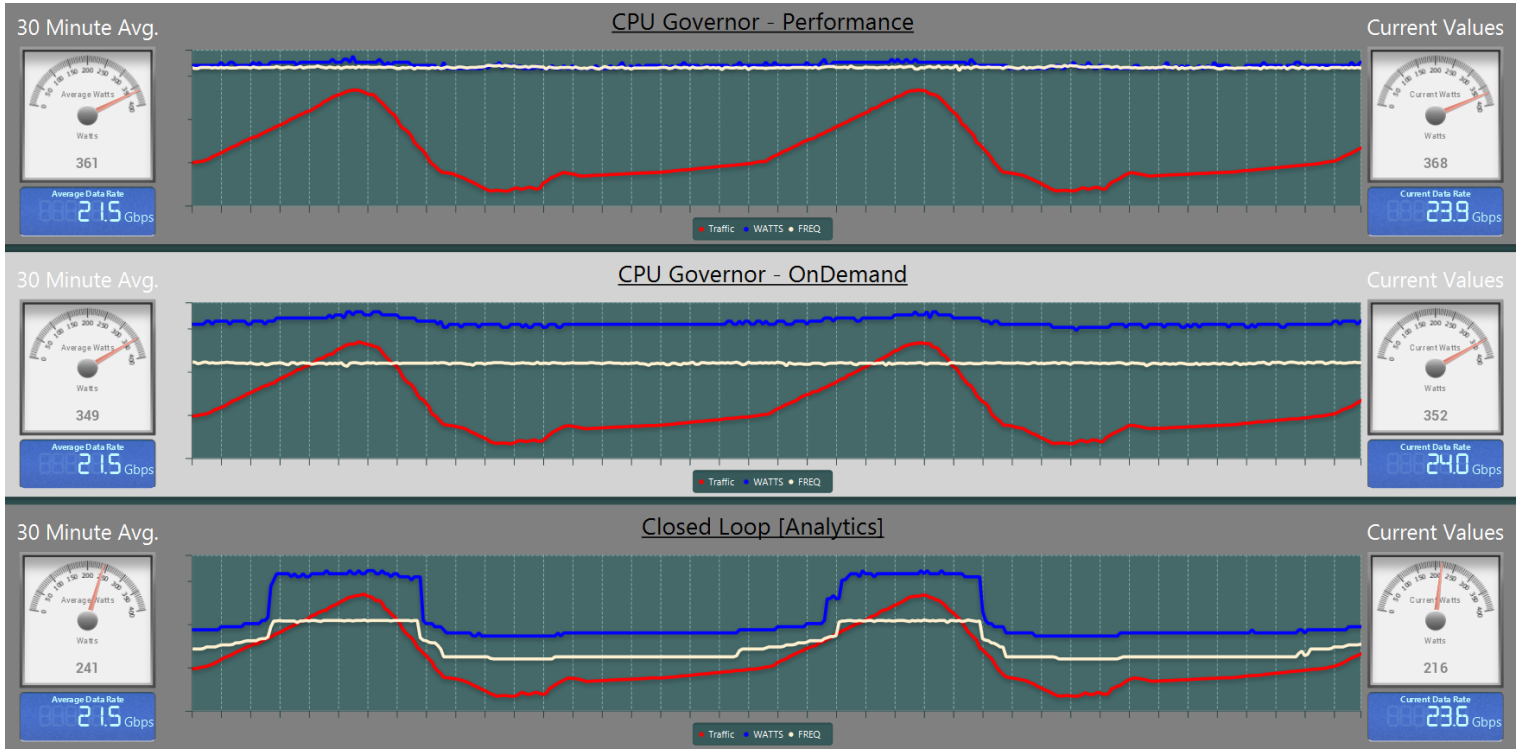
Intel CPU Frequency Tuning Approach



P_t: Set of CPU platform telemetry features
C_t: Current system status, e.g., CPU core frequencies
b_t: Traffic bandwidth at time t



Saving 30~40% of power consumption

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Dynamic Frequency Tuning with Traffic Change

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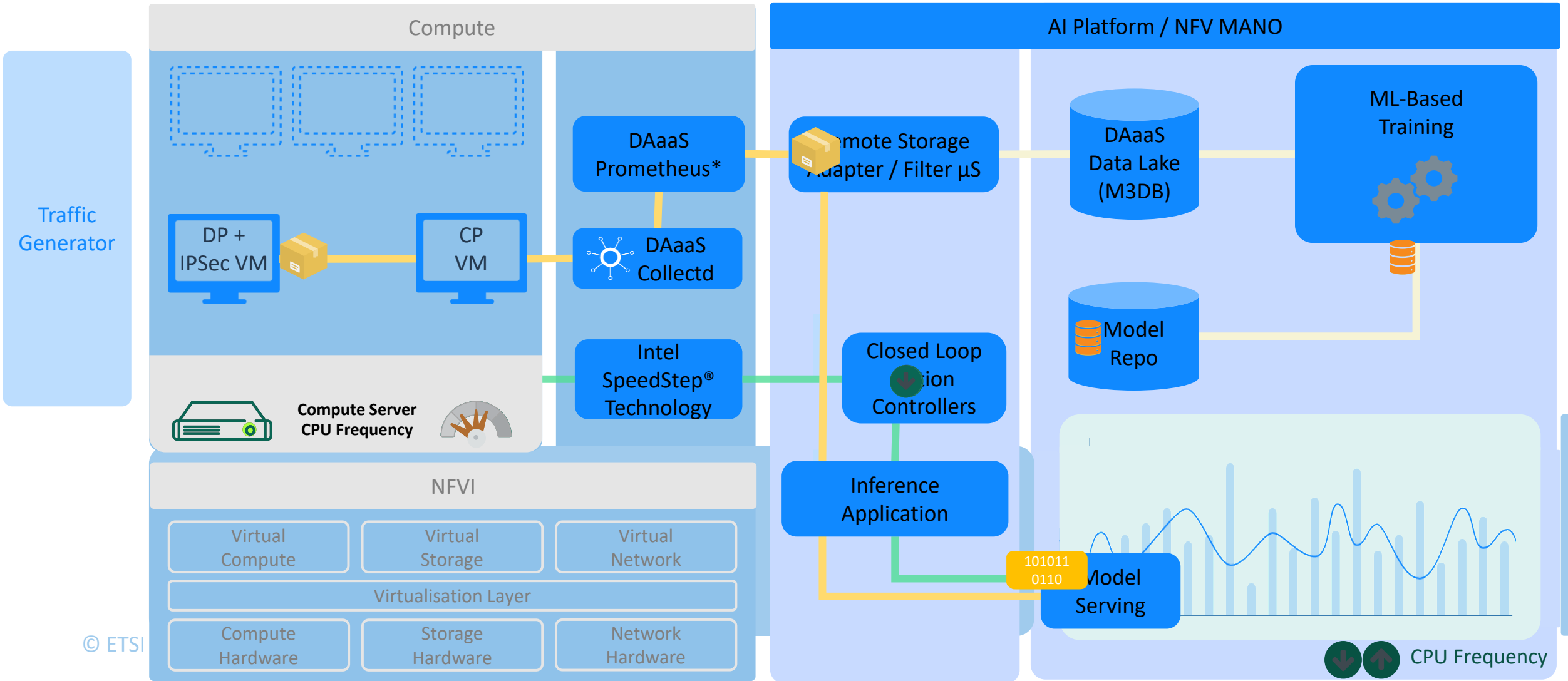
Power Saving for NFV/5G Core Functions in DC



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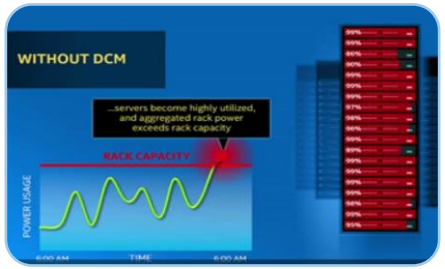
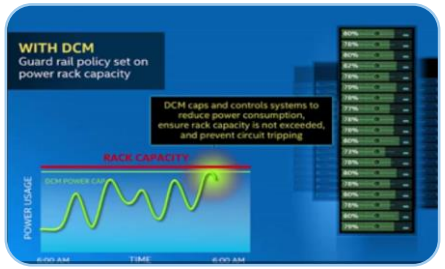
Power control technology (Out-of-band)



Problem statement

- Need to ensure the HPC cluster power consumption stays within allowed limits
- Power saving when HPC cluster is not fully loaded



Power control on the Node and Cluster level

- Easily control power of defined groups of servers
- Cross vendors

Values

- Power cap at the cluster makes sure cluster doesn’t exceed allowed limit
- Power cap servers during low utilization times = **Power Saving**

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PoC Milestones and Current Progress

PoC Milestone	Stages/Milestone description	Target Date	Additional Info
P.S	PoC project submission	03/2020	Presentation during #ENI 13
P.TP.1	PoC Test Plan 1	12/2020	Initial testbed up and running
P.D1	PoC Demo 1	04/2021	Demo at Big Data Expo Kunming 2001
P.D2	PoC Demo 2	06/2021	Internal demo at ENI#18
P.D3	PoC Demo 3	07/2102	ENI webinar demo (27th July)
P.C1	PoC Expected Contribution 1	07/2021	Contributions to ENI use case
P.C2	PoC Expected Contribution 2	07/2021	Contributions to ENI requirement
P.C3	PoC Expected Contribution 4	09/2021	Contributions to ENI terminology
P.C4	PoC Expected Contribution 5	09/2021	Contributions to ENI data mechanism
P.R	PoC Report	09/2021	PoC-Project-End Feedback
P.E	PoC Project End	12/2021	Presented to ISG ENI for information
Note: The deadlines may subject to change according to covid-19 situation.			

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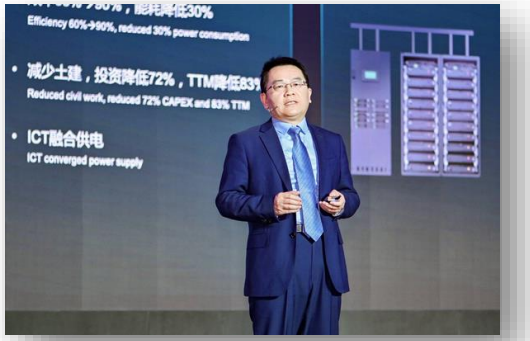
PoC Demos

PoC#11 demonstrated at "eDC" launch on 20th Oct. 2020 Beijing together with Intel and Huawei

MWC Shanghai 2021, Huawei demonstrated 'zero emission network 'including IDCs



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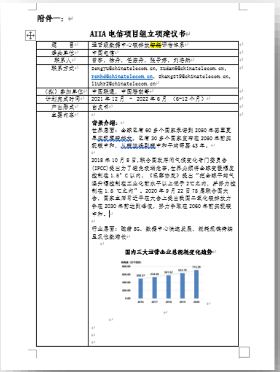
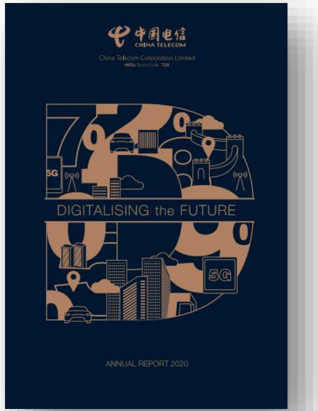
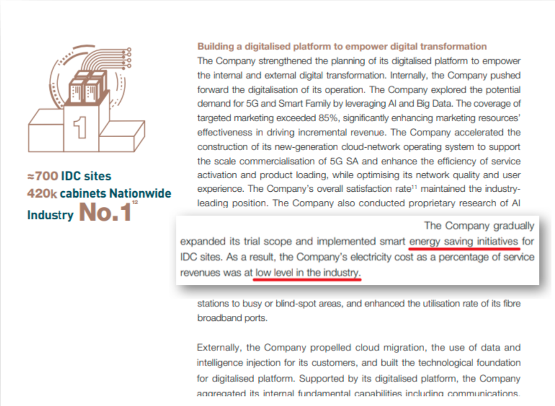
PoC Impact

AIIA Alliance Proposal on “IDC Carbon Emission Estimate ” 6-8 July 2021, supported by China Mobile and China Unicom



China Telecom Annual Report – Key Business Impact





≈700 IDC sites
420k cabinets Nationwide
Industry No.1

Building a digitalised platform to empower digital transformation

The Company strengthened the planning of its digitalised platform to empower the internal and external digital transformation. Internally, the Company pushed forward the digitalisation of its operation. The Company explored the potential demand for 5G and Smart Family by leveraging AI and Big Data. The coverage of targeted marketing exceeded 85%, significantly enhancing marketing resources' effectiveness in driving incremental revenue. The Company accelerated the construction of its new-generation cloud-network operating system to support the scale commercialisation of 5G SA and enhance the efficiency of service activation and product loading, while optimising its network quality and user experience. The Company's overall satisfaction rate[11] maintained the industry-leading position. The Company also conducted proprietary research of AI

The Company gradually expanded its trial scope and implemented smart energy saving initiatives for IDC sites. As a result, the Company's electricity cost as a percentage of service revenues was at low level in the industry.

stations to busy or blind-spot areas, and enhanced the utilisation rate of its fibre broadband ports.

Externally, the Company propelled cloud migration, the use of data and intelligence injection for its customers, and built the technological foundation for digitalised platform. Supported by its digitalised platform, the Company aggregated its internal fundamental capabilities including communications,

Industry Alliance on IDC energy management

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PoC Impact

CCSA 18th meeting 3rd Prize on Network Intelligence 25th April 2021

China Telecom, Intel, Huawei

Big Data Expo, New Product Award on 《AI Based Intelligent Energy Operation System》 2021 26th May, Kunming

China Telecom IDC team

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PoC Impact

Applied The Network Transformation Awards 2021 in SDN NFV World Congress 2021 October by Layer123

1 - 5G Service Excellence

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Key PoC team members