IoTLab.space

Reefer container management

Rel: Mar 2024

IoTLab.space

We create **testbeds** to simulate real-life conditions and anticipate the real-world challenges.

With supports from leading vendors, we are pioneers in applying new technologies across industries. In the era of industry 4.0, we specialize in:

- Providing roadmap advisory to sharpen the competitive edge of enterprises
- Implementing Digital Transformation strategies

Technology:

- Industrial IoT
- IT/OT convergence
- Industrial AI/Analytics
- Digital Twin
- Datacenter/Cloud, Network Infrastructure
- Cyber security

TOC

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2. Survey
3. Technical solution
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6. Commercial offering

1. Requirements

Summary

- Centrally monitor Reefer containers, information included:
  - Container number
  - Temperature
  - Power status
  - ….
- Many sea ports
- Each port may have up to:
  - Many cooling Reefer Container (circulating to other ports)
  - Container vendor: Popular names such as Daikin, Carrier, …
  - Container ships to carry containers to surrounding ports

- Assumption:
  - Wifi coverage at Sea port : Available
  - 220v AC at each container: Available

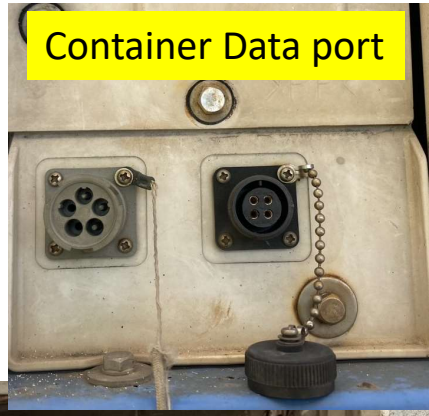
2. Survey

Popular container controller:

- Daikin
- Starcool
- Thermo King
- Carrier
- Denso

Possible ports on container to retrieve data:

- RS-232 Data port
- USDA sensor port
- Some container type may not support Data retrieve over RS-232 port

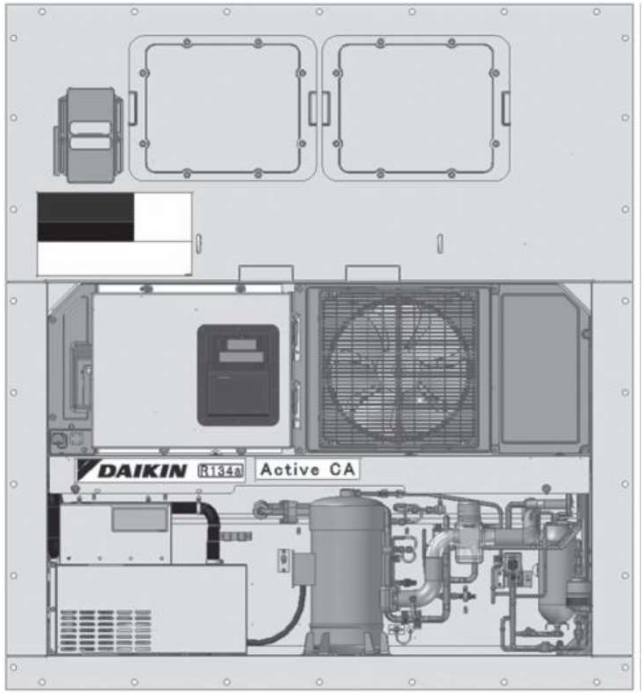


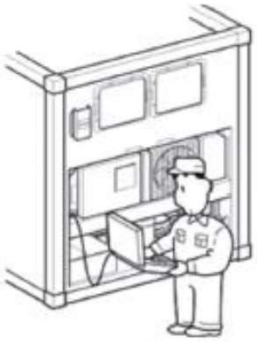
DAIKIN Active CA LXCA04-6

The record data can be downloaded by connecting to a PC port

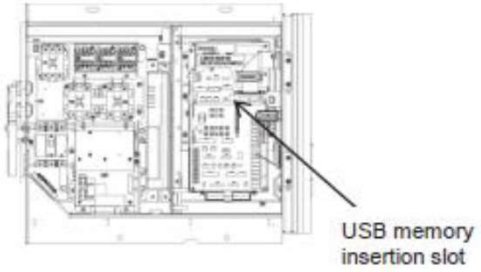
In DECOSIII and later models, all record data in the controller can be downloaded by inserting a USB memory into the USB connection port on the controller. Software in the controller can be uploaded using a PC or a USB memory.

It is also possible to send information (e.g. container ID, cargo name, destination) from a PC to the controller, and memorize it.





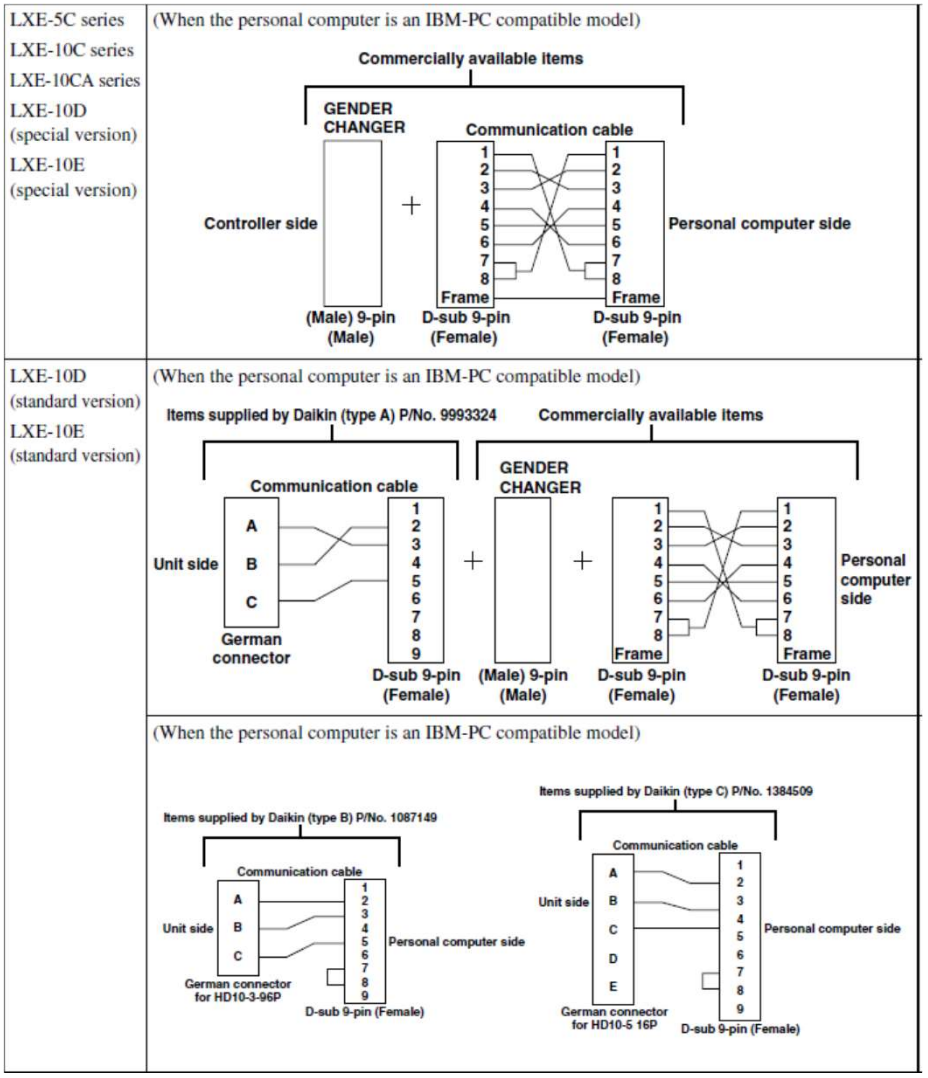
Connect a PC to the communication port



Connect a USB memory to the controller

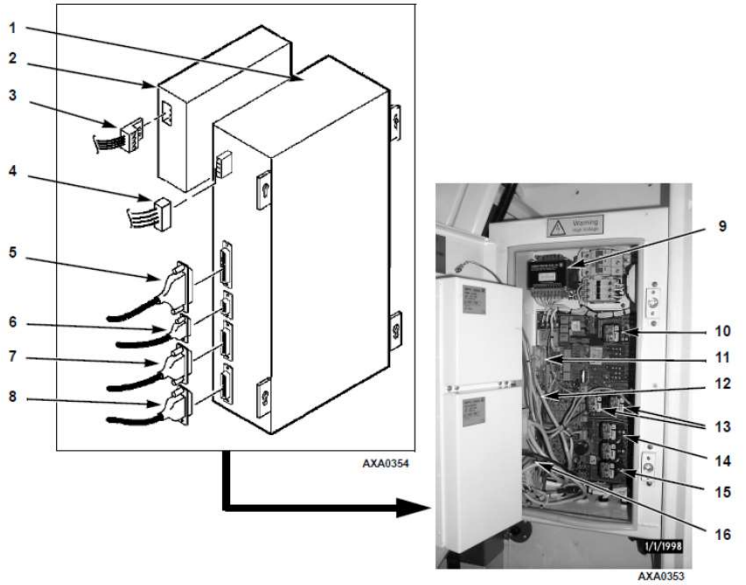
DAIKIN Active CA LXCA04-6

- Type A can be used in the LXE-5C, LXE-10C, and LXE-10D series.
- Type B allows the LXE10D series and the personal computer to be connected directly. (It cannot be connected to the LXE-5C and LXE-10C series.)
- Type C allows the LXE10E series and the personal computer to be connected directly. (It cannot be connected to the LXE5C, LXE10C and LXE10D series.)



Thermo King CRR DF MPC2000

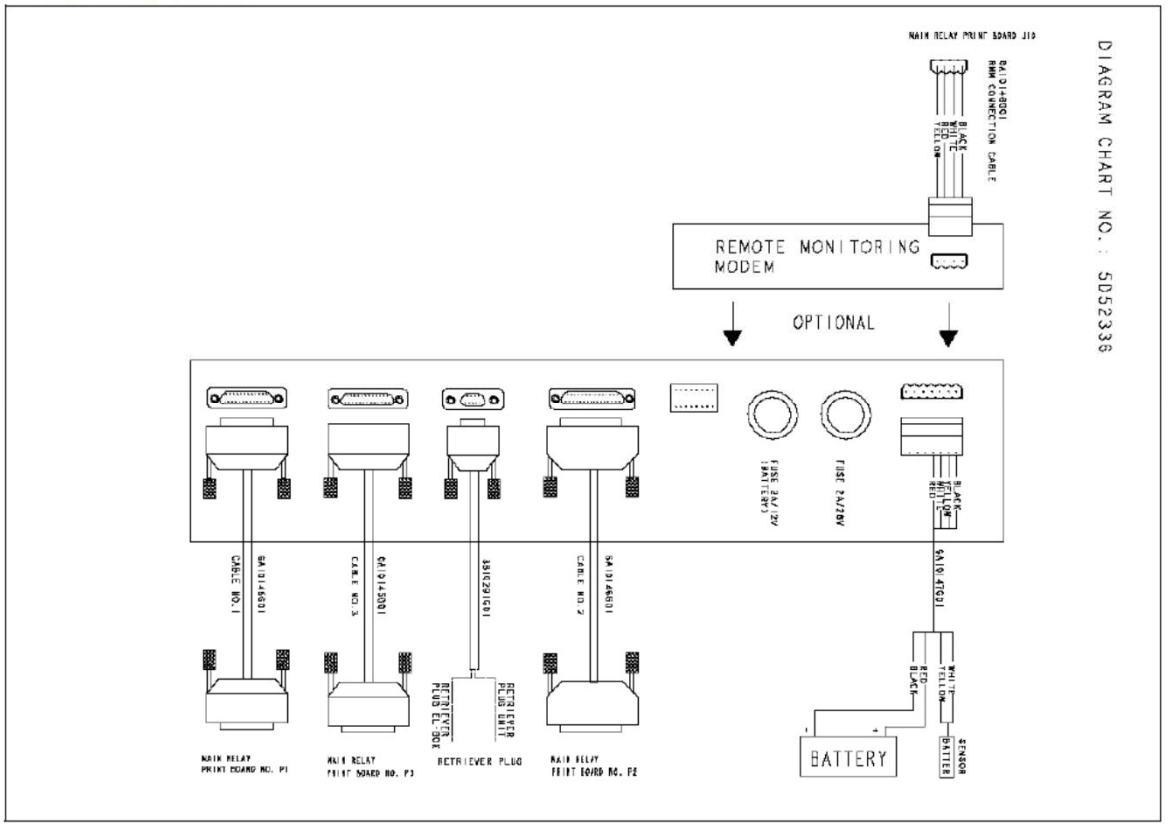
The record data can be downloaded by connecting to a port



1.	MPC2000ID or MP3000 Controller with Integral Datalogger	9.	Control Power Transformer (28 Vac, 29 Vac, 40 Vac)
2.	Remote Monitoring Modem	10.	Heat Relay
3.	RMM Connection Cable	11.	Cable No. 3 Connection to Main Relay Board
4.	Battery Cable Connection to Controller	12.	Cable No. 2 Connection to Main Relay Board
5.	Cable No. 2 Connection to Controller	13.	Phase Sensor Relays
6.	Download Cable Connection to Controller	14.	Evaporator Fan Relay – Low Speed
7.	Cable No. 3 Connection to Controller	15.	Condenser Fan Relay
8.	Cable No. 1 Connection to Controller	16.	Cable No. 1 Connection to Main Relay Board

Figure 8: MPC2000ID and MP3000 Controller, and Remote Monitoring Modem

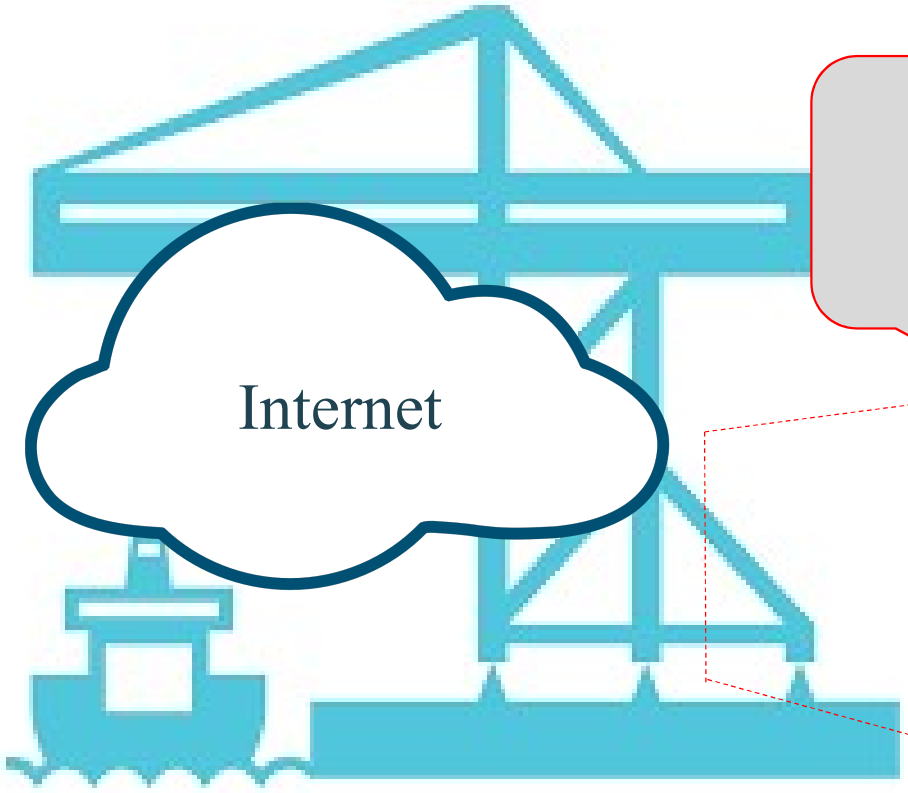
CRR DF MP3000A Controller Diagram



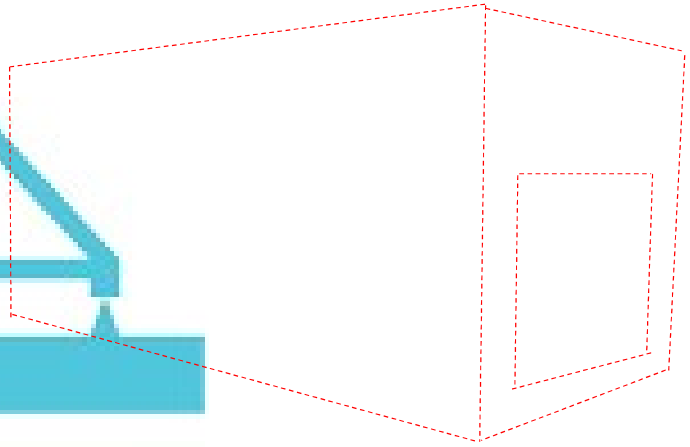
3. Technical solution

Building Digital twin for reefer containers

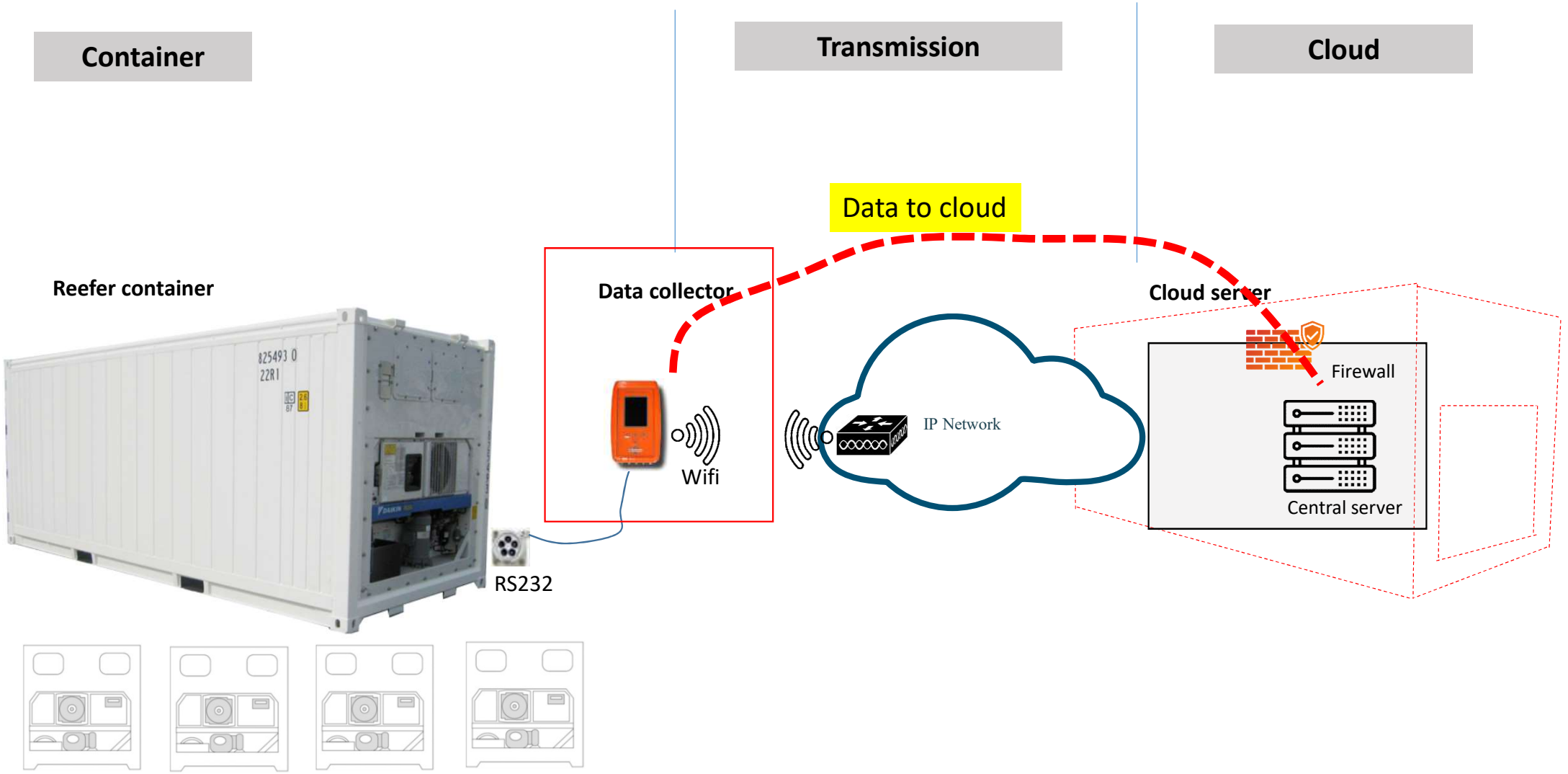
Central management



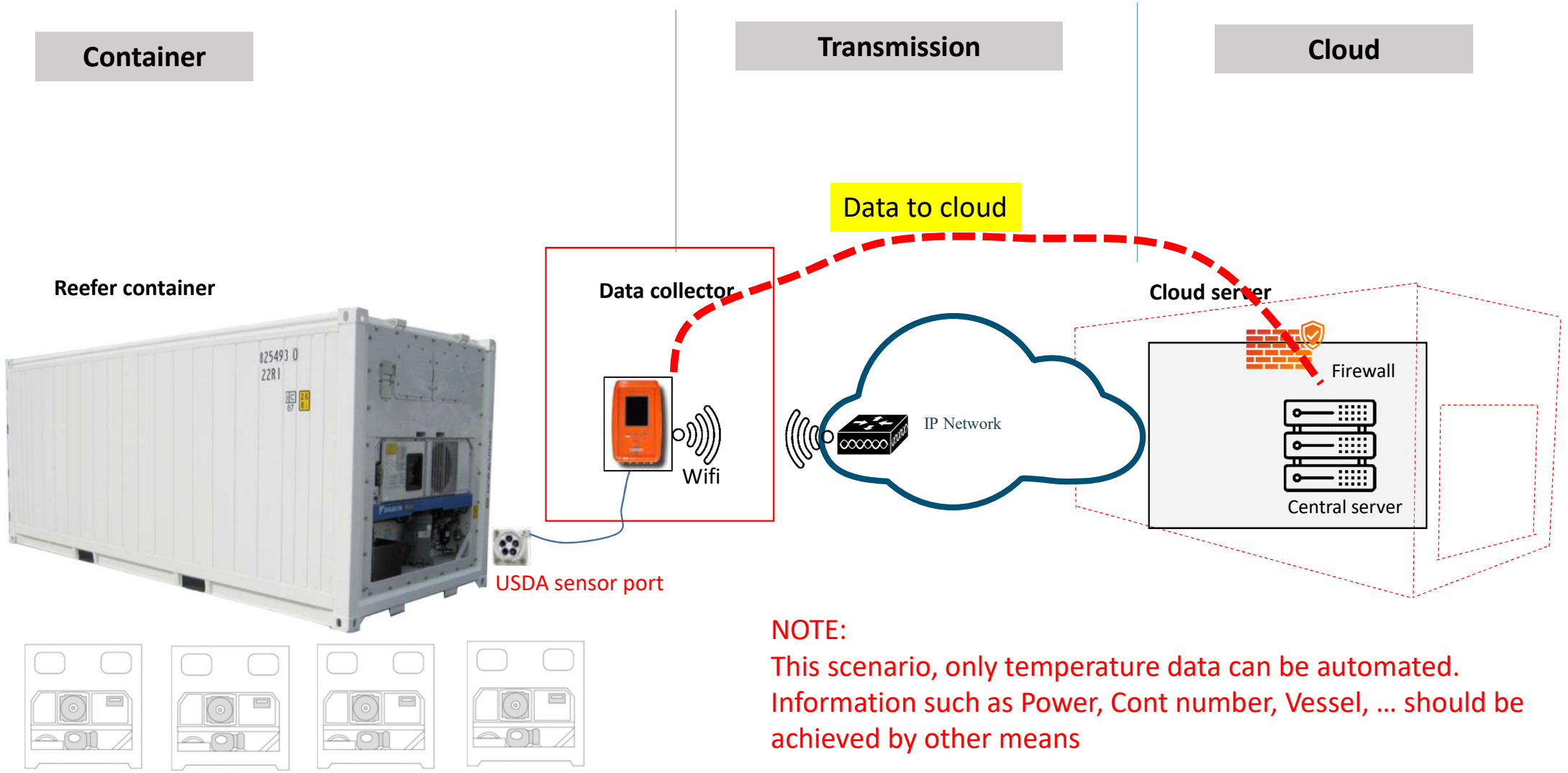
Container number
Vessel
Tracking location
Temperature
Power status
…



Data collection: for containers with RS-232 data port



Data collection: without RS-232 data port



NOTE:
This scenario, only temperature data can be automated.
Information such as Power, Cont number, Vessel, … should be achieved by other means

Popular container controller brands are supported

- Daikin: Dencos III, Dencos V
- Starcool: CIM 5, CIM 6
- Thermo King: MPC2000, MPC2000id, MP3000, MP3000a, MP4000
- Carrier: ML2/2i, ML3
- Denso: DEFT1000

Unlisted brands: We will have to do survey

Data collector - Features

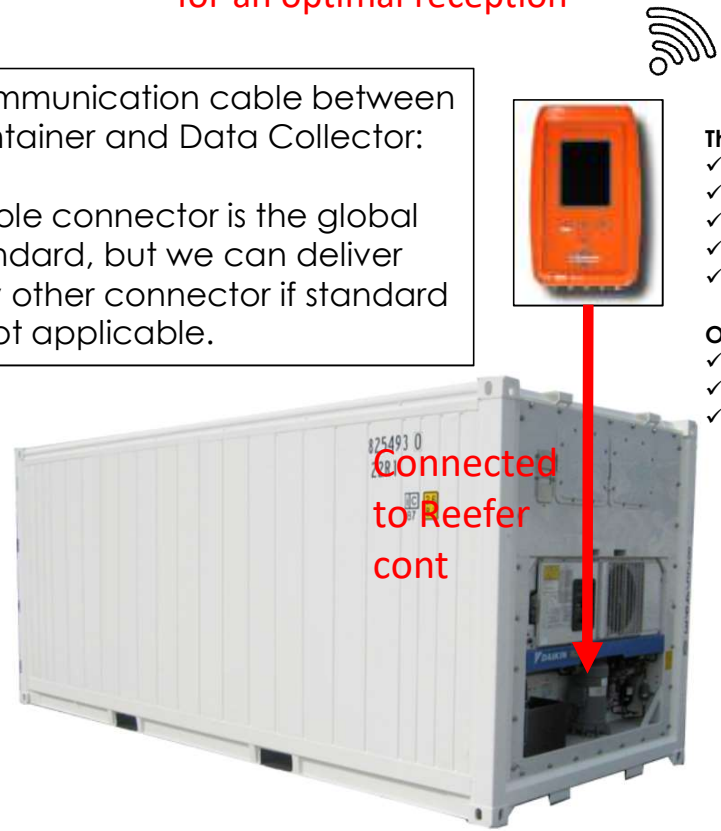
- Remote monitoring and control of the interior environment of a refrigerated shipping container
- A communications and monitoring device is coupled to a data communications port of a controller of a shipping container.
- The device is able to receive an operational parameter directly from the controller, without having to install additional instrumentation within the interior of the refrigerated shipping container

NOTE:

- A yard full of steel containers is a challenge for every signal, especially Wi-Fi.
- Wi-Fi access points are crucial for this application and setup
- Wi-Fi access points must be installed every 40 meters for an optimal reception

Communication cable between container and Data Collector:

5-pole connector is the global standard, but we can deliver any other connector if standard is not applicable.



The Collector will retrieve:

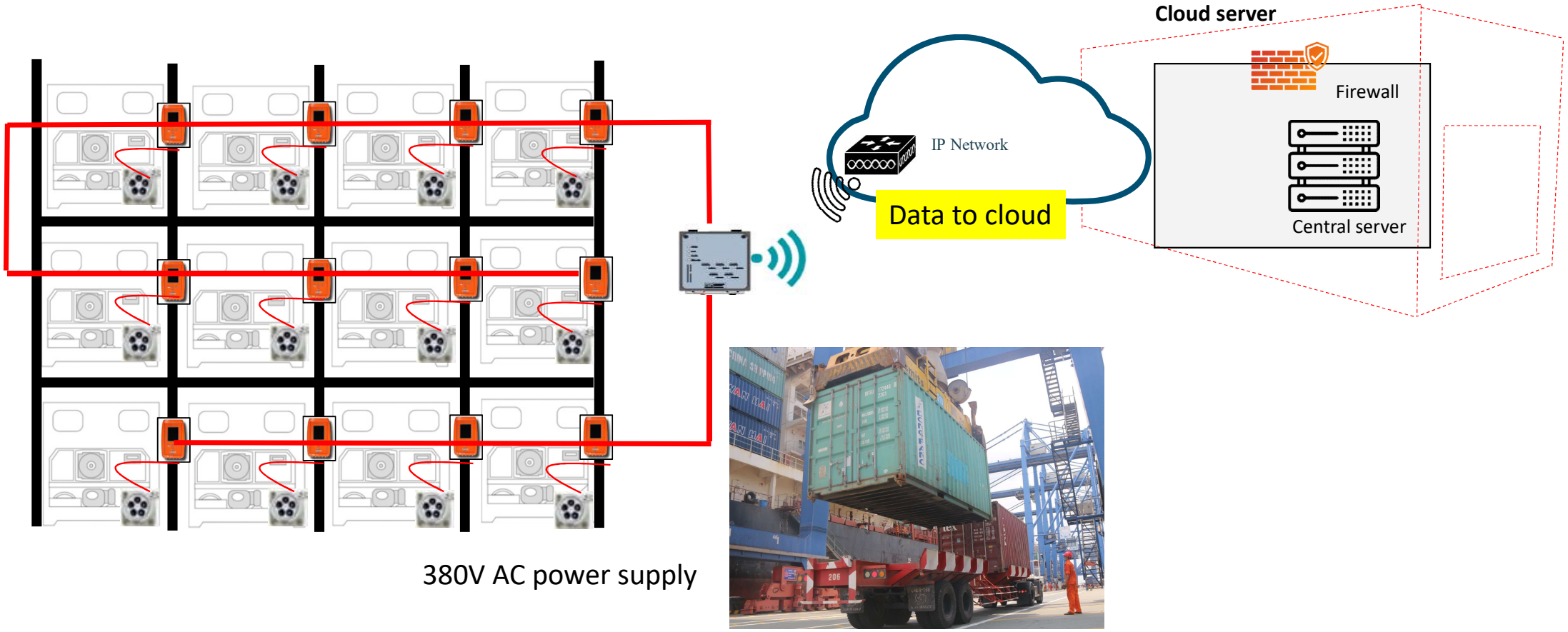
- ✓ All temperature sensors
- ✓ Container mode
- ✓ Container number
- ✓ Time & Date
- ✓ Alarms

Other features

- ✓ Change Setpoint
- ✓ Change Container number
- ✓ Change Date & Time

The monitoring device will sample data periodically

Rack-mounted containers



Protocols and capabilities

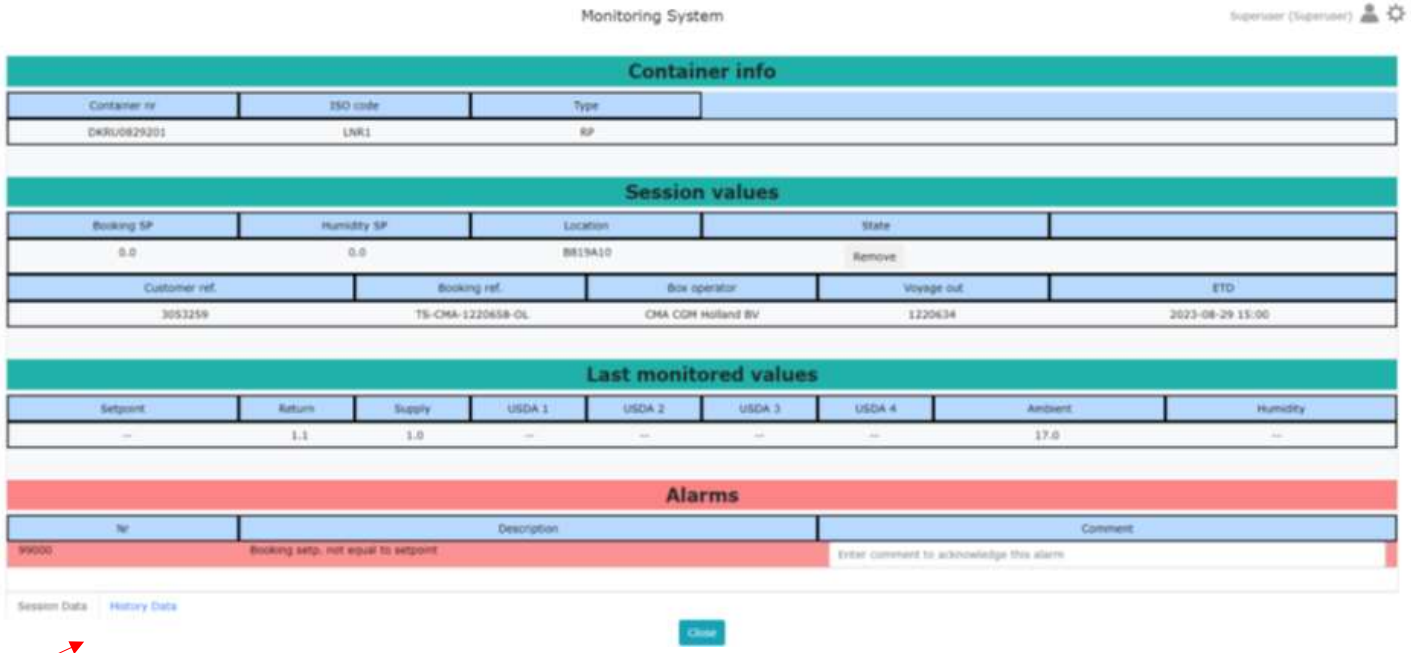
Function		Carrier ML2i	Carrier ML3	Carrier ML5	Daikin <= e	Daikin >e	Starcool	Thermoking MP3000(A)	Thermoking MP4000
Detect		✓	✓	✓	✓	✓	✓	✓	✓
Setpoint	Read	✓	✓		✓	✓	✓	✓	✓
	Set	✓	✓		✓	✓	✓		✓
Sensors	Supply	✓	✓		✓	✓	✓	✓	✓
	Return	✓	✓		✓	✓	✓	✓	✓
	Ambient	✓	✓		✓	✓	✓	✓	✓
	Humidity	✓	✓		✓	✓	✓	✓	✓
	USDA1	✓	✓		✓	✓	✓	✓	✓
	USDA2	✓	✓		✓	✓	✓	✓	✓
	USDA3	✓	✓		✓	✓	✓	✓	✓
	USDA4/Cargo	✓	✓		✗	✗	✓	✓	✓
Alarms	Read	✓	✓		✓	✓	✓	✓	✓
	Reset	✓	✓		✗	✗	✗	✗	✗
Date/time	Read	✓	✓			✓	✓	✓	✓
	Set	✓	✓				✓	✓	
Mode	Read	✓	✓		✓	✓	✓	✗	✗
Download		✓	✓		✓	✓	✓		

Unlisted brands: We will have to do survey

Cloud Application - overview

- Web based
- Multi role users (Technical, Supervisor, Admin)
- Terminal Support: PC Windows, Mac, Android/IOS
- Monitoring:
  - Container operation
  - Device (data collector) operation
  - Alarm
  - Monitoring history

App view - example



Operational overview of containers on port yard

Click on to zoom-in details

Monitoring System

Superuser (Superuser)

Overview | Alarms | Customer: RST | Yard: RST | Legend | SCM's | Yards

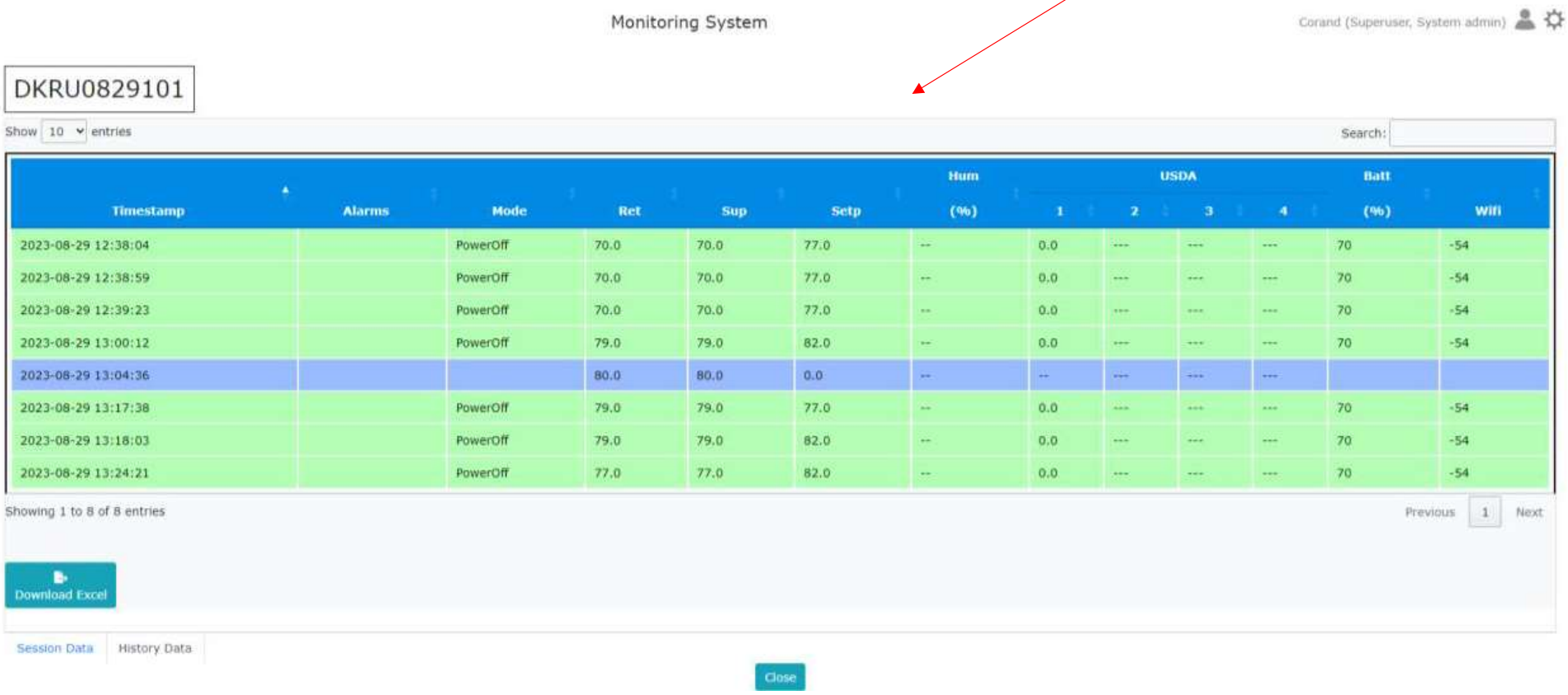
Search container Nr: Enter container nr

Search timestamp: Enter date

Container Nr	Ret	Sup	SetP	BSetp	Physical Location	Alarms	Mode	Ambient	Hum (%)	Model	Software Version	Container Clock	Local Timestamp	Bat	Wifi
AMSU0100004	-0.1	-0.2	0.0	--		15	PowerOff	-0.2	255	Starcool CIM6	0358	2023-06-13 03:21:00	2023-09-20 12:41:39		-42
AMSU3015971	-0.2	-1.0	-0.9	--			Manual	-1.5	--	ThermoKing MP4000	18090500	2023-09-16 14:14:38	2023-09-19 09:50:35		-43
DKRU0829201	1.1	1.0	0.0	0.0	B819A10		PowerOff	17.0	--	Starcool CIM6	0358	2023-08-25 16:00:00	2023-09-14 14:55:35		-54
DKRU0829004	-8.2	-8.3	-10.0	-10.0	466X1		PowerOff	17.0	--	Starcool CIM6	0358	2023-08-25 16:00:00	2023-09-14 14:14:01		-54
TCLU1221278	--	--	--	14.0	B818A10			--	--			---			

App view – example (con't)

Click on history to view data details



Application Customization (optional)

- ERP integration: It is possible to integrate Cloud app to an ERP system, however, this requires additional integration service
- Customize reports

4. Lab test

Daikin Marine type Container Refrigeration

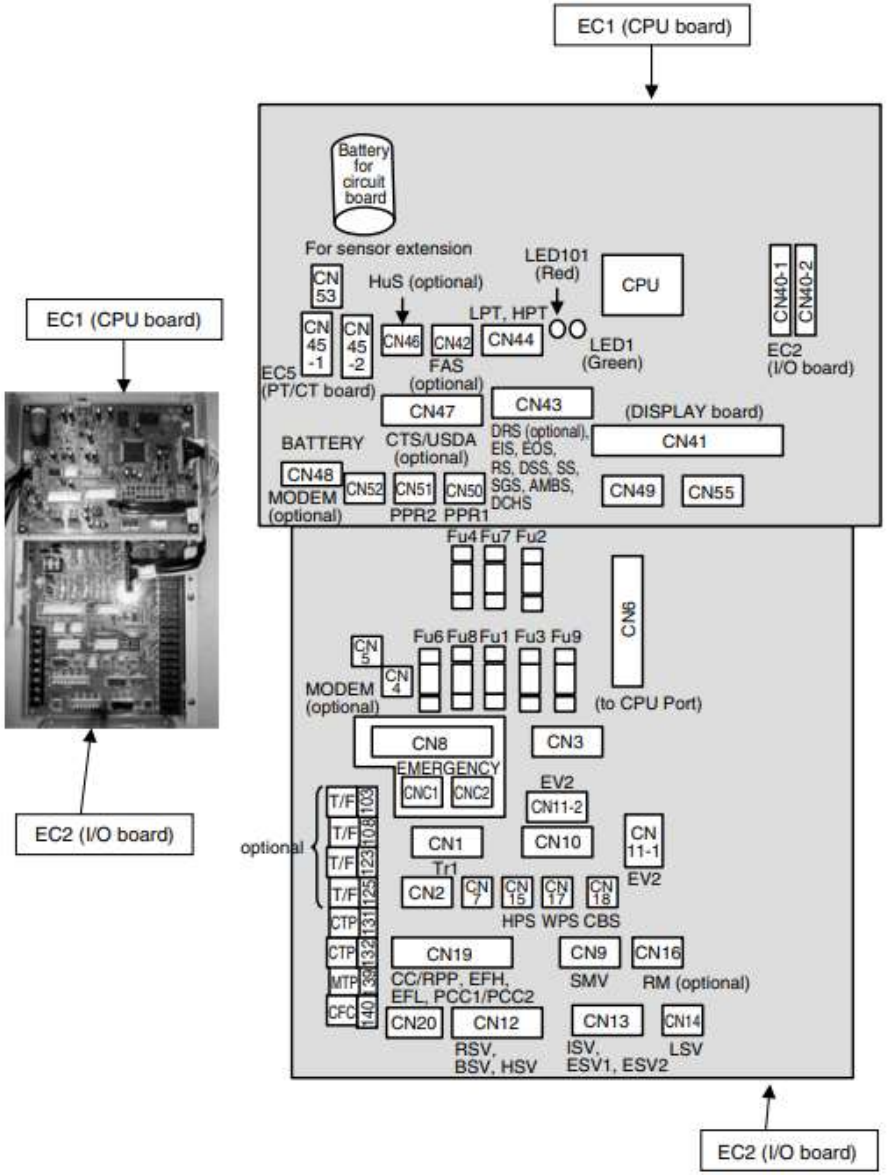
2.7 Communication modem

DECOS Ⅲ h controller can transmit operation data through power line, if slave modem is installed in control box.

The slave modem shall be complied with ISO10368. The following items can be monitored and/or send commands via master modem: (*1)

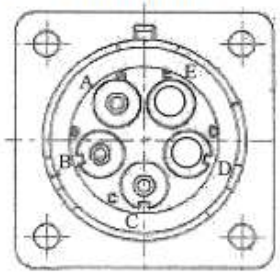
	Item	Description	
1	Inquiries (Remote monitoring)	● Inside temperature and humidity ● Set point temperature ● Defrosting interval ● Container No. ● Logger header information ● Alarm ● Operation mode	● Sensor data ● Trip data ● Alarm data
2	Commands (Remote control)	● Set point temperature changing ● Defrosting interval changing ● Manual defrosting initiation	● Container No. changing ● Unit ON/OFF changing ● Header information changing

(*1) According to the relationship among slave modem, Master modem and controller, items which can monitor and/or 2-way communication are different. Please contact DAIKIN sales office if you have a specific item to monitor or send commands.

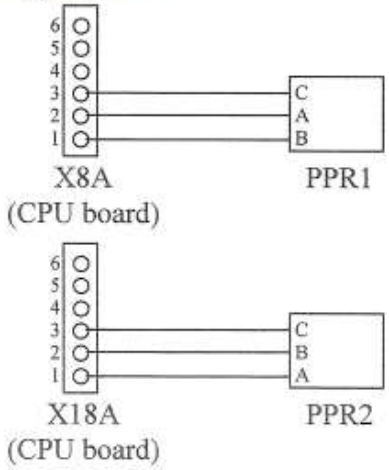


3.4.2 PC port (PPR1,2)

● Location (Seen from front on)

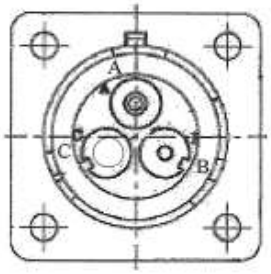


● Wiring diagram

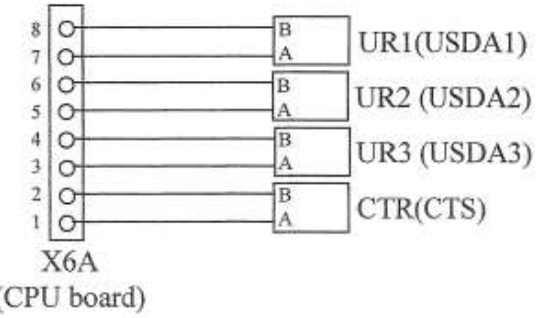


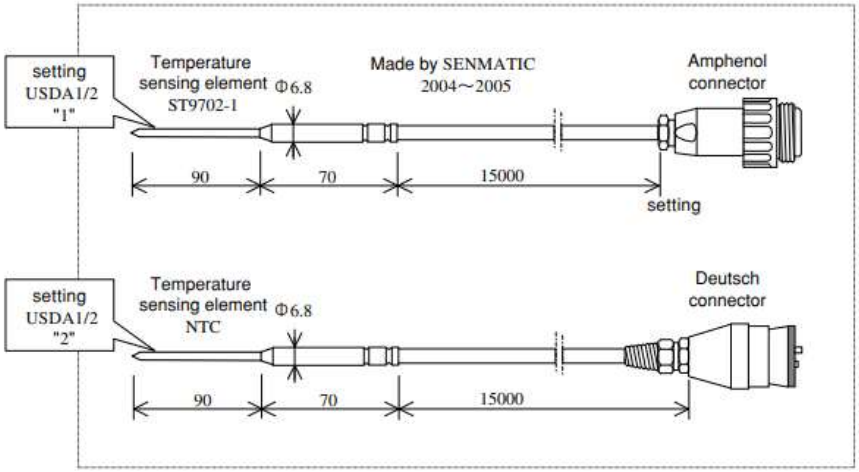
3.4.4 USDA sensor 1-3 junction port (USDA1-3) (Optional) Cargo temperature sensor junction port (CTR) (Optional)

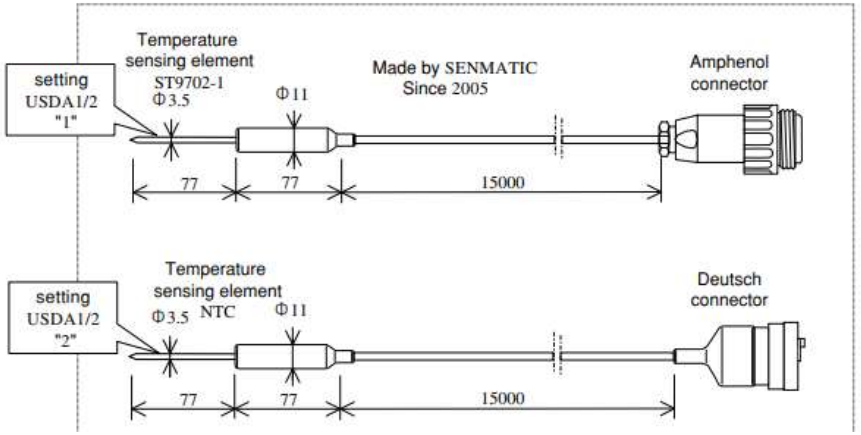
● Location (Seen from front on)



● Wiring diagram



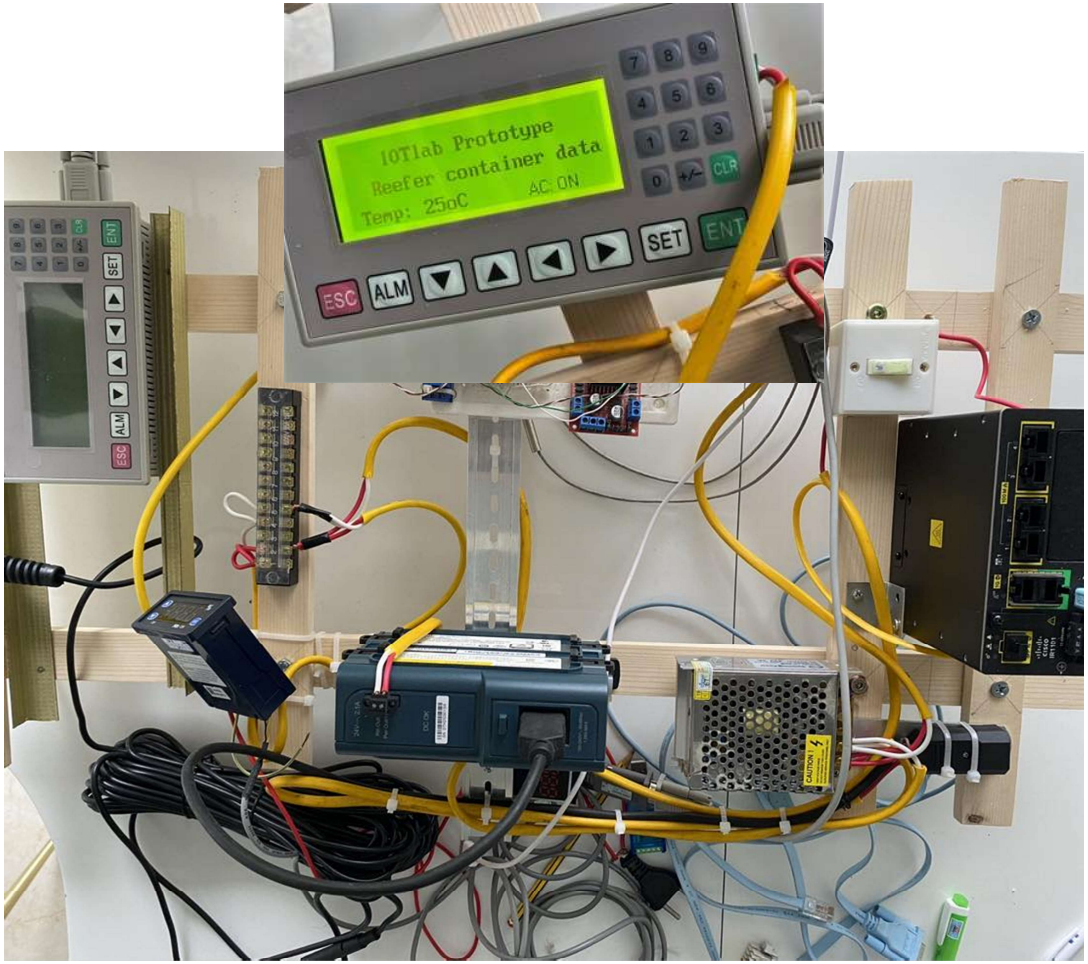




Sensor input	Temperature input Thermocouple: K, J, T, E, L, U, N, R, S, B, W, or PL II Platinum resistance thermometer: Pt100 or JPt100 Infrared temperature sensor (ES1B): 10 to 70°C, 60 to 120°C, 115 to 165°C, or 140 to 260°C Analog input Current input: 4 to 20 mA or 0 to 20 mA Voltage input: 1 to 5 V, 0 to 5 V, 0 to 10 V,or 0 to 50 mV (The 0 to 50 mV range applies to the E5CC-U only for those manufactured in May 2014 or later.)

We have simulated in our Lab

Now we are comfortable to develop solution for unlisted container model



5. Case studies

- **OOCL** Kaohsiung, Taiwan 1996
- **Aarhus Stevedore** Denmark 1997
- **TSI Deltaport** Vancouver, Canada 1997
- **Long Beach Container Terminal (Multi User)** Long Beach, California, USA 1998
- **Arctic Container Operation A/S** Aalborg, Denmark 1999
- **Royal Arctic Line A/S** Nuuk, Greenland 1999
- **Massachusetts Port Authority** Boston, Massachusetts, USA 2001
- **Matson Navigation Co.** Los Angeles, Oakland, Seattle, Honolulu
- **Fraser Surrey Docks** Vancouver, Canada 2002
- **CentrePort** Wellington, New Zealand 2002
- **SSAT** Oakland, California, USA 2002
- **Port of Jurong** Singapore 2002
- **Yang Ming Lines** Kaohsiung Terminal, Taiwan 2003
- **Packer Avenue Terminal** Philadelphia, Pennsylvania, USA 2004
- **Salerno Container Terminal** Salerno, Italy 2005
- **Manzanillo International Terminal** Colon, Panama 2005
- **Cagliari International Container Terminal** Cagliari, Italy 2006
- **Maersk Costa Rica** Limon, Costa Rica 2007
- **Pier 1** Durban, South Africa 2008
- **Terminal San Giorgio** Genoa, Italy 2008
- **Terminal Cuenca del Plata** Montevideo, Uruguay 2010
- **Terminales Rio de la Plata (DP World)** Buenos Aires, Argentina
- **Zuidnatie NV** Antwerp, Belgium 2022
- **Canadian National Railway** Brampton, Canada 2022
- **Westports Holdings** Port Klang, Malaysia 2022
- **Wan Hai** Kaohsiung, Taiwan 2022
- **DP World Caucedo** Dominican Republic 2011
- **Terminal Lorenzini** Livorna, Italy 2012 GRASPNe
- **Terminal Pacifico Sur Valparaiso** Valparaiso, Chile
- **Exolgan (PSA)** Buenos Aires, Argentina 2012
- **Ports America** Long Beach, California USA 2012
- **Oxford Cold Stores** Melbourne, Australia 2013
- **Tranac** Jacksonville, Florida USA 2013
- **DP World Karachi (QICT)** Karachi, Pakistan 2013
- **Luis Ayala Colón Sucrs., Inc.** San Juan, Puerto Rico 2013 RRCE-T, GRASP3 – 200 Reefer Points
- **Roma Terminal Container SPA** Rome, Italy 2014
- **Manzanillo International Terminal (SSA)** Colon, Panama 2014
- **San Antonio Terminal Internacional (SSA)** San Antonio, Chile 2014
- **Rotterdam World Gateway** Rotterdam, Netherlands 2014
- **Assan Port** Turkey 2015
- **Alaska Marine Lines** Seattle Y1 2015
- **River Trade Terminal (HPH)** Hong Kong 2015
- **Terminales Río de la Plata (DP World)** Buenos Aires, Argentina 2015
- **Port Everglades Terminal LLC** Fort Lauderdale, Florida, USA 2016
- **Adani Port** Mundra**,** India 2016
- **Ningbo Terminal** Ningbo**,** China 2016
- **Mersin International Port (PSA)** Mersin, Turkey 2016
- **QQCT**Qingdao, China 2016
- **Colon Container Terminal** Colon, Panama 2023
- **EXOLGAN (PSA) New Yard** 2023
- **Canadian National Railway** Vancouver, Canada 2023
- **HPH LCTPC** Lazaro Cardenas, Mexico 2023
- **DYCSA Group** San Antonio, Chile 2023
- **Terminales Río de la Plata (DP World)** Buenos Aires, Argentina 2016
- **PSA Sines** Sines, Portugal 2017
- **Yangshan 4th Terminal** Shanghai, China 2017
- **Nhava Sheva (India) Gateway Terminal (NSIGT)** Mumbai, India 2017
- **PSA Terminal** Singapore 2017
- **Chiquita Bocas del Toro** Panama 2017
- **PSA Panama** Panama 2018
- **QQCTN** Qingdao, China 2018
- **PSA Tianjin** Tianjin, China 2018
- **River Trade Terminal (HPH) Expansion** Hong Kong 2018
- **COSCO Shipping Ports Abu Dhabi** Abu Dhabi, UAE 2018
- **HPH Mexico – ICAVE (New Terminal)** Veracruz, Mexico 2019
- **Sogester (APM Terminals)** Luanda, Angola 2019
- **River Trade Terminal (HPH) Expansion** Hong Kong 2019
- **Serteba** Santa Marta, Colombia 2019
- **DP World Jebel Ali T4** Dubai, UAE 2020
- **Montecon** Montevideo, Uruguay 2020
- **PSA Tianjin Expansion** Tianjin, China 2020
- **Bayport (SIPG)** Haifa, Israel 2021
- **River Trade Termina (HPH) Expansion** Hong Kong 2021
- **PSA Terminal Expansion** Singapore 2021
- **Terminal de Contêineres de Paranaguá** Paranaguá, Brazil 2022
- **GOLMEX** Veracruz, Mexico 2024 WRAD II
- **Rotterdam World Gateway (Expansion)** Rotterdam, Netherlands 2024
- **Terminal** Colombo, Sri Lanka 2024
- **Northport** Selangor, Malaysia 2022
- **River Trade Termina (HPH) Expansion** Hong Kong 2023

6. Commercial

To be discussed
Thank you