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Whitepaper – Sensor Network for Rack and Room Monitoring

ENCLOSURES | POWER DISTRIBUTION | CLIMATE CONTROL | IT INFRASTRUCTURE | SOFTWARE & SERVICES

FRIEDHELM LOH GROUP

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Executive summary

Data centers today incorporate monitoring systems aimed at enabling IT managers to maintain an overview of the ambient conditions throughout their facilities from a central office. As installations increase in scale, however, their complexity is likewise increased and the cabling of the individual components – including the monitoring system – becomes more and more difficult. The CMC III system from Rittal solves this problem by using a CAN-Bus, which permits serial interconnections between the various monitoring sensors and a central controller. As successor to the proven CMC-TC system, it offers many new functions and improvements, and stands out by way of its simpler installation and cabling and the minimal space requirement. The CAN-Bus and the possibilities for a redundant power supply provide for the required standard of security, reliability and fault detection.
Whereas the predecessor series was designed predominantly for use in larger IT facilities, the Compact version of CMC III can also be recommended for smaller installations and single-enclosure applications. The reduced demand profile allows a narrower scope of functionality and optimisation of the price-performance ratio. By way of OPC, CMC III can be integrated into practically any supervisory control system, making the measured data available to higher management levels.

Introduction

A data center today represents the heart of the IT installations in practically all medium and large companies. It is here that all important data are collected and stored, with corresponding access granted to authorised employees at any time.
Failure of this system can have disastrous consequences. Alongside the temporary interruption to work, the possible data losses would place enormous cost burdens on the company if the work of several weeks – or even months – were to go to waste. Not least for this reason, the data center must be monitored. This permits timely reaction to any arising problems and avoids actual failure of the system. In modern, ever larger data centers, the use of technical aids has become indispensable for IT managers.
For several years, therefore, data center administrators have placed their trust in the proven CMC-TC system (Computer Multi Control – Top Concept) from Rittal. The sensors of this system monitor the various “vital functions” of the data center and transmit their measurements of temperature, humidity, etc. to a central evaluation unit for processing. If any parameter exceeds a defined threshold, the CMC-TC systems sends a text message with corresponding information to a technician, who can thus initiate countermeasures to avert the threatening failure.
In a constantly expanding data center environment, however, the cabling of the sensors becomes an ever greater challenge. In response to this development, Rittal now offers the proven CMC III series as successor to the proven CMC-TC system. In addition to the long-established features and functions of its predecessor, CMC III incorporates a number of innovations.

Objective and requirement

Most manufacturers of IT equipment are today geared to designing ever more powerful and at the same time more compact devices, so as to be able to pack more performance into a network enclosure. The smaller the monitoring system, the more space remains in the enclosure for servers and other components. In this context, problems are frequently encountered with regard to the cabling. A greater number of components in an enclosure means a multitude of wires and cables. The CMC III system is intended to reduce the complexity of cabling and thus to provide for clearer cable routing between the sensors in the enclosures and the central processing unit. At the same time, the system must promise fast and secure data communication without downtimes. A redundant power supply guarantees reliable operation, while occupying only a minimum of the available enclosure space.
Whereas the CMC-TC system was designed predominantly for IT departments with multiple enclosure suites, the scope of possible applications is to be extended with the new generation. To this end, the system must be optimised especially for single-enclosure applications, for building services management and for applications in industry. As reduced demands are usually placed on a security system here, the full functionality of CMC III is not always required. The standard version of CMC is generally over-dimensioned for such applications, and a compact variant is often sufficient. In addition, many potential users in industry and the manufacturing sector use control systems to monitor the whole building infrastructure. As CMC is later to be capable of integration into these control systems, it must be able to communicate with all typically encountered systems. This is made possible by implementing a common protocol (“OPC”).
Complex systems call for significant expenditure and long familiarisation periods before administrators and users reach a higher level of proficiency. Simple handling and uncomplicated installation save above all time and costs, and permit faster deployment of the monitoring systems.

The CAN-Bus

CMC III uses a CAN-Bus (Controller Area Network) for integration of its sensors.
The CAN-Bus was developed by the company Bosch in 1991. Originally conceived for automotive applications, it is in the meantime also widely used in automation technologies.
The CAN protocol is standardised in the international ISO 11898 standard. In the OSI model, the “reference model for manufacturer-independent communication systems”[1], it represents Layers 1 and 2. In other words, CAN manages access to the common medium (the bus) and ensures the correct transmission of messages.
The network users on a CAN-Bus are structured in a line topology. For the physical interconnections between users, either copper cables or other media such as fibre optics or wireless transmission may be used. All network users are treated as equal and are permitted to transmit and receive as long as the bus is free. Message frames are not addressed directly to an individual node. A message is initially sent to all users. Each user then determines the relevance of the message independently and either processes or discards its contents.
To avoid collisions on the bus, a method known as CSMA/CD+CR (**C**arrier **S**ense **M**ultiple **A**ccess/**C**ollision **D**etection + **C**ollision **R**esolution) is implemented, as illustrated in Figure 1. If one of the users wishes to transmit a message, it first listens for traffic on the common medium. If the bus is not already being used by another user, it waits for a further specified time and verifies that the bus is still free before commencing the transmission. If, in the meantime, another user has begun transmitting and has thus occupied the channel, the delay is extended until this transmission is finished. This procedure is called “back-off”[2] and is repeated as often as necessary until the medium is still free after the waiting time. The specified waiting time is reduced after each unsuccessful attempt to increase the probability of the channel remaining free.

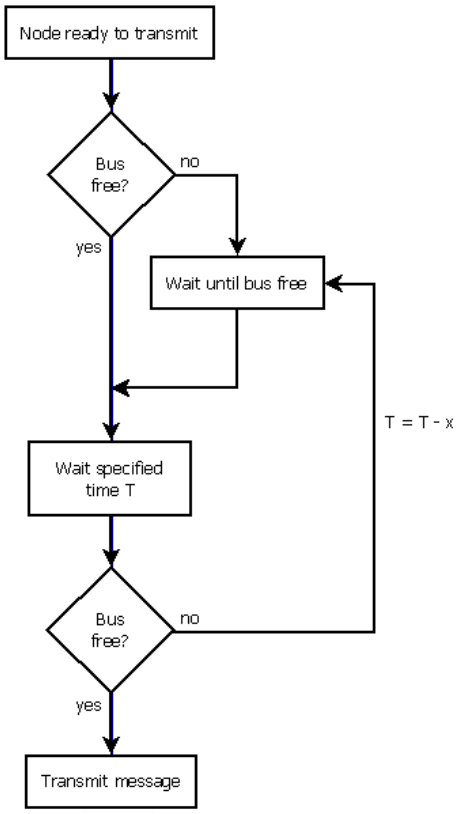

Figure 1: Bus access method

[1] Elektronik Kompendium
[2] Jörg Roth: WLAN – Einfaches CSMA/CA

As this method is unable to exclude collisions completely, the CAN-Bus protocol also specifies the reaction should two users begin transmitting at the same time. On the common bus, a logical “0” is always dominant, and a logical “1” always recessive. If two users transmit different messages simultaneously, the first “1” of the first user will be overwritten by a “0” of the second user. As both users are also monitoring the channel during transmission, the first user detects a “0” on the bus instead of its own “1” and stops its transmission. The second user will not detect an error and will continue to transmit the rest of its message. During this time, the first user waits for the channel to become free, so that it can attempt to transmit its message once more.

The CAN-Bus is capable of transmission rates of 1 Mbit/s over a distance of 40 m. If the cable is longer, the bit rate decreases accordingly. Figure 2 shows the attainable transmission rates for different cable lengths.

There is theoretically no limit to the number of users. The connection components of the individual systems, however, restrict the practically possible number of users, and normally provide for 32, 64 or up to 128 users. The CMC III system permits 32 users to be connected to the bus.

Bit rate	Cable length
10 kbits/s	6,7 km
20 kbits/s	3,3 km
50 kbits/s	1,3 km
125 kbits/s	530 m
250 kbits/s	270 m
500 kbits/s	130 m
1 Mbits/s	40 m

Figure 2: Bit rates and cable lengths
Source: IT-Wissen

With its various control mechanisms, the CAN-Bus features not only a high level of fault tolerance, but also extensive fault detection. This makes the system particularly reliable and thus also suitable for use in environments subject to interference.

The CAN protocol defines bus access and message transmission, but contains no specifications regarding interpretation of the actual user data. For this reason, CMC III uses the CANopen protocol. In this case, the data are assigned to different types and arranged in order of importance. This permits the prioritisation of particular messages. Important data are thus transmitted first and are thus made available faster on the receiver side for time-critical applications.

CMC III

The structure of the new CMC III system is very similar to that of its predecessor. It maintains many of the proven functions and features of CMC-TC, but at the same time eliminates some smaller weak points.
The CMC III system operates with a central controller, the PU III (Processing Unit) depicted in Figure 3. The sensors communicate with the processing unit via serial links – interconnected in series rather than in star topology via an I/O Unit (Input/Output Unit). Whereas it was always necessary to incorporate such an I/O unit between the sensors and a PU II in the predecessor system, the sensors can now be connected directly to the PU III in the CMC III system. The space saved becomes available for other installations.
Alongside a new appearance, the new Processing Unit also features improved functionality. The first access to the PU III is already more convenient for the user. A standard mini-USB port, which unlike a serial interface is today compatible with practically all (mobile) PCs, is used to make the connection between a PC and the PU III, and enables the user to enter the settings necessary for initial configuration of the processing unit.
A further USB port is provided on the rear of the unit to permit data from the PU III to be saved to an external data carrier. Alternatively, an SD card slot in the front panel can be used for the same purpose.

Figure 3: The Processing Unit PU III

Rittal offers a diversity of sensors for use with the CMC III system. Compared to CMC-TC, the spectrum of measurements which can be acquired with the sensors has been widened significantly. Besides parameters such as temperature, humidity, voltage, current, etc., which could already be recorded with the sensors of the predecessor series, it is now also possible to measure values such as active power, apparent power and supplied energy. Furthermore, an interface module permits CMC-TC sensors to be connected to the new PU III. This makes it easier for a user to upgrade to the new system, as it is not necessary to replace the already existing CMC-TC sensors.
Two important sensors are integrated into the PU III as standard. The infrared sensor on the front of the unit serves to monitor the enclosure door, and a temperature sensor is placed behind the front panel to measure the temperature of the inflowing ambient air. Through the integration of these two sensors, it is possible to forego the installation of external infrared and temperature sensors in the direct vicinity of the processing unit.

The PU III acts as a central controller, and thus as the interface between CMC and the user, or between CMC and higher-level management systems. Through a standard network port, the CMC system can be linked into a company network, enabling administrators to access an integrated Web interface from their office PC via the IP address or a name assigned to the processing unit. After entering a corresponding user name and password, they can then view the currently measured values or modify settings. Figure 4 shows the new Web interface with a list of several sensors. Warnings are here highlighted in orange, and alarms in red. The thresholds for warnings and alarms can be defined for each individual sensor.

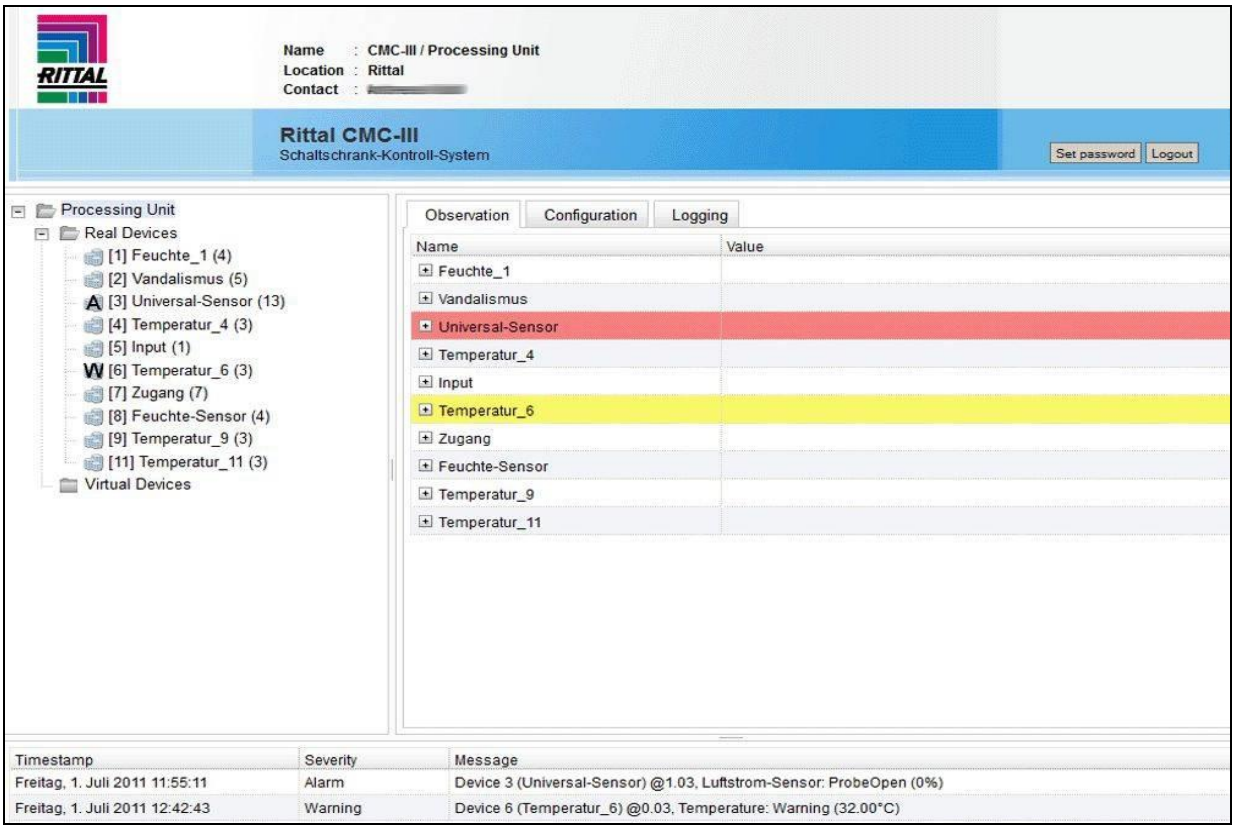

Figure 4: Web interface

When integrated into the Rittal management software “RiZone”, and in combination with SCOM (System Center Operations Manager) from Microsoft, it is possible to trigger automatic countermeasures should a critical state be detected with the aid of CMC, and in this way to avert a total failure and data loss even without direct intervention by the IT staff. The interface to a company LAN serves not only for data communication. It is also possible for the PU III to draw its power from the network by way of PoE (Power over Ethernet), in which case a separate power supply unit is no longer required. Nevertheless, two further power supply connections are available on the rear of the processing unit. Alongside the standard CMC III power pack, terminals can be used to connect a redundant power supply. The user thus remains very flexible with regard to the power supply for the PU III. The facility

for redundancy, moreover, reduces the probability of system failure and further enhances reliability accordingly.

Test setup

The use of a CAN-Bus brings numerous benefits. The bus is not only highly fault-tolerant, it is also suitable for use in environments subject to interference thanks to its extensive fault detection capabilities. Whereas the cabling of sensors posed considerable problems in some cases with the CMC-TC and often resulted in a highly complex installation, the connection of the sensors to the PU III is appreciably more straightforward.
To connect a sensor to a PU II, it was first necessary to connect an I/O Unit at one of the four inputs. Each I/O Unit possessed four sensor inputs. A total of 16 sensors could thus be connected in this manner to each PU II.
Figure 5 shows a test setup in which 8 racks are to be monitored with the CMC-TC system. To this end, four sensors are placed in each rack. Consequently, a total of 32 sensors are incorporated into the enclosure suite and connected to a PU II via I/O Units.

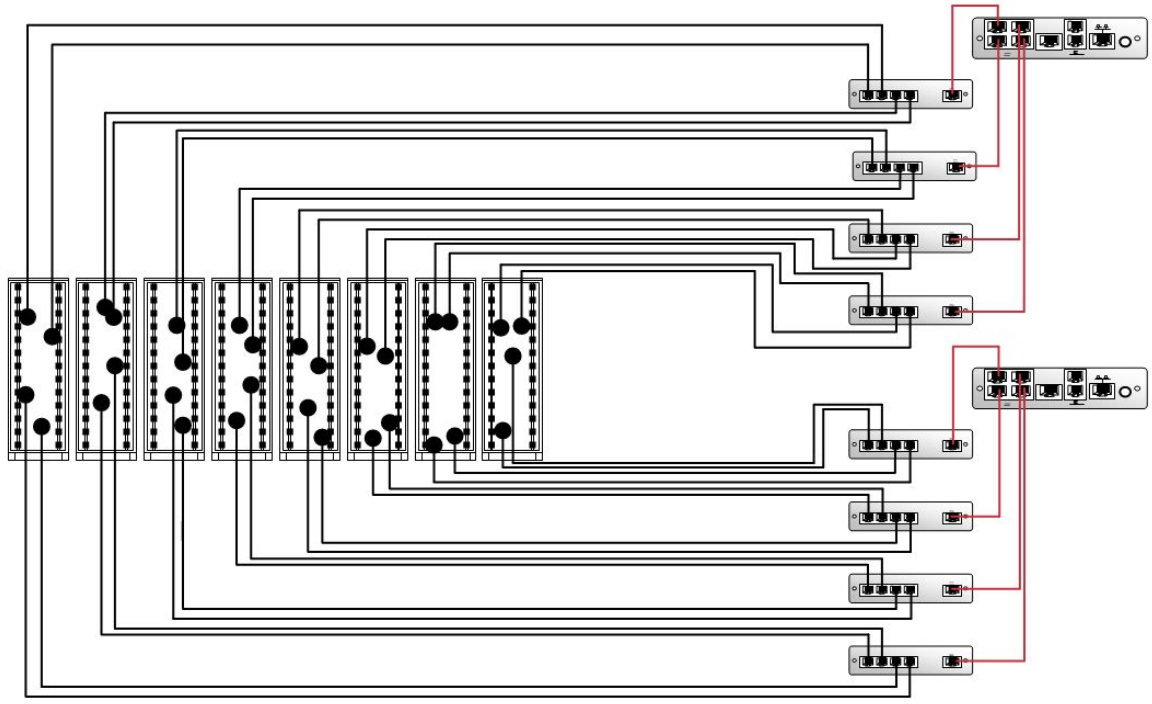

Figure 5: Test setup with CMC-TC

Table 1 lists the components required for this configuration.

Component	Number required
Processing Unit	2
I/O Unit	8
Sensors	32
Connecting	40

cables	

Table 1: Components for test setup with CMC-TC

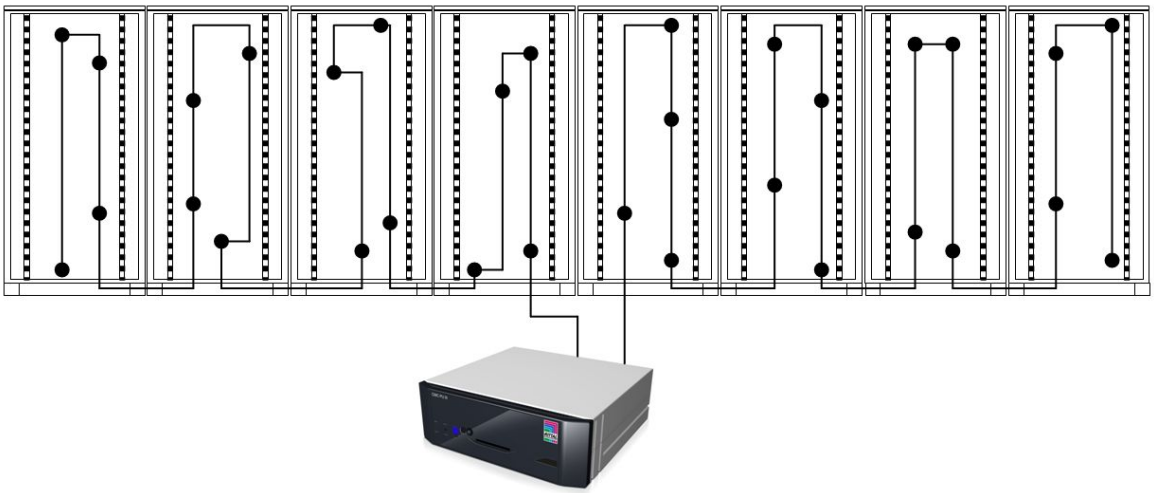

Figure 6: Test setup with CMC III

If the same enclosure monitoring configuration is realised with CMC III, by contrast, the structure is as shown in Figure 6. There are two ports on the rear of the PU III, each of which can be used to connect 16 sensors. The individual sensors are connected in series.
Table 2 lists the components required for this configuration with CMC III.

Component	Number required
Processing Unit	1
I/O Unit	0
Sensors	32
Connecting cables	32

Table 2: Components for test setup with CMC III

If the two test setups are compared, a number of differences are immediately evident. Firstly, the comparison of required components (Table 3) reveals a distinct advantage for the CMC III system, as significantly fewer devices and connecting cables are required.

Component	Number required for CMC-TC	Number required for CMC III
Processing Unit	2	1
I/O-Unit	8	0
Sensors	32	32
Connecting cables	40	32

Table 3: Comparison of components for test setups with CMC-TC and CMC III

At the same time, as can be seen clearly in Figure 5 and Figure 6, the actual installations in the racks are much less complicated with the CMC III system. The fewer cables and devices makes it easier to identify the individual connecting cables and helps to avoid “cable clutter”.

CMC Compact

The new PU III is available in two versions. In addition to the standard version with full functionality, there is also a “compact” version, whose reduced scope of features makes it an ideal choice for smaller installations and industrial applications.
Smaller monitoring systems often serve only a few racks, and control enclosures in production environments usually even stand alone. In both cases, the enclosure installations are far less complex than in a large data center with multiple enclosure suites. The demand profile to be satisfied by such a monitoring system is thus significantly reduced. Many functions are superfluous in a smaller system, with the result that the standard version of CMC III can be deemed over-dimensioned.
CMC III Compact, on the other hand, is tailored specifically for smaller systems. In this version, the SD card slot and the USB port for the saving of data to an external storage medium have been omitted. Furthermore, it is only possible to connect four CAN-Bus sensors, though here, too, a temperature and infrared sensor are integrated into the PU III and the full range of available sensors can be used. Even with these limitations, CMC III Compact is still perfectly adequate to meet the demands of most small systems and single-enclosure applications. Compared to the standard version of CMC III, the compact version thus displays a much better price-performance ratio for smaller-scale installations.
Intelligent networking also permits the programming of further energy-saving and convenience mechanisms in this field. As stand-alone enclosures are usually provided with their own cooling system, for example a Rittal wall- or roof-mounted cooling unit, CMC III facilitates control of this cooling. One possibility is to switch off the cooling unit as soon as the enclosure door is opened, so as not to waste energy.

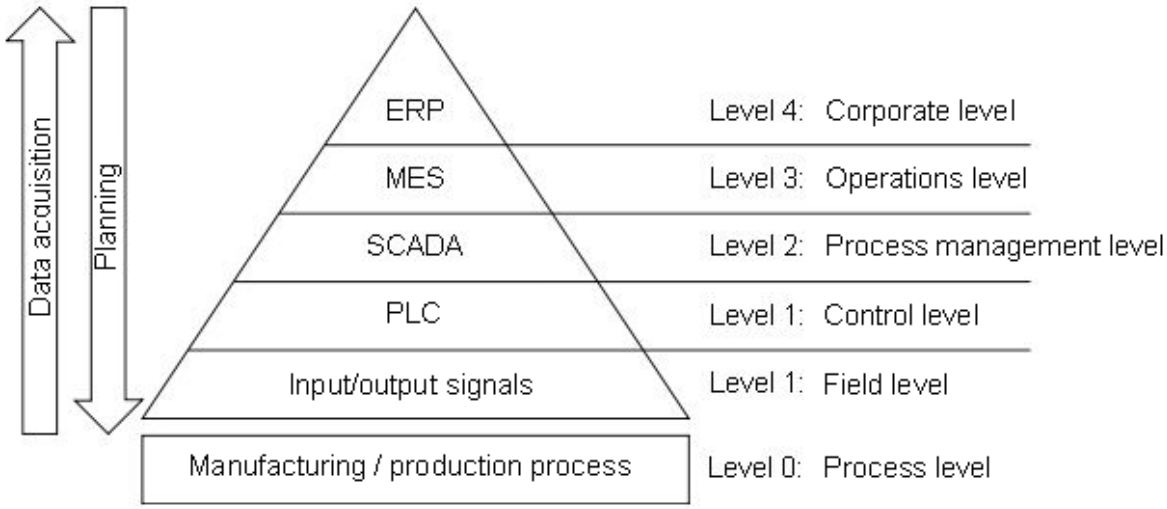

Figure 7: Automation pyramid
Source: Wikipedia

In many cases, a single enclosure contains a PLC (Programmable Logic Controller) to control the production machine. This PLC, together with further components, is usually linked to a higher-level management system. In the automation pyramid depicted in Figure 7, such a control system is represented by Level 2. If the CMC system is now likewise classified according to this pyramid, the PU III, as the central processing unit, can be assigned to the control level (Level 1) and the sensors to the field level. To realise networking between CMC III and a higher level, it is necessary to offer a common protocol which is understood by as many supervisory control systems as possible. As the integrated SNMP protocol does not meet this requirement, CMC III also supports the OPC protocol (Object Linking and Embedding for Process Control). This protocol is available in practically 99% of all control systems and permits direct communication from CMC to a control system without an intermediate third system.
Most of the enclosures which are in use in industrial environments and there incorporate a PLC or the like are not already equipped with a monitoring system. An excessive temperature rise in the enclosure is not noticed until the first electrical components fail. As the PLC system should preferably not be modified, however, it is difficult to integrate monitoring into a running system. The compact version of CMC III, on the other hand, is well suited as a retrofit solution for such cases. The simple installation and the communication via OPC make it possible to add the system without interrupting current operations, as neither a complete production shutdown nor modifications to the PLC software are required.

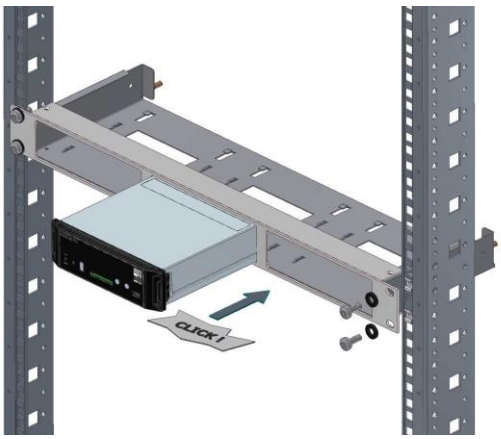

Figure 8: Mounting on 19" mounting frame

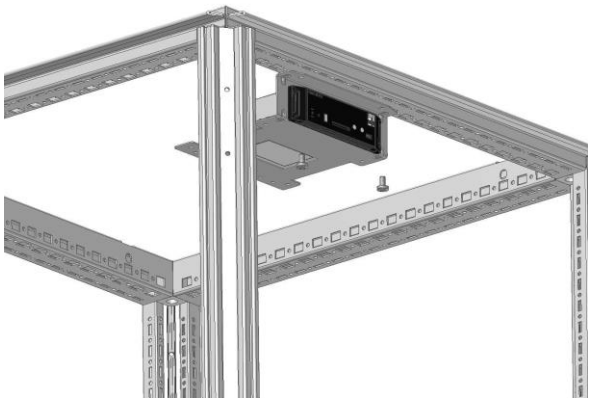

Figure 9: Mounting on enclosure frame

The PU III can be mounted either directly on the enclosure frame (Figure 9) or in a 19" mounting frame (Figure 8).
The uncomplicated plug-in technology saves the user time during installation. It furthermore simplifies possible maintenance work and retrofitting.

Summary

Even electronic components which represent the latest state of the art remain susceptible to failures caused by water, heat, etc. For a corporate user, an interruption to data center operations means high losses and a diversity of consequential problems and costs. Effective means to eliminate this dilemma are not to be expected in the foreseeable future, with the result that data centers must be monitored permanently.
One reliable and flexible solution is the CMC III system from Rittal. The various sensors which monitor the “vital functions” of the data center are connected to a central controller, the Processing Unit PU III, which evaluates the measured values and at the same time provides an interface to the user. If any parameter exceeds a defined threshold, the central unit sends a corresponding message to a technician. In combination with the Rittal software “RiZone” and the “System Center Operations Manager” from Microsoft, it is even possible to trigger countermeasures automatically, without direct intervention by a technician. In this way, failures and the associated data losses can be averted in good time.
Compared to its predecessor CMC-TC, the CMC III system realises above all much simpler cabling of the sensors. Cabling is not only less complicated, but also occupies less space in the enclosure. The most important sensors – temperature and access control – are already integrated into the PU III and must not be installed separately. The power supply for the PU III can be provided with a CMC power pack, via terminals or via PoE. The user thus remains flexible in his choice and can even implement a redundant configuration to maximise operational reliability. The simple installation and a USB port for configuration, furthermore, facilitate deployment, commissioning and retrofitting for the user.
The availability of a Compact version also makes CMC III an interesting option for small systems and single-enclosure installations. As such applications place reduced demands on the monitoring system, CMC Compact is an ideal choice, not least thanks to its correspondingly positive price-performance ratio. With the aid of OPC, the PU III can communicate with practically any supervisory control system, enabling the CMC data to be made available to higher management levels. This facilitates more central administration with a greater spectrum of data and simplifies the monitoring overview for IT administrators.
With the new generation of its proven CMC system, Rittal offers a monitoring system which satisfies not only the demands of the IT sector, but also the needs of industrial users. The system stands out by way of its flexibility and reliability, augmenting these merits with simple installation and configuration.

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List of abbreviations

CAN	-	Controller Area Network
CMC-TC	-	Computer Multi Control - Top Concept
CSMA/CD	-	Carrier Sense Multiple Access / Collision Detection
CSMA/CR	-	Carrier Sense Multiple Access / Collision Resolution
I/O Unit	-	Input/Output Unit
IP	-	Internet Protocol
ISO	-	International Organisation for Standardisation
IT	-	Information Technology
LAN	-	Local Area Network
OPC	-	Object Linking and Embedding for Process Control
OSI	-	Open Systems Interconnection
PC	-	Personal Computer
PLC	-	Programmable Logic Controller
PoE	-	Power over Ethernet
PU	-	Processing Unit
SCOM	-	System Center Operations Manager
SD	-	Secure Digital
SNMP	-	Simple Network Management Protocol
USB	-	Universal Serial Bus

Rittal – The System.

Faster – better – everywhere.

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