Augmented Reality superimposes a computer generated image on top of the real one

Digital Transformation of HVAC Service

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Introduction

Customer Experience Management (CXM) is a rapidly growing and continuously changing field. From a mere back office email- and campaign-based customer relationship management function, CXM has grown to embrace all engagement points across the channels. With digital transformation, CXM brings in transformational technologies to harness information that helps businesses understand their customers and their needs, and to engage with them more effectively. Hence it is imperative for businesses to understand the key drivers and enablers to embark on their CXM journey.

In this article we will cover the following technologies:

(a) Remote Monitoring & Control of HVAC Equipment
(b) Augmented Reality (AR)

About the Author

Arunkumar D. is a mechanical engineer from Annamalai University, with work experience of more than 23 years. He has served the Indian Air Force as a short service commissioned officer, and thereafter has been working in Blue Star Limited for the past 16 years in customer service, currently handling service strategy and business development. He is a member of the Skill Committee of Refrigeration & Airconditioning Manufacturers Association (RAMA), and a representative member of National Cooling Action Plan (NCAP).

Remote Monitoring & Control of HVAC Equipment

Remote monitoring and control of HVAC systems is designed to monitor and control equipment such as chillers, VRFs and packaged airconditioners with some degree of automation. It may receive data from sensors, telemetry streams, user inputs and pre-programmed procedures. The software may send tele-commands to actuators, computer systems or other devices.

This technology advancement enables organizations to harness large volumes of data, and put that knowledge to work in moving the industry towards intelligent systems that intuitively know what customers need in terms of efficiency and comfort, thereby reducing the operating costs and improving system reliability.

The heart of any remote monitoring system is its remote terminal unit (RTU). It is imperative to understand the key features of the RTU. An RTU is a microprocessor-controlled electronic device that interfaces HVAC equipment to a distributed control system or supervisory control and data acquisition (SCADA) system by transmitting telemetry data to a master system, and by using messages from the master supervisory system to control connected objects. An RTU monitors the field digital and analog parameters and transmits data to the Central Monitoring Station (CMS). It contains setup software to connect data input streams to data output streams, define communication protocols and troubleshoot installation problems.

An RTU may consist of a circuit card comprising various sections needed to carry out a custom-fitted function, or may consist of many circuit cards including a CPU or processing unit with communications interface(s), and one or more of the following: analog input (AI), digital (status) input (DI), digital (or control relay) output (DO/CO), or analog output card(s) (AO).

Digital (Status) Inputs

Most RTUs incorporate an input section or input status cards to acquire two state real world information. This is usually accomplished by using an isolated voltage or current source to sense the position of a remote contact (open or closed) at the RTU site. This contact position may represent many different devices, including electrical breakers, liquid valve positions, alarm conditions and mechanical positions of devices. Counter inputs are optional.

Analog Inputs

An RTU can monitor analog inputs of different types including 0-1 mA, 4–20 mA current loop, 0–10 V, ±2.5 V, ±5.0 V, etc. Many RTU inputs buffer larger quantities via transducers to convert and isolate real world quantities from sensitive RTU input levels. An RTU can also receive analog data via a communication system from a master or intelligent electronic device (IED) sending data values to it. The RTU or host system translates and scales this raw data into appropriate units such as the quantity of water left, temperature or megawatts before presenting the data to the user via the human–machine interface.

Digital (Control Relay) Outputs

RTUs may drive high current capacity relays to a digital output (DO) board to switch power on and off to devices in the field. The DO board switches voltage to the coil in the relay, which closes the high current contacts and completes the power circuit to the device. RTU outputs may also consist of driving a sensitive logic input on an electronic PLC or other electronic device using a sensitive 5 V input.

Communications

An RTU may be interfaced to multiple master stations and IEDs with different communication media (usually serial RS232, RS485 or RS422, or Ethernet). An RTU may support standard protocols (Modbus, IEC 60870-5-101/103/104, DNP3, IEC 60870-6-ICCP, IEC 61850, etc.) to interface any third party software.

Data transfer may be initiated from either end, using various techniques to ensure synchronization with minimal data traffic. The master may poll its subordinate unit (Master to RTU or the RTU poll an IED) for changes of data on a periodic basis. Analog value changes will usually be reported only on changes outside a set limit from the last transmitted value. Digital (status) values observe a similar technique and only transmit groups (bytes) when one included point (bit) changes. Another method used is where a subordinate unit initiates an update of data upon a predetermined change in analog or digital data. Complete data transmission must be used periodically, with either method, to ensure full synchronization and eliminate stale data. Most communication protocols support both methods, programmable by the installer. Multiple RTUs or multiple IEDs may share a communications line in a multi-drop scheme, as units are addressed uniquely and only respond to their own polls and commands.

Primarily a form of power supply will be included for operation from the AC mains for various CPUs, status wetting voltages and other interface cards. This may consist of AC to DC converters where operated from a station battery system. RTUs may include a battery and charger circuitry to continue operation in the event of AC power failure for critical applications where a station battery is not available.

Typical Remote Monitoring System

Typical architecture of a remote monitoring system is shown in *Figure 1*.

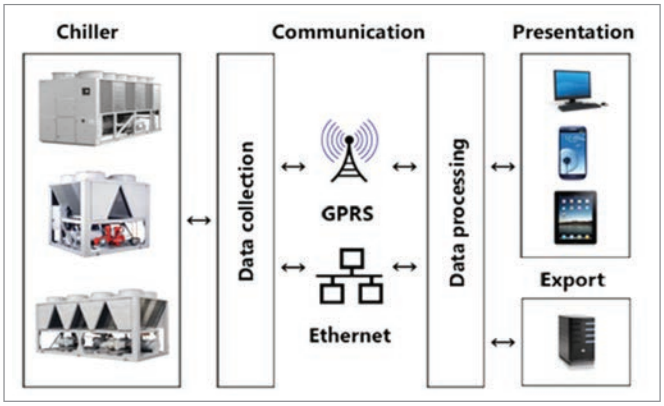

Figure 1: Typical architecture of a remote monitoring system

Authorized users can adjust set points to address customer needs and resolve operational questions, even when the technician is remote, reducing maintenance costs. All parameters are stored and can be retrieved for advanced diagnostics. This facilitates equipment maintenance notifications and keeps a running history of all service performed on the unit, and keeping track of equipment performance from the initial commissioning and on the ongoing maintenance and operation changes, thereby keeping the equipment operating at peak performance.

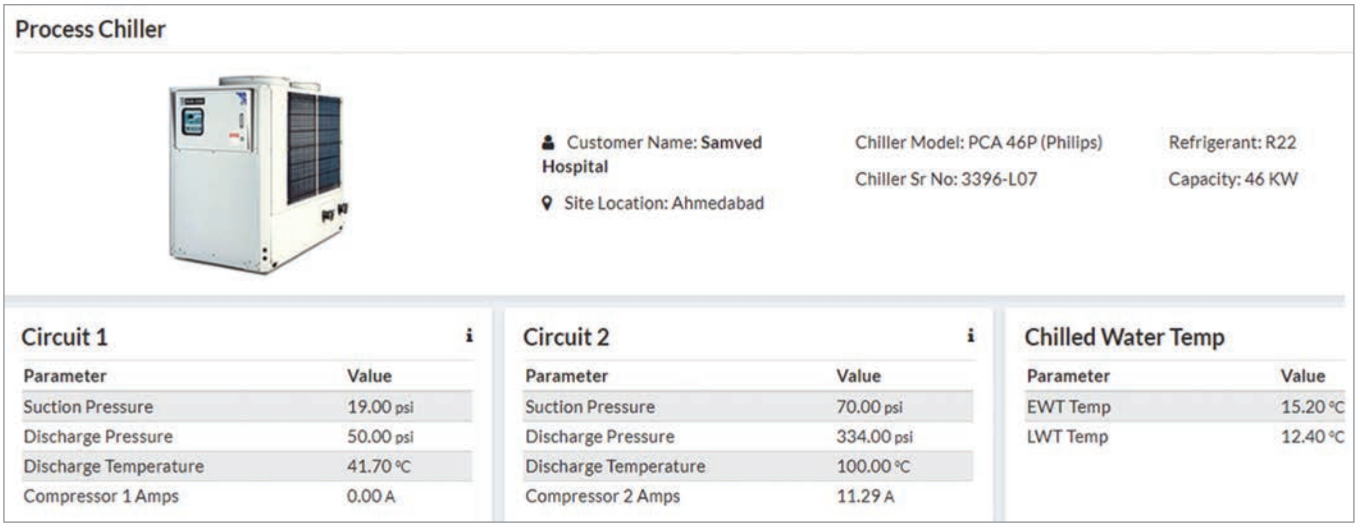

Figure 2: Remote monitoring of parameters

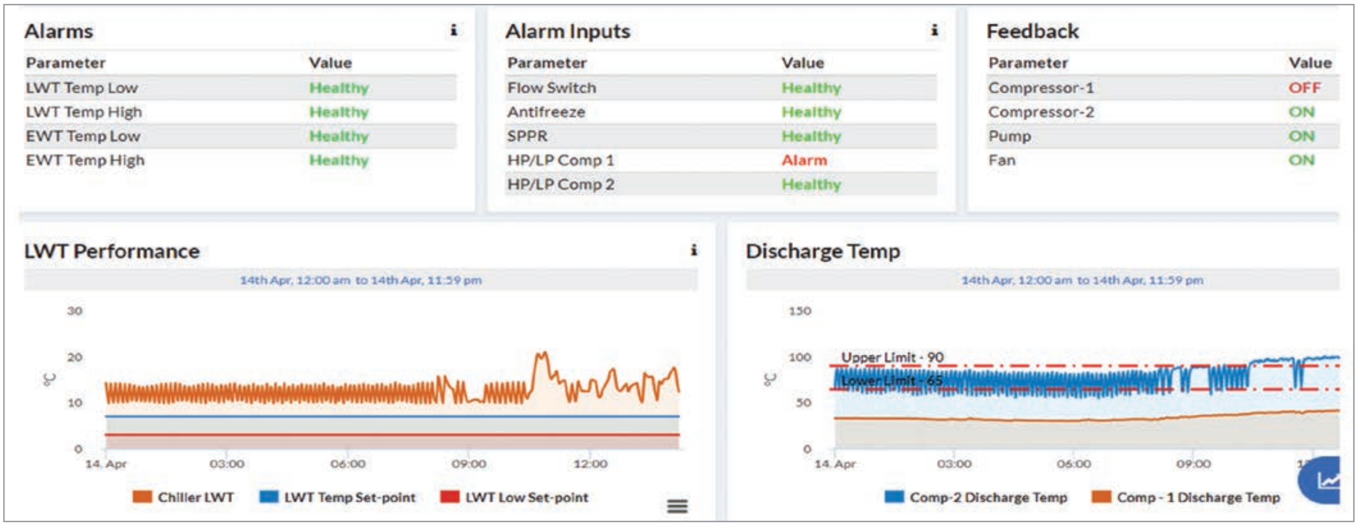

Figure 3: Parameters and alarms

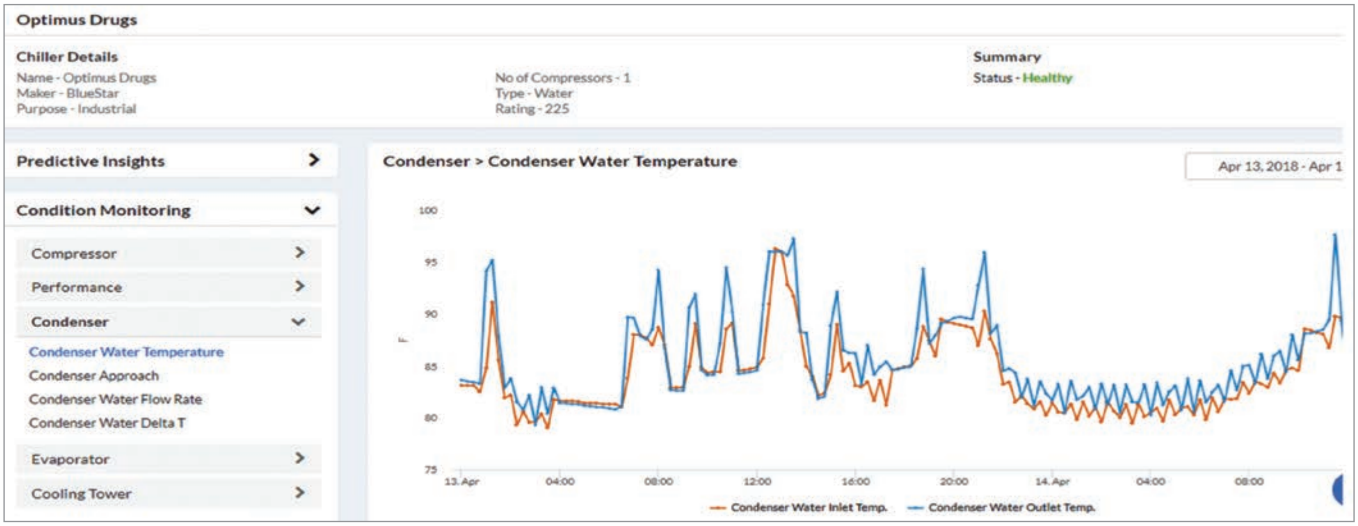

Figure 4: Predictive insights from remote monitoring of condenser water temperature

The performance parameters of evaporator and condenser are monitored and compared with their design parameters to check if there is any deviation. If a deviation is observed or a deteriorating trend is seen, an alarm or a mail can be triggered to the field technician to take appropriate action before the equipment breaks down.

The approach towards maintenance shifts from preventive to predictive, which helps the field technician to seek a planned shutdown from the customer. Thus, predictive maintenance eliminates not only the sudden breakdown of equipment and discomfort to the customer, it also results in saving potential due to prolonged operation of the equipment in adverse conditions.

Figure 5 showcases a few sites with savings potential along with equipment and critical event status.

The following parameters can be monitored for a comparison trend to ascertain the health of an evaporator:

(i) Chilled Water Outlet Temperature and Set-Point
(ii) Suction Pressure with Chilled Water Outlet Temperature
(iii) Chilled Water Temperature Difference
(iv) Chilled Water Temperature Difference and Chilled Water Flow Rate
(v) Chilled Water Temperature Difference and Power
(vi) Chilled Water Flow Rate
(vii) Evaporator Approach

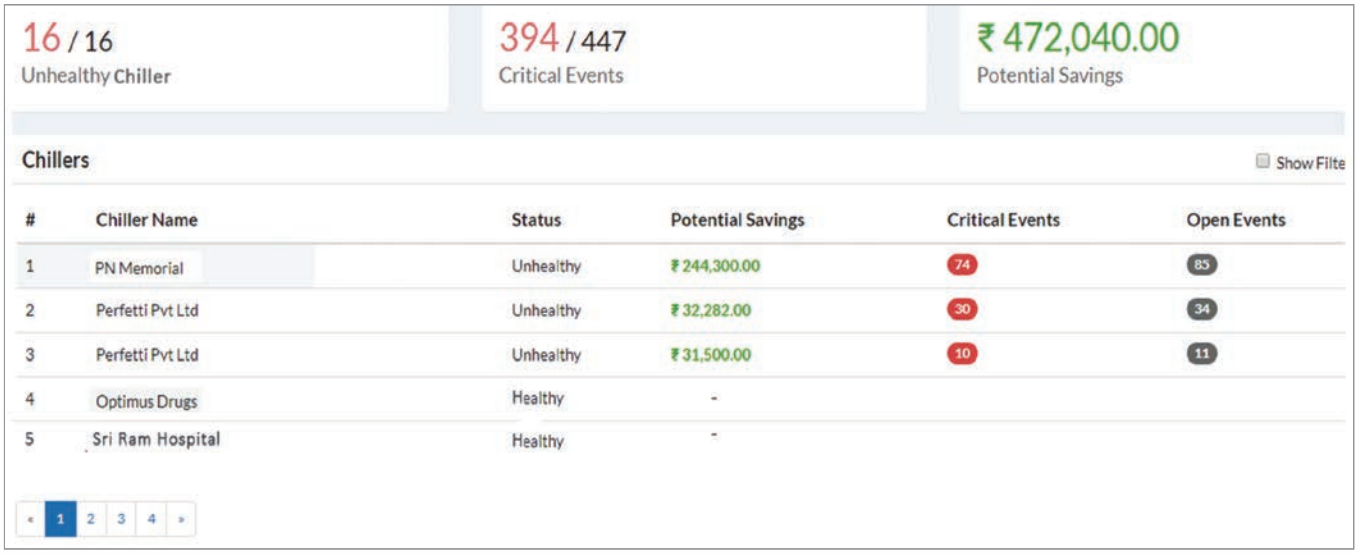

Figure 5: Sites with savings potential, with equipment and critical event status

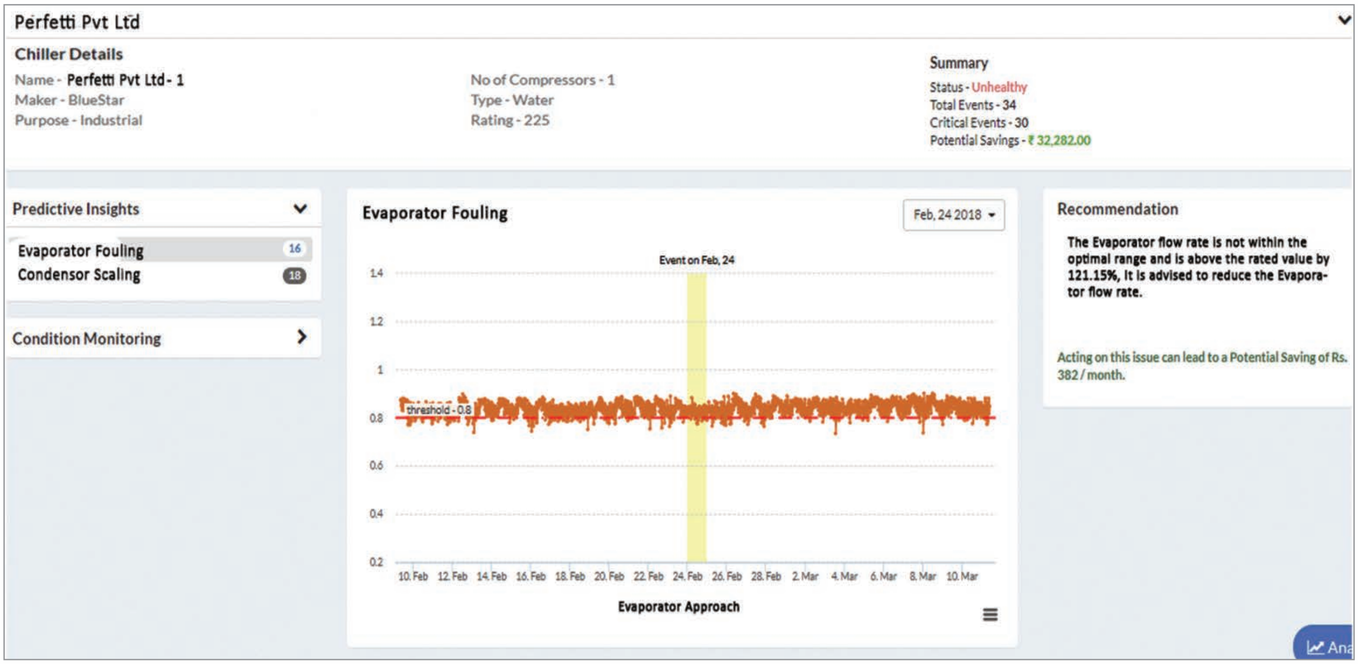

Figure 6: Predictive insights from remote monitoring of evaporator

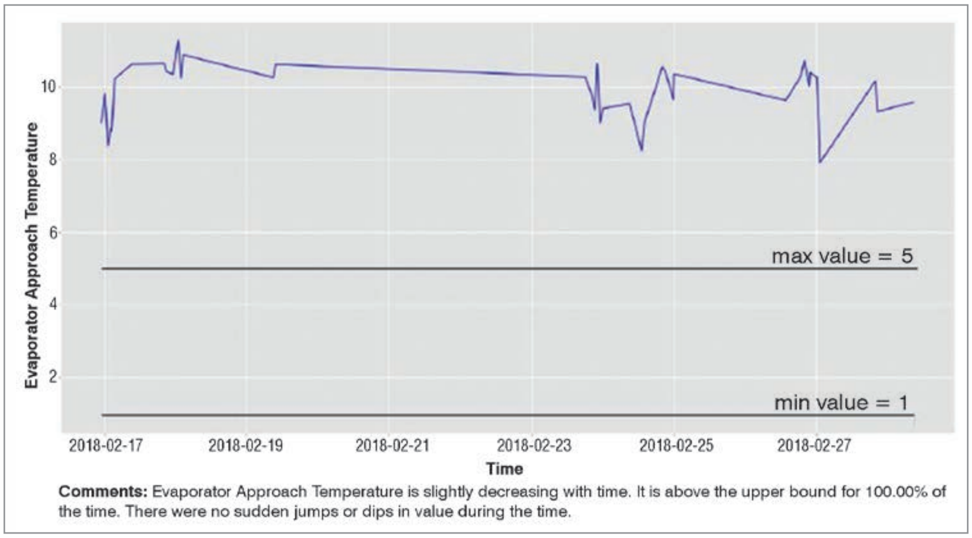

Figure 7: Monitoring evaporator approach temperature trend

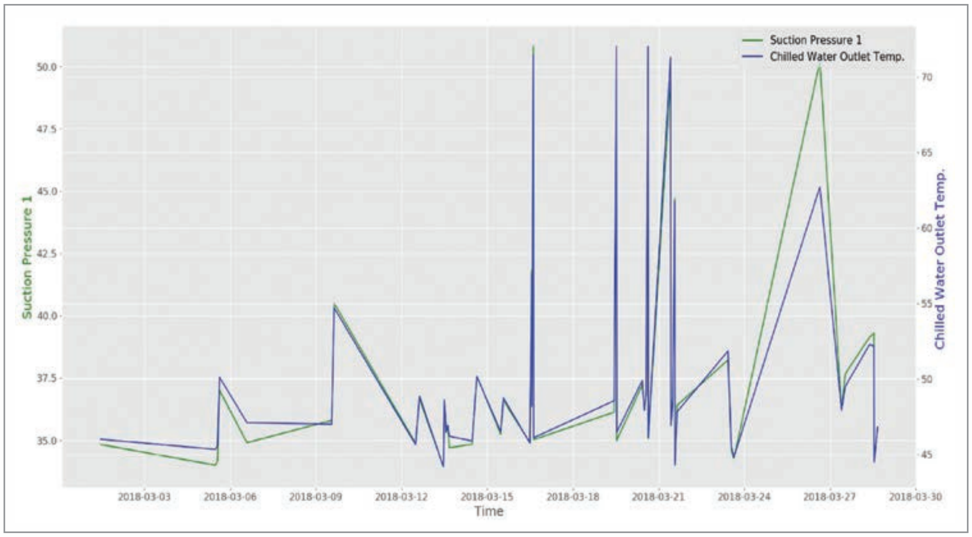

Figure 8: Monitoring suction pressure and chilled water outlet temperature trend

Thus, remote monitoring facilitates the service organization with the following:

(a) Remote operation (ON-OFF) and control of the equipment.
(b) Run time optimization of HVAC equipment.
(c) Efficient and effective operation of HVAC equipment.
(d) Prediction of component failure.
(e) Data analytics and machine learning.
(f) Transparency in the health of equipment.
(g) Huge potential for energy savings from increase in productivity and reduction in material consumption.

Augmented Reality

Augmented Reality (AR) applications connect the real and virtual worlds. The reality is expanded with additional information, explanations, pictures or videos when and where needed. These are shown on mobile devices, e.g. tablets, smart phones and smart glasses, when the user points the camera of the device towards a designated area of the object. *Figure 9* depicts how AR superimposes a computer-generated image on top of a real one and brings forth the machine's inner components.

In the field, control panels for chillers have been 'augmented' to assist the field engineer to virtually dismantle the product and study its wiring and cabling. This process can be particularly tricky without AR, given the complexity of cable routing. Training manuals or work instructions help only to an extent. With AR, the picture is more vivid, much like the CT scan of a human body.

How Augmented Reality Works

Using QR-code like unique identifiers placed on chillers, the software application overlays virtual statistics, real-time data and 3D models of components onto the equipment as viewed through an iPad and broadcast to the technician. The display then indicates a failure linked to an oil filter. In response to a hand gesture, a 3D animation appears showing the step-by-step process for removing and replacing the damaged part. Again, all this is presented via augmented reality, rendered on top of the live video feed.

Figure 9: AR highlights the health of components with different colours, helping engineers to diagnose the problem

It has a unique identification system. The identifier is the bridge between the equipment and data being collected by the various sensors located on it. The identifier also communicates the equipment model to the software, which sets the framework for any augmented reality displays. In short, it closes the loop between the 'thing' and the Internet of Things (IoT).

Once the link between equipment and data is made, the augmented reality experience connects both to the user. The ability to overlay important data onto specific locations of the equipment is a more valuable tool. Providing immediate context to diagnostic information like pressure, temperature and voltage helps to identify and resolve problems faster, resulting in less equipment downtime and happier customers.

Benefits of using Augmented Reality

AR can help a field technician with a basic part replacement procedure rendered in 3D augmented reality – a simple solution with enormous implications. Prominent is the potential for all known maintenance processes to be precisely documented and instantly available in an intuitive format. With a combination of diagnostic data and technician know-how, a failure root cause can be identified quickly and the necessary maintenance can be performed exactly as intended by engineering. This will reduce the frequency of false diagnosis and issues caused by improper maintenance procedures.

Another benefit is the displaying of useful and complementary information and the resulting saving of time. All information such as tools, torque specifications, measurement values, etc. can be displayed when and where needed. For field engineers, this offers the possibility of faster and better repairs thanks to simpler instructions with up to 20% less errors.

Another key benefit is the resulting ease of documenting and maintaining maintenance records. Besides the obvious benefit of facilitating future service, well documented records of equipment in the field are tremendously valuable for quality engineers working with manufacturing and suppliers to proactively solve issues.

Conclusion

Remote monitoring service, currently in its infancy in the HVAC industry, will emerge as a game changing strategy for bringing about customer delight and monetizing it with customized services. While many HVAC organizations are currently using these technologies at various levels and functions, the service landscape of the HVAC industry will see a huge transformation in the next few years with much wider application in customer experience management at various touch points.