

# THE 21<sup>st</sup> CENTURY MUSEUM CLIMATIC MONITORING SYSTEM

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**KEY WORDS:** Museum climatic monitoring system, Radio/GPRS, Off-site store, Gallery

## ABSTRACT

Technology has provided us work convenience and shaped our quality of life; it has enabled an unprecedented level of access to knowledge by flipping screen of a hand-held electronic device without going elsewhere but stay connected wireless communication. This kind of technology has been broadly acquired at museums in Hong Kong for preserving their valuable collections. Similar gadget was applied on the monitoring system to record climatic conditions of museum's stores and galleries. Sensors have been equipped with chips for the wireless transmission of RH/Temp, without installation of any conduit or LAN lines. Useful and important data are grouped into a packet format for efficient delivery. As long as the static IP address of the target workstation has been set, data can be accurately retrieved from one place to another via commercially available browsers, such as: Firefox or Internet Explorer, even by hand-held electronic devices. This paper will discuss the detail of this system, its pros and cons in comparison with the old model. After all, the new technology is highly significant in supporting the current needs and the future developments of the museum service.

## 1. Introduction

### 1.1 The importance of a non-stop RH/Temp monitoring system in museums and stores

It is crucial to have a stable and steady environment for displaying and storing humidity/ temperature sensitive collections in museums, such as metal art pieces, works of art on paper, lacquerers, woods, ivory, horns etc. These objects are vulnerable to physical damages from the undesirable levels or sudden and drastic changes of RH/Temperature during their display and storage. Objects may suffer from irreparable damages if they have been exposed to the adverse condition for long. In fact, a sophisticated Heat, Ventilation and Air Conditioning system controlled by a reliable monitoring and recording system can help reducing the damage. The system logs the data and reports to the user instantly if the readings fall out of the satisfactory range. Data can be plotted and shown as a hydro-thermograph to better illustrate the trend and environmental profile of the place at a specific period of time. Users and keepers can duly adjust the climatic settings from the abnormal environmental condition to the pre-set levels by referring to this figure. Technology plays an important role in resolving problems, yet it may come up with other unexpected issues. (Pretzel, 2009& 2011)

### 1.2 Mode of the systems developed from the 20th century to 21st century – from the 1<sup>st</sup> to the 2<sup>nd</sup> generation

The Conservation Office of Leisure and Cultural Services Department (LCSD) had acquired a set of primitive hand-held RH/Temp data-loggers two decades ago. These loggers are small battery powered devices equipped with sensors and microprocessors aiming at monitoring and recording essential data, like RH/Temp (Conserve, 2011). These loggers only record the climatic conditions at a pre-set duration, yet they cannot show the reading nor report any irregularities during monitoring. Readings can only be retrieved upon the completion of measurement. Any

irregularities cannot be instantly revealed or rectified, but can only be dealt with upon the completion of data download by the control panel (Arentein, 2002).

Given the time lapse on data retrieval, these loggers were soon replaced with its second generation, well equipped with the General Packet Radio System (radio/GPRS). It transmits the essential RH/Temp signals to the control panels instantly by radio wave and shows a viewable climatic chart on a real time basis. The system has been widely used in museums to monitor and control the climatic conditions of 22 galleries and 40 stores with various environmental settings. The data signals of RH/Temp collected from the existing 250 sensors at different museums and stores are then transmitted to/from and kept at the corresponding 15 stations every thirty minutes. Once logged into the system, the recorded information of a target sensor can be viewed by the designated users at the workstation at any time. This system greatly facilitates museum to exchange and retrieve important information for the preparation of upcoming exhibitions, such as the climatic setting for a specific type of exhibits from a particular lending institute. Resources and facilities can be properly managed and shared eventually. Moreover, artifacts displaying in a hermetically sealed showcase will not be disturbed if the data can be sent via radio frequency to the control panel without opening the showcase to retrieve data from the logger.

### 1.3 The latest evolution of technology - the 3<sup>rd</sup> generation

Nowadays, most of the museums strategically relocate their ever-expanding collection to off-site stores at remote areas far away from the museum in order to resolve their over-congested storage problems. The offsite store is required to provide a steady and satisfactory RH/Temp level for storing its treasure with an aid of a monitoring system showing any irregularities and reporting problems. The 3<sup>rd</sup> generation of data-logger performs well in this task. Sensor of this generation facilitates signals transmission from a remote workstation to the main

base somewhere far away. The climatic condition of the store can be viewed at the office of the museum through a computer system given its workstation has been connected through internet. Any alarm signals will be transmitted to the electronic devices of the alert group of users to prompt for their remedial actions when the RH/Temp readings fell out of the satisfactory or pre-set level. The system developed from GPRS technology, a packet-switched technology, can support the internet protocol (IP) and is currently used in wireline communications. With the same protocols as internet, the GPRS base station serves as a host and possesses its own IP address. With the recognized static IP address, data and settings collected by the sensors placed at remote stores can be instantly identified, viewed and interacted anywhere via commercially available browsers, such as: Firefox or Internet Explorer etc. The wireline currently applied is an upgraded telephone line called ADSL (Asymmetrical Digital Subscriber Line) and getting online with broadband. 10Mbps would be enough for transmission of raw RH/Temp data.

## 2. Application of the wireless communication

### 2.1 Galleries in Hong Kong

Three main workstations have been placed in three significantly core museums, each of them controlling around 80 wireless sensors in their respective galleries. The workstations collect the RH/Temp data 24/7 non-stop in a day. The data received will then be compared and made reference among the museums as the sensors have the similar settings and calibration standard.

### 2.2 Off-site stores – SR2 Sensors and a workstation

Having six wireless SR2 sensors and a workstation, the 3<sup>rd</sup> generation logging system has been installed in an off-site store for recording the climatic conditions where paintings, installations and bulk collections are stored. Data collected from sensors at different rooms is transmitted to the workstation in the premise via radio frequency signals of about 434.075Hz. A Synergy Management Tool has been installed in the workstation which provides a physical link to the database, allowing synchronizing, calibrating and merging hardware devices at any places via internet. It gives an outstanding mobility of the usage and stability of communication with other devices anytime and anywhere (Wibowo, 2005)

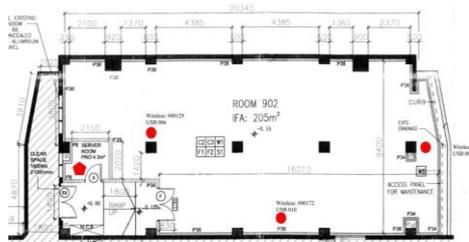


Fig. 1 Layout plan of sensors (indicating by red dots) in Room 902 of an offsite store

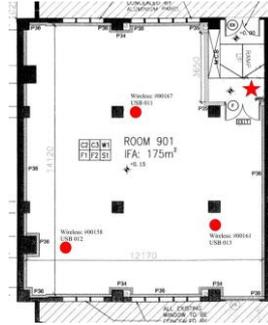


Fig. 2 Layout plan of sensors (indicating by red dots) in Room 901 of an offsite store



Fig. 3 Homepage of the Synergy Management Tool

### 2.3 The Synergy Management Tool

The management tool provides several important functions for the monitoring system, including data retrieval, communication of the individual sensors, data logging, data analysis and alarm notification to user through the smart phone device.

#### Retrieving data

The sensors located at different rooms can be browsed through this managing tool. Data of the selected sensors is available for download. It gives a graphical user interface (GUI) which works on all up-to-date web browsers. Data displays in the forms of graph, table or plan views, which can be chosen by the user.

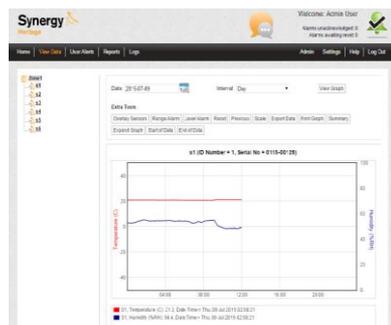


Fig.4 Graphical view display

ID	Sensor Name	Type	Channel 1	Channel 2	Channel 3
1	01	C. Value	21.1	45.9	NA
2	02	C. Value	21.6	57.6	NA
3	03	C. Value	19.3	53.3	NA
4	04	C. Value	20.2	57.5	NA
5	05	C. Value	23.9	54.9	NA
6	06	C. Value	20.6	54.7	NA

Fig.5 Live view display

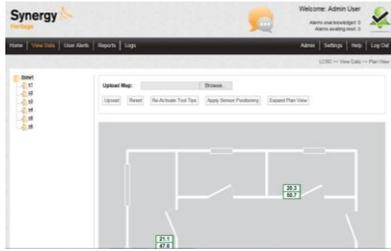


Fig. 6 Plan view display

### Access right

The management tool enhances the security of the usage by introducing different levels of rights for different user groups. The administration users have the authority to grant access right to the system maintenance group and the guests group. There are various levels of application and usage for different group of users.

User Name / Permission	Admin User	System maintain	Guest
Access Archive Database	Allow	Allow	Deny
Access Control	Allow	Deny	Deny
Access Logs	Allow	Allow	Deny
Access Reports	Allow	Allow	Deny
Access Reports - Sensor Groups	Allow	Allow	Deny
Access Settings	Allow	Deny	Deny
Access Sites	Allow	Allow	Deny
Acknowledge Alarms	Allow	Allow	Deny
Activate privileged Access	Allow	Deny	Deny
Bulk Acknowledge Alarms	Allow	Deny	Deny
Change Alarm Settings on Reset	Allow	Allow	Deny
Counter Signature	Allow	Ignore	Ignore
Device Configuration	Allow	Deny	Deny
Disable User	Allow	Deny	Deny
Edit View	Allow	Allow	Deny
Email Alert Group	Allow	Allow	Deny
Live View	Allow	Allow	Allow
Live View - Sensor Groups	Allow	Allow	Allow
Password Security Settings	Allow	Deny	Deny
Plan View	Allow	Allow	Allow
Plan View Edit	Allow	Allow	Deny
SMS Alert Group	Allow	Ignore	Ignore
System Configuration	Allow	Deny	Deny
User Group Management	Allow	Deny	Deny
User Management	Allow	Deny	Deny

Table 1 Access right of the 3-level users

## Synchronizing and configuring the devices

Sensors can be configured and set remotely in the office by the Synergy Management tool, such as its recording start time, end time, recording interval and alarm levels setting etc.

### Alarm notification

Other than setting of monitoring time or duration, alarm levels can also be established for each sensor at different zones under various requirements. When the recorded readings fall out of the pre-set levels, alarm will be automatically triggered and sent to the dedicated Alert Group electronically. Alarm notification will be instantly delivered via Email or SMS or both to Users who are members of the Alert Groups. Immediate action or remedial measures can be taken by the users once alert notification has been received.

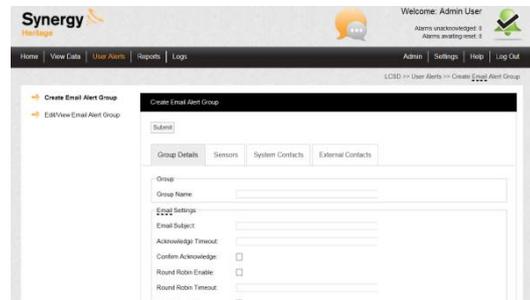


Fig. 7 Set-up of the alarm notification

## 3. The wireless technologies

### 3.1 Pros and Cons of the technology

More and more museum, archive, library and cultural institutes prefer to equip their galleries, stores and book stacks with novel facilities like the wireless network system for monitoring their environmental condition. In this century, the application of a wireless system is more favorable as it provides a higher mobility, reliability and user connectivity than the wired networking system. Though its set-up cost is always on the high side, its installation time is comparatively less even in a complex venue setting or under a difficult installation condition. The recording signals are all transmitted via radio waves or microwaves without any installation of conduit or wiring. Sensor has been self-supported by its own lithium battery which can run for three years. No additional electricity supply is required for the sensor, but just for the workstation. For sure, signals can be automatically, instantly and accurately pop up in front of the viewer without any delay. It establishes a very good reporting mechanism for revealing irregular conditions through sending alarm notification to the users. For example, an alarm was reported at the off-site store at 11:40 and 16:00 on 15 July, showing a raise of relative humidity from 55% to 70% in a very short period of time. It was finally found that doors of the store had been opened for delivery of the storage cabinets during that period of time. The information is so valuable that not only showing the environmental conditions being monitored, but also revealing any

human activities being conducted in the store if any of which has bad effect on the change of RH (Kaur et al, 2014).

### 3.2 The unforeseeable problems encountered and their solutions

There are always two sides of a coin. The wireless communication signals may not be as stable as it claimed. It can be interfered by other radio frequency nearby. In the past, signals have been disturbed by other radio frequency wave used by the police's communication system nearby, especially during the festive seasons or there were any on-going mega events next to the museum. Moreover, the frequency radiation may not be able to pass through thick or metal wall barrier, such as a roller shutter, which had shielded some of the transmissions once it was closed during the non-operating hours of the museum. To tackle the latter problem, a signal amplifier or repeater has to be additionally installed to ensure a smooth transmission of the signals. For the signal interference by others, a special permission of using the specific radio frequency has been sought from the Office of the Communications Authority (OFCA) in Hong Kong to ensure the sole usage of this frequency from other party. Museum has to pay additionally for the license management fee to the government every year to engage this specific wavelength.

After all, the recurrence cost as well as its installation cost has gone up. In fact, it is quite an amount in equipping the whole set of system and its maintenance. The manufacturer is eager to upgrade its existing hardware device for its own profits. Some parts may be obsolete during the upgrading or intentionally re-designed by the supplier. More and more resources have to be reserved by the museum for the system upgrade. Moreover, the migration of software, along with the mega-data and updating the computer OS system are another hot issue to be further addressed and discussed. There are a lot to follow once there is a small change of the system. Needless to say for the launch of a brand new system, relevant and intensive training has to be provided.

It turns out that the traditional logger without distinctive and vital functions may work quite well in some occasions. It does not have the above mentioned difficulties and problems. Sometime, museum prefers using traditional logger to record the shipment condition of its valuable artworks. Data will be kept safely and easily downloaded after the return of trip. Wire/Wireless loggers may not provide significant differences in such cases.

### 4. Conclusion

Technology without doubt greatly increases the efficiency, productivity of work, and better management of our time. Wireless communication allows transmission vital environmental data from a remote site to the office without delay no matter how far they are apart. It can also send alarm notification to remind users for immediate follow-up action if climatic conditions of the place fell out of the desirable range. Though the system did resolve

problems and overcame lot of technical limitations for the museum in the past, it has brought up other hectic issues during its implementation. Museum may need to seriously consider its needs and resources allocation before the adoption of a novel technology or launching a brand new system.

### Acknowledgements

This project can only be made possible mainly subject to the tremendous effort and endless supports from our team of technicians at the Conservation Office. Special thanks to their dedication and commitment over the past two decades to advance the system with new technology relentlessly.

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