Data Acquisition and Monitoring System
- A State Funded Air Quality Monitoring System Development

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Abstract

The Environmental Protection Agency has classified Clark County, Nevada as a "serious" non-attainment area for particulate matter (PM 10 and PM 2.5) and carbon monoxide (CO). The Nevada Center for Advanced Computational Methods (NCACM) of University of Nevada at Las Vegas, is assisting the Department of Air Quality Management (DAQM) to develop and implement a new environmental system that will provide more reliable and flexible data acquisition and monitoring services. Since the regulatory and enforcement role of the DAQM, it is required to measure and report to the public the impact of aeroallergens as well as visibility and haze issues. Around 30 monitoring stations are located throughout Clark County.

This paper demonstrates a data acquisition and management system that can provide agency staffs an integrated environment to acquire, monitor and manage air quality data and the pubic a web-based tool to access the collected data. A four-tier system, data presentation, analysis, repository and acquisition, is designed for this purpose. Collected data are pre-processed before inserting into the back-end MS SQL database repository. More service and analysis tools can be added through its middle-tier data analysis modules. The data acquisition module was written in Microsoft Visual Basic with LABVIEW components provided by National Instruments.

System compatibility and functional flexibility issues were taken into consideration during the development. Data from existing collection module can be processed and save into the new data repository. Data collection schedule arrangement and remote station controls are also configured into the system. Data analysis tier is the centerpiece of the system. Based on the department requirement, more analysis modules will be added.

To ensure that Clark County will reach and maintain attainment of all federal air quality standards, more sophisticated atmospheric forecasting model, developed by the NCACM, will be applied to monitor and predict pollutants around the valley.

1. INTRODUCTION

On average approximately five thousand persons move into Las Vegas, with a steady rate for the past several years. The projected population for the Las Vegas Metropolitan Area (LVMA) of Clark County, Nevada in 2035 is around 2.5 million, doubling the current population. While the Environmental Protection Agency classified Clark County, Nevada as a "serious" non-attainment area for particulate matter (PM 10 and PM 2.5) and carbon monoxide (CO), the DAQM is urgent to upgrade its existing data monitoring system to meet the demands for the rapid growing area.

The DAQM has installed 30 air-quality monitoring stations throughout Clark County. Since the regulatory and enforcement role of the DAQM, it is required to measure and report to the public the impact of aeroallergens as well as visibility and haze issues.

Existing system is less stable and flexible in terms of data acquisition, monitoring and reporting. To ensure that Clark County will reach and maintain attainment of all federal air quality standards, the NCACM is required by the DAQM to design a new system that can provide higher stability on data acquisition processing, more dynamic data collection scheduling and flexible control over monitoring stations. The objectives of this paper will introduce the data acquisition and monitoring system design and on-going progress of the system. Issues on transition from the exiting to the new and newly implemented functionalities of the systems are also discussed. Important insights of the project are briefly mentioned.

2. SYSTEM DESIGN

The current system is using Disk Operating System (DOS) and difficult to operate comparing to the Windows-based system. The existing communication module is less stable

and the data acquisition processing is fixed and cannot be modified remotely. Under the current system, acquired data were saved into a text file and later transmitted to the main office PC and still saved as a text file. No database is involved for the current system.

By characterized those deficiencies in the existing system, the NCACM redesign the current system that will provide a windows-based work environment with new communication and database modules. More remote control capabilities are also included in the new system. The application will be more scalable, flexible and maintainable. We define the system into three distinct tiers as shown in Figure 1:

1. Data acquisition tier – for monitoring station PCs that collect raw air quality data and transmit back to the main office,
2. Data repository tier – for real-time data repository and historical data retrieval,
3. Data processing tier – for data analysis and forecasting modules,

A comparable existing system is also indicated in the chart.

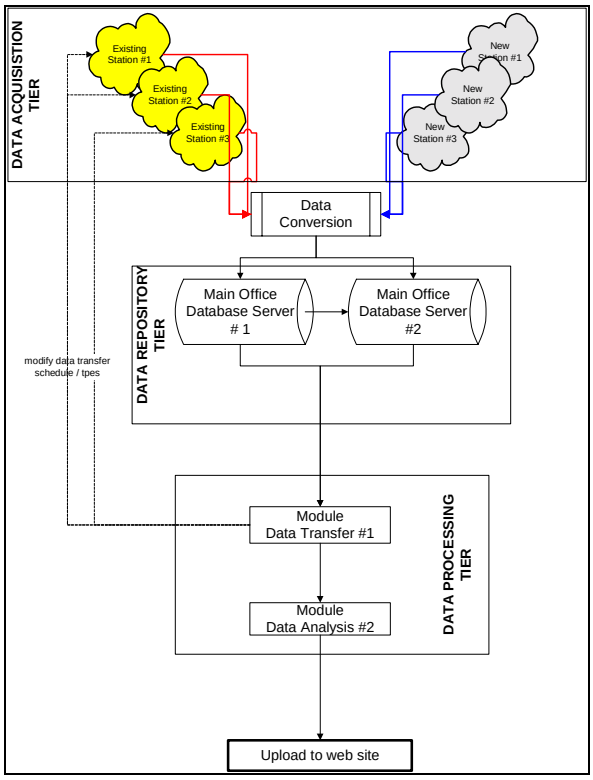

Figure 1. System design flow chart

2.1 Data acquisition

An automatic data acquisition system is setup for scheduled data collection from remote monitoring stations. As shown in Figures 2, the system manager initiates the data request procedure and the station manager receive the instruction and send back the required data sets.

The Nevada Center for Advanced Computational Methods (NCACM) at the University of Nevada Las Vegas uses LabVIEW (Laboratory Virtual Instrument Engineering Workbench), a powerful and flexible instrumentation and analysis software system for the Apple Macintosh computers, IBM PC compatible with Microsoft Windows, and Sun SPARC workstations. LabVIEW departs from the sequential nature of traditional programming languages such like BASIC and provides a graphical programming environment and all the tools needed for data acquisition, analysis, and presentation. The LabVIEW-based data acquisition and monitoring system for air quality related issues such as CO, NOx, PM10, PM2.5, ozone, wind speed and direction, and ambient temperature in Clark County.

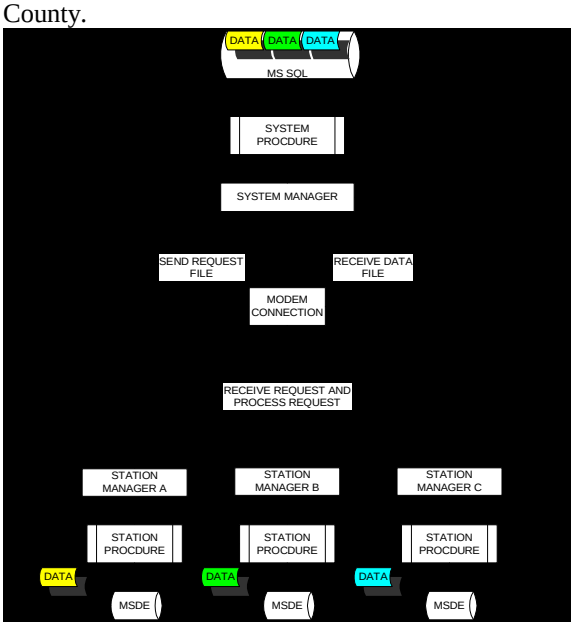

Figure 2. Data acquisition design flow chart

2.2 Data Processing and Analysis Tier

The data processing tier includes two software modules: station manager and system manager. While station manager is a PC data logger designed for ambient air quality monitoring, system manager is a central polling and data management system that operates on the network through modem and telephone line. The main functions include polling, data management, report generation, data presentation, data editing, and strip chart.

The collected data from the station manager transmits into the system manager. The NCACM provides the full control capability to those remote station mangers.

2.3 Data Repository

A relational database management system (RDBMS) is selected for system manager data repository. After qualifying those data from the stations, the data is saved to the designated database.

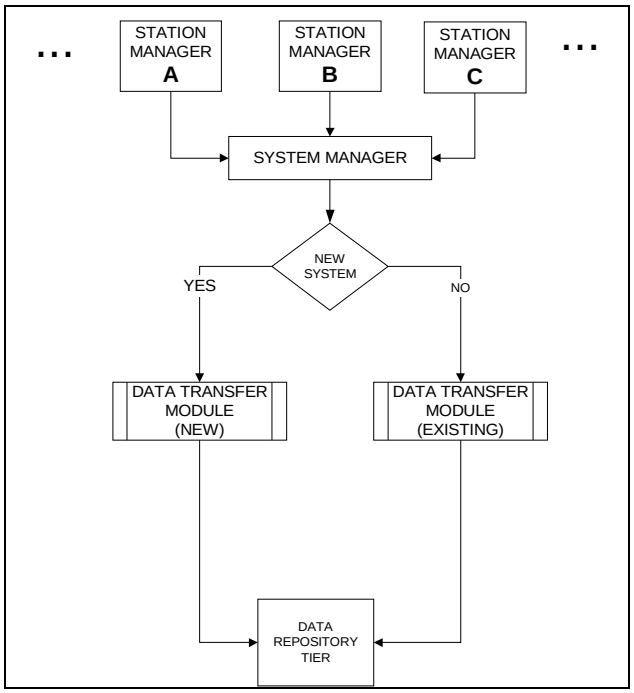

Figure 3. Data processing design flow chart

Some detailed description for the system manager are described below:

1 Intuitive User Interface: System Manager has an intuitive graphical user interface (GUI). A mouse pointing device is used for 99% of the user's interactions with the system

2 Strip Chart: system manager has the same strip display program as station manager. The strip chart display program provides more robust features and capabilities that conventional electro-mechanical strip chart recorders do not offer. The strip chart program can be functioned as multiple strip chart recorders in one computer. It has the ability to display pre-defined strip charts consisting of up to more than ten traces on one screen.

3 Logbook Program: Logbook notes from each station manager monitoring station may be routinely polled and retrieved daily or as desired or as desired by the system administrator desires.

4 Automatic Entries In Logbook Program: Power failure is automatically recorded in the logbook program's data files at each remote station manager monitoring station.

5 Data Displays: system manager offers preview options before printing data. It includes tabular displays of 1-hour averages, 5-minute averages, and 1-minute averages.

6 Integration with Station Manager: station manger is designed to operate as a stand-alone data logger or as a fully integrated remote data logger under the control of the system manager central data manager software.

7 Inventory Program: system manager can integrate inventory program to track and record all consumable materials, spare parts, replacement parts, analyzers, and equipments in each remote monitoring station. This inventory program is intended to be part of a user's total air monitoring network inventory system, and has been designed to be fully integrated with a central inventory program residing on the system manger central data management system

8 Initialization: system manager can be easily initialized. This system includes a program to permit users to copy the initializations for all monitoring stations from their network into any removable storage device. This capability makes it possible to use any station manager at any location, and load the initializations for that unique station into station manager with a single mouse click.

9 Polling: Polling includes retrieve 1-hour averages, calibration data, power failure data, and other types of data.

10 Data Editor: The data editor has a wide variety of editing features, including the ability to edit, replace, delete, or strings of hourly values using linear offsets, slope and intercept, or ramp correction values.

11 Security: System Manager and Station Manager have an integrated, network-wide security and password system. This sophisticated multi-level password system is maintained by a designated system administrator.

3. INTERFACE DEMONTRATION

(Figure 3), such as disconnect data transmission, change of data collection schedule. Data analysis module is used to convert the raw concentration values into Air Quality Index (AQI), a standard index provided by US EPA. The intuitive graphical display interface in the system manager module provides flexible data representation as shown in Figure 4. Figure 5 shows the rose chart data representation. More modules can be added into the system.

The system was written in Microsoft Visual Basic with its efficient object-oriented design (OOD) and object-oriented programming (OOP) in mind. Due to the possible change of data collection scenario, the system is committed to dynamically adjust collection schedules through out all monitoring stations. More detailed tier definition are elaborated below:

Data acquisition
An automatic data acquisition system is setup for scheduled data collection from remote monitoring stations. As shown in Figures 2a and 2b, the system manager initiates the data request procedure and the station manager receive the instruction and send back the required data sets.

The Nevada Center for Advanced Computational Methods (NCACM) at the University of Nevada Las Vegas uses LabVIEW (Laboratory Virtual Instrument Engineering Workbench), a powerful and flexible instrumentation and analysis software system for the Apple Macintosh computers, IBM PC compatible with Microsoft Windows, and Sun SPARC workstations. LabVIEW departs from the sequential nature of traditional programming languages such like BASIC and provides a graphical programming environment and all the tools needed for data acquisition, analysis, and presentation. The LabVIEW-based data acquisition and monitoring system for air quality related issues such as CO, NOx, PM10, PM2.5, ozone, wind speed and direction, and ambient temperature in Clark County.

3.1 Data Repository

A relational database management system (RDBMS) is selected for system manager data repository. After qualifying those data from the stations, the data is saved to the designated database.

3.2 Data Processing and Analysis Tier

The collected data from the station manager transmits into the system manager. The Nevada Center for Advanced Computational Methods (NCACM) provides the full capability to control the remote station manger (Figure 3), such as disconnect data transmission, change of data collection schedule. Data analysis module is used to convert the raw concentration values into Air Quality Index (AQI), a standard index provided by US EPA. The intuitive graphical display interface in the system manager module provides flexible data representation as shown in Figure 4. Figure 5 shows the rose chart data representation. More modules can be added into the system.

4. RESULTS AND DISCUSSION

The air quality data acquisition and monitoring system developed by the NCACM provides high flexibility for data collection, data analysis and data presentation. The Integrated monitoring system allows the system to be operated as a stand-alone or a fully integrated remote air quality data acquisition under the control of the main front panel of LabVIEW. It also includes a checklist to track standard maintenance and QA tasks in each monitoring station. A comparison table between the existing and newly designed systems is shown in Table 1. By completing the system, the AQD will better serve the community around the Las Vegas Valley with more accurate and responding environmental data management system.

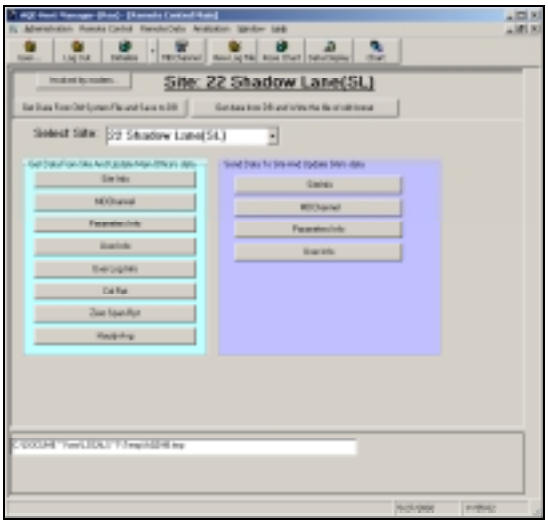

Figure 3. Main system manage control interface.

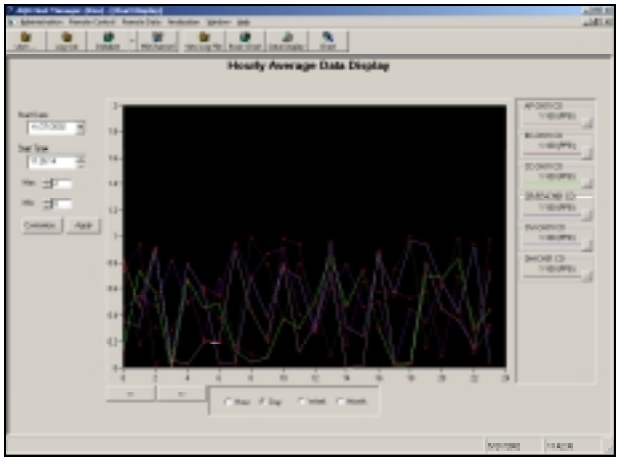

Figure 4. Graphical data representation in the system manager interface.

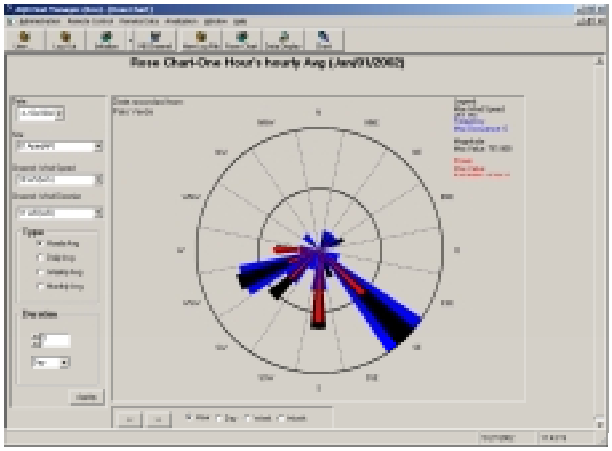

Figure 5. Statistical data representation in the system manager interface.

Table 1. A comparison between the existing and newly designed systems

Functionality	Existing System	New System
Database	No	MS SQL 2000 on the host-side and Data Engine (MSDE) on the remote side
Remote Control Capability	No	System manager can control the remote station activities
Communication	Modem connection. Often crashes.	Modem connection. Stable.
Data Integrity	Often encounters duplicated or missing data. Missing data cannot be resend automatically.	Any missing or incomplete data will be resend on the next schedule.
Data Auditing	Easy to make mistake during data auditing procedure	Timer to remind the six-minute intervals
OS environment	Runs in DOS and cannot have other program running in the background	Runs in windows and supports PCI and USB ports
Data Transmission Error	Comb through data to search for errors	Easier access for data auditing
Automatic Reporting	No	Integrated reporting system

5. REFERENCES

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6. ACKNOWLEDGEMENT

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