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SNL Material Monitoring System: Sensor Configurations and Latest Applications

Lawrence Desonier
Sandia National Laboratories
PO Box 5800, MS1361
Albuquerque, NM 87185 (505-845-8332)

Abstract

Throughout the world, advanced monitoring systems are needed to help monitor and control nuclear material. These monitoring systems should be capable of not only supporting a variety of sensors and video equipment, but they should also be capable of operating in a multitude of configurations and modes. The Sandia National Laboratories (SNL) Material Monitoring System (MMS) fulfills these requirements and more. The SNL MMS can store and deliver sensor information from monitored items and facilities to users anywhere in the world, which ensures a continuity of knowledge of the monitored nuclear material. In addition, the SNL MMS supports various sensor types (e.g., RF and hardwire sensors) and video systems (e.g., still-frame video). This paper covers those sensors and configurations that are now supported by the SNL MMS and the latest application installations. The ultimate goal of the SNL MMS is to provide users with the capability of 1) selecting from a list of desired sensors and video, 2) installing the MMS system, 3) running the system without needing to develop additional software to meet unique monitoring requirements, and 4) use a site configurable user interface for data review and analysis.

Introduction

The SNL MMS was originally designed and built to provide for a continuity of knowledge for material monitoring. The first system was built to demonstrate that a monitoring system could acquire data from both hardwire and RF sensors, store that data in a SQL database, and then allow for retrieval of the data and display to a user. To accomplish this, a flexible, hierarchical architecture was conceived that would use industry standards and an equipment arrangement that would provide for data acquisition at the sensor location, possible storage at another location, and viewing at yet a third location. This architecture is represented in Figure 1.

MMS relies heavily on commercial applications for its operation. It is built to run under the Microsoft Windows NT 4.0 operating system, store data in Microsoft SQL Server 7.0 Database server, use TCP/IP as it communications medium, and rely heavily on the Microsoft Foundation Classes (MFC) in the base source code. The input for sensors also relies on commercially available platforms such as Echelon LonWorks or RS-232 serial input.

Using the flexible architecture, commercial additions, and SNL developed applications has allowed for the extensibility, successful installation, and use of MMS at several sites around the world.

Architecture

The architecture of MMS allows for the acquisition and delivery of sensor information from any site to any user in the world in near real-time. The lowest level of the architecture is naturally

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the sensor. The sensor configurations supported in MMS will be discussed in Sensor Configurations below.

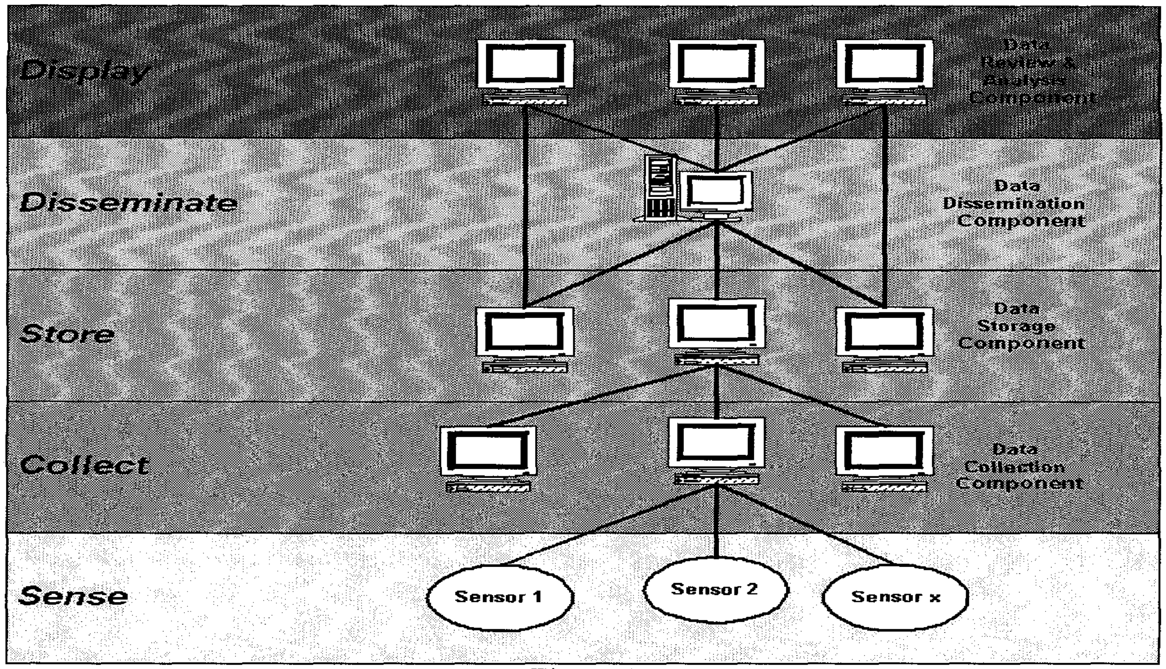

Figure 1

The next level of the architecture is the Data Collection Component (DCC). This component allows for acquisition of the sensor data, the temporary storage (buffering) of the data, correlation of sensor data with video data, the packaging of data into a Common Data Format (CDF), and the transmission of this data to the next level of the hierarchy in a Message Passing Interface (MPI) protocol.

The Data Storage Component (DSC) is the next level in the architecture. The DSC receives data from a single DCC or multiple DCCs and stores this data as events in the Microsoft SQL Server Database, writes the data to WEB files (if configured to do so), passes the data up to the next level in the hierarchy, and passes the data to any connected users.

The next level in the hierarchy is the Data Dissemination Component (DDC). The DDC receives the data from a single or multiple DSC(s) and writes that data to WEB files and/or passes that data to any connected user(s). At the very highest level is the Data Review Component (DRC) which allows users to review data.

This type of hierarchical architecture used allows MMS to be scalable from a low end of monitoring a single area at a single site up to a high end of being used as a national system.

Sensor Configurations

The MMS supports several types of sensor configurations either alone or in any combinations. These sensor configurations are the Sandia developed T-1 Electronic Sensor Platform (ESP), the Echelon LonWorks sensor network, the Neumann DCM14 video subsystem, and the Los Alamos National Laboratory (LANL) developed NTvision video system. To add additional sensor systems would require the development of additional CDF translators for those systems at the DCC.

The T-1 system consists of any number of T-1 RF ESPs and a T-1 interrogator transceiver. The T-1 ESP is a two-way RF node that supports a fiber optic seal, case tamper, motion, temperature, and battery monitoring. The node also supports three additional binary I/O ports for added digital sensor monitoring. All data from the T-1 ESP is authenticated inside the T-1, using the TEA algorithm, with the authentication signature as part of all messages coming from the T-1. Messages/events are transmitted from the T-1 to the interrogator transceiver. The messages/events are then passed to the DCC by a serial RS-232 link into a PC communications port.

The Echelon LonWorks interface is supported through the LonWorks Networks services (LNS). The LonWorks network is tied directly into the DCC with a special Echelon PC card. Any commercial sensor supported by the LonWorks network is supported in MMS. The data is acquired through Echelon nodes and passed through the LonWorks network to the DCC. The Echelon network is easily managed by the Echelon Lon Maker for Windows application.

The Neumann DCM14 system consists of a DCM14 module, an Echelon serial node for video triggering on an event, and a camera. The DCM14 stores video on a PC card internal to the DCM14 module. The DCC acquires the data by using an RS485 card in the DCC and the DCM poller software supplied by Neumann.

The LANL NTvision system consists of a National Instruments PCI-1408 video acquisition card in a separate computer from the DCC and the LANL NTvision software. The system can support video acquisition from four separate cameras into one NTvision computer. The NTVision uses motion detection in the video scene to trigger an event. The event results in still video of the event and a "movie" consisting of a sequence of frames of video. The DCC acquires the data by monitoring the creation of the event video and then moving that video up to the DSC for insertion into the MMS database and WEB pages.

A typical configuration showing all sensor systems is shown in Figure 2.

Development Update

One of the main focuses for MMS development in the last year has been adding redundancy to the MMS system for both reliability and to guarantee continuity of knowledge (no lost data). This was accomplished by using two DCCs installed in parallel. The first phase of this redundancy schema, which has been completed, only works with the T-1 system at the present time.

Another area completed was a real-time WEB page for the browser user. This consists of a map that is updated with current sensor status every ten seconds. By clicking on a sensor the user is presented with the most current details of the status of that particular sensor.

The paradigm for the real-time WEB page is also being pursued in a stand-alone user data analysis and review component. The user will be presented with a map of the building or area. From this map the user can "drill down" to the room or magazine (See Figure 3 for example).

The status of all sensors will be shown in color on that map. By clicking on the sensor the user will be able to see current details of the sensor.

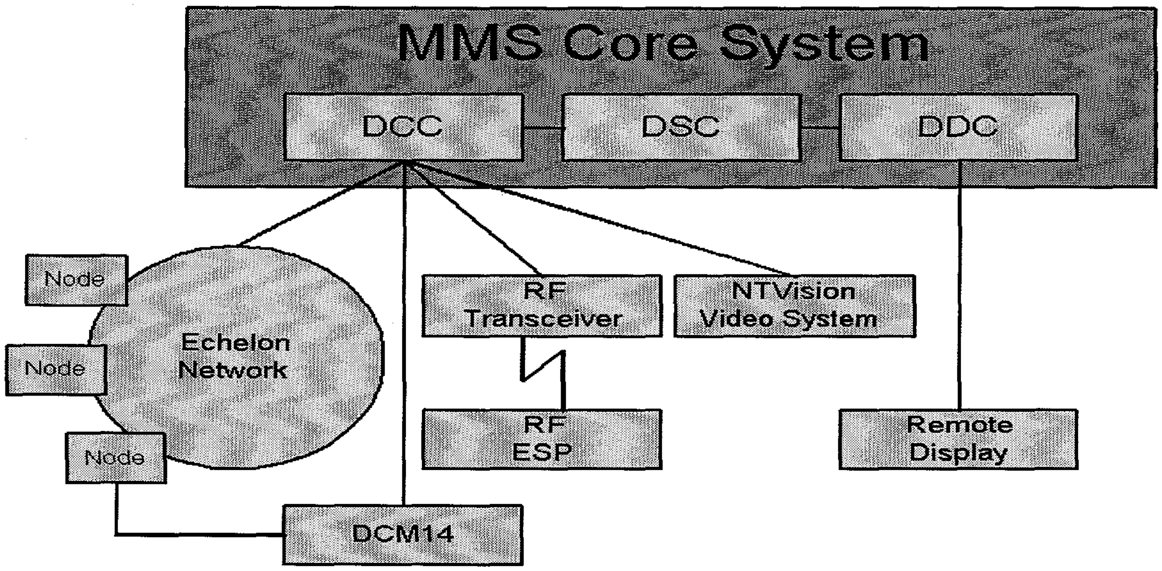

Figure 2

Another important issue that is being developed into MMS is the handling of the data authentication aspects of the sensors in the MMS system. The data produced by the sensor is authenticated at the sensor and this data with its authentication signature is preserved end-to-end in the MMS system.

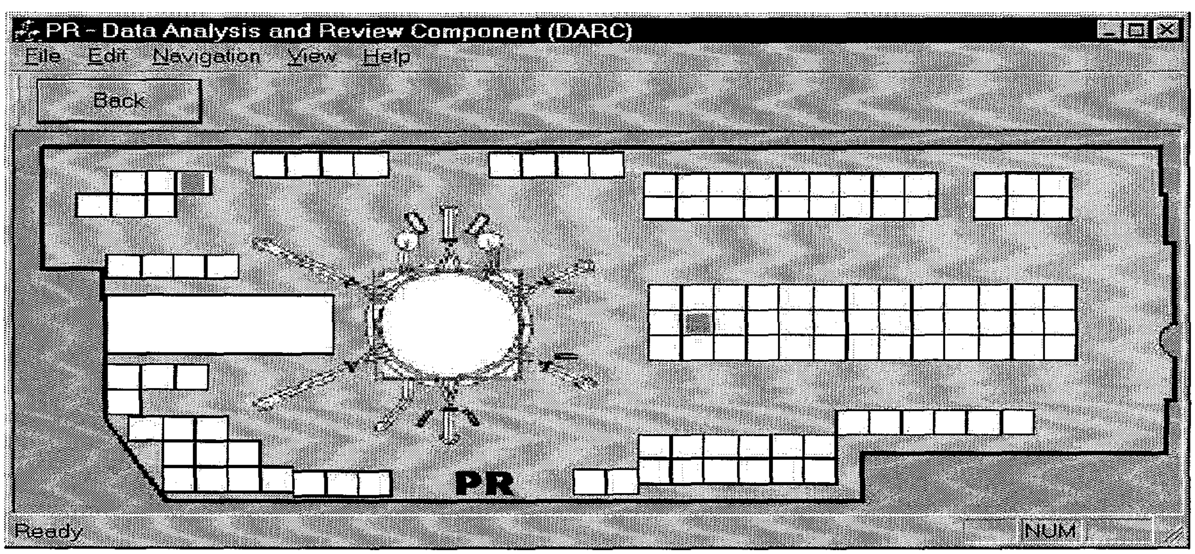

Figure 3

Another aspect we have looked into is the remote access to stored data and remote maintenance of the fielded systems. The methods we have used are remote access through the Internet, remote access by modem, and remote access through a Virtual Private Network. The choice of which method to use at a site allows each site to control appropriate remote access to the MMS system depending on local network security requirements.

Depending on availability of funding we are planning on expanding on the redundancy in the system to other supported sensor systems, adding more features to the user interface, making it simpler for the sites to install and maintain, and adding more types of sensor systems.

Applications Update

The Magazine-to-Magazine project between a Sandia Livermore bunker and Arzamas 16 in Russia was reported in an INMM paper last year. In addition, the installation in Embalse, Argentina and Joyo, Japan were also discussed.[1]

This past year there were many additional installations (Figure 3) including: 1) WIPP at Carlsbad, New Mexico, 2) the K-Area Material Storage (KAMS) project at Savannah River, 3) the Facility-to-Facility project at Savannah River, 4) the Integration Technology Implementation Project (ITIP) demo at Pantex, 5) the Cooperative Monitoring Center (CMC) System demo at Sandia, 6) the Helsinki, Finland, project, and 7) a Korea project.

The WIPP project at Carlsbad was installed as part of an initial effort for transparency in underground repositories. The system at Carlsbad consists of an Echelon network collecting mostly environmental data, a T-1 system, and an NTVision system. This system was installed in the summer of 1999.

The KAMS project was installed to support the domestic monitoring of material to be stored in the Savannah River Site K-Reactor. It uses only the T-1 sensors. However, there are plans to potentially use 600 to 900 T-1 sensors. The site has also installed an NTVision system, but it is not integrated with the MMS system.

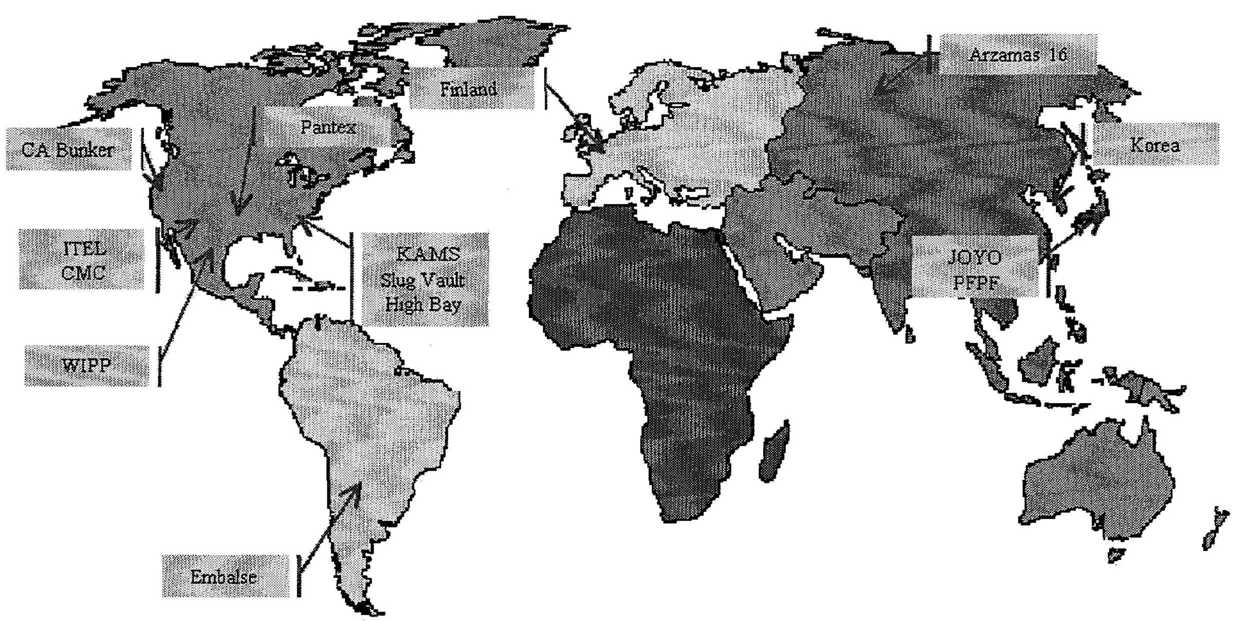

Figure 4

The Facility-to-Facility project at the Savannah River Site consists of two systems in two different areas of the K-Reactor Assembly Area. One of the systems uses T-1 sensors, an Echelon network, a DCM14 video system, and NTVision system. The other system consists of T-1s and NTVision only.

The ITIP demo was installed in a bunker at Pantex to demonstrate that all of the sensors could be installed in a single enclosure placed over the door of the bunker. It consists of a system that incorporates the T-1 and DCM14 video system.

The Helsinki, Finland, project was an upgrade to an earlier system and uses Echelon in combination with the DCM14. One of the main purposes of this installation was to demonstrate the use of a Virtual Private Network (VPN) for transmission of data between a site and the IAEA. The VPN consists of hardware and software that allows data to be authenticated, encrypted, and routed over the Internet with no impact on the architecture of MMS. It basically provides for secure links between the MMS components.

The Korea project was set up as a demonstration in a laboratory as part of a monitoring workshop to allow familiarization of the technology; the project uses Echelon, DCM14, and NTVision.

The CMC system was installed at the Cooperative Monitoring Center at Sandia National Labs, Albuquerque to be used for demonstrations of the technology and for testing new sensors and configurations. The system consists of Echelon, T-1, DCM14, and NTVision sensors.

MMS may be used in other different applications in the future depending on need by different sites. Some of these applications may even be non-storage applications like environmental monitoring, security systems, and monitoring for material disposition. There is also the potential to interface to various inventory control and information systems and knowledge generation systems.

Conclusions

The MMS uses a flexible, hierarchical architecture to provide for the near real-time acquisition of data and display of that data virtually anywhere in the world. The use of commercially available components and various sensor configurations has allowed for the successful application of MMS at many different locations throughout the world and for many different projects.

[1] J. Damico and L. Desonier, "Material Monitoring System Update: Enhancements and Applications", 40th Annual Meeting, Proceedings of the Institute of Nuclear Materials Management, 1999.

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