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CONF-9007106--33

ARGUS-Demonstration of an Integrated Materials Monitoring Tracking and Accounting System

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SAND--90-0742C

DE90 014369

ABSTRACT

The Argonne Unified Safeguard (ARGUS) System (1) is currently in the process of being demonstrated as a functioning integrated materials monitoring/tracking and accounting system in the Fuel Manufacturing Facility (FMF) located at Argonne National Laboratory (ANL) in Idaho Falls, Idaho. ARGUS is the product of an interlaboratory project with Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and ANL. Accounting and communications software were developed by LANL personnel while materials monitoring and tracking software and hardware were developed by SNL personnel. ANL has provided project coordination, operational support and the facility that serves as the test bed for this demonstration.

The ARGUS system is made up of three major components. These components perform the functions of observing all container movements, authorized materials access approval, initiation and receipt of materials transfers, and perform materials accounting for the facility. ARGUS system benefits can be summarized as follows: near real-time accountability, full traceability of materials access and transfer, enforcement of approved personnel access to materials, electronic confirmation of materials surveillance procedures during materials access and transfers, continuous surveillance of all material not directly involved in the manufacturing process,

*This work is Supported by the U. S. Department of Energy Reactor Systems, Development, and Technology under Contract W-31-109-ENG-38.

**This work is supported by the U. S. Department of Energy under Contract DE-AG04-76DP00789.

***This work is supported by the U. S. Department of Energy, Office of Safeguards and Security.

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transfer initiation and receipt, and automatic notification to security for identified anomalies. The contributions of each of the participants in this project will be described.

BACKGROUND

The work being discussed began at LANL with development of a materials accounting system for application on personal computers. This pc executable accounting software is known as Personal Computer Dynamic Materials Accounting (PC-DYMAC) and was originally a translation of the main frame relational accountability software in use at LANL. Following its development, PC-DYMAC was installed in the ANL-W FMF where it currently performs all accountability functions.

A Personnel Monitoring and Tracking System (PMTS), developed by SNL and aimed primarily at mitigation of the insider threat, was demonstrated in the ANL-W FMF. Materials tracking was accomplished by placing motion sensing radio frequency transmitters on materials containers. If permission was not granted prior to movement of a material container, an alarm would be enunciated. Permission to access and authority to transfer the protected containers was determined through interaction with a sophisticated bar code reader. Personnel tracking was determined by knowledge of which portal a person had passed and their direction of travel. Significant data were collected and lessons learned by both SNL and ANL-W personnel, in the areas of system performance, design, and operational facility and personnel interface. The findings from this exercise are summarized in Ref. 1. One point, especially applicable to ANL-W, was an understanding of the requirements and preparations to successfully prepare and participate in a test and evaluation of this type in an operating environment.

Results of these two development programs were recognized as having significant potential, not only on a stand alone basis but as an integrated system. The ARGUS system, Ref. 2, is an attempt to combine the best of these two efforts and consists of an accounting function and a materials monitoring/tracking function. The accounting function is performed by a Central computer and three peripheral computers. The accounting function is coordinated through the Central computer which receives messages from all other computers in the ARGUS system. Materials monitoring/tracking function is coordinated by the Computer Augmented Materials Access (CAMA) system which interfaces with the Mobile Authorization Verification Inventory Station (MAVIS) and Wireless Alarm Transmission of Container Handling (WATCH) subsystems. These subsystems provide the continuous surveillance of that material not involved in the manufacturing process. All hardware and software employed in the ARGUS system is listed in Table 1.

The various aspects of integration represent a significant amount of coordination, communication and effort in general between the participating national laboratories. Very early in the integration of these products it was realized that a clear

Table 1. ARGUS System Components
Hardware and Software

SOFTWARE	ARGUS SYSTEM APPLICATION	VENDOR
Xenix Ver. 2.3	Operating System Development System	The Santa Cruz Operation
Vermont Views Ver. 1.1	Graphic Windowing Utility	Vermont Creative Software
CTREE Ver. 4.3	File Handler Utility	FairCom
RTREE Ver. 1.1	Report Generator Utility	FairCom
HARDWARE		
IBM/AT - 80 mb internl hard disk - 5 1/4" internal double density disk drive - 5 1/4" internal high density disk drive	Peripheral Computers (3)	International Business Machine
HP laserjet printer	Peripheral Computers (3)	Hewlett Packard
IBM-PS/2 Model 80 - 115 mb internal hard disk - 5 1/4" external double density disk drive - 3 1/2" internal disk drive	Central Computer (1)	International Business Machine
IBM-PC/AT - 30mb internal hard disk - 5 1/4" internal double density disk drive	CAMA (1)	International Business Machine
Printer	CAMA (2)	Serial Port
Programmable laser bar code readers	CAMA (3)	Intermec
Dumb bar code reader	CAMA(1)	Microsystems

separation of function would be required to allow the necessary work to be performed at the different laboratories. This separation was provided along functional lines and has allowed a clean and expeditious integration of products.

DISCUSSION

Los Alamos National Laborotory - ARGUS Communication

The accounting and communications software was developed at LANL. It provides the system capabilities of a near real-time inventory and the traceability of materials access and transfer.

Hardware Description

The ARGUS system is composed of four personal computers, linked by RS-232 serial lines. The three peripheral computers are IBM/AT's and the Central computer is an IBM PS/2 model 8O. The current configuration includes an 8-port adapter for the Central and a 4-port adapter for each peripheral.

ARGUS Communications Software Overview

In ARGUS, each serial line is dedicated to either sending or receiving messages. The peripheral computers can only send or receive messages to the Central computer. The Central computer has three send lines and three receive lines, one for each peripheral. The materials monitoring/trackin computer only sends the messages to the Central computer.

When files are sent over a line, software handshaking is performed to ensure message integrity. A checksum is included in each message packet. Messages are broken into packets small enough that the serial port hardware buffers and system buffers do not overflow. If the receiving computer indicates the message was garbled, the packet is immediately retransmitted. If an unrecoverable error occurs, or if the receiving computer does not respond within a specified time interval, then the entire message is retransmitted, starting with the first packet. The files containing the messages are not deleted until all packets are sent successfully. This ensures that no information is lost, even if communications fail.

Communications Protocol

Messages sent are composed of one or more packets. A packet is written to the serial port by the sending process. An internal clock is set to wait for a response, currently with a 10-second duration. If the time expires, the first packet is retransmitted. The receiving process performs a checksum on the packet and matches it against the checksum calculated by the sender and sent with the packet.

A check is continually made to see if any send message files exist, if any are found they are sent. A file is deleted only after it has been sent successfully.

Message Files

File messages are distinguished by their length. A PC-DYMAC file message is 716 bytes long and a CAMA message file is 62 bytes long. The creation time of the transation is used to ensure that the database is updated in the correct sequence.

When all packets for a message have been received, a message is written to a file. A signal is sent to the PC-DYMAC process, which then initiates reading of the file, updating of the database with the transaction, and deletion of the message file.

Operational Characteristics

When ARGUS starts up, the first operation to be performed is a check of the directories for any messages to process or send. A delay may follow as it processes waiting messages.

Message files are processed only when the main menu or a submenu appears on the screen. As files are received or created, the screen clears and the transaction identification, container name, room/zone information, and file name appear. This indicates normal message processing.

Some transactions create many messages, such as shipping a container. When PC-DYMAC receives the first message in such a series, it displays a message on the screen and disables the menu on the receiving computer until the last message in the series is processed. This is done to prevent conflicting transactions from being entered before the entire transaction updates the database.

Sandia National Laboratories - Software Overview

The materials monitoring/tracking software and hardware developed at SNL provides enforcement of personnel access to materials, electronic confirmation of materials surveillance procedures, continuous surveillance and automatic notification to security for identified anomalies.

The ARGUS materials monitoring/tracking subsystem is a near real-time system, which provides surveillance of material. It implements near real-time material accountability by its interaction with the accounting subsystem. All materials monitoring/tracking software is written in the C computer language and in the Interactive Reader Language (IRL). The software consists of thirteen processes or program units which execute in a multi-tasking environment. The multi-tasking feature provided by the operating system allows many tasks or program units to share the computer's CPU time.

Communication with hardware is accomplished through parallel and RS-232 ports and across a Radio Frequency (RF) link. An overview of these program units and the communication between them and the hardware is given in Figure I.

Design Goals

The main design goal of the CAMA/MAVIS/WATCH subsystem is to provide 1) material monitoring and surveillance, 2) verification and authorization of material access, and 3) initiation and completion of material transfers. Through these transfers, the accounting subsystem is supplemented by providing these material movements electronically in near real-time. The WATCH system provides function 1. Functions 2 and 3 are provided by the MAVIS. The software was designed in a structured modular manner to be easily maintained. This software was also designed to be a flexible system so any future user requirements or enhancements could be easily introduced by the addition of other processes or hardware.

Program Unit Descriptions

The previously mentioned program units and the IRL program unit which together make up the software are described as follows with the function each one plays in the CAMA/MAVIS/WATCH Subsystem.

The main processes that execute system administrative functions by menu selection are; Security, Alarm, Mavis, Inventory, Logger, and Watch. The Security process allows the security inspector to log personnel in and out of the facility and executes various other security functions. An Alarm process automatically logs personnel out of the facility at a specified time. The Mavis Manager routes MAVIS messages from the RF base station modem to the correct Mavis process. These Mavis processes execute the functions requested by the material handlers at the MAVIS. The Inventory process keeps track of shipping and receipting containers. Two additional processes handle the communication of messages between the materials monitoring/tracking subsystem and the accounting subsystem. The Logger process sends all messages or alarms to a parallel printer. The two Watch processes report all WATCH alarms. The IRL program which is executed from the bar code reader, queries the material handlers for the necessary information and then interfaces with the computer to carry out the material transfers.

Hardware Overview

The hardware for the ARGUS materials monitoring/tracking subsystem is represented by the circles in Figure I. Five RS-232 ports and one parallel port on this computer are utilized in the communication with the various pieces of hardware.

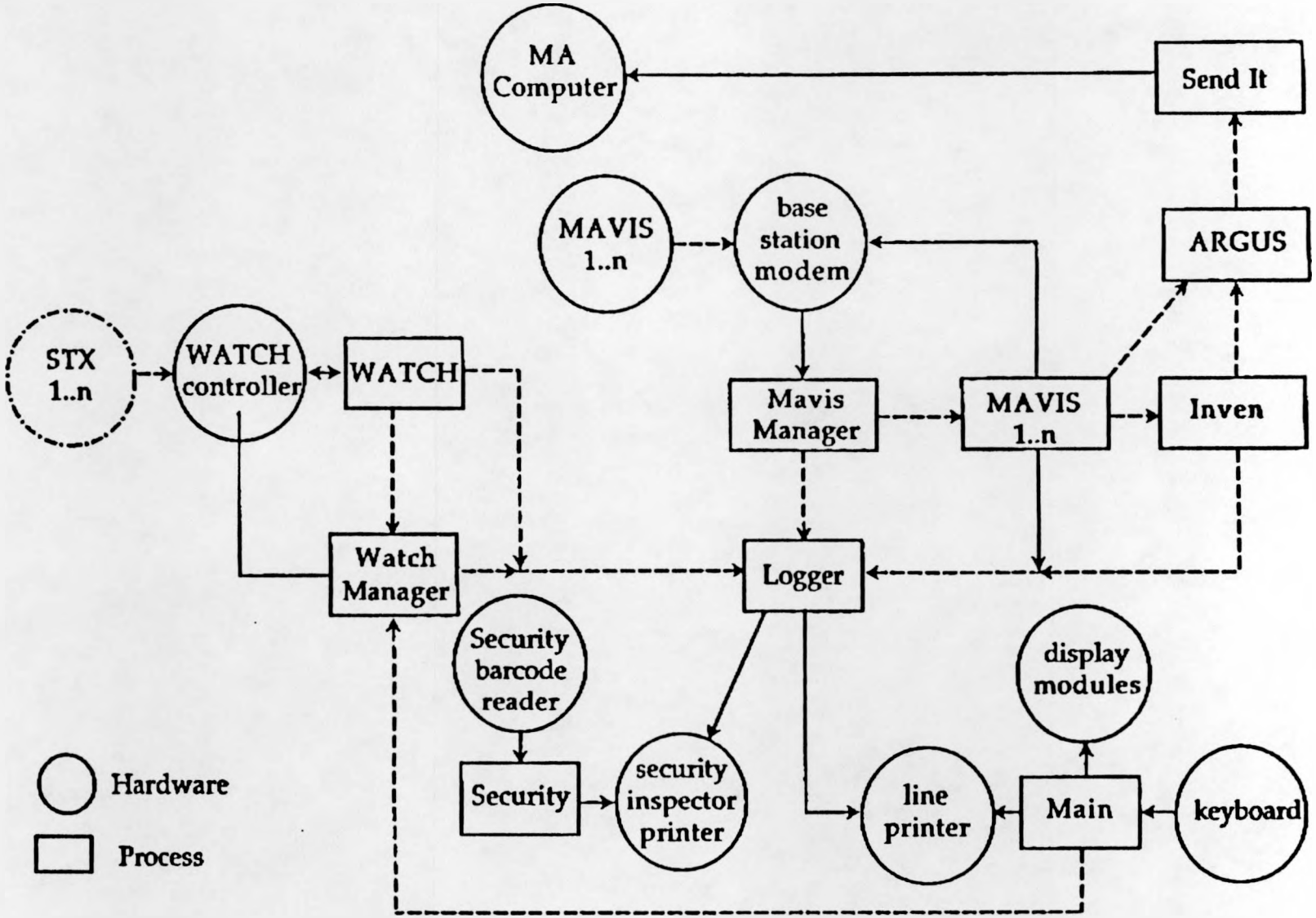

Figure 1. ARGUS Materials Monitoring system overview.

Communications Between Subsystems

The two subsystems of ARGUS communicate through an RS-232 cable. This link provides the capability to send material transactions.

MAVIS

The MAVIS hardware for each station consists of an intelligent programmable laser bar code reader attached to a mobile stand. Each stand contains an Esteem RF modem which is powered by a 12 volt power supply. The bar code reader uses a rechargeable battery.

WATCH

The WATCH hardware consists of a controlling device, Esteem RF modems, RF receiver and RF sensor/transmitters (STXs). The STXs are the units which are placed on the containers and have the ability to sense motion. When motion is sensed, a message is transmitted to the controlling device identifying which STX was involved. An unauthorized movement signifies an alarm. If appropriate the message is passed on to the CAMA computer.

Argonne National Laboratory - West

ANL-W contributions have been centered around the following areas: project coordination, project support with respect to the facility and it's required interface, testing of the product as received, providing assurance that the product perfoms adequately and finally in the training of the technicians who will be performing the test and evaluation.

Project Coordination

The function of project coordination was one of maintaining inter-laboratory communications with respect to the operational requirements of ANL-W. This function consisted primarily of maintaining close communications between ANL-W and Los Alamos personnel and between ANL-W and Sandia personnel.

Facility Support

The FMF is an operational facility which provides fuel, both experimental and driver fuel, for the EBR-II. The installation of the ARGUS system into an existing facility was not taken as a simple task. This installation has driven a significant portion of the preparation for the ARGUS test and evaluation. Currently materials accounting within the FMF is performed using the generation of accounting software written previous to ARGUS, i.e., PC-DYMAC. The performance of the ARGUS system is required to be equal to or better than that of the current accounting system

performance. This new system must therefore be thoroughly tested, debugged, and users trained so that the operation is not impacted negatively.

Facility modifications required to support the installation of the ARGUS system consisted of installation of the wiring for intrasystem communications. This was performed in a typical manner with all communications lines installed in conduit. All major conduit runs were installed at ceiling or near ceiling height to minimize the potential for communication system tampering.

Product Testing

Early testing of ARGUS was performed and evaluated at either LANL or SNL as required. As work progressed and the initial system came together it was installed at LANL for the convenience of testing near the developers. In this mode of operation the system underwent testing with a limited number of WATCHes, MAVIS, CAMA and the latest version of PC-DYMAC. During December 1989 the accounting portion of the system was delivered to ANL-W for installation and continued development. This was followed in January 1990 by the addition of the MAVIS and CAMA systems at ANL-W. Development has continued from this point with final operator trouble shooting of the software and user training. Ongoing during this development was the continuous and persistent oversight of the current PC-DYMAC system manager, who is responsible for maintaining and required system modifications.

Training

Training of the end user during the later stages of development has accomplished a number of goals. Primary among these was the trouble shooting or debugging of the software which occured to a large extent while training was being conducted. The software had received extensive testing prior to arriving at ANL-W and other than specific areas was in excellent condition. Major errors were not seen by the end user, who it was assumed, would not be as receptive to the system if their initial contact with it resulted in a less than optimum experience. However, the training was not timed so late in the development of the system that the software configuration was fixed and unalterable. An observation from the previous installation of PC-DYMAC was that small suggestions that are made by those who will be "living with" a system go a long way toward fostering a positive attitude in those personnel that have to learn a new or modified system. One way to generate a positive attitude toward a new system is to listen to the user and their requirements or suggestions. In the experience here at ANL-W, more often than not the end user knows the requirements and generally has significant input.

PROS AND CONS

Los Alamos National Laboratory

The choice of CTREE and VERMONT VIEWS appears to be a sound decision. The CTREE file handling systems work reliably and quickly. The drawback to using a file handler rather than a relational database package is that ad hoc reports are more difficult to develop. The CTREE package does include an RTREE package for preparing reports, but it has not been as convenient for these purposes as other systems. This disadvantage is more than made up by the speed with which CTREE operates.

VERMONT VIEWS has allowed the development of good screen handling interface with many useful features. Although the help key feature has not been implemented, the pop-up window choice list feature has proved very useful. The major drawback to this feature is that its search capability within a choice list is limited to finding a match to a single (first) character. It would be of significant benefit in many cases to be able to search on more than the initial character.

Sandia National Laborotories

As with most systems, the ARGUS materials monitoring/tracking subsystem has encountered some difficulties during implementation. The major problems have been with the hardware and with interfacing between the materials monitoring tracking subsystem and the accounting subsystem. Through extensive debugging and testing the majority of these problems have been solved.

The WATCH subsystem is still being developed. New software and improved hardware are being tested for the ARGUS project.

Argonne National Laboratory - West

The mode in which ARGUS was developed is potentially specific to this particular development. However specific, the approach was successful and not necessarily cumbersome with respect to bringing a system of this magnitude on line. Advantages of system development in the mode which ARGUS was developed include a clean interface between subsystems, specifically the intra-system communications, and the ability to easily divide the system into its minor components, i.e., accountability, CAMA and MAVIS, and the WATCH system.

The most significant advantage of the ARGUS system is the flexibility inherent in its basic structure. This was made apparent when the decision was made to install ARGUS subsystem by subsystem. The accounting subsystem is a stand alone accountability system, the capabilities of which are only enhanced when integrated with the CAMA/MAVIS/WATCH subsystems. The combination of the accounting function and the CAMA/MAVIS, for example, has no immediate drawbacks,

although it would have less than full ARGUS capability. The addition of the WATCH subsystem will only enhance the overall system. Thus, there is an additional degree of flexibility inherent in the ARGUS system and available to those users who might not need or require all of the capability available.

SUMMARY

The ARGUS system has successfully been assembled at ANL-W for test and evaluation. The ARGUS system is currently operating in parallel to the current accounting system in FMF. In this manner the system will generate confidence that it performs to the same level of the current accounting system while providing a realistic training venue for the end user. Installation, followed by the test and evaluation, is anticipated to take place during this fiscal year.

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