The GraFIC™ Facility Management Software

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ABSTRACT

The Graphical Facility Information System™ (GraFIC™) is an intelligent facility and information management system that provides near real time, verifiable status of safeguarded materials in a nuclear storage facility. GraFIC™ is a versatile software package that is designed to operate in a distributed computing environment and to provide item and facility activity information to an unlimited number of authorized clients. Recent extensions to GraFIC™ include the ability to link graphical entities to multimedia documents, interfaces to multiple material control and accountability systems, and alternate data entry and operator interaction mechanisms. Relevant multimedia documents such as still images and iPIX™ immersive images can be summoned on demand from their icons on floor plans. An iPIX™ image server, equipped with the appropriate sensors can signal GraFIC™ that an event that warrants the review of a series of saved iPIX™ images has occurred. GraFIC™ provides mechanisms for presenting information obtained from sensor-based monitoring systems and/or other information systems in a common, easy-to-use graphical format. GraFIC™ was initially integrated with the Continuous Automated Vault Inventory System's (CAVIS™) suite of rugged, low-cost sensors that remotely monitor the physical and/or assigned attributes associated with stored nuclear materials. GraFIC™ can now interface with the ReflectoActive Seals™ (RASeals) System. The framework designed for the RASeals interface is suitable for integrating with other systems, such as SmartShelf™. GraFIC™ can import existing data for stored material from other information systems. By retrieving existing information from other information systems, the expense, effort, and possible inaccuracies associated with manual entry are eliminated. Another data entry method involves offloading the data from the hand held terminals/barcode readers used by operators on the warehouse floor. GraFIC™ also contains facility management tools needed for the day-to-day management of storage and other facilities and gives facility managers and personnel instant access to the information they need to run their facilities. Any authorized client can obtain information about facility procedures, storage space availability, physical dimensions of areas, record management, location of assets, and a variety of other facilities needs.

INTRODUCTION

GraFIC™ is an information system that provides an inexpensive and flexible method of remotely verifying complete "up-to-the-minute" inventory status of stored Special Nuclear Material (SNM) without compromising security and while avoiding exposure of personnel to radiation. Intelligent Facility Management System (IFMS) is the set of convenience and productivity tools incorporated into the GraFIC™ software package to assist in the management of facilities. The IFMS components of the GraFIC™ software package provide the functionality needed for the day to day management of facilities. These components provide the user with an intuitive interface for viewing information about the physical facility or about the assets that exist within that facility.

GraFIC™ is built on a multi-tiered client-server model. It is implemented using Intel-based PCs as server and workstations. Data are stored in an Oracle database, and communications among the processors uses TCP/IP. GraFIC™ combines an easy to use graphical user interface with extensive online help so users need little training. GraFIC™ can be configured to work with most sensor systems used to monitor facility assets.

The initial deployment of GraFIC™ at the Oak Ridge Y-12 National Security Complex utilized CAVIS™ to monitor weight and radiation attributes of SNM that is stored in Modular Storage Vaults (MSVs). The features of GraFIC™ at that time included: inventories on demand, real-time alarm notification, hierarchical view of facility status and assets (overview to detail), long-term storage and retrieval of inventory data, linking of documents, drawings, and assets to associated facility areas, space planning and management, easy update of configuration information, many built-in reports that can be viewed on-screen or printed, and the ability to interface with other sensor systems.

GraFIC™ software development has continued since that deployment. Discussions with the material clerks who are using the system and closer scrutiny of the procedures that they perform and practices that they follow has fostered refinements and changes to the existing GraFIC™ features and subsystems, as well as the incorporation of new features. The enhancements and new features implemented in the current release include: interfaces to remote databases, enhanced item locator functions, easy customization and update of configuration information, dynamic storage capabilities, the ability to link multi-media to storage levels, RASeals, iPIX™ WebCam monitoring, migration of administrative functions to the user interface, and event/alarm e-mail notification.

Although GraFIC™ was originally developed to manage storage facilities for Special Nuclear Material (SNM) at the Oak Ridge Y-12 National Security Complex, it has many potential applications. GraFIC™ would be useful for any facility that houses valuable assets or dangerous items. Some examples are law enforcement agency evidence lockers, military weapons storage facilities, and art museums.

A key feature of the IFMS is its intelligent graphical interface, enabling point-and-click entry to a variety of applications and data sources. The IFMS system will make pertinent information and analysis available to key personnel. The result will be more efficient use of resources (cost savings), improved decision making, more informed planning, improved regulatory compliance, and quicker response to audit requests.

SYSTEM COMPONENTS

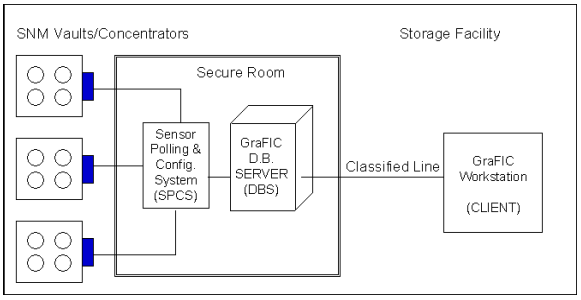

Figure 1 Typical Installation

The GraFIC™ system is designed on a client-server model. The server and all client software can be run on a single system, but a more typical arrangement would include at least the following three processing units: a database server, one or more sensor sub-systems, and one or more client workstations. A typical GraFIC™ installation is depicted in Figure 1.

The main purpose of the Database Server (DBS) is to control client access to the relational database. The database is logically partitioned into three subsets. One group of tables holds the current facility configuration and the current facility status. The second group of tables holds configuration and status history. These data are kept for thirty days and are provided for use in problem resolution. The third group is made up of a single table, the DAILY_ARCHIVE table. This table contains inventory data. This information is kept online for a year and then is archived to offline storage.

A GraFIC™ installation may include one or more front-end processors that comprise a sensor sub-system. The sensor sub-system is responsible for obtaining periodic sensor readings and reporting alarm conditions to the DBS for instant alarm notification. A generic sensor system interface is provided through tables residing on the DBS. A more tightly coupled interface is provided to the CAVIS sensor system and is called the Sensor Polling and Configuration System (SPCS).

A GraFIC™ installation may have one or more workstations to provide access to the user interface. These workstations may be placed in locations that are convenient to the workers who need to use them. The user interface portion of the product is given a more thorough treatment in later sections.

CONCEPTS

HIERARCHICAL STORAGE Central to the design and use of the GraFIC™ system is the idea that all storage may be hierarchically represented -- that any particular storage container is housed by a parent container and so on until the root storage level is reached. For example, one might have a site that has buildings located on it. Each building may have one or more floors that are subdivided into rooms. Each room may have cabinets, racks, vaults, etc., that may in turn be further subdivided almost without end. The storage hierarchy one chooses to implement is left totally to the end users discretion. Storage level types, parent-child relationships, and storage level instances are all user-definable.

LINKAGE TO/FROM STORAGE LEVELS Each storage level may have properties unique to the application assigned to it. For example, a storage level of type building may have a manager or custodian assigned to it, or perhaps a storage level of type container may have a lid assigned to it. In addition to the user-definable properties mentioned above, each storage level may have one or more of the following assigned to it: CAD drawings, documents, entry requirements, seals, assets, and sensors. Not only can various attributes/objects be linked to storage levels, but storage levels can also be linked to graphical entities (polygons, lines, and icons) on a drawing/map. This allows those entities to reflect the state of the storage level. It also provides the user with a geographically based view of the storage hierarchy along with the ability to access any storage level.

VIEWING STORAGE AND STATUS Access to and viewing of the hierachical storage arrangement is provided primarily through the Storage Explorer (see Figure 2). The hierarchical storage tree is displayed on the left while information regarding the selected storage level is provided in a list on the right. An alarm indicator is placed beside any branch that contains an alarm condition. Information appearing on the right may include sensors and their current state, any storage level specific alarms, child storage levels, assets contained in the storage level, seals for the storage level, drawings or documents attached to the storage level, and entry requirements for the level. After selecting an item in the list, the user may view, edit, add, or delete, depending upon

his/her assigned privilege. In addition, when a sensor is selected, the user can view a plot of sensor readings over time.

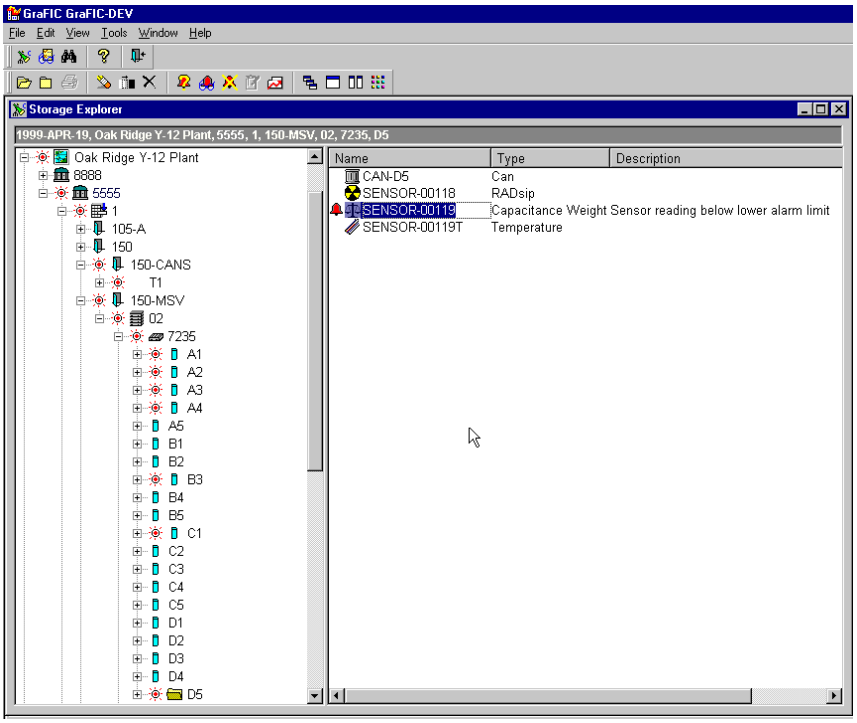

Figure 2 Storage Explorer

GraFIC™ provides a second major method of viewing storage and asset information through its map and drawing functionality. Each drawing/map is a to-scale representation of a storage level. The drawing could be a site map, a building floor plan, or a sketch of a container. Graphical entities on the drawing can be attached to other storage levels and thus reflect the storage level's state and provide a means to access the storage level's data. Storage levels may be represented on the map as

Figure 3 Map/Drawing Example

either a shaded polygon or as a point icon. Icons are re-locatable to reflect their actual geographical location. The state of a storage level icon/polygon represents its current alarm status.

Linked storage levels that have drawings attached to them may be directly accessed from the parent drawing. Figure 3 depicts a world map that has point icons linked to a site storage level, which has a site map attached to it. Storage level polygons on the site map represent buildings that in turn have a floor plan attached to them. The floor plan in turn has point icons that represent vaults contained in the various rooms of the building's floor. At any point along this chain, the user may point, click, and choose a storage level from the map for inventory, editing, or viewing purposes; thus an entire site, building, room, or cabinet can be inventoried with a click while viewing the item in its actual physical location.

REFINEMENTS AND ENHANCEMENTS

Some of the GraFIC™ improvements were geared toward the inventory confirmation aspects of the software while others were designed to assist in the day-to-day management of facilities. Many refinements and enhancements implemented were focused on giving the user the ability to configure and customize GraFIC™ to the specific facility's needs. Several functions previously handled by a standalone configuration program were moved into the user interface. For example, using GraFIC, one now can define new storage or sensor types, add icons, or update the alarm assessment list. With this new functionality, virtually all database information updates can be handled via the user interface.

The IFMS Find feature that allows the user to search for assets, alarms, drawings, documents, sensors, or any storage level that contains all or part of a user provided search string can now be augmented with an AND/OR clause. A count of the number of items found was added to the displayed list and the printed results. GraFIC™ now has the ability to e-mail alarm notifications to specified recipients. General state-of-health messages can be delivered as well. There is now a distinction between "monitored" and "non-monitored" storage. Monitored storage is storage that is either monitored by a sensor system or storage that is a child of monitored storage. All other storage is non-monitored. Updates to monitored storage are governed by the two-person rule. Two security enhancements were incorporated. Password expiration was implemented to force periodic changes of database passwords, and an inactivity logout was implemented to force an automatic logout from the datbase after a specified period of user inactivity was reached.

REMOTE DATABASE INTERFACE Manual data entry can be a tedious and error-prone task. Eliminating data entry errors can be accomplished by importing the desired data from other networked information systems. Data that is necessary for GraFIC™ inventory reports exists in other Material Control and Accountability database systems at the Y-12 National Security Complex. GraFIC™ requires minimal data entry to query remote databases to obtain the necessary data for the stored items. The process for initializing a stored lot within GraFIC™ requires the user to only specify the item ID. GraFIC™ will use this ID to query a remote database to obtain the needed information to complete the initialization transaction. If the remote database has no data for the item, the user is given the option to manually enter the requisite information. To assure agreement between the information that exists in the GraFIC™ database and the information that exists in the

remote database(s), GraFIC™ performs a comparison of item data for all items in its database with the remote database once per day.

DYNAMIC STORAGE CAPABILITIES To the GraFIC™ user, dynamic storage is the ability to move things (containers, assets, sensors, etc.) from one storage level to another. Using the Storage Explorer, the GraFIC™ user can move objects from one location to another using Cut and Paste features. All database links are automatically updated, and tracking information (when, who, and why) is collected and saved. Multiple item selection for moves, deletes and inventories can also be performed. With the multiple item selection feature, the user selects all items to be moved/deleted/inventoried and then issues only one move/delete/inventory command.

LINKING MULTI-MEDIA TO STORAGE LEVELS An extremely powerful feature available to the GraFIC™ user is the ability to easily associate facility attributes with pertinent electronic documents. These documents can be procedures, reports, entry requirements, drawings, maps, and multimedia. GraFIC™ typically uses a document's native application for viewing the linked documents so the types of files that are supported are only limited by the applications that are available to the particular computer. Web browsing applications typically allow multiple file types to be displayed through browser plug-ins or helper applications. Once the links are established between the facility attributes and the documents, two mechanisms are available to access those documents. The Storage Explorer can be used to navigate through the facility's attributes and view the lists of the documents associated with those attributes. Graphical representations of those documents on facility drawings and maps provide another means to access them.

Figure 4 – iPIX™ image Icons on a Floorplan

Multimedia documents provide visual data of facility attributes to the facility operators. Images can include traditional still images, streaming video, immersive iPIX™ images, or any data accessible through a WEB-browser. The multi-media linking capability was implemented using immersive iPIX™ images. Immersive iPIX™ images provide a 360 degree X 360 degree user-navigable image from two opposing images captured with a fisheye lens installed on a digital camera. Immersive iPIX™ images can be created for rooms and areas within a facility, as well as areas

outside a facility. These images are then assigned to their respective storage level with the Storage Explorer's "Add Document" capability and also can be linked to the GraFIC™ floor plans.. Using either method, the user can select the iPIX™ icon and display and navigate the image. The diplayed view is of what would be seen if the user were standing at the icon's location on the drawing. Figure 4 shows the a building floorplan with the iPIX™ icons.

IPIX™ images also can be linked to each other by placing hotspots in the images, allowing the user to 'walk' from one image to another as the user might do in the real world. Using this capability, the series of images of a room and adjacent areas can be linked, and the GraFIC™ user can navigate from one image to another. The series of linked images provides proper orientation when passing from one to the other. Each iPIX™ immersive image file has a single initial view. When that image is opened, that initial view is presented as the initial orientation of the viewer. Depending on which door you enter an iPIX™ image, you want to be presented with an initial view as if you just came through the door. The proper links can be established so that the transitions between images maintain the viewer's orientation.

iPIX™ WEBCAM MONITORING iPIX™ WebCam images were added to the other various document types that GraFIC™supports. An iPIX™ WebCam has a fish-eye lens that captures a 180 x 180 degree field of view. The camera can be strategically mounted in an area so that the area of interest can be monitored with a single camera. The viewing software, either a plug-in to a browser or a standalone viewer, allows navigation (pan, scroll, and zoom) of an iPIX™ image. The camera is always connected to a computer, and the computer controls how many images are archived and the rate at which the images are taken and downloaded. The maximum refresh rate is limited by the serial communication nature of the camera connection to approximately 30 seconds. With the camera aimed looking downward from the ceiling of a room, everything except what is above the camera can be viewed. A PC controls and downloads the camera's images and also provides storage for these images. The iPIX™ WebCam software acquires and builds iPIX™ images at a user definable rate. A software application was written to monitor the iPIX™ WebCam software image file creation and save the most recent image to a file with a fixed name. Using a web browser, this image is then available for retrieval as the "current image".

An icon linked to the image HTML document was assigned to a room on a floor plan via the Storage Explorer's "Add Document" capability and also linked to the GraFIC™ floor plan using the map functions provided. Opening the icon (from either location), and thus the HTML document, launches a web browser and displays the latest image that the iPIX™ WebCam has acquired. The image is self-refreshing.

Functionality to signal GraFIC™ of a room intrusion event and present a series of pre- and post-intrusion event images was incorporated into the iPIX™ Assistant software. A beam-break detector and a motion detector were added to the hosting computer system for signaling a room intrusion. When a sensor signals an intrusion, the iPIX™ Assistant software builds a web page that displays the previous nine images that the iPIX™ WebCam has acquired and then adds the ensuing nine acquired images to the web page as they become available. The information needed for incorporation into the GraFIC™ sensor tables that identify the two new intrusion sensors has been specified.

RASEALS INTEGRATION Integration of the RASeals system with GraFIC™ allows the individual reflecto-active seals to appear as sensors to the GraFIC™ user. This permits the state of the seal (breached/secure) to be displayed in a similar fashion as an alarm for a weight or radiation sensor. The integration is accomplished by periodically polling the RASeals system(s) looking for changes in configuration or alarm condition. The GraFIC™ configuration is modified at each scan to reflect the current configuration of the RASeals system. Thus, newly added links or seals will be automatically detected and displayed on the GraFIC™ side during the next polling session. Changes in alarm conditions are reported in real-time to GraFIC™. RASeal alarms can also be acknowledged from the GraFIC™ system.

HANDHELD TERMINAL/BARCODE DATA ENTRY Barcode reading devices are used in warehousing applications to gather data for reconciling inventories, accepting shipments, confirming deliveries, and defining material movements. Data from these various activities are transferred from the barcode reader to an information system. The use of a barcode reader to assist in warehouse operations offers productivity gains as well as eliminating any data entry errors. An application on a handheld terminal offers its user a menu of the type of transaction to be performed. As the user scans the appropriate barcodes for the particular transaction, a transaction file within the terminal is being created. When the user has completed his tasks, the terminal is plugged into a docking station at a GraFIC™ workstation and the download of the transaction file is initiated. The transaction records are interpreted and the database is updated to reflect the current state of the stored items. Discrepancies determined during the update of the database are reported as alarms and must be reconciled.

SUMMARY

The GraFIC™ system is being developed initially to provide fast and inexpensive SNM inventory status confirmation, real-time alarm notification and other storage facility management features for the Oak Ridge Y-12 National Security Complex. The system also has many other potential applications. The GraFIC™ project team has designed the system so that it can be easily adapted to fit any facility or inventory situation. Display details are easily adjusted to reflect any storage environment. GraFIC™ can also be configured to interface with existing databases to provide access to already collected facility and personnel information without the need for duplication.

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