

CONF-961092--3

SAND 96-0509C

SAND--96-0509C

## An Annunciator Architecture for the Year 2000

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JUL 22 1996

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*Abstract* -- Exciting new safeguards and security technologies are on the horizon, and some are even on the shelves today. Self-testing sensors, smart sensors, and intelligent alarm analyzers are all designed to provide useful information to the operator. However, today's current annunciator systems were not designed to accommodate these new technologies. New display technologies are also changing the look and feel of the annunciator of the future. Annunciator technology needs to "catch up" to these other security technologies. This paper presents the concept for a new, object-oriented approach to annunciator architecture design. The new architecture could accommodate simple, switch-closure devices as well as information-rich sensors and intelligent analyzers. In addition the architecture could allow other leading-edge interfaces to be easily integrated into the annunciator system. These technologies will reduce operator workload and aid the operator in making informed security decisions.

### BACKGROUND

*What is the state of annunciator technology today?*

There are many capable alarm communications and display systems (annunciators) on the market today. These systems are designed to accept switch closures from intrusion detection

sensors and display them as text in a tabular format. Most systems also have a simple graphical display which shows site maps. An operator runs the system by use of a keyboard and interacts through manipulation of the tabular text display.

A few systems have advanced graphical features. Many of the newer systems make use of a mouse, track-balls, or touch screens. The operator interacts through manipulation of the graphics display.

These commercial systems are sufficient for today's security needs. But new technologies and methods of handling and displaying security alarm information are quickly making current annunciator technology obsolete.

*So what are these new technologies?*

### *Self-Testing Sensors*

Several new sensors, such as Balanced Magnetic Switches and Passive Infrared Sensors, are providing the capability to initiate and report the results of self tests on the sensor. This is a powerful feature, which increases the confidence in the operability of the sensor as well as potentially decreasing the frequency required of walk-testing certain sensors. Most annunciators available today only accept switch closures corresponding to alarm events from sensors, and cannot initiate or accept the results of self-testing sensors.

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### Smart Sensors

In the past, intrusion detection sensors indicated intrusion alarms by closing a switch. There was an intrusion detected, or there was not. No intermediate values were allowed. In reality, many sensors have the ability to provide a graded output. This output ranges from no intrusion to intrusion and all values in between. Several commercially available sensors have integrated computer chips that can provide such a graded intrusion output.

### Display Technology

Methods of displaying information continue to evolve. Techniques range from simple light panels, to tabular text displays, to two-dimensional color graphics. New developments include "heads-up" displays, 360-degree "wraparound" displays, and virtual reality. The approach is to display important information without overwhelming or confusing the security system operator.

### Intelligent Alarm Analysis

This is a new area of research focused on applying alarm processing and sensor fusion techniques to provide more useful information to the central alarm station operator. The idea is to correlate and integrate a variety of inputs such as: sensor information and features from several physical protection system sensors, environmental data, knowledge of sensor performance under certain conditions (such as weather and visibility conditions), sensor priority, and recent operator feedback to modify the confidence of an event. Intelligent alarm analysis also incorporates trend analysis using historical knowledge of false and nuisance alarm data to identify installation, setup, or maintenance problems. Future research includes the integration of site data, such as sensor configurations and target locations to predict intruder movements and intentions and aid in dispatching a response force. Intelligent alarm analysis is a high order

process which takes a global look at the intrusion detection system and uses that look to enhance the information passed to the operator.

This paper will discuss a few ideas for incorporating the preceding technologies into an annunciator architecture for the year 2000.

### AN OBJECT-ORIENTED ANNUNCIATOR ARCHITECTURE

Figure 1 shows a conceptual drawing of an object-oriented annunciator design.

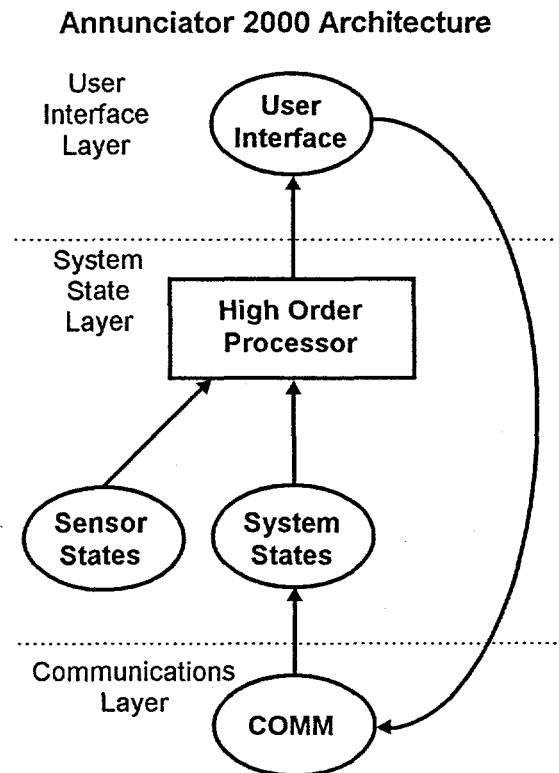


Figure 1

Object-oriented designs have several features; the principal feature used in this architecture is data encapsulation. It is desirable to create software which runs in a "need to know" environment. For example: only the user interface object "needs to know" how information is displayed. The communications object has no use for such information. Such a

"need to know", data encapsulated design is also called information hiding.

The concept of data encapsulation is a powerful one. For example, the user interface could display information as text, graphics, or on a three dimensional display. Other parts of the system would not be affected. An added benefit is that changing the user interface is easy. Just unplug the old and plug in the new.

Other components of the architecture operate in the same manner. Communications, sensor handling, higher order processing, and other objects can all be modified or upgraded. The only component which must remain constant is the interfaces between these objects. The primary benefit of information hiding is that it de-couples software functions from one another. No component depends on the details of another. Component objects communicate via rigidly defined object interfaces.

Figure 2 shows an expanded design. This illustrates how additional features could be attached to the basic system as required. The figure shows one method of adding entry control functions. Conceptually, additional features such as redundant consoles or assessment systems would be similarly added.

#### DESCRIPTION OF THE ARCHITECTURE

The architecture has a "three-tiered" design consisting of user interface, system state, and communications.

**User Interface** - This tier performs all interaction with the operator. The methods used to display data are isolated in this layer. Also isolated are the details of how an operator communicates with the system. Keyboards, track-balls, or other methods are hidden from the other layers. Any operator commands are converted to messages, and passed to the communications layer for processing.

#### Annunciator 2000 Architecture

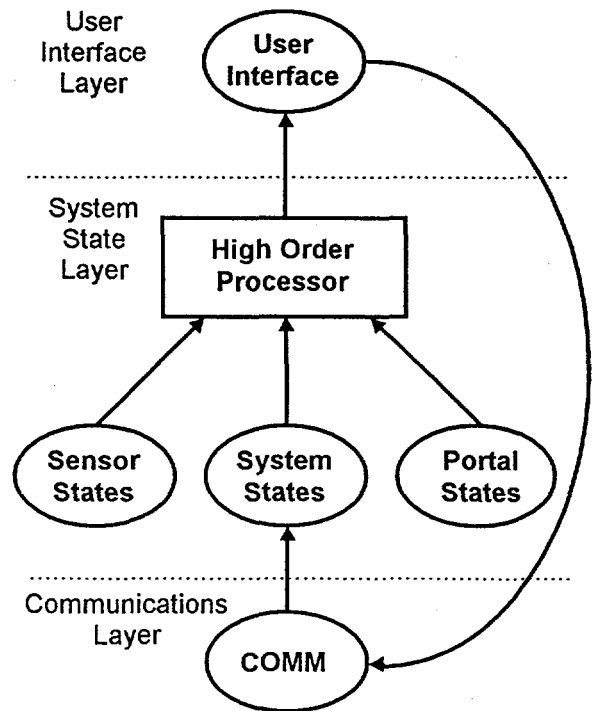


Figure 2

**System State** - This layer models the state of each system component. Each sensor is represented, and its current status is maintained. The status of each component is tracked, so that changes are detected, and can be passed on to the user interface.

**Communications** - The communications layer handles all interaction with the outside world. This includes all sensors, entry control devices, and other systems. Communications presents a common interface to the system state layer, but may be internally partitioned into several parts.

#### HIGHER ORDER PROCESSING

An annunciator architecture as described could easily handle new display technologies, or new input devices. It can also be expanded to process entry control data, and other types of information. High order Processing (HOP) is

the part of the architecture which performs intelligent analysis, and uses smart sensor data.

The HOP sits at the top of the system state layer. The HOP gets notified anytime something changes. It then looks at the global system status and decides if the changes are sent to the user interface. Smart sensor data would be processed by the HOP. For example, a low confidence alarm (the sensor is 10% sure an alarm has occurred) alone might not be passed to the operator. However, the HOP looks at all system activity and notices a similar low confidence alarm, from a separate source, in the same physical location. The combination of these two alarms could be sent to the operator. The filtering of alarm information is, however, always under the control of the operator.

Prioritization would be handled by the HOP. This could be a simple, static prioritization scheme that is currently used by most annunciators, or it could employ a more sophisticated dynamic prioritization algorithm based on the current state of the physical protection system.

HOP can process entry control data or other information to filter invalid alarms from the user interface. In addition, advanced sensor fusion techniques could be added to the HOP to improve the quality of alarm information.

#### CURRENT RESEARCH

The Security Technologies Department at Sandia National Laboratories is researching several areas which have applicability to the proposed architecture. They include:

##### *Object-oriented annunciator design*

A demonstration annunciator has been constructed which implements an object oriented architecture. This system is being used to demonstrate concepts for a rapidly deployed security system. The system runs on

standard personal computers and runs a three-tiered design.

##### *Advanced user interfaces*

Our current demonstration annunciators use an interactive graphical display to communicate alarm information to the user. All sensor information and control is performed by interaction with the graphics. This concept is not new, and several commercial systems perform similarly. Recent developments in display technologies have the potential to radically change the way humans interact with annunciator systems. With the cost of computer power dropping every year, sophisticated virtual reality displays are affordable and a viable option for interfacing with alarm management and control systems.

Sandia is currently exploring ideas for using a VR or 3D display as the user interface for an annunciator. We have developed a system which combines volumetric video motion detection (VVMD) with Virtual reality (VR). With VVMD technology, three dimensional information is obtained by the fusion of detection data from multiple, non-coaligned video sensors. The VR technology allows an operator, or security guard, to be immersed in a three-dimensional graphical representation of the remote site containing the video cameras. VVMD data is transmitted from the remote site via ordinary telephone lines and displayed in real-time within the virtual environment. This allows sensor information to be more easily interpreted when the operator can "move" through the virtual environment and explore the relationships between the sensor data, objects, and other visual cues. This research is in its infancy, but it has great potential for displaying vast quantities of data in an intuitive format.

##### *Intelligent alarm analysis*

There is ongoing research into sensor fusion techniques for intelligent alarm analysis. For one project, Sandia fused the information from three coaligned sensors: a CCTV linear

imager, a thermal linear imager, and a millimeter wave radar. Each sensor is processed individually with a motion detection and tracking algorithm to develop a track list for each sensor. Then the track lists are fused together, along with the incorporation of environmental information and operator feedback, to develop a single event list with an associated confidence. This list indicates all current system activity and ranks the activity by a confidence value. Higher confidence events are more likely to be passed to an operator. This fusion methodology is currently being extended to exterior intrusion detection sensors most commonly used at high-security facilities.

In another intelligent alarm analysis effort, Sandia is considering the application of "real-time risk measurement" analysis methods to true alarm data using site-specific vulnerability analyses to predict intruder movements and intentions. This effort is just getting underway.

#### CONCLUSION

A new annunciator architecture has been described. Its key features are:

*Object-oriented design* - System features are broken into distinct blocks called objects. Each external interface is handled by an object. New devices or features are added by adding new objects, or changing existing ones. Only the interfaces between objects must remain constant. New features and devices are easier to add to the system.

*Three-tiered architecture* - The system can be broken into three tiers or layers: communications, system state, and user interface. This structure de-couples various system components from one another and can make the system more reliable.

*High Order Processing* - All system events and data are passed through a high order processing function which combines data into a

filtered information stream. This information, not the raw data, is passed to the operator. The net result is a higher quality of information being passed to the operator.

By combining these three concepts, a new annunciator architecture ensues. The system has a built-in capability to handle smart sensors, new display technology, and intelligent analysis, as well as other leading-edge features not yet developed or even thought about. A potentially powerful annunciator system is the result.

#### ACKNOWLEDGMENTS

This work was sponsored by the US Department of Energy under contract DE-AC04-94AL85000.

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