Incursion Response System: An integrated geographical information system (GIS), database and web application for the management of exotic disease and pest responses

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Summary

The Incursion Response System (IRS) is an integrated geographic information system (GIS), database and web application for the management of exotic disease and pest responses. This paper presents the geographic information requirements of the IRS and describes how spatial and aspatial data are integrated to provide a comprehensive geo-spatial management information system for exotic disease and pest responses.

Introduction

Geographic Information Systems (GIS) have an important role in the management of an exotic disease or pest incursion. Effective use of GIS enhances the presentation and communication of critical information supporting situation analysis, planning, and resource deployment processes. The New Zealand Ministry of Agriculture and Forestry (MAF) has relied upon desktop GIS software, ArcView™, and MapInfo™, to meet its geographic information requirements. However, when an incursion response is either large, or has multiple operational centres, GIS scalability problems have been encountered. These include, lack of multi-user editing functionality, insufficient trained GIS personnel to keep the GIS and printed maps up-to-date, and version problems between the geographic information stored at different operational centres.

MAF has addressed these GIS scalability issues by developing the Incursion Response System (IRS). The IRS integrates GIS technology (ArcSDE™, ArcIMS™, ArcGIS™ and ArcPAD™) with database and web technologies (IBM Dynamic Server™ (IDS), Crystal Reports™ and the Microsoft .NET™ framework) to provide a comprehensive management information system for incursion responses. This paper describes MAF's geographic information requirements for managing an incursion by an exotic disease or pest, and how the IRS provides a scalable GIS solution able to provide real-time geographic information to incursion response personnel.

Analysis

User requirement analysis determined the data storage capability and functionality required of the IRS. Spatial data requirements include both geographic context information and response specific spatial data. Geographic context information provides the spatial reference layers enabling the user to interpret response specific data in its New Zealand context. Examples include roads, railways, rivers, lakes, place names, local government boundaries and geo-rectified images.

Response specific spatial data include premises, strata, traps, hosts, plumes, treatments, operational centres, and a variety of zones and areas used to manage response activities. The premise, strata, trap and host layers define epidemiological (or ecological) frames for referencing aspatial response data and scheduling field activities.

The premise layer is based upon legal or pseudo-legal entities such as farms, urban land parcels or apiaries depending upon the nature of the exotic disease or pest incursion. The strata, trap and host layers may be used as alternate response frames when the incursion response involves vectors such as feral animals, or insects. The strata layer defines vector habitat, the trap layer defines the locations that traps are set, and the host layer defines the location of host species (e.g. trees).

Response specific aspatial data include the details of surveillance, tracing, movement control, and organism management activities. Many of these data sets reference the either the premise, strata, trap or host layers, and therefore can be joined with the appropriate response frame layer to create new map layers. These map layers are particularly valuable for response managers and personnel as they provide answers to questions such as: “Where are the infected premises?” “Where have vectors been trapped in the last 6 weeks?” “Where has cleaning and disinfection been completed?”

All response role holders require read and write access to spatial and aspatial information stored in a single centralised repository. However, the appropriate method for accessing geographic information varies by response role. Field GIS personnel, require the ability to view, edit and add spatial data using a PocketPC™. Other field personnel require paper-based maps. Personnel located at the operations centres require access to geographic information using a simple, easy-to-use application interface. Epidemiologists and GIS Officers require applications capable of providing comprehensive mapping, analysis, editing, and geoprocessing functionality.

Design

The design of the IRS enables: storage of spatial and aspatial response data in a single repository, customisation to adapt the IRS to requirements of different incursions, and the ability to populate premise data from three external data sources. User functionality is provided by a variety of applications depending upon the type of data (spatial vs. aspatial), and the requirements of the response role.

Response data is stored in multiple IBM Dynamic Server™ databases. The ‘New Zealand Layers’ database contains geographic context information and a national set of address points. Response specific spatial and aspatial data are stored in a separate database for each active incursion response. All database tables containing spatial information are registered with the ArcSDE™ gateway.

At the initiation of each incursion response an IRS database template is selected from a library of IRS templates and loaded onto the production server. Each IRS template

contains information customising the IRS to the requirements of the specific incursion response. If the appropriate template has not been developed, the closest match is selected from the library, and the IRS Administrator customises the functionality of the IRS using a series of web forms.

Subsequent to loading an IRS template onto the production server the premise data is loaded from an external database. The IRS application includes IBM Dynamic Server™ and ArcSDE™ administration tools that enable a Database Administrator to load premise data from Agribase™ (a spatial farm database), the Digital Cadastral Database, or the Apiary Database.

Response specific spatial data are maintained using ArcPad™, ArcEditor™, ArcInfo™ and the Microsoft .NET™ framework. GIS Officers maintain the majority of spatial data using ArcPad™ deployed on a Pocket PC™ and/or ArcEditor™ and ArcInfo™ delivered through the Citrix™ desktop. Web form users maintain simple spatial features such as buffers using IBM Dynamic Server's™ native spatial query capabilities.

Response specific aspatial data are maintained using the Microsoft .NET™ framework. Database views are used to join aspatial data describing surveillance, tracing, movement control, and organism management activities with the appropriate spatial response frame. These database views are registered with the ArcSDE™ gateway to provide additional layers of geographic information that describe premises, strata, traps and hosts and by disease or visit status.

Response maps are created using ArcView™ and ArcIMS™. Epidemiologists and entomologists use ArcView™ delivered through the Citrix™ desktop to perform spatial analysis. Paper based maps for field personnel are also created using ArcView™. Web mapping pages required by the majority of personnel located at operations centres are provided by ArcIMS™.

Web reports and forms are generated using Crystal Reports™ and the Microsoft .NET™ framework. These applications are able to query spatial data by utilising the native spatial query capability of IBM Dynamic Server™. This enables the generation of reports based upon spatial regions and the inclusion of geographic information in computation of movement permitting decisions.

Conclusion

The IRS provides MAF with a solution to the GIS scalability problems encountered in previous incursion responses. The integration of GIS, database and web applications will enable response managers and personnel to access accurate and up-to-date geographic information. Consequent improvements in decision making and the deployment of field resources are expected to provide a significant strategic advantage when responding to future incursions by exotic diseases and pests.