

A Tool for Automating Network Layout and Importing Legacy TNAPS+ Networks

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Abstract

We have developed and continue to enhance an automated network layout tool based on user requirements that interfaces with OPNET via ODK and can import legacy TNAPS+ networks into OPNET or NETWARS. This tool, referred to as INCOT, is being developed for the US Air Force. By incorporating expert knowledge of network engineering, policies, available components and their characteristics, INCOT is providing an interactive goal-driven rapid design tool. TNAPS+ is a tool presently in use by the Air Force to perform network configuration. The standalone TNAPS+ translator allows legacy networks to be further analyzed or incorporated into other OPNET/NETWARS/JNMS networks.

Introduction

Modern conflict is becoming ever more dependent on larger quantities of information and communications. Intelligence and other critical information in the field are often transmitted over networks that may need to be configured under severe time constraints. Given these time constraints, it is imperative that networks in tactical military situations be designed to maximally support the goals of the mission. Thus, a solution is needed to meet the goal of engineering networks to meet mission critical data requirements, while allowing for the design, testing and optimization of such networks under severe time constraints.

The problem is compounded because network engineering under any circumstance requires expert knowledge that is dependent on the context and environment in which the network will need to operate. In addition, there are various other constraints, including available equipment, security considerations and other policy-based constraints. Present commercial simulation engines are powerful tools for developing and testing potential networks, but their power has, to date, been accompanied with a high level of complexity, so the utilization of commercial simulation engines has associated with it the need for understanding of the complex software, sometimes including programming skills, although many aspects of the software may never be used. A related problem is that many network engineers utilize legacy systems, so thus have no experience with modern commercial simulation engines.

Fortunately, the power afforded by the state-of-the-art in commercial network simulation tools is sufficient to simulate most of the networks that need to be constructed. The major obstacle is that the complexity of the tools does not allow their power to be exploited under the time constraints afforded by modern tactical military situations, except via the most expert users who may not be available. Another way to view the problem is that users with a working knowledge of

communications networks (though not necessarily an expert in any network simulation tool) need to be able to construct optimal networks quickly. These less-than-expert users must still build the network as if they had expert knowledge of device characteristics, and they must adhere to all policies. An associated problem for network engineers with experience only with legacy systems is to allow the legacy networks to be utilized in state-of-the-art commercial network simulation tools.

System Description and Design

The following sub-sections provide the objectives, a functional description and an overview of the architecture for the Intelligent Network Configuration Optimization Toolkit (INCOT).

Objectives

The objective of INCOT is to develop an innovative intelligent toolkit interface to OPNET, a COTS simulation engine, to configure and optimize network configuration and operations. (Reference to 'OPNET' refers to any tool developed by OPNET Technologies, Inc.) This toolkit will allow rapid design and optimization of communications networks without requiring the user to have programming skills or knowledge of the underlying OPNET simulation engine. By incorporating expert knowledge of network engineering, policies, available components and their characteristics, INCOT will be able to provide an interactive goal driven rapid development tool to the network engineer that will quickly generate optimal network configurations.

Functional Description

INCOT greatly extends the power of other networking tools, while simplifying its operation for Air Force network engineers. One of the greatest examples of this extension is the goal or requirements-driven design option; instead of building the physical network and then using a network simulator, e.g., OPTNET Modeler, to determine if it meets the requirements, INCOT starts with the requirements and then tries to build and optimize the physical network. INCOT does this while only using available devices, allowable services, satisfying security requirements, etc.

INCOT can be used independently, but has also been integrated with OPNET tools and tools derived from OPNET, e.g., NETWARS. Since NETWARS is a component of JNMS, INCOT can benefit JNMS users also. When INCOT is utilized with OPNET or OPNET derived tools, commands are available that enable the operator to quickly modify network components via a database of known devices, add or delete connections, and test for proof of adherence to policies or perform optimization. An iterative session with INCOT helps the network engineer determine the necessary equipment, cost, end points and

performance while taking into consideration geographical constraints, locations of ground facilities, forces and related space-based assets (such as data-relay communication satellites).

Graphical representations (as well as reports) are available to illustrate the quality of the network coverage provided. Finally, mouse-gestures enable the operator to zoom in on a specific geographic area, to obtain detailed information about a specific sub-network or component, and to quickly assemble alternate displays designed to support specific types of decisions.

System Design Overview

INCOT's goals include being a complement, not a competition to COTS networking tools. Therefore, to maximize the foundation provided by the commercial simulation engine, Stottler Henke teamed with OPNET Technologies: their Modeler product as well as other OPNET products provide the industry's leading network technology development tools. Modeler itself allows for design and analysis of networks, devices, protocols and applications. Modeler already provides graphical editors that mirror the structure of actual networks and network components, so INCOT leverages these as well as many other powerful facilities available in Modeler.

In addition, INCOT is not tied to OPNET products. That is, a subset of INCOT functionality can be performed without any OPNET or other tools. Since INCOT performs requirements-based automated network design that other tools do not, many aspects of this automation can be performed without other tools. For example, the inventory of equipment and the input of requirements can be performed independent of other tools. This also allows INCOT to be available to users that do not have access to OPNET products.

Figure 1 presents an overview of the major components and data flows of INCOT. The following sub-sections describe the major components of INCOT and the user interaction.

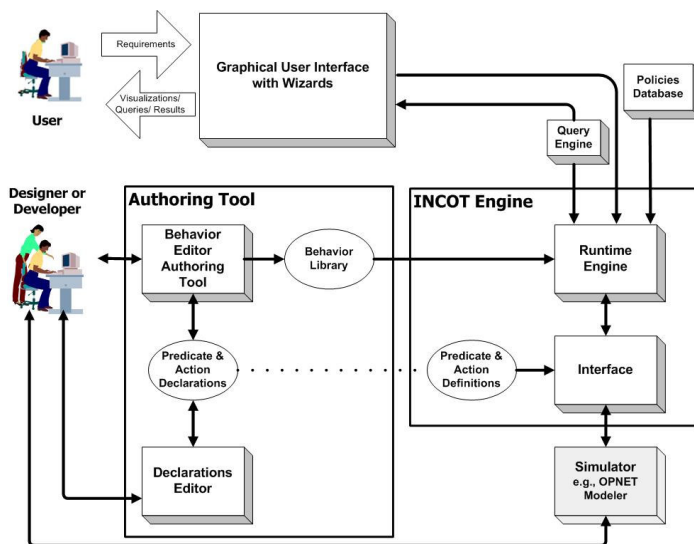


Figure 1. System Design for INCOT

Graphical User Interface with Wizards —The user interacts with INCOT and indirectly with other tools, e.g., NETWARS, via the Graphical User Interface with Wizards [1]. Via the Graphical User Interface, the user provides INCOT with the network goals, with their relative priority, the environmental / geographical situation, policies, and constraint data.

Much of the initial design setup interaction provided is via a Wizard interface. That is, the user is led through the network design process via step-by-step requirements-driven hierarchical workflow. As expanded upon later, the user is first asked high-level questions, e.g., the number of locations that will be involved in the network, and then later is asked about the particulars e.g., how many secure computers are needed in a particular sub-net.

INCOT Engine —From the goals, available devices, policy constraints and present environmental/geographical situation, the INCOT Engine can hypothesize on network configurations. When the INCOT Engine has enough information to start designing the network configuration, it builds a network configuration.

Policies Database — The Policies Database provides a repository for all the various policies that may need to be in effect. A default set of policies are initially active. The user has the option of relaxing certain policies and activating other policies. This can be done interactively to see if the “bending” of a policy will allow for more of the goals to be reached.

Query Engine — The Query Engine is simply an interface between the INCOT Engine and the Graphical User Interface with Wizards. If more information is needed from the network engineer, the INCOT Engine can formulate questions via the Query Engine. That is, the Query Engine will take the information request from the INCOT Engine and formulate a query that is easy to understand by a network engineer.

Simulator — INCOT can interface with different OPNET and OPNET-derived simulators. For example, INCOT can work with NETWARS, a DISA product built with OPNET products. The Simulator products handle the network simulations to provide the results for any particular configuration generated by the INCOT Engine. OPNET and OPNET-derived products provide a devices database that can be customized so that INCOT will only show the inventory of devices that are available. In addition, OPNET and OPNET-derived products include an Environment / Geography Database; that is, topological information for the entire world is supported already as part of OPNET. Therefore, if INCOT proper requires any device or topological information it will query the appropriate OPNET or OPNET-derived products.

INCOT Evolution: Initial Prototype, Alpha & Beta

The Alpha and Beta versions of INCOT were implemented using

- OPNET Modeler, with the following add-on modules,
 - Radio,
 - Terrain Modeling, which are customized via the
 - OPNET Development Kit (ODK)

INCOT Evolution: Alpha

The INCOT alpha release provides customized, highly interactive, menu tools and dialogs that simplify the workflow of planning a communication network. The following describes some of the simplified and automated capabilities provided in the alpha release.

- The user can define the area of operations giving latitude and longitude coordinates of the deployment location.
- The user can layout any number of subnets at the desired locations in a hierarchical order. The top-level subnet is the world, i.e. the world is the root subnet.
- The user can set a satellite linkback from any subnet to predefined base locations.
- The user can create microwave radio communication between any two subnets using microwave antennae.
- The user can create local area networks within any subnet for data communication.
- The user can create local voice networks within any subnet for voice communication.
- INCOT can automatically lay down the backbone of the networks in all the subnets in the deployed area and links the LANs and phone networks to the WAN.

A menu and nine action buttons have been added to the generic Project Editor. The project Editor's user interface is shown in Figure 2.

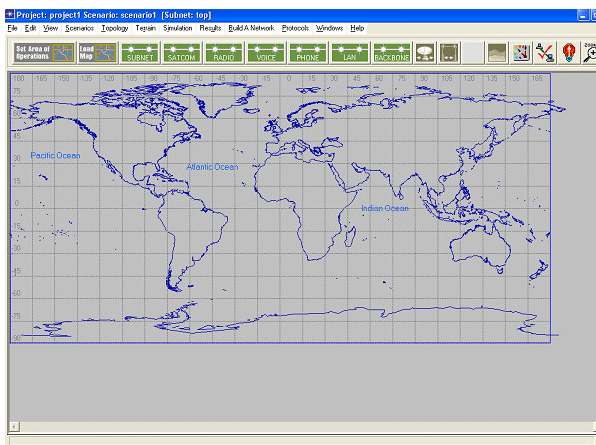
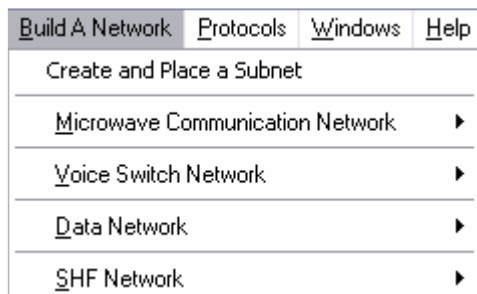


Figure 2. INCOT's Project Editor User Interface

The menu added to the Project Editor is:

Build A Network




This menu contains operations that relate to creating and adding various communication networks and communication devices used by the military, such as:

- Microwave Radio (LOS) Network
- Voice Switch Network
- NIPR/SIPR Data Network, and
- Super High Frequency Network (SHF).

The Project Editor provides action buttons for frequently used operations. The action buttons added to the project editor are shown in the diagram below.



For example, now the area of operations is set via the Set Area of Operations button, , which brings up the form shown in Figure 3.

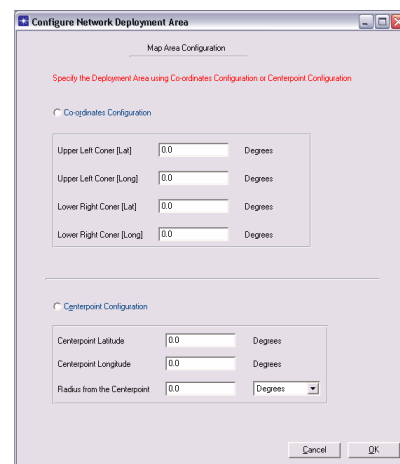


Figure 3. Area of Operations Form

Defining the rest of the network occurs mainly via the action buttons, which lead the user through a series of forms.

A powerful feature of the Alpha release is its ability to automatically lay down the backbone connections and hardware in all the subnets. That is, the user essentially defines the leaf nodes in all the subnets (e.g., number of computers, number of phones, etc.) and the user also defines the type of connections between the subnets. From this information, INCOT can automatically generate the rest of the network, such as laying out the needed hubs, switches, multiplexers and interconnections. This automation is simplified somewhat in the military domain since there is a restricted set of equipment from which to build the rest of the network from.

INCOT Evolution: Beta

The Beta software implemented a Wizard interface that was derived from the Task Manager in NETWARS. The Defense Information Systems Agency (DISA) develops the Network Warfare Simulation (NETWARS) software. NETWARS is a communications modeling tool, built on top of OPNET tools, that enables the warfighter to credibly model tactical and operational communications demands with all the stresses that

combat places on communications systems. The NETWARS Web page is located at www.disa.mil/tis/netwars. NETWARS is a component of the next-generation Joint Network Management System (JNMS). The Joint Network Management System (JNMS) is an automated software system that will provide communications planners with a common set of tools to conduct high-level planning, detailed planning and engineering, monitoring, control and reconfiguration, spectrum planning and management, and security of systems.

The Task Manager in NETWARS and the Wizard in INCOT look essentially the same; Figure 4 shows the Wizard in INCOT. The difference is that the Task Manager is only a Help system, it informs the user on what to do for each stage textually. The Wizard provides the same information but *also* walks the user through the whole process.

When a user starts a new project in INCOT, the Mission Requirements Workflow portion of the Wizard (displayed in Figure 4) is present. Using The Mission Requirements Workflow, the user defines the equipment available in the mission, the areas of operation, JTF and STEP sites, sites (organizations) in the operation area, the transmission system backbone, etc.

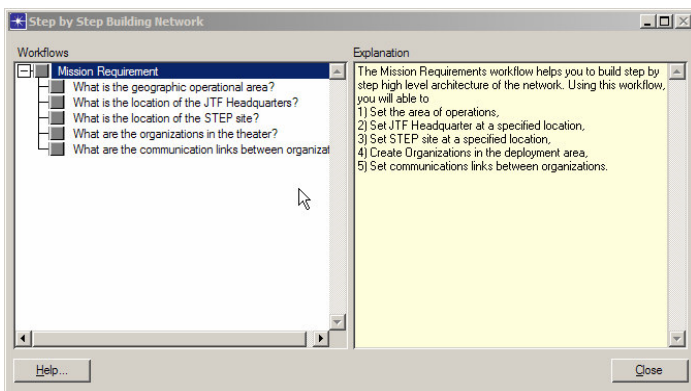


Figure 4. INCOT Wizard Interface

If the user selects the first option, “What is the available equipment for the operation”, the user will be taken to the *Add Equipment* dialog, shown in Figure 5. The user can set which inventory to use in this mission via a pull down menu. Each inventory has list of equipment with quantities.

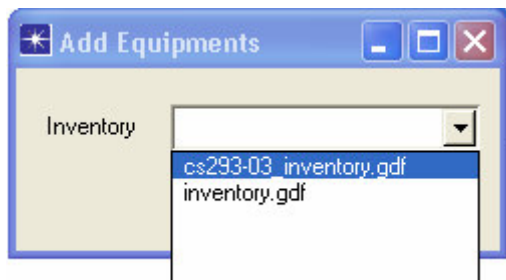


Figure 5. Add Equipment Dialog

The rest of the Wizard works similarly, that is, the user selects a step in the workflow and Wizard guides the user through the process of providing the information. As another example, when the user selects the “What are the organizations in the theater?” step the *Add Organization* dialog will be presented as shown in Figure 6.

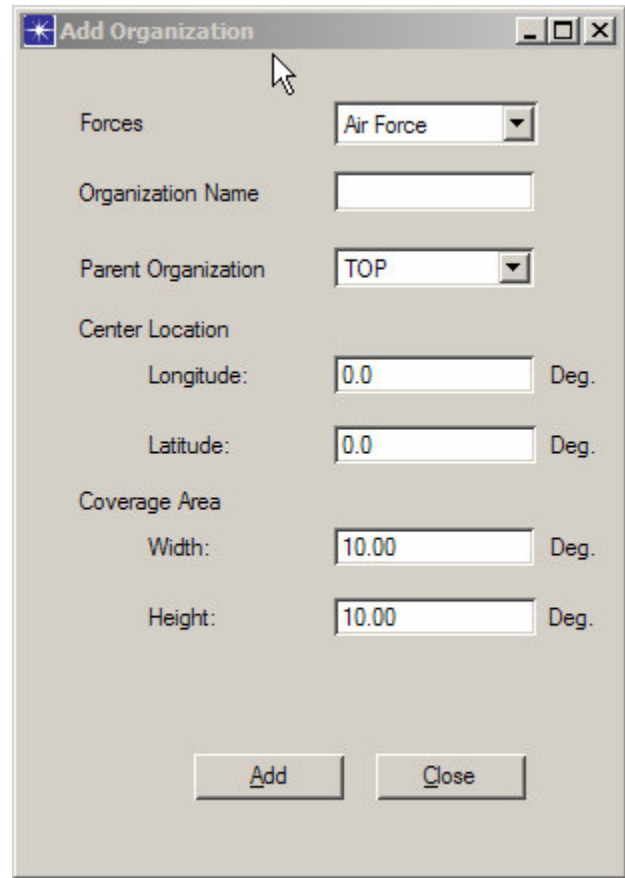


Figure 6. Add Organization Dialog

For example, by selecting *Data Requirements* the user defines the number of secure and non-secure workstations or servers in the organizations via the dialog shown in Figure 7.

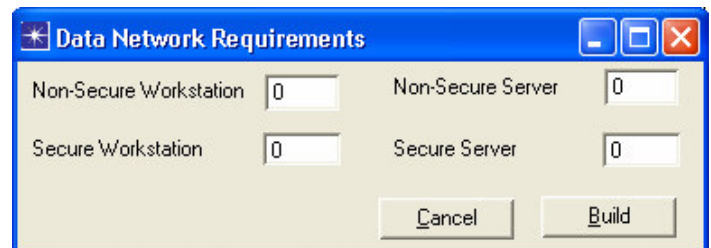


Figure 7. Data Network Requirements Dialog

When the user has completed defining all the data and voice requirements, they can select *Auto Build Backbone* to have INCOT build the rest of the organizations network based on the data and voice requirements and the inventory of equipment that is available.

This Beta release of INCOT demonstrates how we can further enhance NETWARS by evolving the Task Manager to a Wizard and adding automated network construction.

INCOT Release

The released version has extended the functionality beyond the Beta functionality in two significant ways

1. Abstraction of INCOT core: INCOT can be used independent of any other product.
2. TNAPS+ Integration: INCOT can now read TNAPS+ legacy data, since the Air Force still uses TNAPS+.

The following sections describe in further detail these INCOT capabilities.

INCOT Core

Previous versions of INCOT were integrated with OPNET or an OPNET derived product. However, as INCOT has become more powerful it became obvious that a standalone INCOT Core was a powerful tool in and of itself. Since INCOT performs requirements-based automated network design that other tools do not, many aspects of this automation can be performed without other tools. For example, the inventory of equipment and the input of requirements can be performed independent of other tools. This also allows INCOT to be available to users that do not have access to OPNET products or NETWARS.

The core makes it easier to add new functionality to INCOT per Air Force needs, for example, the ability to calculate the azimuth and elevation of a ground station given the location of a geosynchronous satellite was requested and added to the INCOT's core capability as this capability in no way needs or relates to OPNET.

TNAPS+ Integration

The Tactical Network Analysis and Planning System Plus (TNAPS+) is a PC-based tool utilized by the Air Force and other military branches for tactical communications planning and control (<https://esc-digd.hanscom.af.mil/Tnaps>). TNAPS+ assists the planner in building an exercise or operation database that consists of state-of-the-art commercial equipment and TRI-TAC equipment. TNAPS+ produces a series of output records describing the resulting networks and equipment configurations. The system controller can use this database, with program support, to monitor, manage, and reconfigure in-place communications. It is a detailed planning and engineering tool built around a database management system (DBMS). TNAPS+ supports tactical communications planning and control at two levels: the network level and the nodal/equipment level. Most of TNAPS+ is a Windows product with a small portion running under DOS but operating on the same database. An example of TNAPS+ Windows user interface is shown in Figure 8.

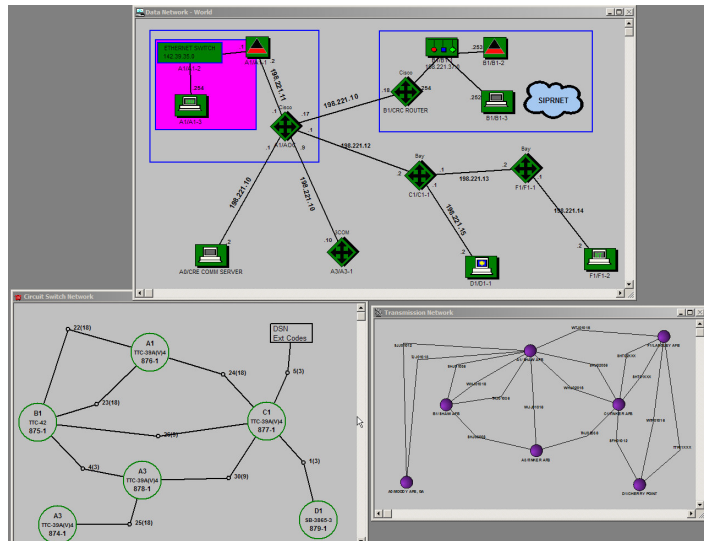


Figure 8. TNAPS+

Building the network in TNAPS+ is a requirement for many Air Force deployments; therefore, users would not wish to duplicate anything in TNAPS+ and INCOT. Because of this, INCOT has the capability to read data from TNAPS+. This allows the TNAPS+ user to benefit from much of the additional functionality provided by OPNET tools and INCOT without having to rebuild the network in INCOT.

This also makes the training much simpler, because the Air Force trains users to use TNAPS+, but not OPNET tools. By reading information from TNAPS+, much less knowledge needs to be learned about OPNET tools or INCOT to be productive.

OPNET tools have many capabilities beyond TNAPS+, an example is location. TNAPS+ does not store geographical location information with entities, one can record textually where something is but this has no meaning to TNAPS+. So once information is imported, location information could be added so the wireless transport analysis could be performed, etc. Most other types of analysis are not available in TNAPS+ either.

Conclusion

By incorporating expert knowledge of network engineering, policies, available components and their characteristics, INCOT is able to provide an interactive rapid development tool to the network engineer, while simplifying its operation for Air Force and other DoD network engineers. INCOT is greatly extending the power of OPNET offerings and OPNET derived tools; one of the greatest examples of this extension is the goal or requirements-driven design option; instead of building the physical network and then using OPNET/NETWARS to determine if it meets the requirements, INCOT starts with the requirements and then builds the physical network. INCOT does this while only using available inventory. By enhancing NETWARS concepts, INCOT will be benefiting the next generation of military networking tools, (e.g., Joint Network Management System (JNMS)), and by interfacing to TNAPS+, INCOT is allowing the Air Force to re-use legacy network modules and reach the next generation sooner. INCOT is available gratis now to the entire DoD community providing an

automated intelligent system for designing communications networks.

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