TREK

INTERPLANETARY OVERLAY NETWORK CONFIGURATION (IONConfig)

USER GUIDE

January 2023

Approved for Public Release; Distribution is Unlimited.

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1 Welcome

The Telescience Resource Kit (TReK) is a suite of software applications and libraries that can be used to monitor and control assets in space or on the ground.

The TReK IONConfig application provides the capability to create a set of Interplanetary Overlay Network (ION) configuration files.

1.1 Getting Started

Start with the Introduction which provides an application overview. Next, try the Quick Start Guides for "How Tos" for common functions. For help with details, reference the Details section. See the FAQ and Troubleshooting section for helpful hints and solutions to the common "gotchas".

2 Technical Support

If you are having trouble installing the TReK software or using any of the TReK software, please contact us for technical assistance:

TReK Help Desk E-Mail, Phone & Fax:

E-Mail: trek.help@nasa.gov
Telephone: 256-544-3521 (8:00 a.m. - 4:00 p.m. Central Time)
Fax: 256-544-9353

If you call the TReK Help Desk and you get a recording please leave a message and someone will return your call. E-mail is the preferred contact method for help. The e-mail message is automatically forwarded to the TReK developers and helps cut the response time. The HOSC Help Desk (256-544-5066) can provide assistance as needed and is available 24x7.

3 Introduction

The TReK IONconfig application provides the capability to create a set of Interplanetary Overlay Network (ION) configuration files.

If you are not familiar with Delay Tolerant Networking or the Interplanetary Overlay Network software, please see the TReK Delay Tolerant Networking Tutorial for an introduction to these topics.

Figure 1 shows an example of a Delay Tolerant Network (DTN) diagram that can be created with the IONconfig application. In this example diagram, there are four nodes with connecting ducts. Once the DTN diagram has been created and the node and duct

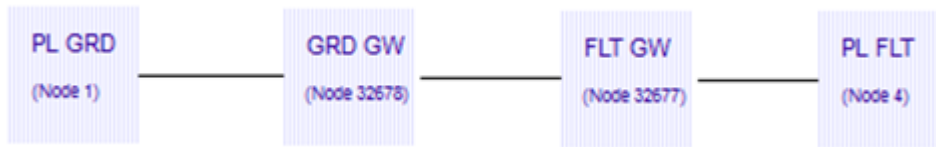properties have been populated, a set of ION configuration files can be generated for the configuration.

Figure 1 DTN Diagram Example

For each node in the diagram, the following files will be generated. This includes ION configuration files, script files that perform various tasks, and text files used by the scripts and/or the IONizer application. Table 1 shows all of the files generated by IONconfig that are used by ION administration programs. Table 2 shows the other files that are generated that are related to TReK operations. Some of these files can also be used without TReK. Items in both tables marked by an asterisk (*) are only applicable for nodes connecting to ISS via the HOSC to Payload Ethernet Gateway (HPEG).

File	Description
contact_plan.ionrc	An ION configuration file that describes contact times between nodes. Only applicable when LTP is used.
start.bprc	Contains the information for the ION bpadmin program to use when configuring an ION node.
start.cfdprc	Contains the information for the ION cfdpadmin program to use when configuring an ION node.
start.ionconfig	Contains configuration information for the SDR (data store).
start.ionrc	Contains the information for the ION ionadmin program to use when configuring an ION node.
start.ionsecrc	Contains the information for the ION ionsecadmin program to use when configuring an ION node.
start.ipnrc	Contains the information for the ION ipnadmin program to use when configuring an ION node.
start.ltprc	Contains the information for the ION ltpadmin program to use when configuring an ION node.
stop.ionrc	Contains information needed to successfully stop an ION node.

Table 1 ION Configuration Files Generated by IONconfig

File	Description
chk_node_num.bat*	A Windows batch file to ensure that node numbers in the configuration files are the same as those in the current HPEG configuration.
chk_node_num.sh*	A Linux bash script to ensure that node numbers in the configuration files are the same as those in the current HPEG configuration.
deletesdr.bat	A Windows batch file to delete the SDR (data store) associated with the configuration. This should only be executed if the SDR becomes corrupt. You will see a message in the ION log file if that happens.
deletesdr.sh	A Linux bash script to delete the SDR (data store) associated with the configuration. This should only be executed if the SDR becomes corrupt. You will see a message in the ION log file if that happens.
process_temp.txt	A file containing a list of the expected processes for the IONizer to monitor.
proxy_available.txt	A file containing information on if a proxy is available for this node. If contents of file is Yes, then auto configuration should be used.
renamelog.bat	A Windows batch file that renames the log file. ION must not be running when this batch file is executed.
renamelog.sh	A Linux bash script that renames the log file. ION must not be running when this script is executed.
startion.bat	A Windows batch file that starts all of the ION processes associated with a node.
startion.sh	A Linux bash script that starts all of the ION processes associated with a node.
stopion.bat	A Windows batch file to stop all of the ION processes.
stopion.sh	A Linux bash script to stop all of the ION processes.

Table 2 TReK Related Files Generated by IONconfig

4   Overview of the User Interface

4.1   Main Window

The main window contains several areas as shown in Figure 2. In some cases an area is a dock window that you can float or dock. To float a dock window, use your left mouse button to click and hold the title area while dragging the window to another area of the screen. To dock, use the title bar to drag the dock window over the main window and drop.
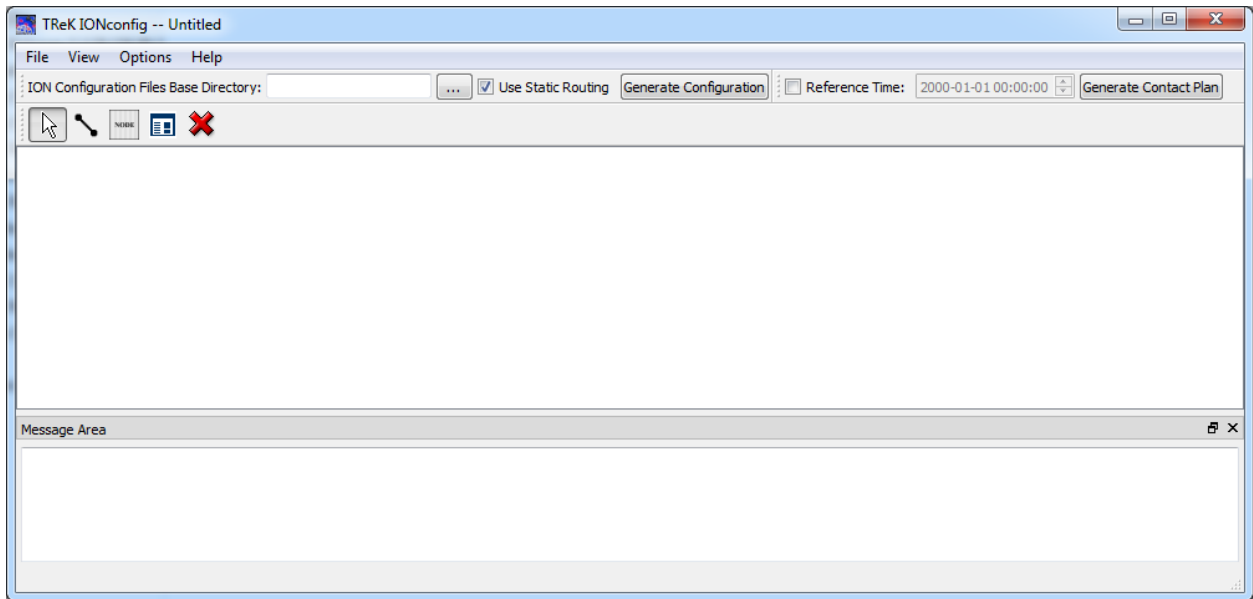
Figure 2 Main Window

Toolbars
There are three toolbars: Configuration, Contact Plan, and Drawing. The Configuration toolbar provides the capability to enter information that will be used when generating ION configuration files. The Contact Plan toolbar provides support for generating a contact plan. The Drawing toolbar provides access to drawing tools used to define a Delay Tolerant Network (DTN) diagram composed of nodes and ducts.

Drawing Area
The Drawing area is used to define a Delay Tolerant Network (DTN) diagram composed of nodes and ducts.

Message Area
The Message Area displays important status and error messages. The message area can be cleared using the View menu.

4.2   Toolbars

There are three toolbars: Configuration, Contact Plan, and Drawing.

4.2.1   Configuration Toolbar

The Configuration toolbar is shown in Figure 3.

Figure 3 Configuration Toolbar

Each item in the Configuration toolbar is described below:

ION Configuration Files Base Directory
The ION Configuration Files Base Directory is used to identify the top level directory where the ION configuration files should be placed when they are generated. Figure 4 shows a diagram with four nodes.
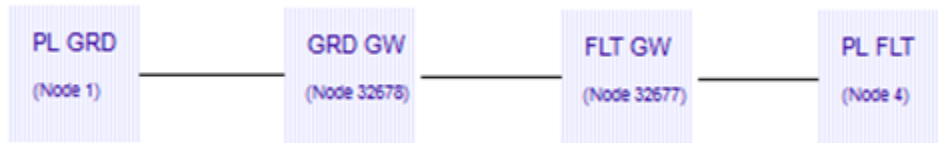

Figure 4 ION Configuration Files Base Directory Example

If the base directory entered was "/home/kirk/ion/", the "/home/kirk/ion/" directory would contain the following subdirectories after the configuration files are generated:

node_1
node_32678
node_32677
node_4

Note: The directory must exist when the "Generate Configuration" button is pushed.

Use Static Routing Checkbox
Static routing refers to the routing of bundles through a known path. With static routing the sending node often relies on other nodes to forward bundles and the sending node has no knowledge of the route or link availability along the route.

Generate Configuration
The Generate Configuration button is used to generate the ION configuration files. The DTN diagram must be valid in order to generate the configuration files.

4.2.2   Contact Plan Toolbar
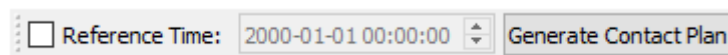The Contact Plan toolbar is shown in Figure 5.

Figure 5 Contact Plan Toolbar

Each item in the Contact Plan Toolbar is described below:

Reference Time

The Reference Time field is used to enter the Reference Time that should be used in the Contact Plan. If you do not enter a reference time, the contact plan will be generated to use the ION start time as the reference time.

Generate Contact Plan

The Generate Contact Plan button can be used to generate contact plans without generating the other configuration files. The ION Configuration Files Base Directory field must contain a valid directory and the DTN diagram must be valid before this feature can be used.

4.2.3   Drawing Toolbar

The Drawing toolbar is shown in Figure 6. The Drawing toolbar is used to create a Delay Tolerant Network (DTN) diagram composed of nodes and ducts.

Figure 6 Drawing Toolbar

Each tool is described below:

Tool	Purpose
	The Arrow tool is used to select one or more items in the diagram.
	The Duct tool is used to draw a duct between two nodes. A single line drawn between two nodes defines two ducts: one in each direction.
	The Node tool is used to place a node on the diagram.
	The Properties tool is used to edit node or duct properties. This can be done by first selecting a node or duct and then pushing the properties tool.
	The Delete tool is used to delete one or more items on the diagram.

Once a drawing tool is selected, it will stay selected until a different tool is selected. While selected, you can perform the tool's function repeatedly until selecting a different tool. For example, if you select the Node tool, each time you use the left mouse button to click on the diagram a new node will be created and placed at the location clicked. The Node tool will stay selected and you can continue to place nodes until you are finished. To perform a different function, such as drawing a duct or deleting a node, you will need to select the desired tool.

4.3   Menus

The application menus are: File, View, Options, and Help. Each of these menus is described in more detail below.

File Menu

The File menu provides the capability to manage configurations and exit the application.

<u>View Menu</u>
The View menu provides the capability to clear the main window message area.

<u>Options Menu</u>
The Options menu provides access to the Messages dialog.

<u>Help Menu</u>
The Help menu provides access to on-line help and application version information.

5 Quick Start Guides

This section provides "How Tos" for common functions.

5.1   How to Create a DTN Diagram

The following steps explain how to create a DTN diagram with two nodes and the ducts that connect the nodes.

The Drawing toolbar provides a way to select a drawing mode. The mode defines what object will be drawn on the diagram when you press the left mouse button in the diagram area. For example, when you push the Node tool, each time you press the left mouse button in the diagram a node will be drawn. To deselect a mode, press the Arrow tool.

1. Push the Node tool button on the Drawing toolbar. Use the left mouse button to place two nodes in the diagram as shown in Figure 7.
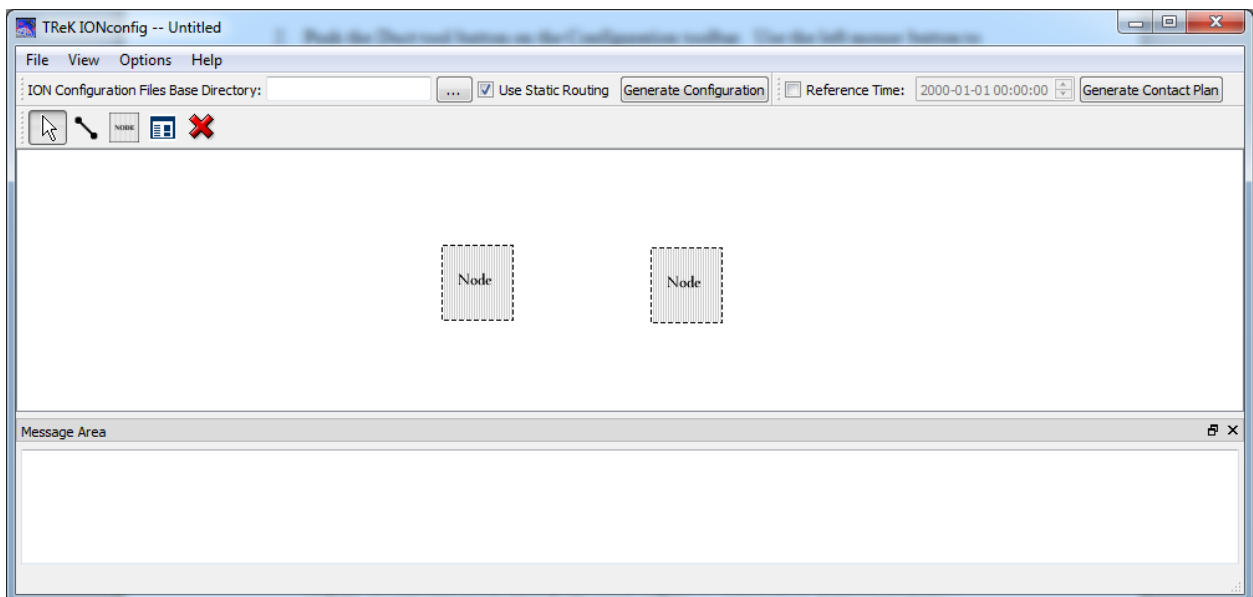

Figure 7 Two Nodes

2. Push the Duct tool button on the Drawing toolbar. Use the left mouse button to draw a line between the two nodes as shown in Figure 8.
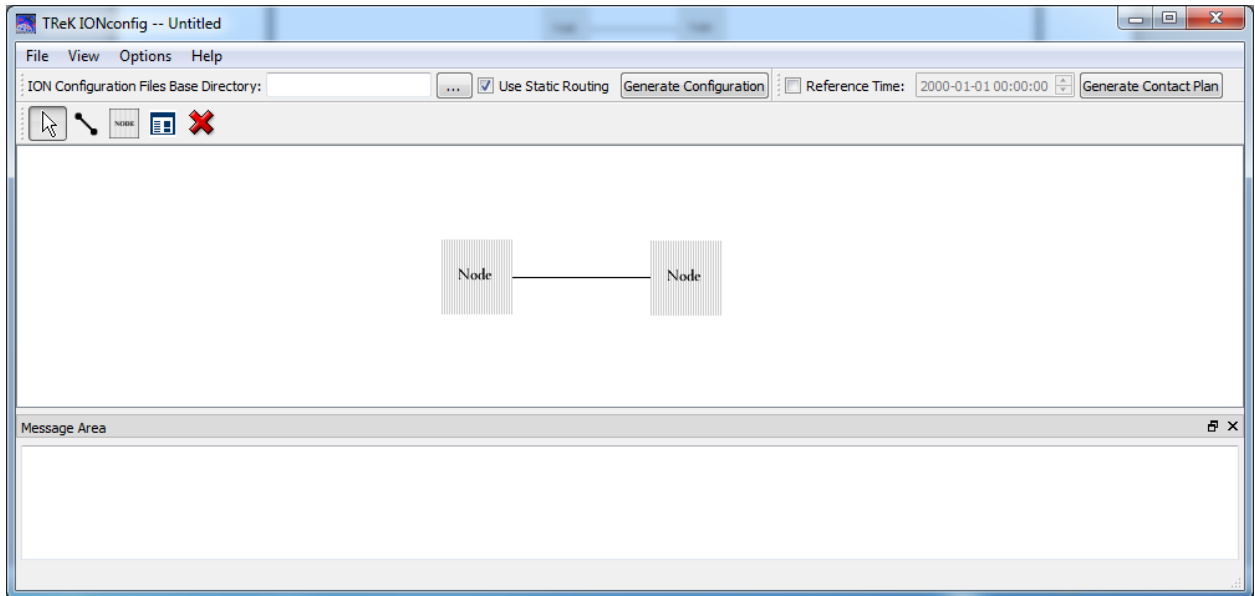

Figure 8 Two Nodes Connected

3. Use the left mouse button to double click on the left Node in the diagram. This will display the Modify Node dialog shown in Figure 9. Enter an IP address for node 1 and Ground for the Node Name. Push the OK button to save and close the dialog.

Figure 9 Modify Node Dialog for Node 1

4. Use the left mouse button to double click on the Node on the right side of the diagram. This will display the Modify Node dialog for node 2. Enter an IP address for node 2 and Space for the Node Name. Push the OK button to save and close the dialog.   The diagram should look like the one in Figure 10. Notice that once a node has valid data the node will be displayed with a different color. The Node Name is not required. But it can be handy to have node names.
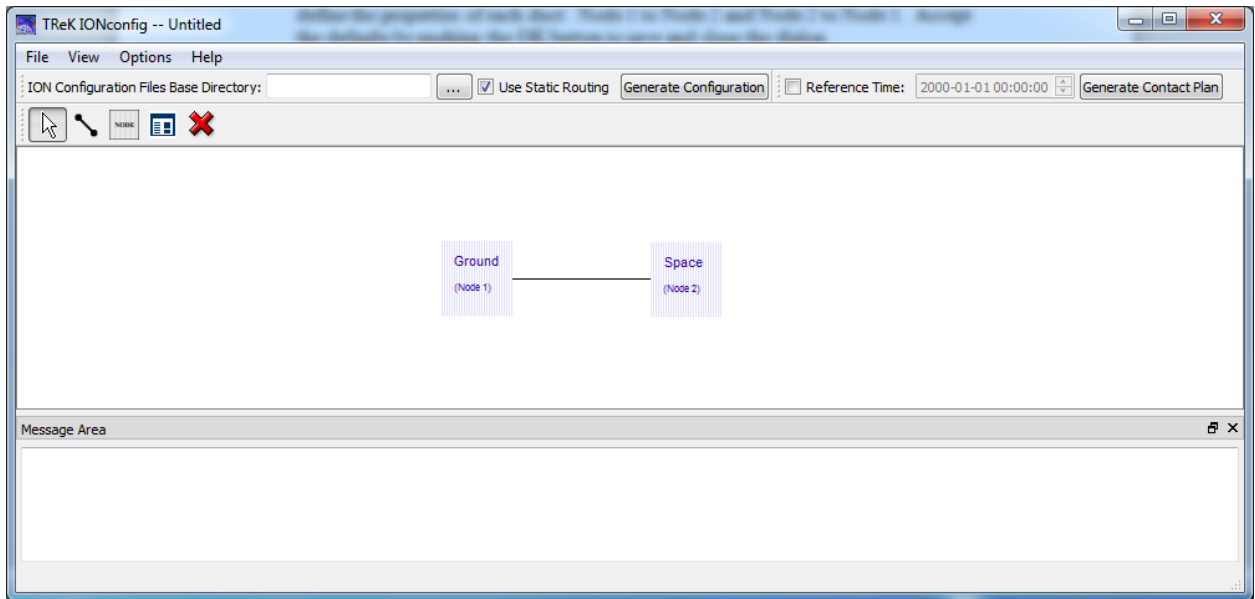
Figure 10 Two Nodes with Valid Data

5. Use the left mouse button to double click on the line that connects the two nodes. This will display the Modify Duct dialog as shown in Figure 11. Notice that you can define the properties of each duct: Node 1 to Node 2 and Node 2 to Node 1. Accept the defaults by pushing the OK button to save and close the dialog. (Note: If you plan to use the defaults provided in the Modify Duct dialog, you can skip this step and the defaults will be used when you generate the diagram).

Figure 11 Modify Duct Dialog for Node 1 and Node 2

The diagram is now valid and can be used to generate configuration files.

5.2   How to Generate ION Configuration Files

This section describes how to generate ION Configuration Files. ION configuration files can only be generated for a valid ION diagram. The following steps assume the drawing area contains a valid DTN diagram.

1. Set the ION Configuration Files Base Directory using the field in the Configuration toolbar.
2. Push the Generate Configuration button. The ION configuration files base directory will contain a set of subdirectories corresponding to the nodes in the diagram.

6 Details

This section covers various application details.

6.1 Modify Node

The Modify Node dialog contains multiple tabs. Each tab "roughly" corresponds to a specific ION configuration file. If you need help remembering the purpose of a field, try placing the mouse cursor over the field for a tooltip. Most of the fields are equipped with a tooltip.

6.1.1 General Tab

The General tab is shown in Figure 12. The General tab contains information that isn't necessarily tied to a single ION configuration file. The *Node Number* is what makes this node unique in the delay tolerant network. The *Node IP Address* defines the IP address to use for DTN communications. The *Node Name* is a user defined name that is only used for display purposes in the diagram. ION can generate watch characters that give visual indications of the underlying protocol activity. These can be very helpful if there are ever any errors transferring bundles. ION watch characters are sent to standard output. One or more services can be added for DTN enabled applications. The services needed to use CFDP are automatically added when you enable CFDP. So there is no need to add the CFDP service numbers (64 and 65) to the list. To add a service number, you click the "Add" button to the right of the service list. This will place a row in the service list with a default receipt action of "queue". Just type in the service number and change the receipt action if needed (the other option is "drop" which will drop the incoming bundle if a DTN enabled application isn't running to process the bundle).

Figure 12 Modify Node (General Tab)

6.1.2   Configuration Tab

The Configuration tab is shown in Figure 13. The *SDR File Path* is the directory where your data store will be located. It needs to be a directory where you have write privilege. Do not use spaces in the SDR File Path. The *Heap Words* describe how large to make the data store. ION calculates the number of bytes for the data store by multiplying the value you provide here with the number of bytes in the processor. For a 64-bit computer that will be 8x250,000 or 2 million bytes if you keep the default. You will want to increase this value for operations. A recommendation will be provided in a later TReK release of the TReK DTN Tutorial.

Note: The *SDR File Name* is the name of the data store. You should use the default value of *ion*. It is required unless you have set up a computer to run multiple nodes (see ION documentation on how to do that). The *wmKey* must also have the default value of 65281 when using a single node per computer configuration.

You will need to modify the SDR File Path and the Heap Words. The rest of the defaults will work for most configurations.
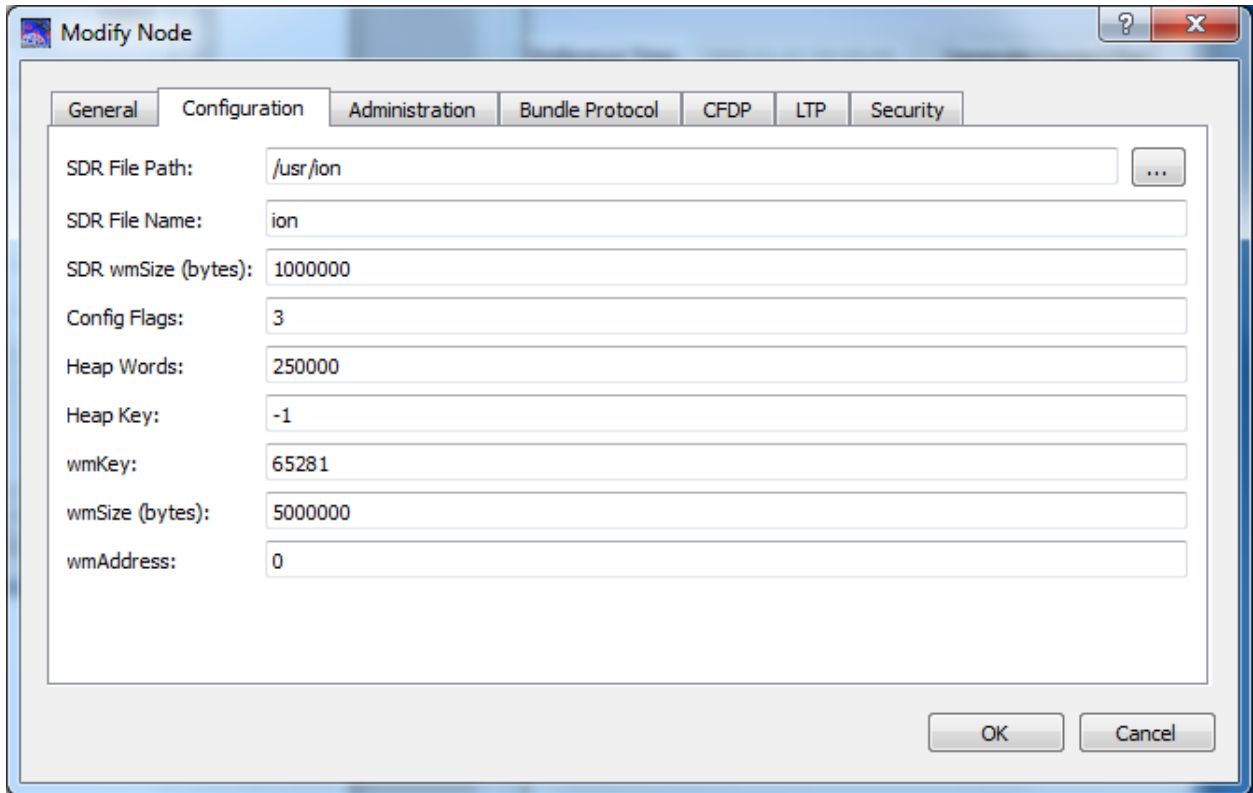
Figure 13 Modify Node Dialog (Configuration Tab)

6.1.3 Administration Tab

The Administration tab is shown in Figure 14. It is unlikely you will need to make any changes to the default values shown.
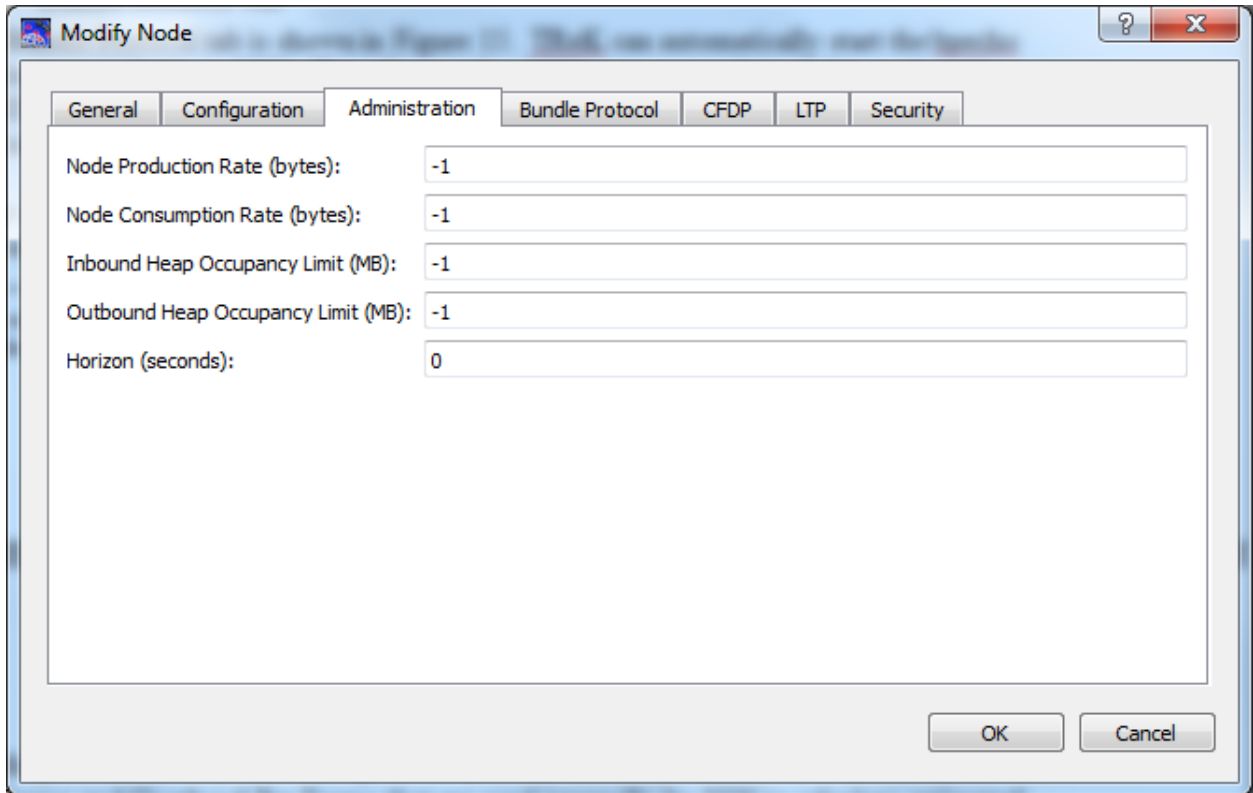
Figure 14 Modify Node (Administration Tab)

6.1.4   Bundle Protocol Tab

The Bundle Protocol tab is shown in Figure 15. TReK can automatically start the bpecho application available in ION. This allows other ION instances to "ping" this node with the ION bping application. The echo service is on by default. You can select a different service number for the echo service. It is automatically added to the services list.[1]

There are four supported convergence layers: TCP, UDP, STCP, and LTP. The STCP convergence layer is unique to ION and cannot be used with other implementations of the bundle protocol (DTN). For each protocol you can select the number of *Payload Bytes Per Frame* and *Overhead Bytes Per Frame* that are used internally by ION to calculate estimated transmission capacity for each bundle and aid in congestion forecasting. It is probably just best to use the default values. The *Nominal Data Rate* can be used to throttle the amount of data sent from an ION node for TCP, UDP, and STCP. If you use zero the data is sent as fast as the convergence layer will allow. The nominal data rates are in bytes per second. The data rate for LTP is controlled in the contact plan.

You will need to modify the nominal data rate for the protocol you select. The rest of the defaults will work for most configurations.

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[1] The echo service number defaults to the ISS designated service number. At this time the service number is undocumented and will change prior to operational use.
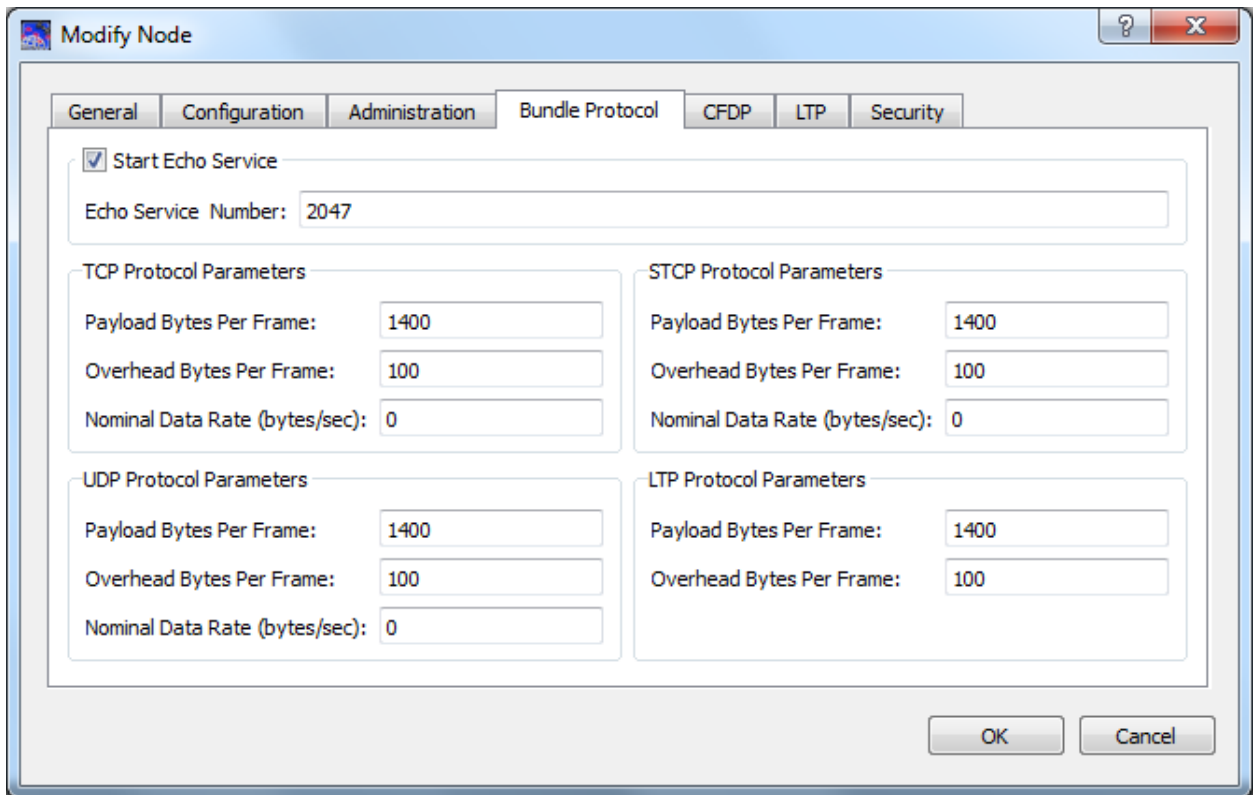
Figure 15 Modify Node (Bundle Protocol Tab)

6.1.5   CFDP Tab

The CFDP tab is shown in Figure 16. The CFDP checkbox enables/disables CFDP for the ION node. If it is enabled, the service numbers (64 and 65) used by CFDP will be automatically added. The *File Fill Character* is the fill pattern used by the ION CFDP engine for missing data. The valid values are 0-255 (0x00-0xff). The *PDU Segment Size* defines how large the CFDP Protocol Data Unit (PDU) will be. It is best to leave this value unchanged. Small PDU sizes can cause performance problems with the CFDP engine. The *Inactivity Period* defines how long a file transfer can be idle before the file is canceled. The *Max Event Queue Size* determines the maximum number of events that can be queued for CFDP. These events are used by TReK (e.g., to determine when a file is completely transferred). The ION default is 20, but TReK configuration files beginning with TReK-5.2.0 will default to 200. An event queue size of 200 works well for a transfer of 300 simultaneous files via a dropbox. Indications that the event queue is overflowing can include dropbox files being renamed with an .unknown extension and the status for a CFDP transaction set to unknown. In those cases, increasing the *Max Event Queue Size* and restarting ION may alleviate the problem.

In most cases, the defaults provided in this dialog will work for most configurations.
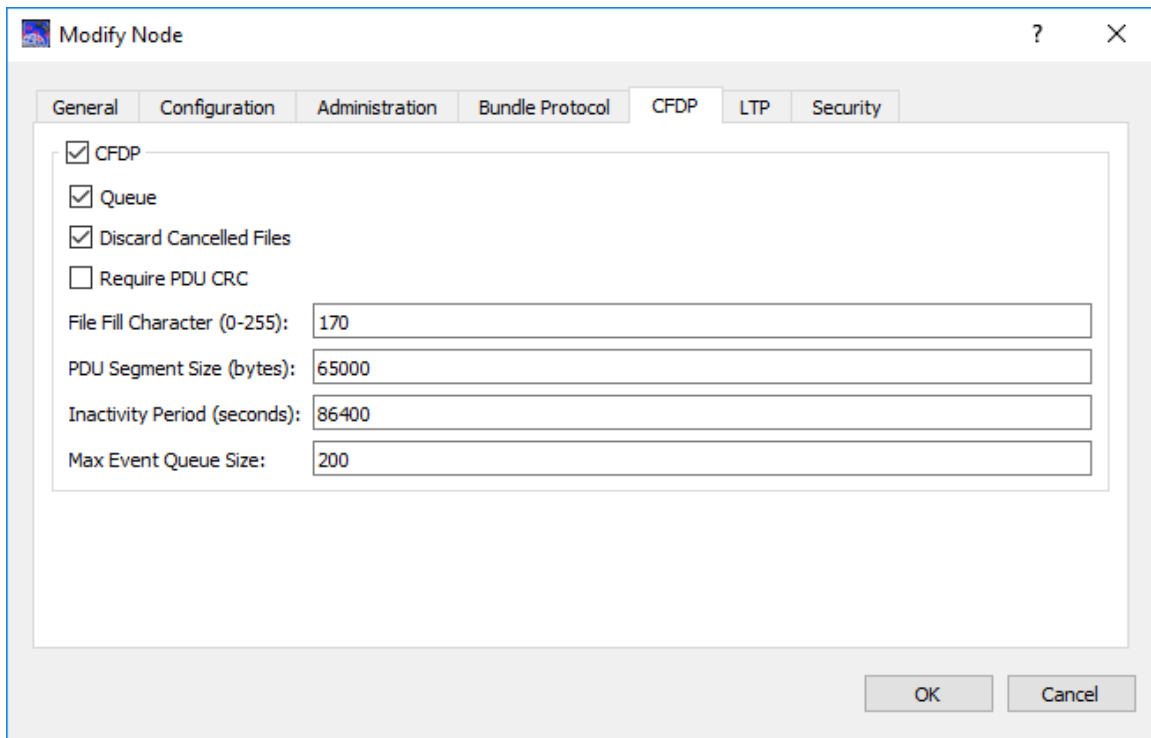
Figure 16 Modify Node (CFDP Tab)

6.1.6 LTP Tab

The LTP tab is shown in Figure 17. The LTP checkbox enables/disables LTP for the ION node. LTP uses "sessions" of data. Data generated by the node is referred to as "export sessions". Export Sessions are defined in the Duct dialog and stored in a map. ION uses a hash table to access sessions quickly during processing. *Maximum Export Session Scale Factor* controls how the maximum number of allowed export sessions is calculated for this node. The minimum allowed value is 1.0 which creates a hash table equal to the sum of all export sessions for this node. Increasing this value will create a larger hash table and *may* increase lookup speed. The maximum value of the export sessions will be the sum of all export sessions multiplied by the *Maximum Export Session Scale Factor*. Unless you have reasons to believe that this has become a problem, just leave the default.

The *Screening* checkbox allows you to require ION to throw away unexpected LTP data. ION knows when data should arrive based on the contact plan. If screening is turned on, then ION will drop any data received outside of a known contact. This requires computer clocks at each node to be synced. It is recommended that you leave this option off.
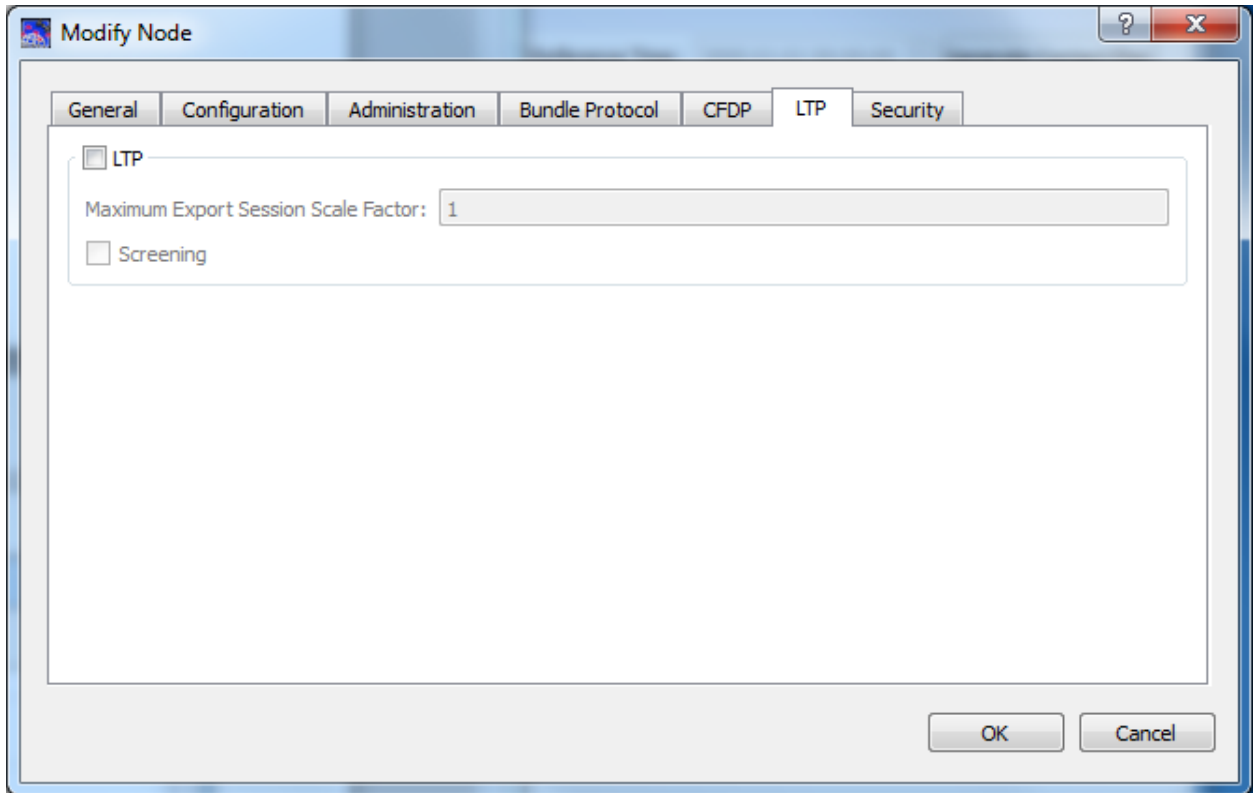
Figure 17 Modify Node (LTP Tab)

6.1.7 Security Tab

The Security tab is shown in Figure 18. Turning on the security prevents unwanted messages from appearing in the ION log file.
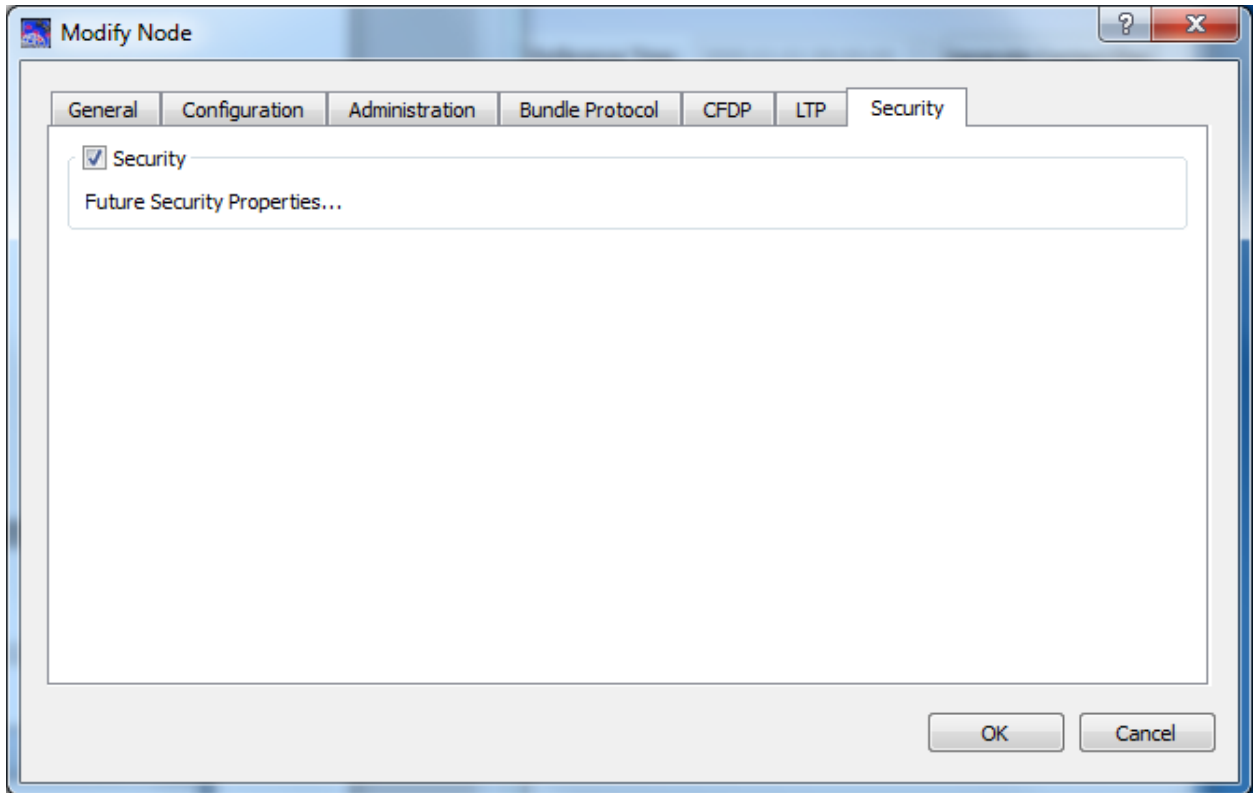
Figure 18 Modify Node (Security Tab)

6.2 Modify Duct

When two nodes are connected, there are two ducts between the nodes. The Modify Duct dialog contains a tab for each duct. Figure 19 shows a DTN Diagram with two nodes connected. Figure 20 shows the Modify Duct dialog displaying the properties for the line between the two nodes (Node 1 and Node 2).   The Modify Duct dialog provides the capability to modify the Duct properties for data flowing from Node 1 to Node 2 and the Duct properties for data flowing from Node 2 to Node 1.   The port numbers all default to the 'official' bundle protocol port, but you can change it as needed.[2] The From Port is the port associated with the first node in the tab title. The To Port is the port associated with the second node in the tab title.

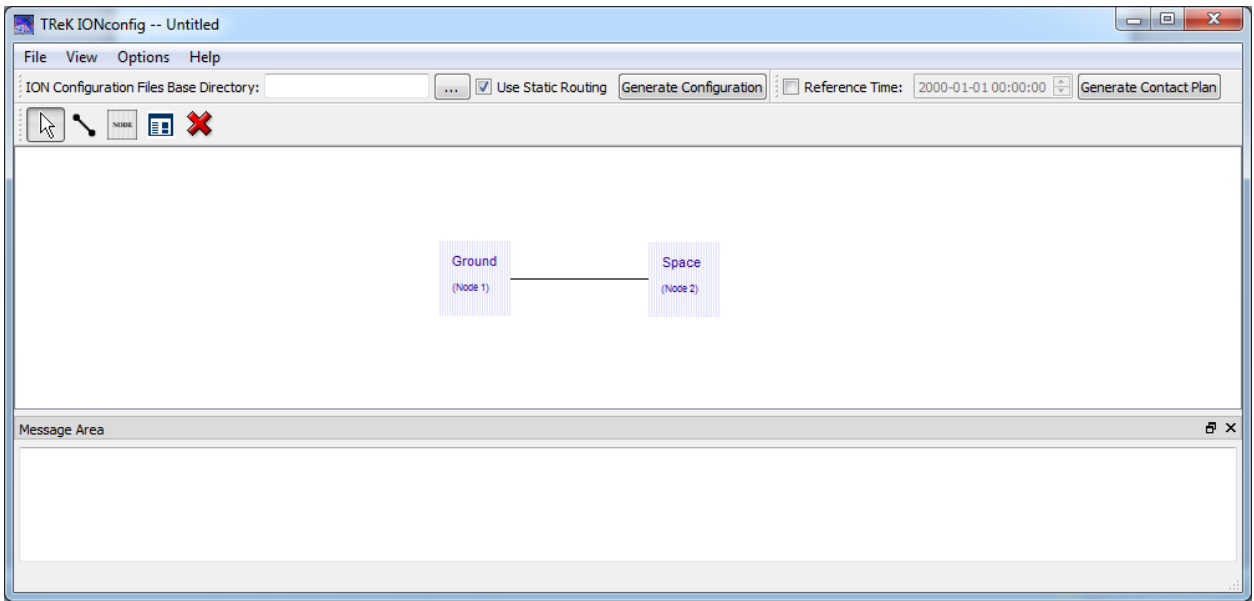[2] If you decide to run multiple nodes on a single computer, changing the port number is necessary.

Figure 19 DTN Diagram With Two Nodes

Figure 20 Modify Duct Dialog

The four options available when you select LTP are related and should be set based on your operational needs. The ION installation includes a spreadsheet and document that can help you determine the values to use. The following paragraphs also contain guidance. It is suggested that you run tests with these parameters to ensure that they work well.

The *Maximum Export Sessions* impose flow control on LTP and helps prevent the space in the data store from being filled up by LTP transmission sessions. The value you use for *Maximum Export Sessions* should take into consideration the expected size of bundles, the data rate for your transmission, any delay in the network (the time it takes to get to the next node), and disruptions in the link (data that may not make it to the next

node). If you underestimate the number of export sessions needed, you will impose an additional throttle on your transmission rate. If you overestimate the number of export sessions needed, you will use more system resources (memory) than necessary.

You can use the following formula to help determine the value to set for *Maximum Export Sessions* (Note: The result is a minimum required value to prevent unwanted throttling of data and may need to be increased after testing in an operational environment.):

maximum export sessions = df * xr * rtt / (asl * 8)

Where:

df: disruption factor to cover undelivered data (suggested value 1.2)
xr: transmission rate defined for contact in this dialog
rtt: round trip time for packets on this network (generally twice range value)
asl: aggregation size limit as set in this dialog (times 8 to convert to bits)

The *Maximum Segment Size* defines the block size for outbound data. Typically this will match the value for the "payload bytes per frame" set on the Bundle Protocol tab of a node. The default value of 1400 should be sufficient.

The *Aggregation Size Limit* is used when smaller bundles are used with LTP. LTP will aggregate these small bundles into a single "session". The *Aggregation Size Limit* defines how much data to collect before creating a new LTP session to transmit it.

The *Aggregation Time Limit* defines how long LTP will wait while aggregating small bundles prior to sending them. Aggregating small bundles allows LTP to require fewer sessions.

You should test your LTP parameter values to ensure they will provide optimal performance. LTP can still work with bad inputs for these parameters, but you will not efficiently use the bandwidth.

LTP requires knowledge of the contacts. For actual space operations this is typically accomplished by ingesting formatted information about satellite and ground contacts into a program to generate the correct ION formatted files. You can also manually add contacts on the Duct dialog. The *Transmission Rate* is used to throttle the LTP data. The *Range* defines how long it takes for data to travel between the two nodes.

Contacts are only valid when using LTP.

6.3 Application Messages

Various types of application messages are generated including information, progress, warning, error, and debug messages. Application messages are stored in memory and

written to a temporary log file. The temporary log file is created on application initialization and exists as long as the application is running. It is deleted when you exit the application. The log file is located in the temporary directory provided by the operating system. Only a subset of messages are stored in memory while all messages are written to the temporary log file. The maximum number of application messages stored in memory is controlled by the message storage setting in the Configure Messages dialog. Once the maximum is reached, older messages are deleted to make room for new messages. Setting the maximum value to a large number can impact application performance since it will increase the amount of memory used by the application. Setting this number too low can cause you to miss important messages. The application default was selected to protect against both of these scenarios. Messages stored in memory are displayed in the Main Window Message Area and the Messages dialog. The Messages dialog is shown in Figure 21. The Main Window message area only displays Info, Warning, and Error messages. The Messages dialog displays messages based on the display preferences defined in the Configure Messages dialog. By default, the Messages dialog will display information, progress, warning, and error messages. Columns in the Messages dialog can be sorted by clicking on the column header. The Messages dialog is available from the Options menu.
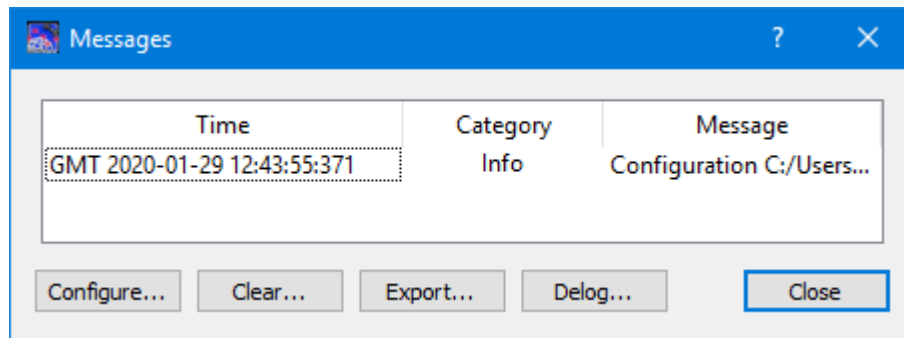

Figure 21 Messages Dialog

Configure
The Configure button provides access to the Configure Messages dialog shown in Figure 22. This dialog provides access to preferences associated with messages. Display preferences can be set to filter the types of messages (category) displayed in the Messages dialog. Export Preferences control how the time tag is added to the filename that is created when messages are exported. See the Export section for details. Message storage defines the maximum number of messages that will be stored in memory while the application is running. Once the maximum is reached, older messages are deleted to make room for new messages. The Set to Defaults button can be used to reset these properties to application defaults.
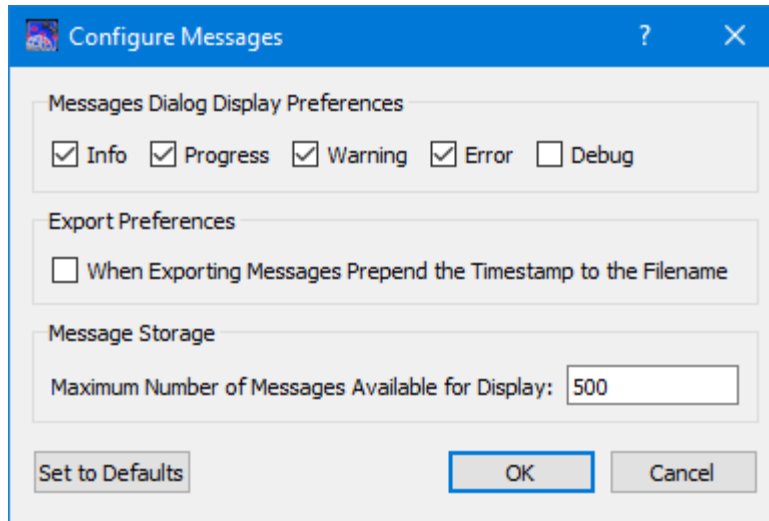
Figure 22 Configure Messages Dialog

Clear

The Clear button provides access to the Clear Messages dialog shown in Figure 23. This dialog provides two ways to clear application messages stored in memory. You can clear all the messages or clear selected messages. Once you clear messages, the messages are permanently deleted in all views (Main Window Message Area and the Messages dialog).
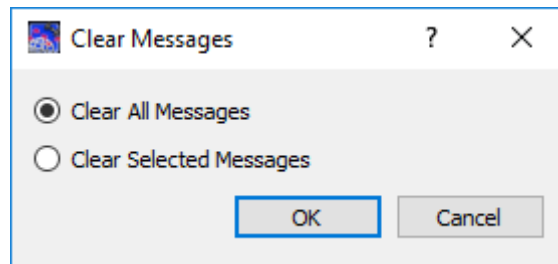

Figure 23 Clear Messages Dialog

Export

The Export button provides the capability to save all the application messages currently in memory to a file. When you push the Export button you will be prompted for a directory and filename. Export will save all messages in memory, not just the messages currently displayed in the Messages dialog (i.e. the Display Preferences are not applied). The name you provide for the file will be modified with a time tag that is added to the filename. The time tag indicates the time the file was closed. The default is to append the time tag to the filename. For example:

Filename Input: messages.txt
Filename Output: messages_2017-05-07_13~03~28.txt

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If you would like to prepend the time tag to the filename you can set this preference in the Configure Messages dialog. This would result in the following:

Filename Input: messages.txt
Filename Output: 2017-05-07_13~03~28_messages.txt

<u>Delog</u>
The Delog button provides the capability to save all application messages generated since the application was started. Delog will retrieve the messages from the temporary log file. When you push the Delog button you will be prompted for a directory and filename. A timetag is not applied to the filename.

Filename Input: messages.txt
Filename Output: messages.txt

6.4   Application Configuration File
The DTN diagram and application preferences are saved in the application configuration file. The configuration cannot be saved if the DTN diagram is not valid.

6.5   Application Settings
The IONconfig application saves some settings as application settings each time you exit the application. The next time you run the application, the application will initialize with the previous application settings. The following application settings are saved:

> ➢ Application Window Size
> ➢ ION Configuration Files Base Directory
> ➢ Configure Messages Selections

6.6   Application Command Line Arguments
The IONConfig application accepts the following command line arguments:

> ➢ trek_ionconfig.exe <filename>

filename   to open a configuration file (full path to file)

A value must be wrapped in double quotes if it contains spaces.

Examples:

> ➢ trek_ionconfig.exe "D:/ionconfig config.xml"

> ➢ trek_ionconfig.exe D:/ionconfig_config.xml

7   FAQ and Troubleshooting

This section addresses Frequently Asked Questions and provides tips for troubleshooting common gotchas.

7.1   What is ION?

The following text is from the Interplanetary Overlay Network (ION) documentation:

"The Interplanetary Overlay Network (ION) software distribution is an implementation of Delay-Tolerant Networking (DTN) architecture as described in Internet RFC 4838. It is designed to enable inexpensive insertion of DTN functionality into embedded systems such as robotic spacecraft. The intent of ION deployment in space flight mission systems is to reduce cost and risk in mission communications by simplifying the construction and operation of automated digital data communication networks spanning space links, planetary surface links, and terrestrial links.

A comprehensive overview of DTN is beyond the scope of this document. Very briefly, though, DTN is a digital communication networking technology that enables data to be conveyed between two communicating entities automatically and reliably even if one or more of the network links in the end-to-end path between those entities is subject to very long signal propagation latency and/or prolonged intervals of unavailability."