DH+ Statistical Analysis Module

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DH+ NETWORK OVERVIEW

Data Highway Plus is an Allen Bradley, Rockwell Automation, token passing data communications network. This protocol consists mainly of Tokens, Solicits, ACKs, NAKs, Timeouts and Data messages. The device IDs are octal numbers running from a value of 000 to 077 **octal**. Tokens are passed in an orderly fashion from lowest ID to highest ID with the potential for a single Solicit per complete Token Rotation in order to pick up any additional devices on the network. Once a token is received, the receiving device can place Data Messages on the network (usually up to 4 at a time), wait for Acknowledgements or Timeouts, send a Solicit to the next device on the solicit list or pass the Token to the next Token Successor. See Figure 1 below.
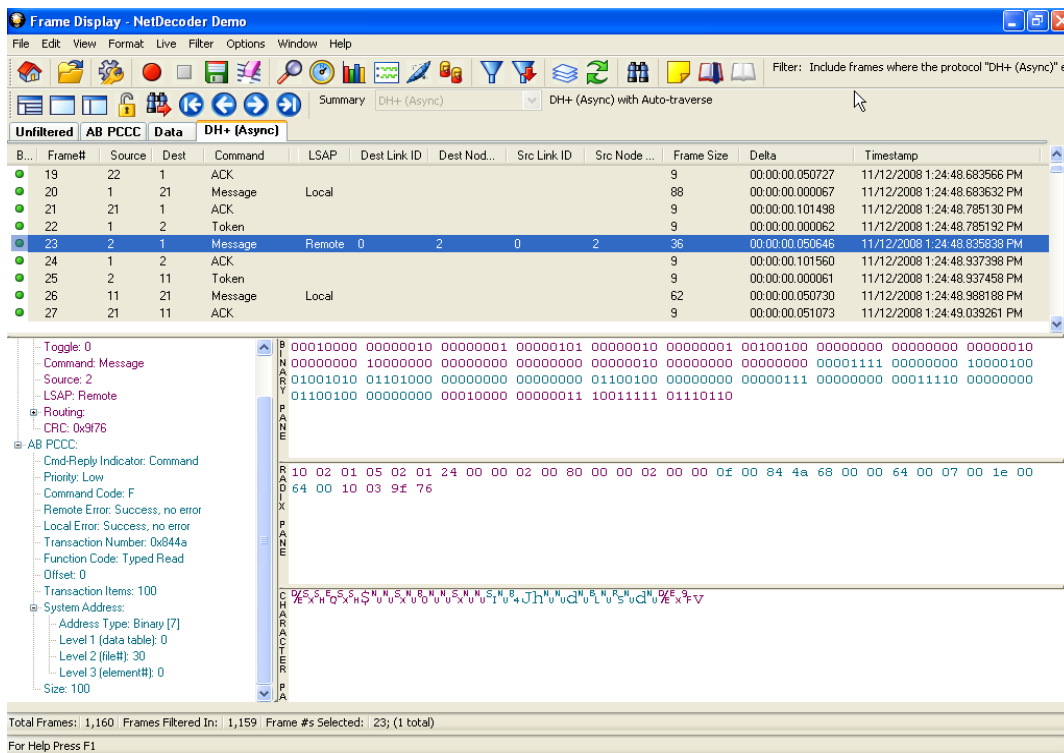

Figure 1 Frame Display

The above capture was from a multi-device network. You will notice that Source Device 001 passes the token to Destination Device 002. Device 002 in turn sends a Data Messages to Device 001, waiting for ACKs, NAKs or Timeouts between Data Messages. When Frame 23, which contains this communications, is selected, the user then can see a complete breakdown of the message details. Next, Device 002 passes the Token to Device 011, who in turn sends a Data Message to Device 021. Periodically there is a "Solicit" function which checks for the next device on the solicit list, to see if it has become active. Finally, the Token will work its way up to Device 077 who will then pass the Token back to Device 000, the Successor. This completes one Token Rotation. Understanding this sequence of events is an important first step that will help when surveying, benchmarking, analyzing and troubleshooting existing DH+ networks with Frontline Test Equipment's NetDecoder software.

UNDERSTANDING NETDECODER DH+ STATISTICS

Frontline Test Equipment's NetDecoder Analyzer provides a powerful statistics module that can be very helpful when starting up, surveying, benchmarking and troubleshooting DH+ networks. The statistics module is comprised of primary screens. Each screen will be explained in the following sections.

DH+ Statistics Overview Screen

From this view, the user can easily see the health of the overall network as well as all of the devices identified as being on the network. This screen is comprised of four primary topics of information. These topics are Active Devices, Top Talkers, Top Conversations, Token Rotation Times and Network Throughput.
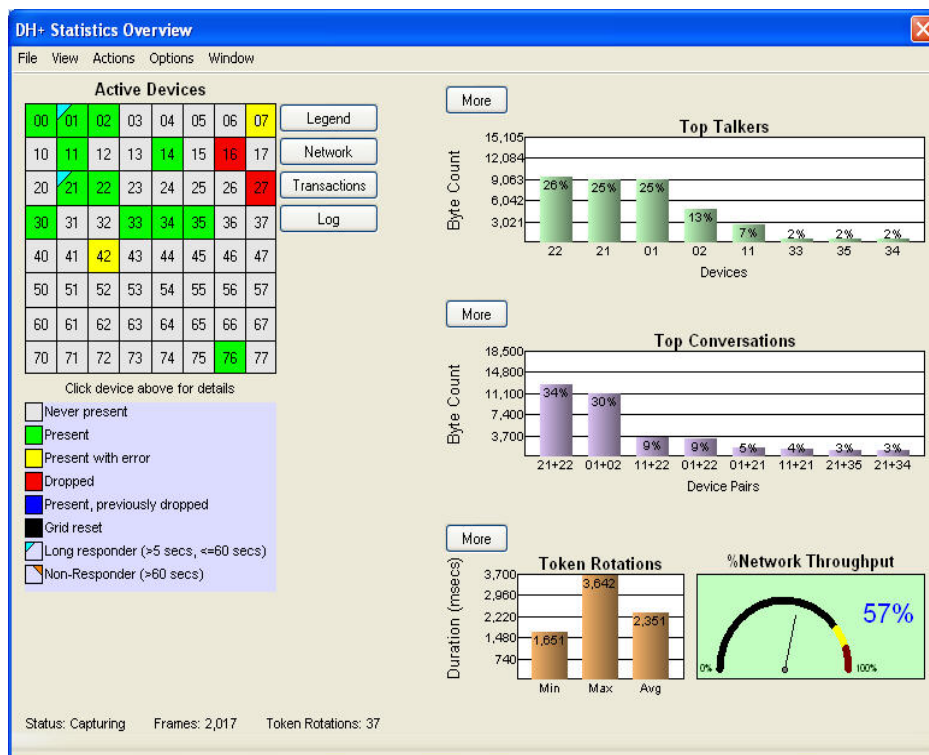

Figure 2 Statistics Overview

Active Devices Grid

The top left portion of the screen contains a color-coded Active Devices grid that ***provides an intuitive view of the health and number of devices that are active on the DH+ network***. The help button to the right of the Active Device grid explains the color code as follows:

- GREY – Device Never Present
- GREEN – Device Active, No Problems
- YELLOW – Device Active, Sent NAK, Sent Out of Turn, Sent Bad Message
- Red – Device Dropped Off Network

- BLUE – Device Active but had Previously Dropped Off of the Network
- ORANGE TRIANGLE IN CORNER – Non-Responder >60 Seconds
- BLUE TRIANGLE IN CORNER – Long Response Time >5 Seconds < 60 Seconds
- BLACK – Device Not Present After Statistics Reset

In the lower right below the grid, information is provided which details the number of complete token rotations the minimum time, maximum time and average token rotation time. More statistics and information can be view by depressing the "More" button. Note that only the frames from a complete token rotation are included in the statistics calculations. This avoids the potential for partial network scans to skew the statistics.

Device Transactions

Individual device statistics can be obtained by clicking on the device number box in the grid, for the device of interest. This display will detail all traffic to or from the device in question. Notice that the display breaks the various conversations down into their individual components; Commands, Replies, Acknowledgements, and Negative Acknowledgements.

The top most table displays all of the communications statistics for traffic that has originated from the device of interest. Conversely, the bottom most table displays all of the communications statistics for traffic that has taken place with this device but was originated by other devices. *Notice that response times are displayed here as well. These can be used to determine worst case device performance.*

Note that in general, the number of Commands, ACKs and Replies should be equal on a well-behaved network. Due to the timing of the capture being started and stopped, single digit number differences may occur but any differences of 10 or more indicate a loss of communications between the devices in question. It is also likely that one of the two devices in question will have either a yellow, red, or blue box on the grid or a red triangle in the upper right corner of their box, indicating a problem with that device. See Figure 3 below.
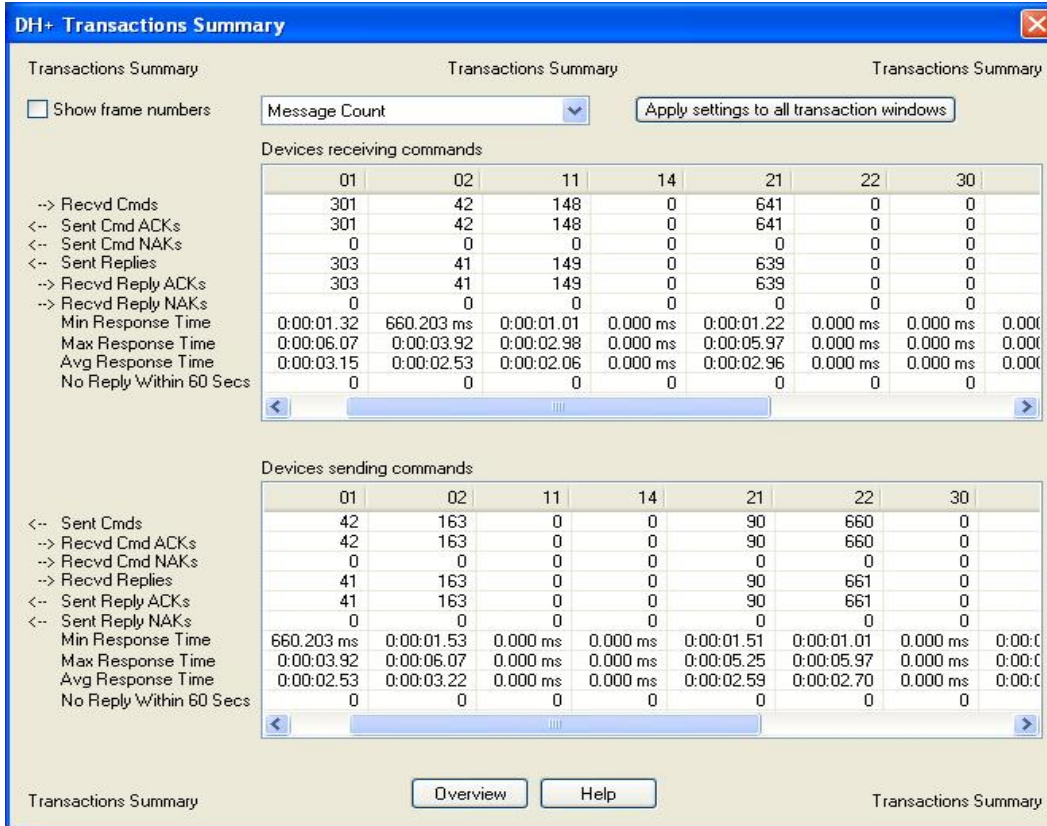
Figure 3 Device Transactions

Rotations

From the Device Transactions dialog, the user can select the Rotations Button at the bottom of the screen. A new dialog will appear that provides details about the specific device behavior during a token rotation. Minimum, maximum, average and total values are provided for the duration that a token has been held, total bytes sent, command bytes sent, and reply bytes sent. From these statistics, the user can determine how much a device is contributing to the token rotation time as well as whether this contribution is due to the device initiating conversations or replying to requests from other devices. Figure 4 is an example of this dialog.
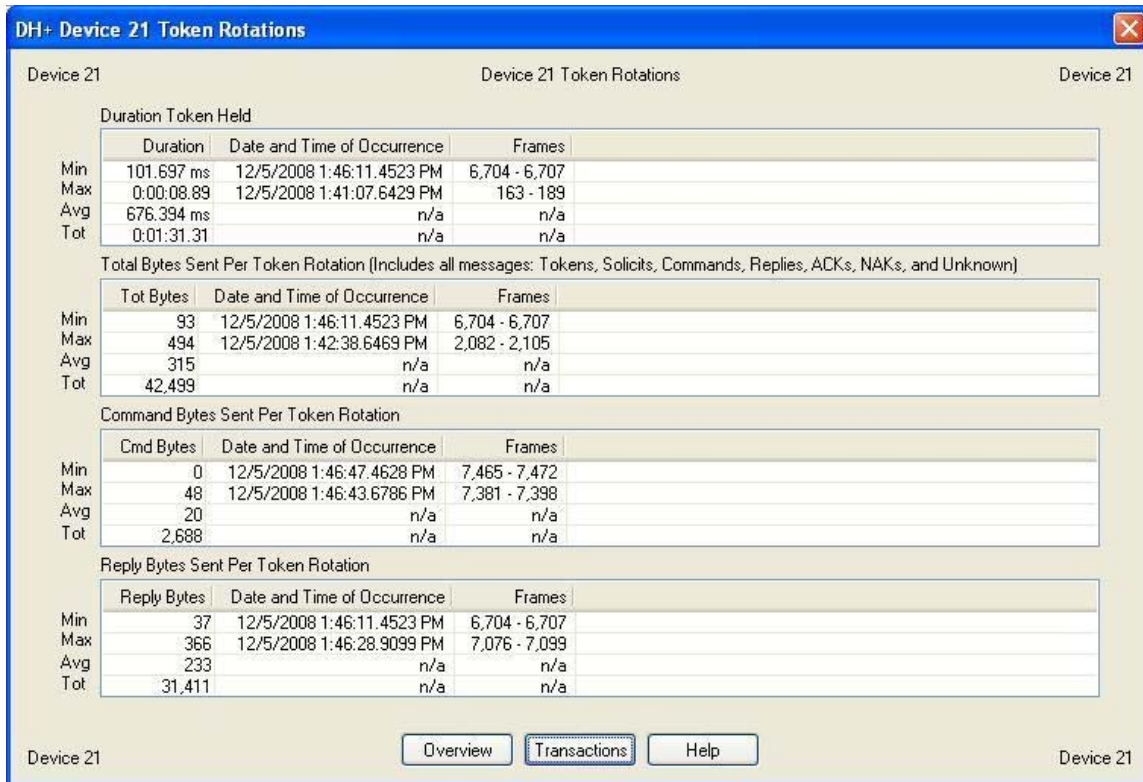
Figure 4 Token Rotations

Top Talkers

The top right portion of the DH+ Statistics Overview screen shows a chart that contains information about the Top Talkers. The Top Talkers chart *displays which device is using up most of the available network bandwidth.* These numbers only include Command and Reply messages, and not other required protocol messages since the device has no control over these. Clicking on the "More" button will provide you with additional statistics concerning Top Talkers.

Top Talkers Statistics

The Dev Num (Device Number) shows the address of the device, in octal. The Byte Count column displays the number of Command and Reply Bytes sent by this device. The %Bytes column shows the percentage of command and reply message traffic generated by this device. The Msg (Message) Count column shows the number of command and reply messages that have been sent by this device. The %Msgs (Messages) column gives the percentage of all command and reply messages originating from this device. The Avg Len (Average Length) column displays the average length of command and reply messages sent by this device. Notice that the rows are sorted by Byte Count, in order to show the Top Talker first.
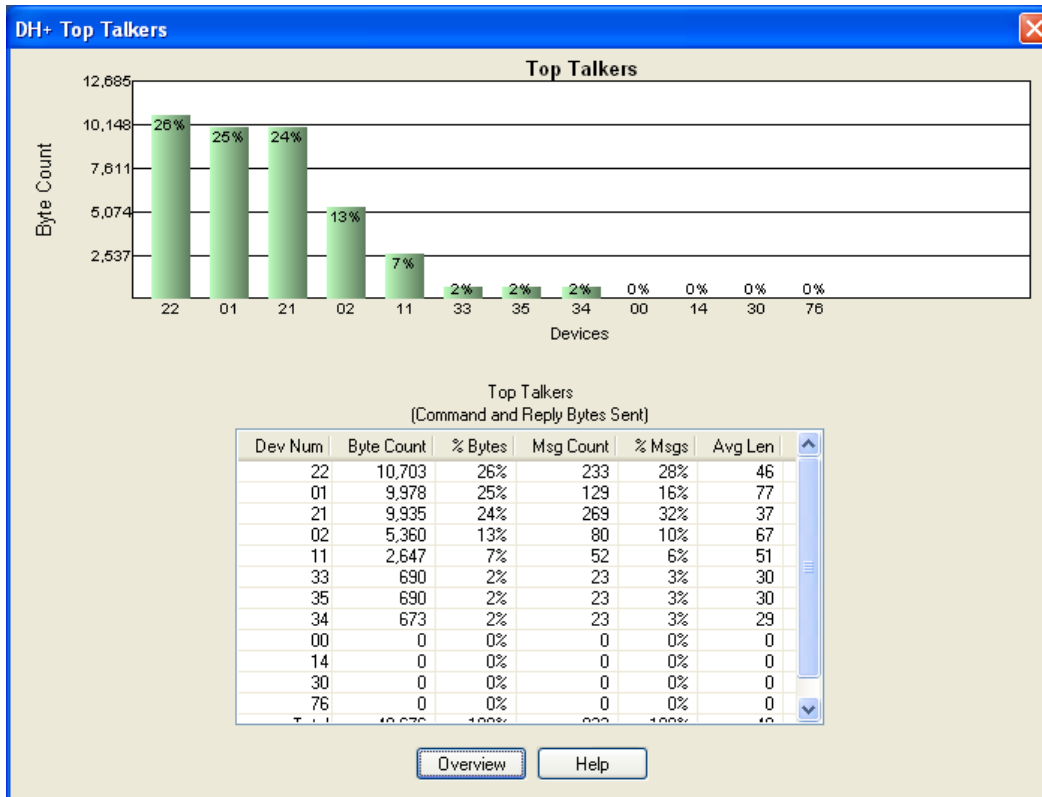
Figure 5 Top Talkers

Top Conversations

The middle right portion of the DH+ Statistics Overview screen shows a chart that contains information about the Top Conversations. The Top Conversations chart displays **which pair of devices is communicating the most on the network.** These numbers only include Command and Reply messages, and not other required protocol messages since the device has no control over these. Clicking on the "More" button will provide you with more statistics on Top Conversations.

Top Conversations Graph

The Dev Num (Device Number) column shows the addresses of the device pair, in octal. The Byte Count column displays the number of Command and Reply Bytes exchanged between these devices. The %Bytes column shows the percentage of command and reply message traffic generated between these devices. The Msg (Message) Count column shows the number of command and reply messages that have been exchanged between these devices. The %Msgs column gives the percentage of all command and reply messages exchanged between these devices. The Avg Len (Average Length) column displays the average length of command and reply messages exchanged between these devices. Notice that the rows are sorted by Byte Count, in order to show the Top Conversation first. Below is an example the additional statistics available.
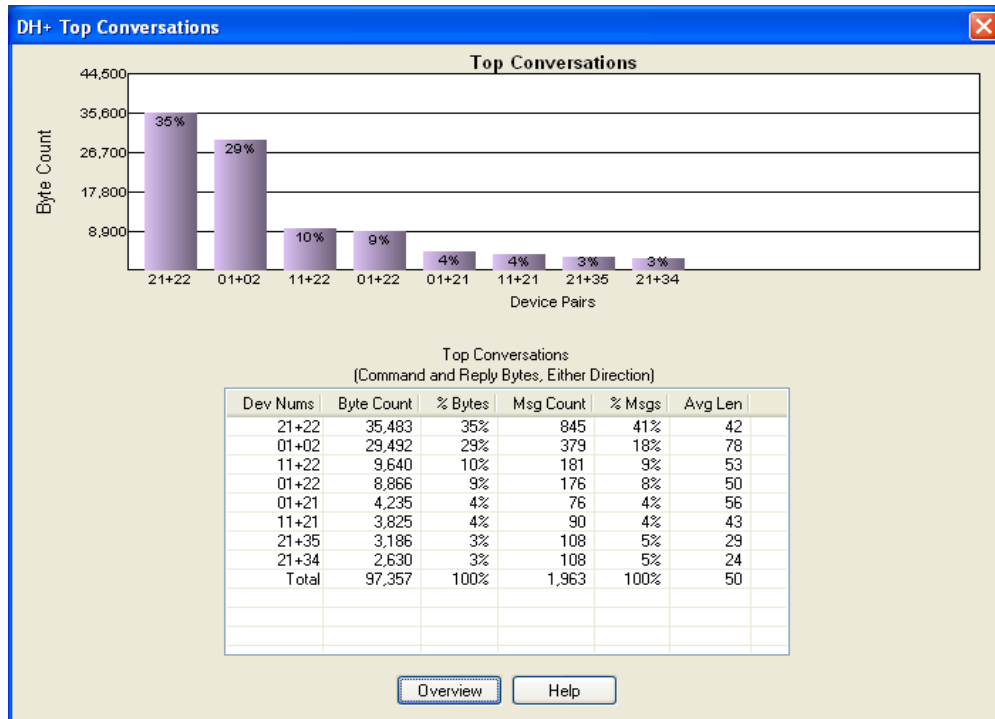
Figure 6 Top Conversations

Token Rotation Times

The bottom most table of the DH+ Statistics Overview screen shows a table that contains information about the Token Rotation Times, including minimum, maximum, average and current values. This section is directly related to your network performance as far as throughput goes. Token Rotation Times are ***an indicator of system throughput and performance.*** Remember that a complete conversation can take up to, one sending device Scan + up to 2 Token Rotation times + the receiving device Scan.   NetDecoder calculates and displays actual response times on the individual Device Transaction screens as well as the Transaction Summary screen.

The first column is the actual measured token rotation time. A complete token rotation time is considered to be the time from when the token is passed from a higher to a lower device number, up through incrementing device numbers, until again passing from a higher to a lower device number. Details of the last 2000 maximum and the last 2000 minimum token rotation times can be studied from the Token Rotations dialog shown in the following section.

Token Rotations Dialog

The Token Rotations dialog can be displayed by selecting the "More" button to the left of the "Token Rotations" chart located on the lower right of the Stats Overview Chart. This dialog displays the value of the last 2000 maximum and the last 2000 minimum token rotation times. These values identify the best and worst case token rotation times. These token rotation times directly affect the throughput capabilities of the network. See Figure 7 below.
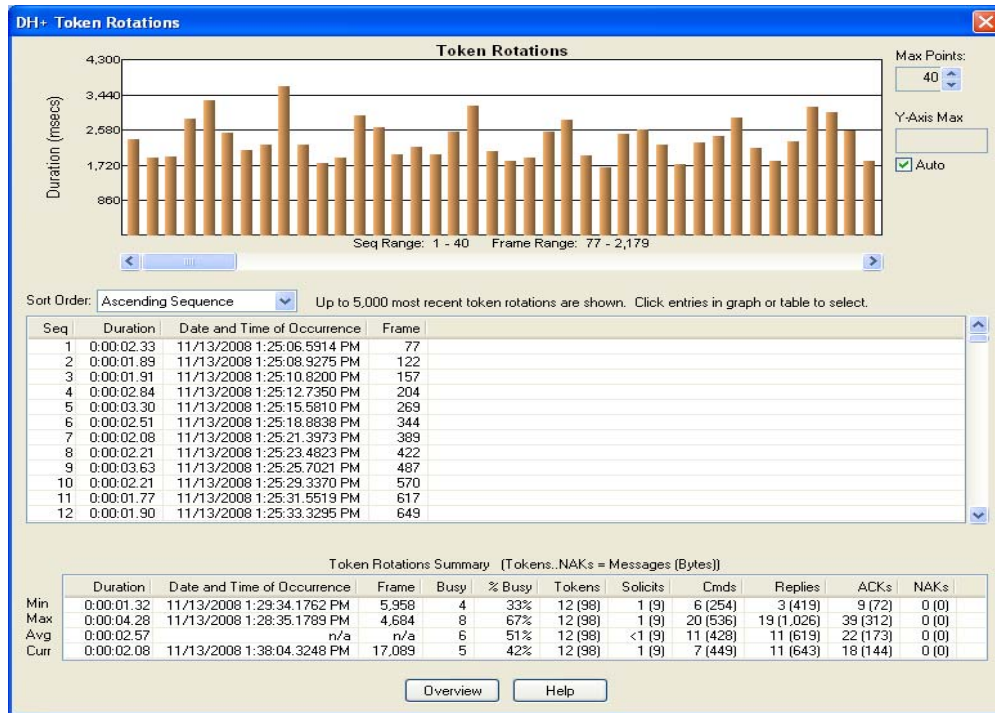
Figure 7 Token Rotations

Top Listeners

Selecting View, Top Listeners from the DH+ Statistics Overview Screen will show a dialog that details ***the number of Command and Reply Bytes that have been directed towards a specific device***. Remember that the device itself has no control over the amount of command bytes that it receives, but it does in fact directly control the number of reply bytes that it receives. The break out of command versus reply bytes can be seen on the network bytes sent screen as well as the individual device screens. Figure 8 is an example of Top Listeners.
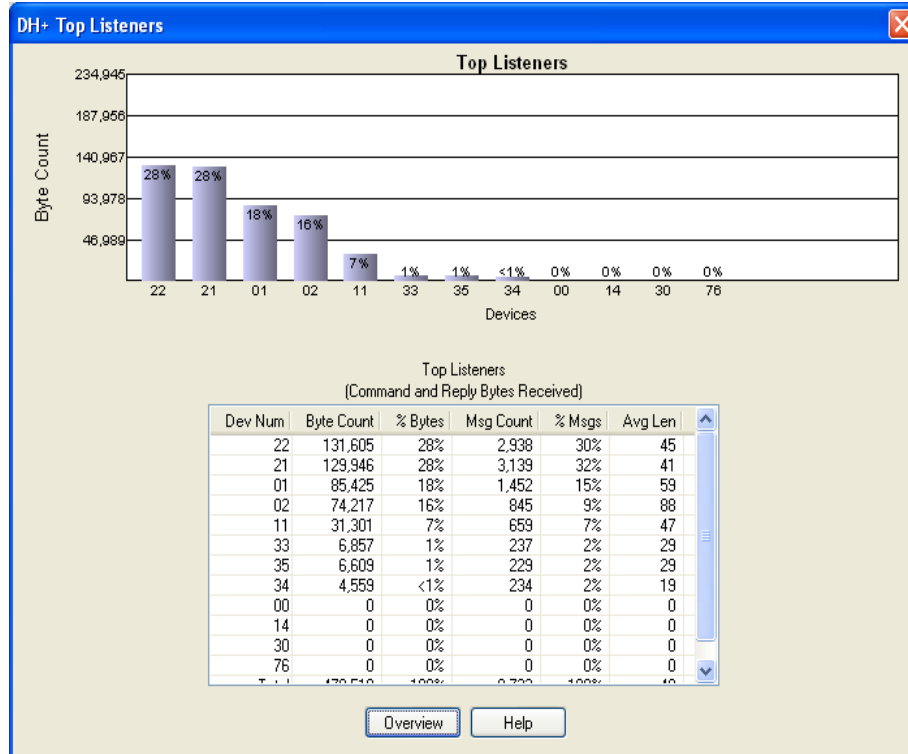
Figure 8 Top Listeners

Network Bytes Sent

Clicking on the Network push button or selecting View, Network Bytes Sent from the DH+ Statistics Overview Screen will show a dialog with a breakdown of all the bytes sent on the network by each device. Protocol overhead bytes, message overhead bytes and payload data bytes are shown for each device. The example below shows the ***total bytes sent by each device*** as well as the message breakdown. Remember that reply data bytes are not under control of the device replying but rather that of the devices requesting the replies. These replies can be either data packages or confirmation of receipt of data packages. See Figure 9 below.
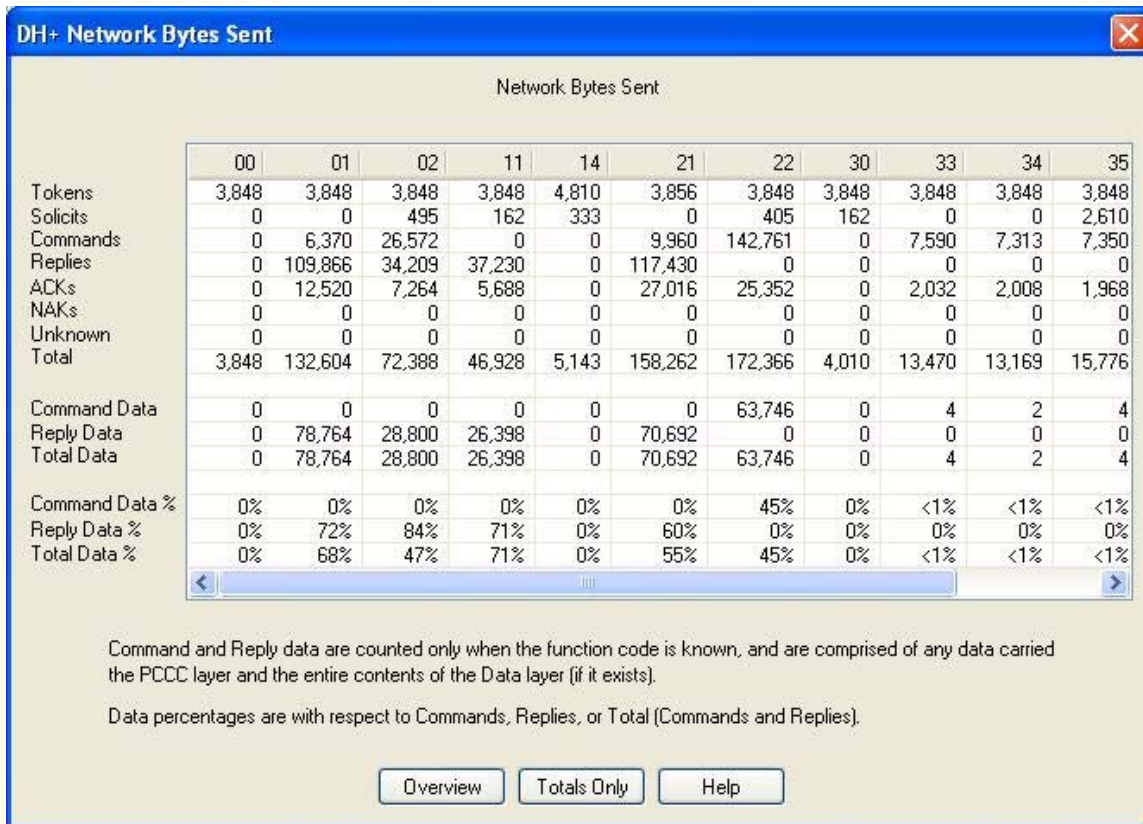
Figure 9 Network Bytes Sent

Transactions Summary

Clicking on the Transactions button or selecting View, Transactions Summary from the DH+ Statistics Overview Screen will show a dialog with a breakdown of the ***command and reply transactions as well as response times for each device*** on the network. Note that it is a very good sign when the numbers in a single column are equal on this screen. That means that every command was acknowledged and replied to, as well as the replies were acknowledged. Take notice of the response time listings as these numbers reflect the throughput of your system. Each device will experience different throughput depending upon many variables including device scan, device communications loading, device ID, and token rotation time. Below is an example. Notice on Figure 10 on the next page that Device 001 has had 3 occurrences where it did not respond to a request for information within 60 seconds. (Top chart, bottom row) This may be an indication of a device that is starting to fail.
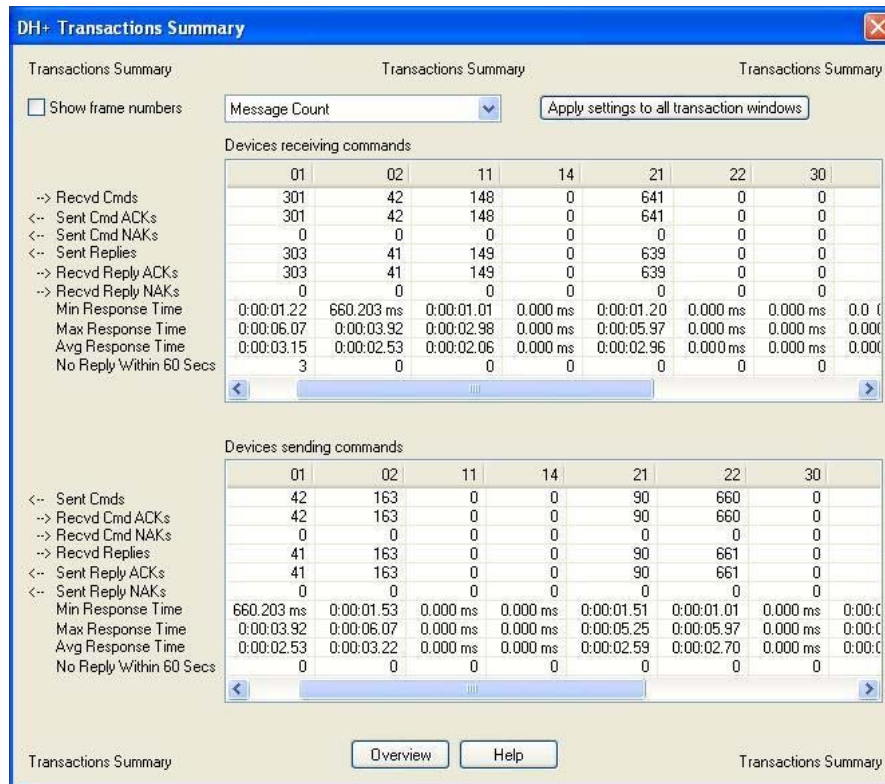
Figure 10 Transaction Summary

Network Event Log

Clicking on the Log button or selecting View, Network Event Log from the DH+ Statistics Overview Screen will show a dialog with *a breakdown of various network events that are automatically logged*. This information provides additional details about the health of your network. This log stores the most recent 2000 events and can be easily overrun by devices being powered down if the logic is not written to consider this fact. Large percentages of network bandwidth can be absorbed by messages and retries directed at devices that are no longer on the network. The non-responder and long responder markings on the device grid, and the network event log will help to identify this kind of inefficiency. You will notice that in the example below, Device 021 appeared on the network and then took more than 5 seconds, but less than 60 to respond to commands sent to it. An indication that this has occurred is readily available on the Active Devices Grid, by way of the blue triangle in the device ID box for device 021. This could be an indication that Device 21 is overloaded or is starting to fail. The Network Event Log provides supplemental information regarding how often a particular device is not responding or is a long responder. Figure 11 below is an example of the Network Event Log.

Figure 11 Network Event Log

SUMMARY

In summary, the DH+ statistics overview screen provides a quick and easy to understand analysis of your overall network performance. The additional screens are used in order to drill down deeper into the individual device and conversation statistics. These screens can be captured for use in reports by pressing the ALT and PRINT SCREEN keys and pasting them into your reports. The information provided in the statistical analysis module can be used to survey and benchmark existing networks, assist in the commissioning of new networks or network expansions, and diagnose intermittent device communications. All of this information can also be exported to a csv file for further analysis or custom report writing from the File Menu. The statistical analysis module can be run or rerun on any previously captured DH+ network files. Keep in mind that if a capture file is set to wrap, the original statistics are calculated over the entire capture session as opposed to merely representing what has been captured to disk. If you recreate the statistics from the File Menu, your original session statistics will be overwritten to reflect only the data captured to the disk file. Statistics files are named using the same name as your capture file and a file extension of sts. It is possible to save both session and capture file statistics by saving the capture file to another name and then recreating the statistics from the File Menu.