Performance Test Terminology for EtherNet/IP Devices

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Revision	Sections	Remarks	Date	Author(s)
0.7		Initial Draft	7/15/04	EtherNet/IP Performance Workgroup
0.8	2.7, 4.x	(2.7) Removed text referring to throughput being tested with no background traffic. (4.x) Split out definitions of Loaded, Unloaded, Within-Spec, and Outside-Spec. Updates made per Workshop #13 comments	9/14/04	James Gilsinn
1.0		First release after Workshop #13 approval	9/16/04	James Gilsinn
1.1	Various	Updated document per recommendations from EtherNet/IP Performance Workgroup.	03/14/05	James Gilsinn

Abstract

This document discusses and defines a number of terms that are used in describing performance tests and the results for EtherNet/IP devices. The terms and definitions presented in this document will be used in additional documents to describe performance tests and the suggested format in reporting the results for these tests. This document is a product of the EtherNet/IP Performance Workgroup of the Open DeviceNet Vendor Association (ODVA) EtherNet/IP Implementors Workshop.

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1 Introduction

The specifications used to define the performance characteristics of network devices are often written in different ways from different vendors. This makes it difficult for users to compare similar devices from without doing painstaking searching through manuals or hours contacting engineers from the vendors to determine how the different performance characteristics relate. This document and follow-up documents attempt to define a specific set of terminology and tests that vendors can use to measure and report the performance characteristics of network devices.

This will provide the user comparable data from different vendors with which to evaluate these devices. [1]

2 Metrics

2.1 Term (Definition Format)

Definition:

The specific definition for the term.

Discussion:

A brief discussion of the term, its application, and any restrictions on the measurement procedure.

Measurement Units:

The units used to report measurements for this term, if applicable. When possible, the International System of Units (SI) will used.

Issues:

A discussion of issues or conditions that relate to the term.

See Also:

A list of other terms or references that relate to this term or its discussion.

2.2 Action Latency

Definition:

The closed-loop latency of a device to process a command and return a desired physical output or vice versa.

Discussion:

Action Latency measures the latency for a device to either process a network command and produce a physical output or process a physical input and produce a network packet. An example might be for a device to change a digital output from off (logical 0) to on (logical 1). The Action Latency would be calculated as the time difference between the last bit of the command packet received by the DUT (or the last bit of the last command packet if the command requires more than one packet) and the physical output being turned on. A similar example might be to measure the time difference for a physical input to a device to be changed from off to on and the first bit of the network packet received by the test equipment.

Measurement Units:

Nano-Seconds (ns)

Issues:

Action Latency for EtherNet/IP devices may be affected by the Requested Packet Interval (RPI) or Actual Packet Interval (API). Since data is only sent over the wire at specific rates, the Action Latency for an input device would be affected by the API of the device. Output devices may be less affected by the API value, since they are likely to send the output as quickly as they can after receiving the command. (Tests will have to be conducted to determine the validity of this for individual devices.)

See Also:

Latency
Response Latency

2.3 Jitter/Variability

Definition:

The amount of change in the measured times for a series of events.

Discussion:

This term is a modifier for other terms, i.e. Throughput Variability or Latency Jitter. (When used separately, the terms Jitter or Variability usually refer to Throughput Jitter/Variability.) This measure includes the difference between the minimum and maximum values as well as the standard deviation of the measured times.

Measurement Units:

Nano-Seconds (ns)

Issues:

None

See Also:

Reference [1]

2.4 Latency

Definition:

The time interval between a message being sent to a device and a corresponding event occurring.

Discussion:

Latency shows the time delay for a device to actually process data. A device may be asked to process a command and return some data or may be commanded to perform some action. The type of action will be determined by the test data required. When the DUT is receiving a network packet, latency is calculated as the time difference between the last bit of the message packet received by the DUT (or the last bit of the last command packet if the command requires more than one packet) and the corresponding event occurring. When the DUT is sending a network packet, latency is calculated as the time difference between the event occurring and the first bit of the message packet sent by the DUT.

Measurement Units:

Nano-Seconds (ns)

Issues:

None

See Also:

Action Latency
Response Latency
Reference [1]

2.5 Overload Behavior

Definition:

A qualitative description of the behavior of a device in an overload state.

Discussion:

Overload states exist when the device's internal resources either receive too much information to process or receive enough bad information to cause the device to go into a state other than its normal run mode.

Data recorded for overload states should:

- Describe the device behavior when its resources are exhausted.
- Describe the system management response in an overload state.
- Describe the device recovery from an overload state.

Measurement Units:

None

Issues:

None

See Also:

Reference [1]

2.6 Response Latency (a.k.a. Response Time)

Definition:

The closed-loop latency of a device to process a command and respond to it.

Discussion:

Response Latency measures the latency for a device to process a network command and return a value from memory. This should represent the minimum latency for a device to process a command through its network stack. An example might be for a device to return a value from the EtherNet/IP identity object. Since the identity object is a specific EtherNet/IP and CIP concept, the command would have to be processed through the entire communications stack to the application layer. The primary performance concern is for real-time I/O response time, so the actual object and values requested from the device will have to be determined before the test is conducted. The Response Latency is calculated as the time difference between the last bit of the command packet leaving the test equipment (or the last bit of the last command packet if the command requires more than one packet) and the first bit of the response packet received by the test equipment.

Measurement Units:

Nano-Seconds (ns)

Issues:

Response Latency for EtherNet/IP devices may be affected by the Requested Packet Interval (RPI) or Actual Packet Interval (API). Since data is only sent over the wire at specific rates, the Response Latency for an input device would be affected by the API of the device. (Tests will have to be conducted to determine the validity of this.)

See Also:

Action Latency
Latency

2.7 Throughput

Definition:

The maximum continuous traffic rate that a device can send/receive without dropping a single packet.

Discussion:

This metric determines the maximum amount of traffic a device is capable of producing at one time. The metric should produce a 2D matrix of results for the data collected during the series of tests conducted.

This metric gives the user an understanding of how much data the device is capable of actually producing or consuming. It shows the difference in the data rates from the device in contrast to the data rates of the network interface (10/100 Mbits/s).

Measurement Units:

Frames per second (s) @ a given frame size (# of bits/bytes) or Bits/Bytes per second (s)

Issues:

The amount of data produced or consumed by the device will be dependant on the number of connections the device is capable of handling and the RPI values for those connections. An example would be a device that is capable of handling 4 connections at a RPI rate of 10 ms and 8 connections at 50 ms all at a frame size of 128 bytes.

$$Throughput = \left[\left(4\ frames \times {}^{1}\!/_{10ms}\right) + \left(8\ frames \times {}^{1}\!/_{50ms}\right)\right] @ \left(128\ {}^{bytes}\!/_{frame}\right)$$

$$Throughput = 560\ {}^{frames}\!/_{s}\ @\ 128\ {}^{bytes}\!/_{frame} = 71680\ {}^{bytes}\!/_{s} = 573440\ {}^{bits}\!/_{s}$$

See Also:

Reference [1]

3 Types of Equipment

3.1 Term (Definition Format) [*]

Definition

The specific definition for the term.

Discussion:

A brief discussion of the term, its application, and any other pertinent information.

Examples:

Examples of the equipment type. These examples may give manufacturer or product names.

See Also:

List of other terms or references that relate to this term or its discussion.

3.2 Device Under Test (DUT)

Definition:

The device to be tested.

Discussion:

The device should be conformance tested to the EtherNet/IP specification before being subjected to performance tests.

Examples:

Programmable Logic Controller (PLC)
Distributed/Remote Input/Output Block

See Also:

Reference [1]

3.3 Network Analyzer

Definition:

A device capable of recording network packets and analyzing the timing of those packets.

Discussion:

These devices may be software or hardware based. They may be combined with Protocol Analyzers to form a more generic solution.

If the network analyzer is software based, the timing of the packets is subject to whatever limits exist for the hardware platform. On a Microsoft Windows platform, timing resolutions may be as high as 150 ms depending on how the software is

[*] Commercial equipment and software referred to in this document are identified for informational purposes only, and does not imply recommendation of or endorsement by ODVA, the National Institute of Standards and Technology, HRL, or the other organizations represented in this document, nor does it imply that the products so identified are the best available for the purpose.

configured to use the system's clock. However, most of the software packages are configured to get near millisecond resolution of their timing signals.

Hardware network analyzers are usually dedicated pieces of hardware specifically designed to facilitate performance testing and network troubleshooting. They have greater capabilities, higher resolution timing, and more flexibility. Many times, these devices have removable network interface cards that allow them to be used for networks other than Ethernet. In addition, they usually have the capability to analyze network packets at higher layers in the ISO/OSI 7-layer Reference Model above layer 2 (Data Link layer). Some of the devices are capable of full 7 layer operation.

Examples:

Frontline Test Equipment's NetDecoder
Spirent's SmartBits
Ixia's 400T System

See Also:

Protocol Analyzer
Traffic Generators
Test Equipment

3.4 Network Infrastructure Equipment

Definition:

Any device associated with connecting the Test Equipment to the DUT over the network.

Discussion:

Network infrastructure equipment is a necessary piece of the test but should not impede the test in any way. The network infrastructure equipment should be performance tested prior to testing any other devices. Any jitter or latencies associated with the infrastructure equipment can be taken into account when analyzing the results from the DUT.

Examples:

Ethernet Switch
Ethernet Hub
Network Router

See Also:

Device Under Test (DUT)
Test Equipment

3.5 Protocol Analyzer

Definition:

A device capable of decoding and analyzing network packets.

Discussion:

Protocol Analyzers are usually software packages capable of decoding all the protocols in a network packet. They allow the individual portions of the packet to be analyzed separately and in protocol specific terms instead of trying to interpret the bits or hex-code equivalent. They are often bundled with network analyzer functionality so they can capture packets and analyze the timing of the individual packets.

Examples:

Frontline Test Equipment's NetDecoder
Ethereal

See Also:

Network Analyzer

3.6 Test Equipment

Definition:

Any equipment used during the performance tests to stimulate, record, or control the test.

Discussion:

Any device used during the test that is not specifically the DUT or Network Infrastructure Equipment is considered Test Equipment. Test equipment may consist of more than one device if a complex test is to be performed.

Examples:

Network Analyzer
Traffic Generator
Protocol Analyzer
Programmable Logic Controller (PLC)
Distributed/Remote Input/Output Block
Laptop Computer

See Also:

Traffic Generator
Network Analyzer
Protocol Analyzer

3.7 Traffic Generator

Definition:

A device capable of generating network packets during the test.

Discussion:

Traffic generators will control the flow of traffic during the test. They provide the stimulus that other devices react to. These devices may produce industrial specific network traffic or background traffic used to determine the performance of the DUT. Before any test is conducted, the performance of the traffic generator must be understood. If it is a dedicated traffic generating device, the performance is probably orders of magnitude better than the DUT, which should not affect the results of the tests. Other devices that do not include such dedicated hardware or are themselves industrial devices may have performance characteristics that are similar to the DUT. These performance characteristics need to be accounted for when analyzing the results of any test conducted.

Examples:

Spirent's SmartBits
Ixia's 400T System
Programmable Logic Controller (PLC)
Distributed/Remote Input/Output Block
Laptop Computer

See Also:

Test Equipment

4 Other Terms

4.1 Unloaded

The test is conducted with no background traffic on the network.

4.2 Loaded

The test is conducted with background applied to the network.

4.3 Within-Spec

The test is conducted within the manufacturer's specifications.

4.4 Outside-Spec

The test is conducted outside the manufacturer's specifications.

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6 Acknowledgments

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- Scott Bradner, Harvard University

7 References

[1] Bradner, S. ed., “Benchmarking Terminology for Network Interconnection Devices,” RFC 1242, July 1991, Internet Engineering Task Force (IETF), http://www.ietf.org/rfc/rfc1242.txt .

[2] Bradner, S., McQuaid, J., ed., “Benchmarking Methodology for Network Interconnection Devices,” RFC 2544, March 1999, Internet Engineering Task Force (IETF), http://www.ietf.org/rfc/rfc2544.txt .

[3] *EtherNet/IP Specification*, version 1.0, June 5, 2001, Open DeviceNet Vendor Association (ODVA), http://www.odva.org/ .