Cable ONE Internet Usage Meter Accuracy Certification Report

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The Cable ONE Internet data usage meter system measures and reports how much Internet data traffic a subscriber consumes and generates. Cable ONE engaged NetForecast to independently audit the accuracy of its usage meter system. This report details the accuracy results from measurements of three residential Internet service accounts in Fargo, ND, Sherman, TX, and Cottonwood, AZ, from September 6th through October 6th of 2016. In addition, tests were conducted in Twin Falls, ID to assess the impact of Cable ONE's VoIP service on the usage meter.

NetForecast performed active reference tests in which a NetForecast PC and server generated the only traffic on dedicated test lines. NetForecast performed independent traffic measurements, obtained hourly usage meter records from Cable ONE for each location, and compared NetForecast's measurements with Cable ONE's records.

Cable ONE established a goal for its Internet data usage meter to correctly measure traffic passing through a subscriber's cable modem within plus or minus (+/-) 1% accuracy. NetForecast validates that the meter was within the +/- 1% accuracy goal. Accuracy for the three circuits measured under field laboratory conditions was +/-0.7% for the month measured.

This report describes how the Cable ONE usage meter works, the NetForecast meter validation methodology, NetForecast's analytical methodology, NetForecast's meter validation results, and useful information should you wish to perform your own accuracy validation of Cable ONE's usage meter.

The Cable ONE Usage Meter

Cable ONE's Internet usage meter provides subscribers with information about how much traffic has traversed their residential Internet connection. Subscribers can view a usage summary for the current billing period as shown below.

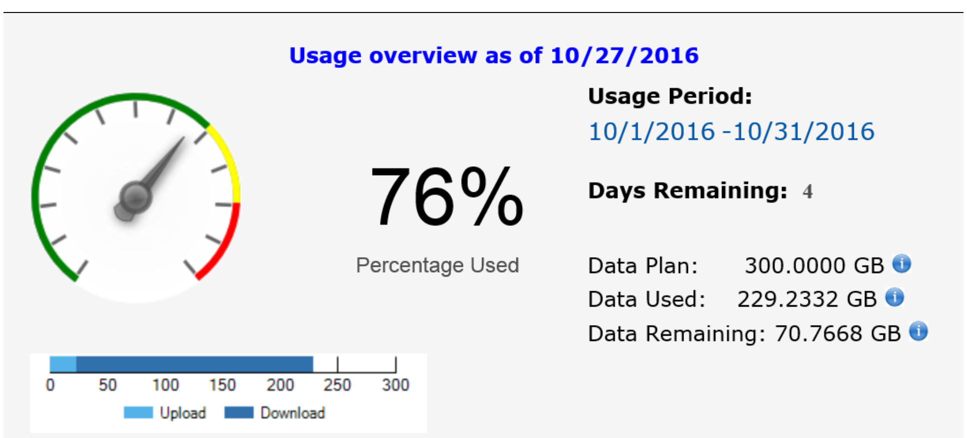

Figure 1 – Cable ONE Cumulative Daily Usage View

NetForecast Report
NFR5124

Usage reports can be found at Cable ONE's customer portal: http://www.cableone.net/. Subscribers who have set up an online account at cableone.net can access their individual Internet usage report by selecting *My Services*, then *My Account*, and then logging in to obtain the summary view shown in Figure 1. Detailed graphical and tabular views of daily and monthly down and up traffic (as shown in the following examples), are also available.

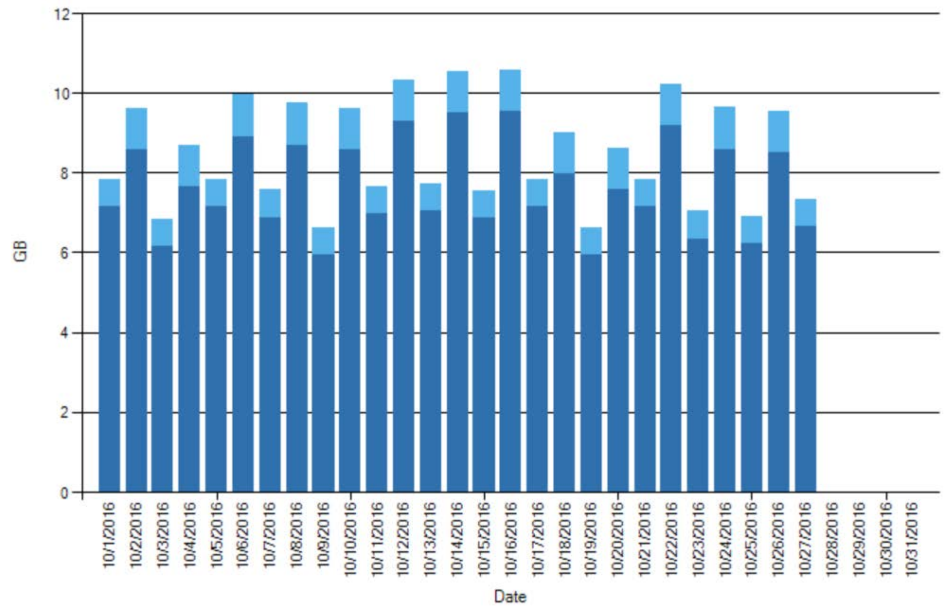

Figure 2 – Daily Usage Graphical View

Date	Download (GB)	Upload (GB)	Total (GB)
10/1/2016	7.1391	0.6862	7.8253
10/2/2016	8.5720	1.0479	9.6199
10/3/2016	6.1431	0.6810	6.8241
10/4/2016	7.6560	1.0438	8.6998
10/5/2016	7.1390	0.6850	7.8240
10/6/2016	8.9095	1.0472	9.9567
10/7/2016	6.8635	0.7011	7.5646
10/8/2016	8.6952	1.0473	9.7425
10/9/2016	5.9286	0.6809	6.6095
10/10/2016	8.5718	1.0471	9.6189
10/11/2016	6.9571	0.6837	7.6408
10/12/2016	9.2842	1.0458	10.3300
10/13/2016	7.0481	0.6830	7.7311
10/14/2016	9.4876	1.0465	10.5341
10/15/2016	6.8662	0.6829	7.5491
10/16/2016	9.5199	1.0452	10.5651
10/17/2016	7.1391	0.6840	7.8231
10/18/2016	7.9720	1.0452	9.0172
10/19/2016	5.9394	0.6811	6.6205
10/20/2016	7.5756	1.0428	8.6184
10/21/2016	7.1500	0.6852	7.8352
10/22/2016	9.1825	1.0482	10.2307
10/23/2016	6.3466	0.6840	7.0306
10/24/2016	8.5827	1.0470	9.6297
10/25/2016	6.2341	0.6819	6.9160
10/26/2016	8.5028	1.0475	9.5503
10/27/2016	6.6413	0.6847	7.3260
10/28/2016			
10/29/2016			
10/30/2016			
10/31/2016			

Figure 3 – Daily Usage Tabular View

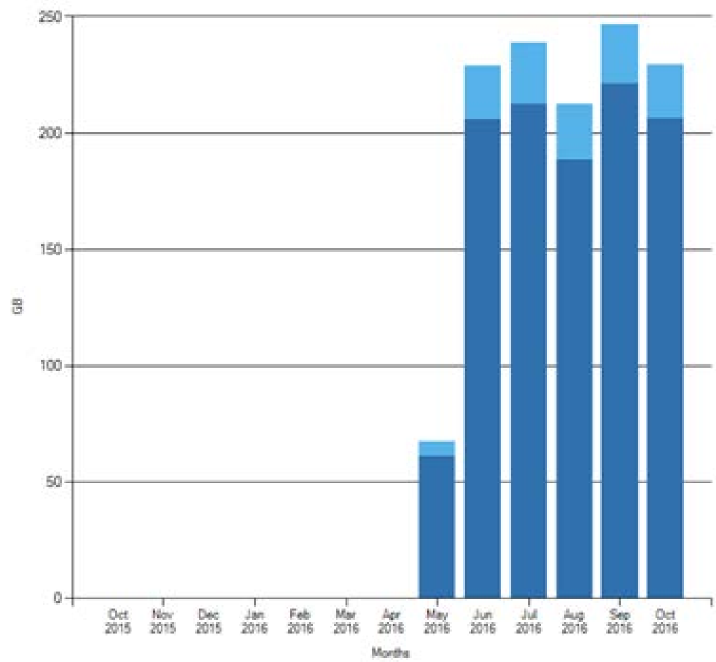

Figure 4 – Month-End Graphical Usage View

Month	Year	Download (GB)	Upload (GB)	Total (GB)	
October	2015	0	0	0	View Detail
November	2015	0	0	0	View Detail
December	2015	0	0	0	View Detail
January	2016	0	0	0	View Detail
February	2016	0	0	0	View Detail
March	2016	0	0	0	View Detail
April	2016	0.0006	0.0006	0.0012	View Detail
May	2016	60.9737	6.1854	67.1591	View Detail
June	2016	205.8061	22.7237	228.5298	View Detail
July	2016	212.0859	26.5774	238.6633	View Detail
August	2016	188.4266	23.6074	212.034	View Detail
September	2016	220.7016	25.9793	246.6809	View Detail
October	2016	206.0482	23.1876	229.2358	View Detail

Figure 5 – Month-End Tabular Usage View

Cable ONE subscribers connect to the Internet through a cable modem at the subscriber's location, and from there traffic travels over a local coaxial and hybrid fiber-coaxial (HFC) cable system to a cable modem termination system (CMTS). The traffic then continues through Cable ONE's network and to the Internet.

The CMTS counts downstream and upstream traffic for each subscriber cable modem it serves. Downstream traffic flows from the Internet to the subscriber, and upstream traffic flows from the subscriber to the Internet. A CMTS feeds the down and upstream counts in an Internet Protocol Detail Record (IPDR) into the meter processing system shown in Figure 6.

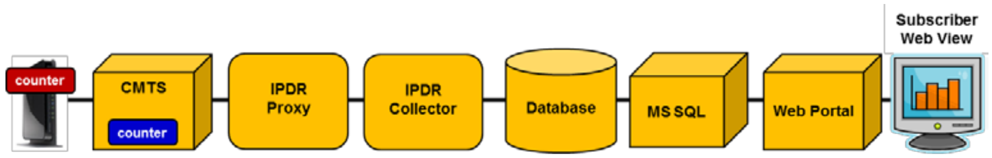

Figure 6 – Cable ONE Internet Data Usage Meter Process Flow

From the CMTS, IPDRs are sent to an IPDR collection system that performs data remediation to ensure that each IPDR format is correct and that the CMTS counters are incrementing for each cable modem. This prevents faulty data from entering the system and causing usage reporting issues.

At the next stage, IPDRs from several collectors are aggregated and incremental traffic counts are converted into traffic data. Meter data is passed to databases, which ultimately feed usage information to the Cable ONE subscriber portal, which displays the usage views shown in the previous section.

The requirements for how a cable modem communicates with the CMTS and for how subscriber traffic is transported is defined in the Data over Cable Service Interface Specification (DOCSIS) developed by CableLabs. The IPDR specification is managed by the TeleManagement Forum (TM Forum). A DOCSIS Management Information Base (MIB) defines how traffic is counted in the IPDR

NetForecast Internet Usage Meter Accuracy Validation Methodology

All measurements were performed using the NetForecast UMap service delivery platform shown in Figure 7. The UMap system is enabled by measurement and reporting software embedded into customized, fully-featured, wireless home routers supplied and supported by NetForecast. Once installed, the routers register with the NetForecast UMap management and reporting system.

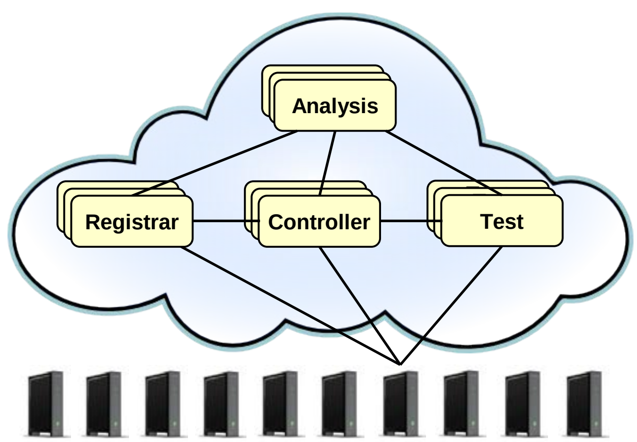

Figure 7 – NetForecast UMap Service Delivery Platform

UMap is a parallel data usage counting system deployed in subscribers' homes. The UMap platform has a high degree of security and resiliency, and strong safeguards to protect participants' privacy.

The UMap system operating on the Cable ONE network performed active testing, as shown in Figure 8. This report is based on results from three active measurement sites.

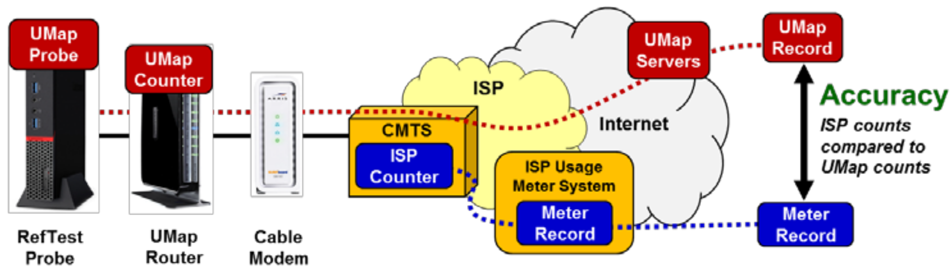

Figure 8 – The NetForecast Active Testing Methodology

Active sites are installed on standard circuits that are dedicated to NetForecast tests and measurements using synthetically-generated traffic. NetForecast installs a test PC (UMap probe) running NetForecast software on each Internet connection. We use FTP accounts on NetForecast servers on the Internet. NetForecast obtains subscriber accounts and performs usage meter accuracy validation testing. We perform both downstream and upstream testing under a variety of conditions.

The tests consist of repeatedly transferring files of varying sizes in complex patterns. The system generates a log file documenting the transfer results and capturing detailed timing information for each transfer.

Calculating Meter Error

UMap data is adjusted to assure that UMap measurements count the same overhead as the CMTS counts. NetForecast then aligns the hourly usage records from UMap and the Cable ONE meter system so that the same hours are compared. Daily sums are genenerated for each site. NetForecast applies the following formula to the UMap and the Cable ONE usage meter daily traffic measurement records.

$$\boldsymbol{Error} = \frac{(\boldsymbol{Cable\ ONE\ Record} - \boldsymbol{UMap\ Record})}{\boldsymbol{UMap\ Record}}$$

If the error result is positive, the meter is overreporting. If the error is zero, the meter is as accurate as it can be, and if the error result is negative, the meter is underreporting. Results are shown as a percentage.

NetForecast Meter Accuracy Assessment

Cable ONE worked with NetForecast to create a Cable ONE-specific Internet Data Usage Meter Accuracy Specification that defines goals for factors against which NetForecast performed its independent meter accuracy validation. The following table summarizes the goals for the specification factors, and Cable ONE's performance relative to those goals. A comprehensive description of data usage meter specification factors is available in NetForecast's report, *General ISP Data Usage Meter Specification and Best Practices*, reference [1].

Factor	Cable ONE Goal	NetForecast Assessment
What Is Counted	The goal is to count all subscriber-generated IP traffic across the subscriber's Internet access line, except for Cable ONE's voice over IP service traffic. The CMTS counts all subscriber-generated IP traffic across the subscriber's Internet access line, including IP protocol management traffic and Ethernet framing as carried in the DOCSIS frame. DOCSIS framing is not counted. Cable modem management traffic such as boot files are counted as data.	NetForecast validates that the Cable ONE meter system counts as specified.
Meter Record Update Rate	Usage data is uploaded as a formal meter record in 15-minute increments identified in Mountain Standard Time (MST).	NetForecast validates that the meter records are processed and stored in variable timespans using Mountain Standard Time.
Accuracy Time Period	Measure accuracy on a cumulative daily and month-end basis.	Accuracy was measured on a cumulative daily and month-end basis.
Error Bounds	Meet an accuracy goal of +/-1% on a cumulative daily basis.	NetForecast validates that accuracy for the 3 circuits measured under field lab conditions is +/-0.7% on a cumulative daily basis.
Timeliness	Traffic shows up on the Web portal by 6AM MST the day after the traffic is generated.	NetForecast validates that the timeliness goal was met.
Granularity	The data is reported to the level of gigabytes. Traffic measurements are displayed to four decimal points, and the fifth decimal point is rounded down (i.e., truncated).	NetForecast validates that the data is reported in gigabytes to four decimal points, and the data is truncated.
Mathematical Consistency	The sum of the individual traffic consumption values displayed to subscribers for each day equals the monthly total displayed to subscribers.	NetForecast validates that the mathematical consistency goal was met.
Accessibility	Cable ONE's usage meter portal view is accessible on the customer portal home page.	The usage meter portal view is accessible within one click of the login page.
Availability	Availability will be 99%.	NetForecast confirms that the customer portal view was available when accessed, but did not continuously monitor to determine if the 99% availability goal was met.
Clarity	The usage meter is explained in a FAQ accessible from the Cable ONE portal.	NetForecast finds that the FAQ page is adequate, although it could be improved.

Figure 9 shows the cumulative daily error distribution across the three sites audited. A negative error indicates that the Cable ONE meter value is low relative to the NetForecast reference value (underreporting). A positive error indicates overreporting. All of the tests fell within the plus or minus (+/-) 1% range. The overall mean for all tests was slightly positive, indicating a slight bias toward overreporting. Cumulative daily error across the test month was within +/-0.7%.

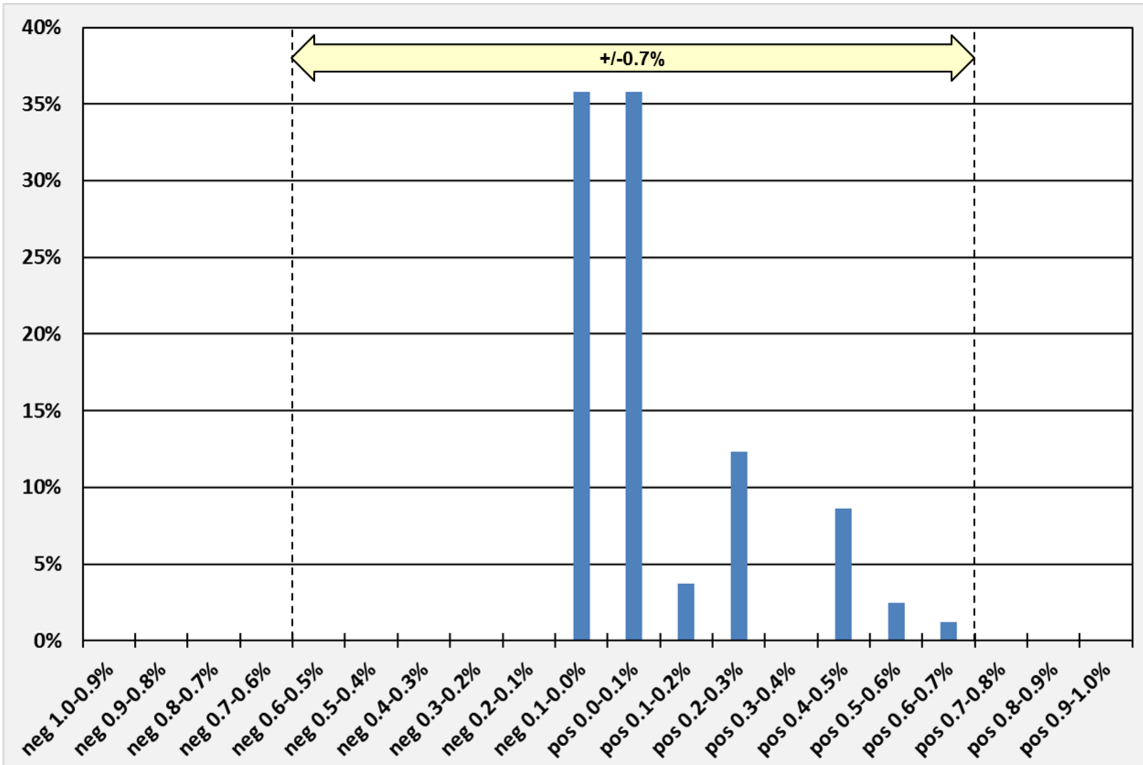

Figure 9 – Cable ONE Cumulative Daily Data Usage Meter Error Distribution

Useful Information if You Want to Do Your Own Counting

If you wish to perform your own Internet Usage meter validation testing, it is important to understand factors that may cause your measurements to vary from what the meter states.

Avoiding binary versus decimal math confusion

ISP data usage meters report in gigabyte increments, so if you are measuring your own usage, make sure you are using binary math. One gigabyte is a binary number not to be confused with one billion bytes. The following table illustrates the danger of applying decimal notation to byte counts.

Binary		
KB	Kilobyte	1,024
MB	Megabyte	1,048,576
10 MB	Megabyte	10,485,760
100 MB	Megabyte	104,857,600
1000 MB	Megabyte	1,048,576,000
GB	Gigabyte	1,073,741,824
TB	Terabyte	1,099,511,627,776

Decimal	
Thousand (Kilo)	1,000
Million	1,000,000
10 Million	10,000,000
100 Million	100,000,000
1000 Million	1,000,000,000
Billion	1,000,000,000
Trillion	1,000,000,000,000

Here are some typical errors introduced by binary/decimal confusion:

- One GB is 2.4% larger than 1000 MB (green vs. pink in the table above). Many people mistakenly believe that 1000 MB is the same as 1 GB. It is not. The reason for the confusion is the mixing of binary and decimal math.
- One GB is 7.4% larger than 1 billion (pink vs. blue in the table above).

Where you measure matters

You can gather your own usage information either from a computer or from the network on your premises. A computer can track what is downloaded to/uploaded from it, but it does not report network protocol overhead because such data is hidden within the PC operating system (you need special instrumentation software to see all the protocol traffic).

For example, if one looks at the size of a file on a PC, that value does not include any protocol overhead, which may lead one wrongly to conclude that the ISP meter is over-counting.

If you measure traffic at the network layer, you will see the payload traffic plus overhead from protocols like TCP/IP and Ethernet, which generally add about 6% to 9% overhead to the payload traffic for large packets and a larger percentage for small packet traffic like VoIP. The meter system counts the traffic as seen on the wire, which includes the payload plus protocol overhead, so it should closely match the network view.

Network layer counting is best done using an intelligent switch or router. Be aware, though, that these devices often fail to count all protocols (e.g., Ethernet), so you may be under-counting. It is important that your network device counts ALL traffic passing into and out of the Internet, and that your device does not count local traffic (e.g., traffic to printers or local music servers). You must be certain to count all Wi-Fi traffic to/from the Internet. You must be careful to configure your measurement software to count only the relevant traffic.

Doing your own counting also requires careful data gathering. Switch and router counters typically default to zero when the device boots, and subsequently display cumulative usage counts. These counts continue to increment past ISP billing month boundaries. To track your ISP's usage meter accurately, you must record counts periodically—especially at the billing date boundary. Keep in mind that the date boundary depends on the time zone your ISP uses.

Details that may seem minor can mess up your counts. For example, we recently discovered a home router that appeared to count properly, but it only counted usage for devices in the DHCP table at start up. Usage by devices added to the network after the router booted went uncounted. Rebooting the router brought the new devices into the counts from the reboot onward. The subscriber reasonably concluded that the ISP was over-counting, but in fact, months had passed since the last router reboot, and new devices were introduced into the home during that period. These new devices generated significant usage that the router did not count but the ISP did. Properly measuring home usage requires technical know-how, careful attention to process, and patience.

Conclusions

Cable ONE established an accuracy goal for its Internet data usage meter to correctly measure traffic passing through a subscriber's connection within +/-1% over a month. Based on hourly measurements at three locations from September 6th through October 6th 2016, NetForecast validates that the Cable ONE data usage meter had a cumulative daily accuracy of +/-0.7% for the month.

Assuming the Cable ONE usage meter system operates as it did under field laboratory conditions during the test period, NetForecast's measurement results indicate that subscribers should be able to rely on the meter's accuracy.

References

1. Sevcik, Wetzel, and Lacy, *General ISP Data Usage Meter Specification and Best Practices*, NetForecast Report 5119, May 2015.
2. US Computer Emergency Readiness Team (US-CERT), *UDP Amplification Attack*
3. Sevcik, *Empowering Internet Users to Manage Broadband Consumption*, NetForecast Report 5109, presented at The Future of Internet Economics, Technology Policy Institute, June 15, 2012.

About the Authors

Peter Sevcik is president of NetForecast and is a leading authority on Internet traffic and performance. Peter has contributed to the design of more than 100 networks, including the Internet, and is the co-inventor of three patents on application response-time prediction and congestion management. He pioneered Internet usage tracking techniques, and invented the Apdex methodology. He can be reached at peter@netforecast.com.

Andrew Lacy is NetForecast's director of development, has a 30-year track record delivering solutions to complex business and technical requirements. He has extensive experience as a development leader designing, building, and deploying products. He has a strong technical background in data communications, game software, server-based gaming, embedded systems, server software, web, and database design.

Rebecca Wetzel is a principal at NetForecast, and a data communications industry veteran. She helped realize the commercialization of the Internet in its early days, and worked to design and market some of the Internet's first value-added services such as IP-based VPNs, web hosting, and managed firewall services, as well as Internet protocol implementation testing services. She also spent many years as an Internet industry analyst and consultant.

NetForecast provides deep insights into difficult network performance problems.

Additional information is available at: www.netforecast.com