Understanding IPDR Service Flow Counters for Usage Metering Applications

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A white paper prepared by Active Broadband Networks, Inc.
Introduction

The IP Detail Record (IPDR) protocol provides a standard framework and mechanism for collecting usage and performance data for IP-based services. IPDR is gaining popularity with cable operators as a highly efficient and scalable means of measuring DOCSIS subscriber usage and activity. MSOs can leverage IPDR to produce usage reports, billing records for high-speed Internet services, meter tiered services, or monitor and enforce SLAs or acceptable use policies.

Supported by DOCSIS 2.0/3.0 complaint CMTS, each CMTS streams high volume management information to a collector. The Subscriber Usage Billing Records stream or SAMIS stream is the only stream available in DOCSIS 2.0 and one of twelve streams available in DOCSIS 3.0.

SAMIS records are created for every service flow active during the reporting period. The reporting period is configurable with a minimum interval of 15 minutes. As shown in Figure 1, a CMTS maintains a subscriber’s service flow packet and byte (octet) traffic counts as monotonically increasing IPDR service flow counters correlated with the subscriber’s cable modem (CM) MAC address.

CMTS IPDR service flow counters do not reflect DOCSIS framing overhead, however they do include operator-initiated management, control traffic, and Internet-originated traffic (ARP, ping, port scans) which must be considered when metering Internet usage. IPDR records are also created for PacketCable Voice or other Managed IP Services carried over the cable modem that may not be considered part of the subscriber’s metered Internet service. This traffic should be excluded from usage reports.

This white paper describes the contents of the detail records generated and sent by a CMTS using IPDR and identifies DOCSIS framing overhead and other non-user data reflected in IPDR service flow counters. It also explains how an IPDR Collection,
Storage and Processing System can be used to efficiently gather and normalize raw CMTS IPDR information while filtering records associated with PacketCable Voice or other Managed IP Services.

This paper is intended for MSO engineers and technical staff who utilize IPDR information in Internet metering applications or other BSS or OSS systems. Armed with a better understanding of how a CMTS processes and reports IPDR information cable operators can implement more accurate Internet usage, billing and SLA applications.

**DOCSIS SAMIS IPDR Records**

CableLabs has adopted IPDR DOCSIS 2.0 and DOCSIS 3.0. The DOCSIS Subscriber Accounting Management Interface Specification (SAMIS) IPDR record contains elements of information describing the subscribers service flows. Table 1 lists the elements of a DOCSIS 2.0 SAMIS IPDR record. DOCSIS 3.0 has two forms of SAMIS, one similar to DOCSIS 2.0 called SAMIS-TYPE-1 and a version normalized with the other information streams called SAMIS-TYPE-2.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMTSHostName</td>
<td>Name of the CMTS serving the reported subscriber</td>
</tr>
<tr>
<td>CMTSIPAddress</td>
<td>IP Address of the CMTS serving the reported subscriber</td>
</tr>
<tr>
<td>CMTSSysUpTime</td>
<td>SysUpTime taken from the CMTS when the IPDR record was created</td>
</tr>
<tr>
<td>CMTSCatvIfName</td>
<td>CATV interface name from the Interfaces Group MIB serving the reported subscriber</td>
</tr>
<tr>
<td>CMTSCatvIfIndex</td>
<td>CATV interface index from the Interfaces Group MIB serving the reported subscriber</td>
</tr>
<tr>
<td>CMTSSupIfName</td>
<td>Upstream interface name from the Interface Group MIB serving the reported subscriber</td>
</tr>
<tr>
<td>CMTSSupIfType</td>
<td>Upstream interface type, either regular or DOCSIS Upstream Logical Channel</td>
</tr>
<tr>
<td>CMTSdownIfName</td>
<td>Downstream interface name from the Interfaces Group MIB serving the reported subscriber</td>
</tr>
<tr>
<td>CMmacAddress</td>
<td>The MAC address of the Cable Modem</td>
</tr>
<tr>
<td>CMdocsisMode</td>
<td>The registration mode for this modem (1.0, 1.1 or 2.0)</td>
</tr>
<tr>
<td>CMipAddress</td>
<td>The IP address of the Cable Modem</td>
</tr>
<tr>
<td>CMCPiepAddress</td>
<td>List of IP address assigned to CPE's behind the Cable Modem</td>
</tr>
<tr>
<td>Rectype</td>
<td>Interim indicating that the Service Flow is still running. Stop indicating that it has completed</td>
</tr>
<tr>
<td>RecCreationTime</td>
<td>UTC time of record creation</td>
</tr>
<tr>
<td>serviceIdenifier</td>
<td>Service Flow ID or DOCSIS 1.0 SID</td>
</tr>
<tr>
<td>GateID</td>
<td>GateID for PacketCable initiated service flows</td>
</tr>
<tr>
<td>serviceClassName</td>
<td>Service Class Names applied to the service flow by the CMTS if implemented</td>
</tr>
<tr>
<td>serviceDirection</td>
<td>Upstream or Downstream</td>
</tr>
<tr>
<td>serviceOctetsPassed</td>
<td>Current or final count of octets passed by this service flow</td>
</tr>
<tr>
<td>servicePktSPassed</td>
<td>Current or final count of packets passed by this service flow</td>
</tr>
<tr>
<td>serviceSlaDropPktS</td>
<td>Number of packets dropped by the CMTS when enforcing a QoS SLA</td>
</tr>
<tr>
<td>serviceSlaDelayPktS</td>
<td>Number of packets delayed by the CMTS when enforcing a QoS SLA</td>
</tr>
<tr>
<td>serviceTimeCreated</td>
<td>The CMTS sysUpTime when the service was created</td>
</tr>
<tr>
<td>serviceTimeActive</td>
<td>Duration of the service in seconds.</td>
</tr>
</tbody>
</table>

Table 1

DOCSIS 2.0 SAMIS IPDR Record Contents
Distinct IPDR records are reported for each unidirectional service flow. As an example, the CM in figure 2 supports six service flows: upstream Internet, downstream Internet, upstream PacketCable Voice Signaling, downstream PacketCable Voice Signaling, upstream Managed IP Service, and downstream Managed IP Service.

The above example will result in six IPDR records during the reporting interval. Service Flows that remain active during the reporting period identified are Interim Records and updated counters are provided for the reporting period. Service Flows that terminate during the reporting period are identified as Stop Records and contain the final count and duration.

**Understanding IPDR Service Flow Counters**

IPDR service flow counters (serviceOctetsPassed and servicePktsPassed) provide the foundation for usage metering and reporting. To create accurate usage and billing applications it is important to understand specifically what these counters represent.

![DOCSIS Variable-length Packet Data PDU MAC Frame Format](image)

IPDR service flow counters are enabled upon service flow activation. They don’t reflect any traffic associated with CM activation, CM firmware upgrades or other events that occur prior to service activation.

Figure 3 depicts a DOCSIS variable-length packet data PDU MAC frame. After a service is initiated, the IPDR serviceOctetsPassed attribute counts the number of octets transmitted from the byte after the MAC header HCS to the end of the CRC.
including Ethernet destination address, source address and Ethernet type/length bytes. The MAC header is not counted.

**NOTE:** The serviceOctetsPassed attribute reflects octets transmitted after DOCSIS Payload Header Suppression (PHS) has been applied.\(^1\)

The IPDR servicePktsPassed attribute counts the number of Packet Data PDUs classified to a service flow. The attribute does *not* count MAC-specific management messages.

**Traffic Captured by IPDR Service Flow Counters**

CMTS IPDR service flow counters reflect all the traffic associated with the service flow and can therefore include traffic not initiated by the subscriber. As shown in figure 4, non-user traffic may include:

- ARP requests from CMTSs
- Operator-initiated management and control traffic (SNMP)
- Unsolicited Internet-originated traffic (port scans)
- Retransmissions of dropped packets

![Diagram](image)

**Figure 4**

IPDR service flow counters reflect operator-initiated management traffic and Internet-originated traffic

Testing carried out by Active Broadband Network in a production environment illustrates the additional, non-customer initiated traffic counted by IPDR.

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\(^1\) DOCSIS Payload Header Suppression (PHS) removes redundant portions in packet headers before transmission to enable more efficient channel utilization.
The following test was carried out on a large operators production network. A newly provisioned modem was connected to a traffic analyzer and filtering was used to ensure that the traffic analyzer did not originate any traffic. Data was collected for 24 hours.

![Wireshark Protocol Hierarchy Statistics]

During the 24 hour period, 50MB of traffic was captured. The traffic consisted primarily of Address Resolution Protocol (ARP) traffic necessary for IP network operation. Examination of the TCP traffic indicated that it consisted of unsolicited connection attempts or port scans. As this modem was recently provisioned and had not been used for normal Internet activities, it is correct to assume that the number of port scans will be greater on an established subscriber modem.

It is important to note that where subscribers have a device connected to a cable modem, such as a Wireless Gateway, service flow counters will increment.

**Accounting for SNMP Traffic**

Operator-initiated management and control traffic is reflected in service flow counters. SNMP traffic for cable modem health checks and other management functions is directed to a cable modem’s IP address and carried over the cable modem’s default service flow. This traffic will be included with Internet traffic if the Internet service is the default service flow.

Figure 5 shows a cable modem with the Internet service configured as the default (and only) service flow. In this case SNMP traffic is reflected in the Internet service flow counters.
For example, where PacketCable Voice is deployed and the voice signaling service flow is designated as the primary service flow, management traffic will be reflected in the voice signaling service flow and does not impact Internet usage metering applications. (figure 6)

Adding an additional service flow for management traffic is the ideal solution to ensure that only traffic attributable to the subscribers use is included in usage meter applications. In practice, this can be challenging with the diversity in the backend operation of operators provisioning systems.

**IPDR Accuracy**

Information provided by IPDR is considered to be “billing grade” and therefore provides the underlying information for accurate Usage Management applications. Testing undertaken by Active Broadband Networks in a lab environment to verify the accuracy of counters identified that IPDR correctly reported the total volume of data transferred.

<table>
<thead>
<tr>
<th>Time</th>
<th>FTP1</th>
<th>SCP1</th>
<th>FTP2</th>
<th>HTTP1</th>
<th>IPDR-Collector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0:02:01</td>
<td>0:02:05</td>
<td>0:02:01</td>
<td>0:02:02</td>
<td>24 hours</td>
</tr>
<tr>
<td>File Bytes</td>
<td>104,857,600</td>
<td>104,857,600</td>
<td>104,857,600</td>
<td>104,857,600</td>
<td>419,430,400</td>
</tr>
<tr>
<td>File MB</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Transfer Bytes</td>
<td>111,974,983</td>
<td>112,417,776</td>
<td>112,224,721</td>
<td>112,216,805</td>
<td>448,834,285</td>
</tr>
<tr>
<td>Transfer MB</td>
<td>106.79</td>
<td>107.21</td>
<td>107.03</td>
<td>107.02</td>
<td>428.04</td>
</tr>
<tr>
<td>Difference</td>
<td>6.79%</td>
<td>7.21%</td>
<td>7.03%</td>
<td>7.02%</td>
<td>7.01%</td>
</tr>
</tbody>
</table>

Using a popular CMTS four transfers of a 100MB file were initiated. Each transfer was measured using a traffic analyzer to identify the overhead added by TCP and the transfer protocols. The IPDR Collector was queried at the completion of these file transfers and the results compared to the individual transfers. In this controlled
environment a consistent protocol overhead of approximately 7% was identified. In production environments this overhead can be impacted by network conditions causing re-transmission of data. Re-transmission will also be included in the service flow counters.

**Independent Verification of IPDR based Usage Metering**

NetForecast has undertaken verification of Usage Metering where the Active Resource Manager is used to process IPDR information. This report, carried out in a production environment concluded that the Usage Meter system implemented by a major US Operator was 99.5% accurate with respect to measuring subscriber-initiated traffic. This result is consistent with the results of Active Broadband Networks tests. In this operational test, the Internet service flow was the primary flow therefore management and other overhead traffic was included. This traffic illustrated in figure 5 explains the +/- 0.5% variance described by NetForecast.

A complete copy of the NetForecast report can be found at:

http://netforecast.com/documents/NFR5101_Comcast_Usage_Meter_Accuracy.pdf

**Active Resource Manager**

Active Broadband Networks Active Resource Manager is a comprehensive IPDR Collection, Storage and Processing System providing a subscriber-centric view of network and service usage. Leveraging IDPR and other mechanisms the system provides unparalleled visibility in to network and subscriber information. The Active Resource Manager is a software system deployed on general-purpose hardware to cost effectively scale to 100M subscriber devices. The system processes DOCSIS 2.0 and DOCSIS 3.0 information into “up-to-date”, ready to use information for operational support and automated subscriber management applications.

A component of the Active Resource Manager, the Usage Statistics System automates the process of identifying and computing Internet service usage counts scaling and simplifying the integration of SAMIS IPDR sourced usage information with Subscriber Portals and Billing/Rating Systems.
Calculating Hourly and Monthly Usage

Each CMTS streams IPDR records to the Active Resource Manager at 15 minute intervals. A varying number of records are sent during each interval dependant upon the number of service flows active on the CMTS. Where PacketCable Voice is deployed, this variance is most noticeable during call busy hours. These records include monotonically increasing service flow counters for every service flow that was active for each subscriber during the previous 15 minute interval.

The Usage Statistics System leverages a unique algorithm to automatically identify the Internet service flows and excluding PacketCable voice flows. Additionally, it allows for specific additional service flows to be added to the Internet Usage Counter. The Usage Statistics System accommodates multiple service flows during the reporting period caused by the inclusion of dynamic services from PCMM or modem resets. From these service flows, the Usage Statistics system computes a 15 minute delta, hourly delta and monthly running total.

Normalizing IPDR Records with Respect to Time

IPDR SAMIS records, typically sent at non-aligned 15-minute intervals, arrive with a distribution of time stamps. This makes the data difficult to present and correlate. The Active Resource Manager simplifies the use of IPDR information by providing time-normalizing capabilities for collected information. The Usage Statistics System enables uniform reporting by aligning Internet Usage Information on hourly boundaries.

Integration with Portals & Rating/Billing

The Usage Statistics System simplifies the integration of SAMIS IPDR Internet Usage Data with user portals and rating/billing systems in two ways.

For each subscriber a single time-normalized record containing the interval usage is computed. To compute this record, the Active Resource Manager and Usage Statistics process a varying number of records. The minimum count of records is two per subscriber where only Internet Service is offered, however this increases dramatically where PacketCable Voice is deployed. Further where PacketCable is deployed, the number of SAMIS IPDR records varies depending on the number of voice calls. By reducing and normalizing the amount of data that needs to be consumed by the portal
and billing/rating system the overall system cost and complexity can be significantly reduced.

The Usage Statistics System offers a number of mechanisms and API’s to allow the computed information to be integrated with user portals and billing/rating systems. The Usage Statistics System can store the results of Internet Usage Computation in the Active Resource Manager PostgreSQL database, allowing easy access using a broad range of available database tools. To enable flexible integration at larger scales, the Usage Statistics System can write a series of organized delimited text files that can be distributed to an ETL system using file transfer techniques such as rsync. Where 15 minute Internet Usage counters are desired, a high volume web services interface using Google Protocol Buffers is available.

**Addressing Scale and Performance.**

The Active Resource Manager applications scale through the use of an in-sliding window of in-memory compressed IPDR records referred to as the Flow State Cache. In addition to compressing and persisting IPDR records to the database, the Active Resource Manager maintains a binary representation IPDR records for a configurable period (default = 3hrs). Instead of attempting to compute Internet Usage by querying the database, the Usage Statistics System queries the Flow State Cache to compute Internet Usage.

This mechanism, also used by other Active Resource Manager applications, dramatically reduces storage I/O increasing overall system performance and preserving storage I/O for other management and reporting purposes.
Conclusion

IPDR service flow counters provide the basis for usage metering and reporting. Using the Active Resource Manager and the Usage Statistics System operators can use SAMIS IPDR to monitor Internet activity, to create billing records, or to enforce acceptable use policies. SAMIS IPDR has been independently verified to be accurate for Subscriber Usage when deployed in conjunction with the Active Resource Manager and is currently operating at one of the world’s largest Cable System Operators.

The Active Resource Manager enables Operators to rapidly deploy Subscriber Usage Metering and integrate Internet Usage with Subscriber Billing. By deploying the Active Resource Manager, Operators can further leverage the Quota Management System and Fair Use Profiler applications to enforce usage quotas and address high-use during periods of congestion. The Active Resource Manager also processes IPDR into network, system and capacity management information and provides the foundation for dramatic improvements in Operational Support System functionality and accuracy with the deployment of DOCSIS 3.0 IPDR.

About Active Broadband Networks

Active Broadband Networks, Inc. is a leading broadband management software and services company. Founded in 2005, we focus on service management software for cable system operators. Our flagship product, the Active Resource Manager, is a comprehensive IPDR Collection Storage and Processing System and deployed at some of the world’s largest Cable System Operators.
Acronyms

ABN       Active Broadband Networks Inc
API       Application Programming Interface
ARM       Active Resource Manager
ARP       Address Resolution Protocol
BSS       Business Support System
CM        Cable Modem
CMTS      Cable Modem Termination System
DOCSIS   Data over Cable Service Interface Specifications
HFC       Hybrid Fibre-coaxial
IP        Internet Protocol
IPDR      IP Detail Record
MAC       Media Access Control
MSO       Multiple System Operator
OSS       Operations Support System
PDU       Protocol Data Unit
PHS       Payload Header Suppression
QoS       Quality of Service
SAMIS     Subscriber Accounting Management Interface Specification
SLA       Service Level Agreement
SNMP      Simple Network Management Protocol