Dialogic

Application Note

Adding Support for Dialogic® Brooktrout® Fax Quality Metrics to Fax Applications

Executive Summary

Migrating fax services from traditional PSTN-based implementations to IP-based solutions introduces a need to detect and correct impairments on the network that may degrade fax performance. To address this, the Dialogic® Brooktrout® Bfv API has been expanded to include a set of Fax Quality Metrics (FQMs) to monitor network performance. The Brooktrout Bfv API offers a combination of end-to-end, transport-independent fax metrics, and also specific metrics for PSTN, IP, RTP, and T.38 transports. Adding support for these FQMs to a fax application could help position ISVs to increase the reliability and quality of their fax product.

This application note focuses on the possible uses of FQMs with fax over IP (FoIP) solutions, and how to report those metrics in a fax application. Details on the FQMs supported by the Brooktrout Bfv API are also provided.

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Introduction

End users expect a high level of reliability for fax, so if the performance of a fax over IP (FoIP) deployment is poor, this would need to be quickly identified and addressed. Before calling their ISV or WAN service provider to report fax issues, network administrators and end users likely will want to first check that their own internal IP network is not the cause. Based on their prior experience with PSTN fax, network administrators and end users might take it upon themselves to determine what the cause might be; however, without tools to identify network issues (e.g., packet loss, jitter, latency), the causes of poor FoIP performance may not be easy to identify and incorrect assumptions might be made as to the cause. This might lead to frustration, which, if it reaches a certain point, could ultimately result in end users unnecessarily abandoning their FoIP solution.

To help ISVs create applications that could aid in identifying the cause of network issues, Dialogic supports Fax Quality Metrics (FQMs) in the Dialogic® Brooktrout® Bfv API. These FQMs can provide direct feedback on fax quality and network performance, enabling ISVs to add value to their fax application by giving network administrators tools to monitor their network Quality of Service (QoS) and to identify network issues, possibly before they escalate.

This application note describes uses for FQMs in a FoIP application, and explains the types of metrics available in the Brooktrout Bfv API. Strategies for how to report the FQMs are discussed, along with a coding example. Details on specific FQM fields are provided in the appendices.

Network Performance Monitoring

Monitoring network performance within a FoIP application can be useful in several ways. Before a particular FoIP application is installed, using the FQMs to provide network performance data could be very helpful as part of product evaluation and for pre-qualifying a network environment. The FQMs also provide a way to measure performance beyond just sending a few test faxes. If potential customers are able to see hard numbers on how their network performs under load, for example, they may be able to address issues before deployment and feel more confident in purchasing a particular FoIP product.

After deployment of a FoIP product, performance metrics could be used to troubleshoot failures. If an end user reports an issue with a fax, the FQMs could be examined to determine the reason(s) for the failure so that network issues could be corrected. As time passes, the local network topology and load may change, and with ongoing network performance monitoring via FQMs, network changes that impact fax performance could be identified before impacting end users.

Enterprises may have service level agreements with their service providers, and FQMs can supply data to verify that the required level of service is being met. And in cases where it is not being met, the FQMs could provide supporting evidence to help service providers investigate issues that may be affecting their network.

Symptoms of Degraded Fax Performance

Due to the robust nature of the T.30 fax protocol, users may unknowingly be experiencing degraded transport service. Implementing application support for the FQMs could help reveal network issues before they become more severe.

What are the signs of degraded fax performance? An obvious one is that fax attempts sometimes fail, leaving the end user to wonder why and to begrudgingly attempt to send the fax again. This condition would be masked if the fax application automatically re-transmits failed faxes until they succeed. In such a case, the end user might not even be aware that an issue exists. But if this is happening frequently, the network administrator needs to be alerted to the situation, and will need tools to troubleshoot the cause.

For example, an increase in fax failures could be the result of packet loss on a network. Figure 1 shows the negative effect that packet loss can have on the fax completion rate [1].

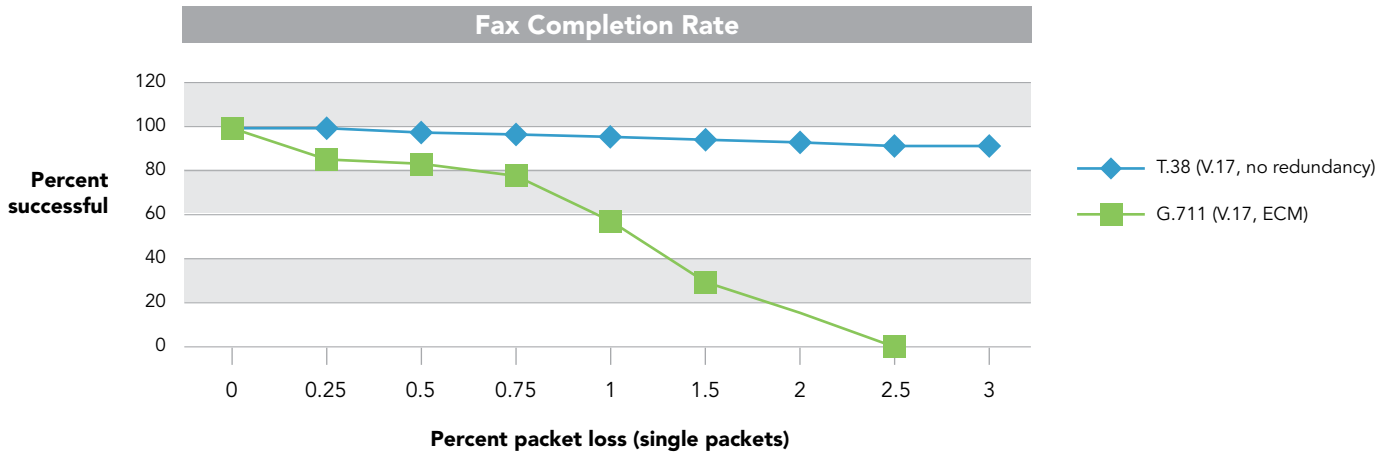

Figure 1 – Fax Completion Rate versus Packet Loss

Another symptom of degraded performance can be the elongation of fax transmission times, where faxes sometimes take longer to transmit or receive than would normally be expected. This may be due to fax transmission speed reductions or the retransmission of lost data, and could result in higher than necessary charges for toll calls as well as higher channel congestion on the fax server due to calls not being processed as quickly as they should be.

A third symptom could be reduced image quality in received faxes when Error Correction Mode (ECM) is not in use. When ECM is not used, image data lost on the network is not retransmitted, which could result in missing or corrupted image data in the received fax image. And depending on the purpose of the fax, the end user may need to resend the fax to attempt to get the full image transmitted.

If the network impairment is small or sporadic, then fax performance might only be degraded in certain situations. For example, sending simple, one-page faxes might work well, but attempting to send multi-page faxes or faxes with complex images might fail. In other cases, issues might only arise when there are many fax calls occurring simultaneously (i.e., at high load). If fax attempts sometimes fail or encounter issues in clusters at certain times of the day, it may be due to other network traffic interfering with FoIP traffic.

Without the FQMs, detecting these types of failures and trends is difficult, if not effectively impossible, for individual end users as they do not have direct insight into the network or what other end users are experiencing. Monitoring failure trends and statistics is well suited to be done automatically by the fax server application, which could then alert the network manager to problems and provide performance data for analysis so that the pattern of the failures could be observed. When used in this way, the FQMs allow network administrators to quantify and manage their fax performance.

Types of Metrics

Primary Metrics

Primary metrics are reported directly by the Brooktrout Bfv API and can be useful for initially detecting network issues so that they can be investigated and resolved.

Fax Figure of Merit: A useful primary metric for flagging general fax issues is the Figure of Merit (FOM) for Facsimile Transmission performance (ITU-T E.458) [2]. It is a high-level summary indicator for QoS, based on a seven-point value scale. It takes into account call cut-off performance, speed reductions, image errors, and ECM retries. Table 1 shows the meaning of each of the seven FOM values

FOM value	Meaning
1	Fax completed at maximum speed with error-free image
2	Fax completed at maximum speed with some image errors
3	Fax completed at maximum speed with severe image errors
4	Fax completed at reduced speed with error-free image
5	Fax completed at reduced speed with some image errors
6	Fax completed at reduced speed with severe image errors
7	Fax did not complete

Note: *When using ECM, an "errored" image is one which required retries to successfully transfer*

Table 1 - Figure of Merit (FOM) Details

Interpreting the FOM values

1 – Error-free transmission at maximum negotiated speed

2, 4, 5 – Successful, but with reduced speed and some errors/retries that may need investigation

3, 6, 7 – Badly damaged or failed fax attempt; indicates corrective action may be required

If the FOM value is consistently greater than 1, it warrants further investigation to determine the cause. When diagnosing network issues, the FOM should be considered along with other indicators and metrics, particularly if the results were not in a controlled test environment. For example, failed calls will return with an FOM value of 7, even if the call failed due to an invalid phone number, or if a human answered.

Packet Loss Metrics: For FoIP systems, other important metrics are those that report packet loss, as these metrics indicate when packets are being dropped by the network. The loss of packets can be particularly damaging to fax transmissions. A packet loss situation needs to be identified or there is a risk that it could rapidly degrade fax performance [1]. Packet loss metrics are available for both G.711 and T.38 transport modes (*Refer to Appendix A for details*).

Other Primary Metrics: There are several other primary metrics that can be useful for identifying the source of degraded fax performance. They include:

- A jitter metric that can flag network congestion problems (RTPRcvrJitter)
- Latency metrics that report the amount of delay packets are experiencing on the network (time_t4 and time_t38)
- Modem speed metrics that report transmission speed reductions (initial_bit_rate and bit_rate)
- Transmission error metrics, such as ECM Partial Page Requests and non-ECM corrupted image scan lines (num_PPR and bad_lines)

Refer to Appendix A for a further description of the FQM API fields.

Detailed Metrics

If the primary metrics indicate that there is a problem with the fax transport, then other more detailed metrics can be analyzed to help determine the cause. Many detailed metrics are provided directly by the Brooktrout Bfv API. For example, if packet loss is detected, then the metrics that report the number of consecutive packets lost may be of interest. They could be used to determine if packets are being lost in bursts or as random single packets. And the metrics that report the total number of packets transmitted could be used to calculate the percentage of packets that were lost. Another example would be examining the out-of-sequence packet metric to see if there are packet routing issues.

These detailed metrics can be more useful for analysis if the specifics of the fax calls involved are also recorded. For example, packet loss is more critical for G.711 fax calls than for T.38, so it is useful to record the transport type for each call along with the metrics. And packet loss due to network congestion at certain times of the day can be identified more quickly if the time a call failed is recorded.

Table 2 lists some possibilities for the information to record with each FoIP call.

Name	Description	How to calculate
FoIP transport type	Mode used to send a fax	FAX_RES media_type == MEDIA_TYPE_T38 for T.38 or MEDIA_TYPE_RTP for G.711
ECM Used	Flag to indicate if a fax was sent using ECM	Check if LINE_DCS(lp)->Error_Correction_Mode is true or if FAX_RES num_ECM_frames is non-zero
V.34 Used	Flag to indicate if a fax was sent using V.34 modulation	Set to true if PAGE_RES bit_rate >= BITRATE_RSLT_2400_V34 && bit_rate <= BITRATE_RSLT_33600_V34
Call duration	How long it took to complete the fax	Subtract the system time at fax completion from the system time at which the fax was started.
Number of pages sent or received	Count of fax pages	Count the number of entries in the FAX_RES reslist_head linked list.
Time of day	The time of day when the fax occurred	Record the system clock time when the fax begins.
Phone number	The destination phone number that was called	Record the phone number that was used to originate the call.

Table 2 – Call Information

If desired, additional calculations can be performed in the fax application to derive ITU-T Recommendation E.450 quality metrics [3]. The E.450 values typically would be updated on a per-call basis and stored in a table for reporting purposes. *Refer to Appendix B for details on calculating the E.450 values using the API-supplied FQM values.*

How to Report Fax Quality Metrics

Aggregating and Filtering Metric Data

To troubleshoot the source of fax problems and to spot trends, it can be useful to view the FQMs at different levels of call granularity (e.g., single calls versus multiple calls) and also over different time periods.

A flexible approach could be to store the metrics on a per-call basis. If a general reporting function is incorporated into the application, the network manager could then view specific fax calls, or generate reports on fax performance over specified time periods, while filtering on various call attributes. For example, the administrator may ask for a report of the quality metrics for all G.711 fax calls during the past week, or for all fax calls sent to a specific phone number in the past year.

However, a general reporting mechanism may require a significant amount of coding effort in the fax application, so simpler approaches could also be used. A running aggregation of metric data over time could be useful, and could take the form of a metrics GUI screen or a report showing the accumulated quality metrics data since last reset. When aggregating the metrics, it can be useful to track the high, low, and average values seen for each metric, and, depending on the metric, to display the results as a percentage (e.g., percent of failed calls, percent of lost packets, etc.) Figure 2 shows how a simple GUI could display accumulated FQM data.

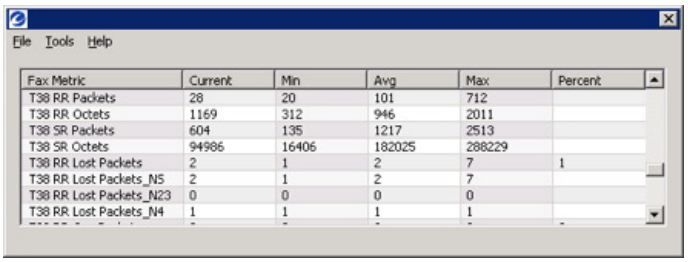

Figure 2 – Example GUI of accumulated FQM data

Warning Thresholds

Day to day, network topology and bandwidth usage may change, and the impact of the change(s) may go unnoticed. To maintain QoS over time, it can be useful to be able to set alert thresholds in the fax application for some of the primary metrics.

For example, if the average FOM falls below a specified threshold, the fax server could send an email to alert the network administrator. After analyzing the metric data, the administrator may decide there is no problem and increase the threshold, or decide that further research is needed to track down the source of the issue.

FQM Reporting Example

A number of the sample programs included with the Brooktrout SDK contain code examples that report FQMs after a fax has been sent or received. Figure 3 shows example code taken from the "tfax" sample program. It shows an example of how the T.38 FQM values can be reported.

```
if (fres->media_type == MEDIA_TYPE_T38)
{
 printf("T.38 statistics:\n");
 printf(" RcvrPackets %u RcvrOctets %u \n",
 fres->T38RcvrPackets,
 fres->T38RcvrOctets);
 printf(" SenderPackets %u SenderOctets %u\n",
 fres->T38SenderPackets,
 fres->T38SenderOctets);
 printf(" RcvrLostPackets %u _NS %u _N23 %u _N4 %u\n",
 fres->T38RcvrLostPackets,
 fres->T38RcvrLostPackets_NS,
 fres->T38RcvrLostPackets_N23,
 fres->T38RcvrLostPackets_N4);
 printf(" RcvrOOSPackets %u RcvrUsedRedundancy %u\n",
 fres->T38RcvrOOSPackets,
 fres->T38RcvrUsedRedundancy);
 printf(" RcvrImageRedundancyLevel %u RcvrControlRedundancyLevel %u\n",
 fres->T38RcvrImageRedundancyLevel,
 fres->T38RcvrControlRedundancyLevel);
}
```

Figure 3 – Example reporting of T.38 FQM values

Figure 4 is an example of the FQM output from the "tfax" sample program after sending a three-page T.38 fax over a local network. It shows both the call details and the FQM values.

```
Page 1: ASCII 0 BdLn 0 TotLn 2320 Res 200Hx200V(Fine) Width A4 Bps 14400 V.17
 ConfVal MCF
 BdLn_NS 0 BdLn_N23 0 BdLn_N4 0
 T4 time 156 ms
Page 2: ASCII 0 BdLn 0 TotLn 1160 Res 200Hx100V(Norm) Width A4 Bps 14400 V.17
 ConfVal MCF
 BdLn_NS 0 BdLn_N23 0 BdLn_N4 0
 T4 time 156 ms
Page 3: ASCII 0 BdLn 0 TotLn 2320 Res 200Hx200V(Fine) Width A4 Bps 14400 V.17
 ConfVal MCF
 BdLn_NS 0 BdLn_N23 0 BdLn_N4 0
 T4 time 157 ms
Duration 69 secs ECM 0 Line Format MR
Init bps 14400 V.17 Figure of Merit 1 (Compl MaxSp ErrFree)
Media type T.38 T1 time 324 ms T.38 time 0 ms
Term phase PHASE_E RTP count 0 RTN count 0 CRP count 0 CTC count 0
RTP statistics:
 RcvrPackets 0 SenderPackets 0
 RcvrLostPackets 0 _NS 0 _N23 0 _N4 0
 RcvrJitter 0 RcvrOOSPackets 0 RcvrRedundancyLevel 0 RcvrClockSkew 0 us
T.38 statistics:
 RcvrPackets 749 RcvrOctets 1968
 SenderPackets 1684 SenderOctets 218463
 RcvrLostPackets 0 _NS 0 _N23 0 _N4 0
 RcvrOOSPackets 0 RcvrUsedRedundancy 0
 RcvrImageRedundancyLevel 2 RcvrControlRedundancyLevel 5
```

Figure 4 – Example FQM output after sending a three-page T.38 fax over a local network

Including Built-in Tests

Some network problems might only occur under a full channel load. If a fax application supports a synthetic full-channel load test, the FQMs could be used in tandem with load testing to evaluate network performance.

For example, if using load testing to pre-qualify a network and to verify that the network has sufficient bandwidth to meet faxing demands, the FQMs can be collected under controlled conditions, using the same endpoint devices and fax images. Doing so can provide a consistent and repeatable baseline assessment of the transport QoS, rather than sending faxes to a wide range of differing endpoints as can typically occur with end user traffic.

Another approach would be for the fax application to periodically test against a known fax endpoint using a specific test image. Using those controlled conditions, the application could verify that the expected fax metrics are reported. This, in turn, can help verify that key transports remain healthy for supporting fax services.

Summary

This application note has described a number of the aspects of FQM reporting. The Dialogic® Brooktrout® Bfv API makes it possible to add support for FQMs to a fax application, allowing end users to monitor their fax QoS and identify and address network problems. Dialogic ISVs can use the sample application code that is included with the Dialogic® Brooktrout® SR140 Fax Software, together with applying the information in this application note, to help add FQM reporting, and the benefits that can come with it, to their fax applications.

For More Information

For more information about Brooktrout SR140 and FQM, see the following topics on the Dialogic website:

- Dialogic® Brooktrout® SR140 Fax Software
- Dialogic® Brooktrout® Bfv API

Appendix A – Fax Quality Metrics API Details

The FQMs reported by the Brooktrout Bfv API are generated on a per-page and per-fax basis using the PAGE_RES and FAX_RES structures [4]. Network problems may cause a fax attempt to fail prematurely during any stage of the call, so specific FQMs will only be populated if the call has reached the stage where that metric has come into play. For example, if a fax attempt fails during modem speed negotiation, the number of Partial Page Requests (PPRs) reported would be zero because PPRs can only occur during the later image transfer stage, when speed negotiation has been successful.

Many of the FQMs are transport-specific. For example, the RTP metrics only apply to G.711 fax calls, while the T.38 metrics only apply to T.38 fax calls. The application could take this into account and only report the relevant metrics for each call; or an easier approach can be to report all the metrics in conjunction with the call information and let users decide which ones are relevant for their network analysis.

Table 3 shows the FQMs in the FAX_RES and PAGE_RES structures, with the FQM fields highlighted in bold.

```
typedef struct {
 int number_of_pages;
 int bad_pages;
 char remote_id[21];
 long duration;
 PAGE_RES *reslist_head;
 PAGE_RES *reslist_tail;
 unsigned initial_bit_rate;
 unsigned ffom;
 unsigned time_t1;
 unsigned time_t38;
 unsigned termination_phase;
 unsigned count_RTP;
 unsigned count_RTN;
 unsigned count_CRP;
 unsigned count_CTC;
 enum TRxMediaType media_type;
 unsigned RTPRcvrPackets;
 unsigned RTPSenderPackets;
 unsigned RTPRcvrLostPackets;
 unsigned RTPRcvrLostPackets_NS;
 unsigned RTPRcvrLostPackets_N23;
 unsigned RTPRcvrLostPackets_N4;
 unsigned RTPRcvrJitter;
 unsigned RTPRcvrOOSPackets;
 unsigned RTPRcvrRedundancyLevel;
 unsigned T38RcvrPackets;
 unsigned T38RcvrOctets;
 unsigned T38SenderPackets;
 unsigned T38SenderOctets;
 unsigned T38RcvrLostPackets;
 unsigned T38RcvrLostPackets_NS;
 unsigned T38RcvrLostPackets_N23;
 unsigned T38RcvrLostPackets_N4;
 unsigned T38RcvrOOSPackets;
 unsigned T38RcvrUsedRedundancy;
 unsigned T38RcvrImageRedundancyLevel;
 unsigned T38RcvrControlRedundancyLevel;
} FAX_RES;
    typedef struct page_res {
 int page_complete_type;
 int continue_breaks;
 unsigned ascii_bytes;
 unsigned bad_lines;
 unsigned total_lines;
 unsigned total_rcv;
 unsigned bit_rate;
 unsigned page_status;
 unsigned char pc_fifo[PC_FIFO_NBYTES];
 unsigned sig_level;
 unsigned line_noise;
 unsigned sig_quality;
 unsigned char lp_fifo[LP_FIFO_NBYTES];
 unsigned char confirm_value;
 int direction;
 int resolution;
 int width;
 unsigned bft_type;
 unsigned long eff_page_type;
 struct page_res *next;
 unsigned bad_lines_NS;
 unsigned bad_lines_N23;
 unsigned bad_lines_N4;
 unsigned num_ECM_frames;
 unsigned num_PPR;
 unsigned num_PPR_NS;
 unsigned num_PPR_N23;
 unsigned num_PPR_N4;
 unsigned time_t4;
 unsigned time_training;
} PAGE_RES;
```

Table 3 – FAX_RES and PAGE_RES FQM Fields

Table 4 describes the meaning of the FQMs in the **FAX_RES** structure.

Field name	Description
initial_bit_rate	The initial bit rate at which negotiation was first attempted; uses the same format as the bit_rate field of PAGE_RES; can be useful for seeing which fax calls trained down to a lower speed by comparing this field with the PAGE_RES bit_rate value
ffom	Facsimile Figure Of Merit (integer 1-7), defined by E.458 standard Values: FFOM_COMPLETE_MAXSP_ERROR_FREE 1 FFOM_COMPLETE_MAXSP_ERRORED 2 FFOM_COMPLETE_MAXSP_SEV_ERRORED 3 FFOM_COMPLETE_NONMAXSP_ERROR_FREE 4 FFOM_COMPLETE_NONMAXSP_ERRORED 5 FFOM_COMPLETE_NONMAXSP_SEV_ERRORED 6 FFOM_INCOMPLETE 7 **Note:** The FOM value might not agree on the sender and receiver sides when network impairments are present. For example, a sender may score a fax with FOM value 1 when ECM is disabled and packet loss is present because the receiver will never request a retransmission, and the sender will not know packets are being lost. The receiver in that situation may detect image errors due to missing data and score the fax with a lower FOM value.
time_t1	Time for both fax devices to identify each other, in seconds
time_t38	Time to switch into T.38, in milliseconds (ms); generally, it increases in direct proportion to network latency, but also dependent on how quickly the remote fax device answers the call and generates fax tones
termination_phase	Fax termination phase: TERM_PHASE_A 0 TERM_PHASE_B_PRE_MSG 1 TERM_PHASE_B_POST_MSG 2 TERM_PHASE_C 3 TERM_PHASE_D 4 TERM_PHASE_E 5 Terminating prior to phase E generally indicates that there was a problem with the fax attempt
count_RTP	Count of Retrain Positives (non-ECM)
count_RTN	Count of Retrain Negatives (non-ECM)
count_CRP	Count of Command Repeat requests
count_CTC	Count of Continue to Correct commands
RTPRcvrPackets	Number of received RTP packets
RTPSenderPackets	Number of sent RTP packets
RTPRcvrLostPackets	Number of lost/late RTP packets
RTPRcvrLostPackets_NS	Number of single lost RTP packets
RTPRcvrLostPackets_N23	Number of 2-3 consecutive lost RTP packets; indicates that there is burst loss
RTPRcvrLostPackets_N4	Number of 4 or more consecutive lost RTP packets; indicates that there is burst loss, and will typically be a small number because burst loss of this magnitude will generally cause a fax attempt to quickly fail
RTPRcvrJitter	Average jitter observed
RTPRcvrOOSPackets	The number of Out of Sequence RTP Packets; often an indication that packets are taking multiple routes through the network
RTPRcvrRedundancyLevel	Level of redundancy used for received RTP packets
T38RcvrPackets	Number of T.38 packets received
T38RcvrOctets	Number of T.38 octets received
T38SenderPackets	Number of T.38 packets sent
T38SenderOctets	Number of T.38 octets sent
T38RcvrLostPackets	Number of T.38 packets lost on receive
T38RcvrLostPackets_NS	Number of single lost T.38 packets
T38RcvrLostPackets_N23	Number of 2-3 consecutive lost T.38 packets; indicates that there is burst loss
T38RcvrLostPackets_N4	Number of 4 or more consecutive lost T.38 packets; indicates that there is burst loss, and will typically be a small number because burst loss of this magnitude will generally cause a fax attempt to quickly fail
T38RcvrLostOctets	Number of T.38 octets lost on receive

T38RcvrOOSPackets	Number of Out of Sequence T.38 Packets; often an indication that packets are taking multiple routes through the network
T38RcvrUsedRedundacy	Number of times redundant T.38 packets were required due to a missing packet. Note: if a packet is recovered through the use of redundancy, it is not counted as a lost packet. So when T.38 redundancy is enabled, adding T38RcvrLostPackets and T38RcvrUsedRedundacy can give a better estimate of the total number of lost packets
T38RcvrImageRedundancyLevel	Level of redundancy used for received T.38 image packets
T38RcvrControlRedundancyLevel	Level of redundancy used for received T.38 control packets

Table 4 – FAX_RES FQM Details

Table 5 describes the meaning of the FQMs in the page result structure.

Field name	Description		
bad_lines	Number of bad lines in the received image (non-ECM only). Note: when there is packet loss present, this number will not include missing lines due to lost packets, because the receiver will not know how many lines were transmitted		
bit_rate	The bit rate at which this particular page was transmitted or received		
	BITRATE_RSLT_2400_V27	0	2400 bps (V.27)
	BITRATE_RSLT_4800_V27	1	4800 bps (V.27)
	BITRATE_RSLT_7200_V29	2	7200 bps (V.29)
	BITRATE_RSLT_9600_V29	3	9600 bps (V.29)
	BITRATE_RSLT_7200_V17	4	7200 bps (V.17)
	BITRATE_RSLT_9600_V17	5	9600 bps (V.17)
	BITRATE_RSLT_12000_V17	6	12000 bps (V.17)
	BITRATE_RSLT_14400_V17	7	14400 bps (V.17)
	BITRATE_RSLT_12000_V33	8	12000 bps (V.33)
	BITRATE_RSLT_14400_V33	9	14400 bps (V.33)
	BITRATE_RSLT_2400_V34	10	2400 bps (V.34)
	BITRATE_RSLT_4800_V34	11	4800 bps (V.34)
	BITRATE_RSLT_7200_V34	12	7200 bps (V.34)
	BITRATE_RSLT_9600_V34	13	9600 bps (V.34)
	BITRATE_RSLT_12000_V34	14	12000 bps (V.34)
	BITRATE_RSLT_14400_V34	15	14400 bps (V.34)
	BITRATE_RSLT_16800_V34	16	16800 bps (V.34)
	BITRATE_RSLT_19200_V34	17	19200 bps (V.34)
	BITRATE_RSLT_21600_V34	18	21600 bps (V.34)
	BITRATE_RSLT_24000_V34	19	24000 bps (V.34)
	BITRATE_RSLT_26400_V34	20	26400 bps (V.34)
	BITRATE_RSLT_28800_V34	21	28800 bps (V.34)
	BITRATE_RSLT_31200_V34	22	31200 bps (V.34)
	BITRATE_RSLT_33600_V34	23	33600 bps (V.34)
sig_level	Signal level (PSTN only)		
line_noise	Line noise (PSTN only)		
sig_quality	Signal quality (PSTN only)		
bad_lines_NS	Number of single bad lines (scaled by resolution); non-ECM only		
bad_lines_N23	Number of 2-3 consecutive bad lines (scaled by resolution) ; non-ECM only		
bad_lines_N4	Number of 4 or more consecutive bad lines (scaled by resolution) ; non-ECM only		
num_ECM_frames	Number of Error Correction Mode frames		
num_PPR	Number of Partial Page Requests; ECM only		
num_PPR_NS	Number of single Partial Page Requests; ECM only		
num_PPR_N23	Number of 2-3 consecutive Partial Page Requests; ECM only		
num_PPR_N4	Number of 4 or more consecutive PPRs		
time_t4	Maximum time to receive responses to commands, in milliseconds (ms); equals the round trip latency for sending and receiving a response to a command from the remote end		
time_training	Duration of training zeroes, in milliseconds (ms)		

Table 5 – PAGE_RES FQM Details

Appendix B – Generating ITU E.450 Metrics

FQMs reported by the Brooktrout Bfv API can be combined over multiple transactions to generate additional E.450 metrics [3].

Table 6 describes how to calculate E.450 FQMs that are not provided directly by the Brooktrout Bfv API.

Metric name	Metric description	How to calculate the metric
Call attempts	Count of incoming and outgoing calls	Increment when an API function is called to originate a call (e.g., BfvLineOriginateCall) or an incoming call is detected (e.g., BfvLineWaitForCall returns with res.line_status == WAIT_FOR_CALL_OK)
PACR	Phase A completion ratio	Divide (count of calls where FAX_RES termination_phase was >= TERM_PHASE_A) by (count of call attempts)
CFS_N	Count of calls with cut-off faxes, defined in E.451 [5]	Increment if FAX_RES termination_phase < TERM_PHASE_E
CFS_1	Cut-off faxes on page 1, defined in E.451 [5]	Increment if FAX_RES termination_phase < TERM_PHASE_E and the number of completed pages for the current fax is zero; LINE_PAGE_CT macro may be used to get the page count or the application can keep track of the page count itself
CFS_2	Cut-off faxes on page 2, defined in E.451 [5]	Increment if FAX_RES termination_phase < TERM_PHASE_E and the number of completed pages for the current fax is one
CFS_3	Cut-off faxes on page 3, defined in E.451 [5]	Increment if FAX_RES termination_phase < TERM_PHASE_E and the number of completed pages for the current fax is two
CFS_{4Plus}	Cut-off faxes on page 4 or higher	Increment if FAX_RES termination_phase < TERM_PHASE_E and the number of completed pages for the current fax is greater than or equal to three
CFS_{1B}	Cut-off faxes pre-phase B failure	Increment if FAX_RES termination_phase <= TERM_PHASE_A
C_I	Calls without modem speed reductions	Increment if (bit_rates[PAGE_RES bit_rate] == bit_rates[FAX_RES initial_bit_rate]) on all pages of a multi-page fax where bit_rates[] = {2400,4800,7200,9600,7200,9600,12000,14400,12000,14400,2400,4800,7200,9600,12000,14400,16800,19200,21600,24000,26400,28800,31200,33600}
C_r	Calls with some modem speed reductions	Increment if (bit_rates[PAGE_RES bit_rate] < bit_rates[FAX_RES initial_bit_rate]) on any page of a multipage fax
C_B	Calls with modem speed reductions during initial phase B	Increment if bit_rates[PAGE_RES bit_rate] < bit_rates[FAX_RES initial_bit_rate] on a page
$\%E_t$	Transaction efficiency	Accumulate ((bit_rates[FAX_RES initial_bit_rate] - bit_rates[PAGE_RES bit_rate])*100)/bit_rates[FAX_RES initial_bit_rate] across calls $\%E_t$ = 100 – (accumulated value/number of calls)
T_{r1}	Transaction time for completed transactions without modem speed reductions, in seconds	Call duration for calls that meet criteria for incrementing C_I; generally averaged over multiple calls
T_{r2}	Transaction time for completed transactions with modem speed reductions, in seconds	Call duration for calls that meet criteria for incrementing C_B; generally averaged over multiple calls.
T_{r3}	Transaction time for all transactions in seconds.	Call duration for completed calls, generally averaged over multiple calls
P_{EF}	Pages with no image errors	For ECM, increment if PAGE_RES num_PPR == 0; for non-ECM, increment if PAGE_RES bad_lines == 0
P_E	Pages with image errors	For ECM, increment if PAGE_RES num_PPR > 0; for non-ECM, increment if PAGE_RES bad_lines > 0
P_{SE}	Pages with severe image errors	For ECM, increment if PAGE_RES num_PPR_N4 > 0; for non-ECM, increment if bad_lines_N4 > 0
P_{GPPR}	Pages with no PPRs	Increment if PAGE_RES num_PPR == 0
C_{EF}	Calls with no image errors	Increment if P_{SE} and P_E are zero
C_E	Calls with image errors	Increment if P_E > 0
C_{SE}	Calls with severe image errors	Increment if P_{SE} > 0
C_{NPPR}	Calls with no PPRs	Increment if PAGE_RES num_PPR == 0 for all pages in the fax
FRER	Frame Error Rate	For ECM faxes, divide PAGE_RES num_PPR by num_ECM_frames

Table 6 – E.450 Metrics Calculations

References

[1] Considerations for Using T.38versus G.711 for Fax over IP – Dialogic White Paper

[2] ITU-T Recommendation E.458: Figure of merit for facsimile transmission performance

[3] ITU-T Recommendation E.450: Facsimile quality of service on public networks – General aspects

[4] Dialogic® Brooktrout® Bfv APIs Reference Manual

[5] ITU-T Recommendation E.451: Facsimile call cut-off performance

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