



ATIS-0100008.2007(R2012)

Defects Per Million (DPM) Metric for Transaction Services
Such as VoIP

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ATIS-0100008.2007(R2012), *Defects Per Million (DPM) Metric for Transaction Services Such as VoIP*

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American National Standard for Telecommunications

DEFECTS PER MILLION (DPM) METRIC FOR TRANSACTION SERVICES SUCH AS VOIP

Secretariat

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Abstract

This standard defines a metric that can gauge the ability of an IP network to deliver transaction services in an acceptable manner. Transactions such as Voice over IP (VoIP) calls are either successfully completed as required, or they are considered to be defects. The DPM metric is defined as the ratio of all defective transactions to the total number of transactions attempted over a pre-determined period, normalized by a factor of one million.

FOREWORD

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Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PRQC Secretariat, 1200 G Street NW, Suite 500, Washington, DC 20005.

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American National Standard for Telecommunications

Defects per Million (DPM) Metric for Transaction-Based Services such as VoIP

1 SCOPE & PURPOSE

This document provides definitions for a metric that can be used to gauge the ability of an IP network to deliver transaction services in an acceptable manner. A *transaction* is defined as an IP network session involving a sequence of related information exchanges and processing operations designed to accomplish a specified service function. Examples of transactions include Voice over IP (VoIP) phone calls, web page access, file downloads, and or e-mail services. Transactions are either successfully completed by an IP network or encounter conditions that prohibit their successful completion. Such failed transactions are called defects. The proposed metric defines the ratio of “defective” transactions to the total number of attempted transactions and normalizes them by a factor of one million - *Defects per Million (DPM)*.

As IP networks evolve, transaction-based services may span several network domains. For example, a VoIP call may originate over an IP network and complete over the Public Switched Telephone Network (PSTN). The scope for estimating the DPM metric is restricted to the traversal over the IP network domain¹. The scope of this document is also restricted to the definition of whether a transaction is “successfully” completed over the IP network portion or not. Thus, transaction quality issues such as degraded VoIP call quality caused by delay and jitter are not considered for the moment. A properly completed transaction is considered to be “successful” irrespective of the transmission quality.

This document provides an illustrative example on the use of the DPM metric for VoIP services. Examples on DPM usage for other transaction services over IP networks (e.g., Virtual Private Network services) will be discussed in future documents.

2 NORMATIVE REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

None identified in this document.

3 DEFINITIONS

3.1 Defects per Million: This metric is defined as the ratio of all defective transactions to the total number of transaction attempts in millions, over a fixed time interval (e.g., one month, one year).

¹ This limitation has been recognized in previous discussions in PRQC, and will be addressed in future documents.

3.2 Transaction: An IP network session involving a sequence of related information exchanges and processing operations designed to accomplish a specified service function.

4 ACRONYMS & ABBREVIATIONS

| | |
|--------|--|
| CAI | Customer Affecting Incident |
| CDR(s) | Call Detail Record(s) |
| DPM | Defects per Million |
| IP | Internet Protocol |
| ITU-T | International Telecommunications Union-Telecommunication |
| NER | Network Effectiveness Ratio |
| PRQC | Performance Reliability and Quality of Service Committee |
| PSTN | Public Switched Telephone Network |
| SLA | Service Level Agreement |
| VoIP | Voice over IP |
| VPN | Virtual Private Network |

5 INTRODUCTION AND RATIONALE

Current network trends indicate significant increases in traffic volume for services of different types over IP networks. Traffic types include real-time services (e.g., VoIP and video), data services, "Enterprise Customer" services over "Virtual Private Networks" (VPN), IPTV services, as well as traditional Internet services such as e-mail and Web browsing.

Estimating the ability of an IP network to deliver acceptable transaction-based services can be complicated by significant operational constraints. IP networks in their current mode of operation are essentially "connectionless". Thus, packets representing any given "session" may be routed over different physical routes over the IP network, so long as the packet reassembly at the IP terminating end point is done in the correct order.

It is however critical to note that services such as VoIP can be considered as transactions and it is possible to track the status of all such transactions even in IP network elements. A transaction can be characterized as a success if all of the following steps are accomplished:

- ◆ *Network Access:* The user gains access to an IP network.
- ◆ *Network Traversal:* The network establishes an end-to-end IP flow.
- ◆ *Termination:* Upon completion, the IP network releases the transaction thus terminating the session.

A transaction is defined to be a *failure* or *defect* if any of the above steps is not accomplished. A *defective transaction* is defined to be either a blocked transaction or a cutoff transaction as follows:

- ◆ A *blocked transaction* is a transaction that is unable to gain network access or network traversal due to network failure or congestion.

- ◆ A *cutoff transaction* is a transaction that achieves network access and traversal, but is prematurely terminated due to some network failure condition. Note that a transaction cut off by an end user due to poor transmission quality is not counted as a cutoff due to the difficulty in measuring transmission quality in IP networks – see Clause 1.

The key element to a transaction perspective is that counting the success or failure of a transaction does not involve a downtime component, and hence, an appropriate metric to gauge the ability of a network to deliver transaction-based services is the Defects per Million (DPM) metric.

The definitions of successful and defective transactions in this standard differ from prior work on a DPM metric pertaining to voice call service as follows. ITU-T Recommendation E.436 describes a *Customer Affecting Incident (CAI)* in the public switched network as a failure incident that results in a level of customer complaints with regard to call completion over and above the normal or nominal level of such complaints². The incident could involve a failure in a network element (e.g., transmission, switching, signaling) or a provisioning or maintenance error in network operations. ITU-T Recommendation E.436 defines Defects per Million due to all CAI's over a fixed time interval (e.g., daily, monthly, quarterly) as the ratio of blocked call attempts (termed Defects) resulting from the CAI's to the total call attempts in millions over the fixed time interval. E.436 excludes blocked calls due to non-CAI conditions (e.g., network congestion) as well as cutoff calls due to CAI and non CAI conditions.

A *cutoff call* is defined in ITU-T Recommendation E.850 as follows: A prematurely released telephone connection is known as a cutoff call when a successfully established connection is completely broken, or when the transmission quality of the connection becomes unsuitable for voice communications³. As noted in Clause 1, the latter condition – transmission quality – may not be measurable in current IP networks.

To summarize the discussion, this standard differs from prior standards in that all transaction defects - blocked and cutoff transactions from both CAI and non-CAI incidents - are considered in the determination of the DPM metric. However, transaction cutoffs initiated by a user due to poor transmission quality are not considered as defects.

The capability of a service provider to detect cutoffs and include their count in reports may depend on their operating procedures. If a reported DPM metric does not include a count of cutoffs, this fact should be noted in the metric report. It is recommended that the metric report also include the period of time covered by the metric, limitations in portions of the network covered (if any), and the total number of transaction attempts in that period.

6 ILLUSTRATIVE EXAMPLE – DEFECTS PER MILLION METRIC FOR VOIP

As noted in Clause 1, the scope for estimating the DPM metric is restricted to the traversal over the IP network domain – see Figure 1. End-to-end DPM estimation (over domains of differing technologies) is for further study.

² ITU-T Recommendation E.425 describes a similar metric called *Network Effectiveness Ratio (NER)* as the ability of networks to “correctly” deliver and complete calls.

³ According to ITU-T Recommendation E.800, the ability to maintain the service for the desired amount of time at an acceptable level of performance is referred to as *retainability*.

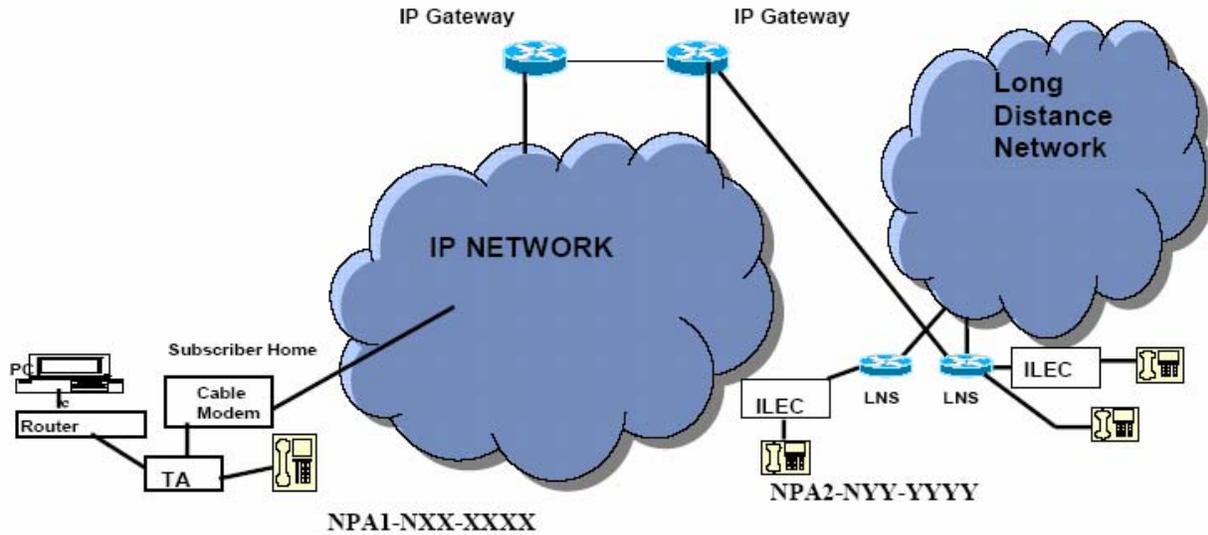


Figure 1 - Generic VoIP Network Interconnection Architecture

6.1 Definition of VoIP DPM Metric

For VoIP service, DPM is characterized in terms of successfully completed VoIP transactions as follows:

$$DPM = 10^{-6} * \left[\frac{\sum d}{\sum a} \right]$$

where:

- ◆ d = All defective transactions (blocked + cutoff as defined in Section 5)
- ◆ a = All attempted transactions (success + defects)

It is noted that call quality degradation is excluded from consideration pending further study. Thus the success or failure of any given VoIP transaction can be defined according to the rules in the following table:

Table 1 - Failure Rules

| | Type of Call | Status |
|----|--|---------|
| 1. | <i>Answered Call</i> - Successfully completed and released call per above definitions and applicable service agreements ⁴ . | Success |
| 2. | <i>Answered Call Cutoff</i> - Call in progress cutoff by some network element outage or defect. | Cutoff |
| 3. | <i>Ring No Answer</i> - Attempted call successfully completed and released when called party does not pickup the phone. | Success |
| 4. | <i>User Busy</i> - Attempted call successfully completed and released when called party is busy. | Success |
| 5. | <i>Dialed Number Error</i> - Attempted call successfully completed and released (error is made by calling party). | Success |
| 6. | <i>Blocked Call</i> - All other scenarios where call cannot be completed as dialed. | Blocked |

6.2 VoIP DPM Measurement Implementation Issues

Vendors have implemented recording capabilities that can enable the tracking and recording of the call status over network elements. These records are known as *Call Detail Records (CDR)*. In principle, the estimation of VoIP DPM requires the examination of the CDRs triggered by the call over all the network elements involved in the IP network. In practice, there are many constraints that introduce operational complexities into the process. Some of these complexities are listed here:

1. *Number of CDRs*: Each call may traverse several network elements. Hence, there may be several CDRs related to a single call. Also, an initial unsuccessful call attempt may generate retries, and thus, multiple CDRs could result from the retries as well. Appropriate processes are required to correlate all captured information across all CDRs and provide a clear inference into the call status.
2. *Differing Vendor Implementation*: Different vendors provide differing CDR formats and content. Additional processing has to be done by service providers in order to interpret CDR information in a consistent manner. Development of standards to resolve differing CDR formats/content is for further study.
3. *Multiple Service Platforms*: A service provider may offer VoIP service to different types of customers. For example, a specific VoIP offering for a high-revenue Enterprise Customer may include greater capabilities (“bells and whistles”) than an offering for residential services. The Enterprise offering in turn could also be subject to specified reliability requirements in a Service Level Agreement (SLA). Additional “rules” defining call/transaction success or defect may come into play for such offerings.
4. *State of Initiating Edge Router*: When the initiating Edge Router is in a failed state (partial or total), incoming VoIP calls may be blocked from entering the IP network depending on the nature of the failure. Under such circumstances, CDRs may or may not be generated for these blocked calls, depending on the nature of the Edge Router failure. It is therefore important to have follow-up processes (e.g., trouble tickets) that can provide estimates of the blocked calls under such situations. The automated DPM estimates can then be updated manually.

⁴ A service agreement pertains to services such as call screening. This involves rejecting a call per user specifications and proper notification to the calling party. In such cases, the network is considered to have completed the call as required and is thus noted as a successful transaction.

7 BIBLIOGRAPHY

ITU-T Recommendation E.436, *Customer Affecting Incidents and Blocking Defects per Million*.⁵

ITU-T Recommendation E.425, *Network Management – Internal Automatic Observations*.¹

ITU-T Recommendation E.800, *Terms and Definitions Related to Quality of Service and Network Performance Including Dependability*.¹

ITU-T Recommendation E.850, *Connection Retainability Objective for International Telephone Service*.¹

⁵ This document is available from the International Telecommunications Union. < <http://www.itu.int/ITU-T/> >.