VoIP Systems Management using Internet Protocol Detail Records

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***Abstract*—The increasing demand for latency sensitive services through the Internet imposes the development of networks capable of delivering quality of service. These networks require the use of enhanced traffic management tools. This paper performs an analysis of IP telephony or VoIP traffic considering Internet Protocol Detail Record (IPDRs). When a VoIP call occurs upon the Internet, a ticket (a file record) is generated to produce information regarding that specific call. These files are called Internet Protocol Detail Record. The IPDR, which is generated for every VoIP call, contains information related to the history of the call. The full set of information in the IPDRs carries a very comprehensive description of what happened to the call and can provide valuable information about the state of the network during the history of the call. Therefore, IPDRs can be used to establish network traffic baselines. This paper presents the development of a baseline that supports VoIP traffic management in Open Access MANs. Our main conclusion is that this method can be used to manage VoIP networks.**

Keywords-Voice Over Internet Protocol; Network Management; Open Access Metropolitan Area Networks; IPDR.

I. INTRODUCTION

As of the mid 90’s, with the steady evolution of technologies, the telecommunications networks have become more and more complex, being capable of bearing multiple services. These services a

re part of a heterogeneous set of pieces of information which can be sent through the Internet, for instance, the telephone calls. In telephony companies, the voice transmission has been migrating from the classic telephony model to the IP networks, thanks to the development of VoIP technology [1][2].

In the beginning of its utilization, the VoIP technology lacked service quality and raised interest only from a specific group of users. Among VoIP technology qualities are its low cost, mobility and multiple functionalities. It, therefore, has become a challenge [3][4] to assure quality to the service within acceptable standards.

A solution which has demonstrated good results regarding to the QoS guarantee is the Open Access Metropolitan Area Networks which operate on broad bands [5]. Nevertheless, the quality of service (QoS) during the calls must be as good as possible, once, nowadays, the users have been becoming more and more impatient with the instability and unavailability of the network.

The Open Access Metropolitan Area Networks [6] are examples of high speed networks that can be utilized to transmit multimedia services, such as: voice, video and data. The Open Access MANs are models for IP network architecture whose one of the main objectives is to interconnect public buildings to the people of the municipality through a convergent multimedia network.

A solution to improve the behavior of the service in the systems is to create automation in the functions on management, aiming, mainly, to mitigate the interruption of services, to optimize the allocation of resources, to reduce costs and to, proactively, detect failures. A way to enhance and upgrade the VoIP traffic management is the utilization of tickets named IP Detail Record (IPDR) [7]. The IPDRs are tickets generated in the voice PABX(Private Automatic Branch Exchange)/gateways during the event of a VoIP call, similar to the CDRS (Call Detail Records) which are generated in the conventional telephony [8]. The IPDR function is to supply detailed information of the whole history of a call. The IPDR standard was defined by the IPDR Organization and the Telemanagement Forum [9].

Our objective in this article is to propose a new management methodology for the VoIP system through the construction of baselines based on the IPDRs analyses. In other words, we seek to offer a new approach/methodology that may contribute to increase quality of service through the characterization of the VoIP traffic. Another component is to study the feasibility of using this model in the process of detecting failures and anomalous behavior. An important factor for this study progress was the lack of an efficient monitoring/management model of the IP telephony system based on the characteristics of phone calls. We do believe in the potential of new methods that approach to the analysis of the VoIP technology behavior and see this behavior from the point of view of the events that happen in the traditional telephony: completed call, call congestion, no answer, wrong dialing, busy lines, and technical failure.

The remainder of this paper is organized as follows. Section II presents the IPDR and the Pedreira´s Open Access MAN. Section III describes the IPDR classification. Section IV presents the concepts of Baselines. Section V describes the case study conducted in Pedreira’s Open Access MAN. Section VI concludes the paper and discusses future works.

II. INTERNET PROTOCOL DETAIL RECORD

As previously stated, the IPDR provides detailed information about the call. These tickets are essentially utilized in the generation of telephone accounts, that is, in the billing of calls made. There is a limited number of works

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which focus on IPDRs. Tartarelli, et al. [10], has addressed the ticket analysis to manage the conventional telephone traffic by identifying problems and observing the utilization profile. He has analyzed a large amount of he logs and recorded all their background to help other operators with similar difficulties. A fraud management system (FMS) was developed based on the analysis of IPDRs carried out by Ruiz-Agundez and Bihina Bella [11][12]. They have proposed this system in NGN (Next Generation Network). In Proença, et al. [13], a baseline is proposed regarding to reliability and safety metrics in order to help network administrators with the system management. In Tartarelli, et al. [10], an approach is suggested in which the logs of gathered data were analyzed by a self-organized mapping system made up of neural networks capable of detecting frauds.

Another possibility is to employ the CDRs and IPDRs to run an analysis in relation to the social aspects of the users.

In Dasgupta, et al. [14], the authors analyze the CDRs to model the behavior of calls made by people who used to change operators very often. The objective of the authors in that case was to investigate the possibility of a person arbitrates to change operator led by influence of friends who had done that before. Besides, they propose an approach which aims to identify people who show bigger potential for changing operator based on their contact network. In addition to that, IPDRs and CDRs can be utilized to develop failure detection systems in communication. In Breda's and Mendes' [9] works, the performance of the algorithms was analyzed to detect failures through the CDRs analysis.

A. Creation of IPDRs

As we have already mentioned, the IPDRs are tickets generated in each call trial, no matter the call has been completed or not. Table 1 shows an example of IPDR in which some fields are shown. The most common use of the IPDR is in the pricing of subscriptions. Nevertheless, the IPDRs can also be utilized in the consumption management, traffic analysis, user profile definition, system dimensioning, among other applications.

TABLE 1. IPDR EXAMPLE

Type	Switch	Start Time	End Time	A Phone Number	...	B Phone Number
00	35	17:17:25	17:19:58	22221056		22221089
00	35	17:17:28	17:17:35	22221087		38932221
00	2	17:17:30	17:28:01	22221045		22221007
00	35	17:17:31	17:18:33	22221009		97435330
00	35	17:17:31	17:21:04	22221033		22221029

To subsidize our research along the six-month period, from January to June/2009, the IPDRs generated inside the Open Access Metropolitan Area Networks in the municipality of Pedreira were collected. This network was designed and, in part, managed by the Communications Laboratory of School of Electrical and Computer Engineering at University of Campinas (UNICAMP). The objective was to gather a real base of IPDRs, within an acceptable time interval so that the baselines developed were according to reality. One of the main reasons to take those IPDRs in consideration to generate the baselines was that such IPDR database had been already set up in the MANs PABX/gateways. It is surely a reliable source of information which portraits a real full-functioning environment.

B. Open Access Metropolitan Area Networks & VoIP

The Open Access MANs can be characterized as being an infrastructure that allows the convergence of applications and multimedia services in municipal scope [15]. Such network calls attention for its high transmission capacity and for the gathering of different kinds of information. One can say the Open Access MANs stand for the public highways of information .

A difference between the existing communication networks and the metropolitan networks is that the Open Access MAN have a universalizing character, and because they are multi-service ones, they can enable the distribution of various contents such as voice, video and data in a simple and unified way, what is currently taken in a separate way by the traditional operators.

Figure 1 shows the physical structure of the Open Access MAN of the city of Pedreira [16]. The network interconnects various public buildings, such as: city hall, board of educational, police station, hospital, municipal schools, daycare institutions, secretaries, houses, etc. The interconnection makes use of two technologies: optical enlacements and radio links. The lines in red stand for the optical fiber backbone of 1 Gigabit (1000BaseLX) connections.

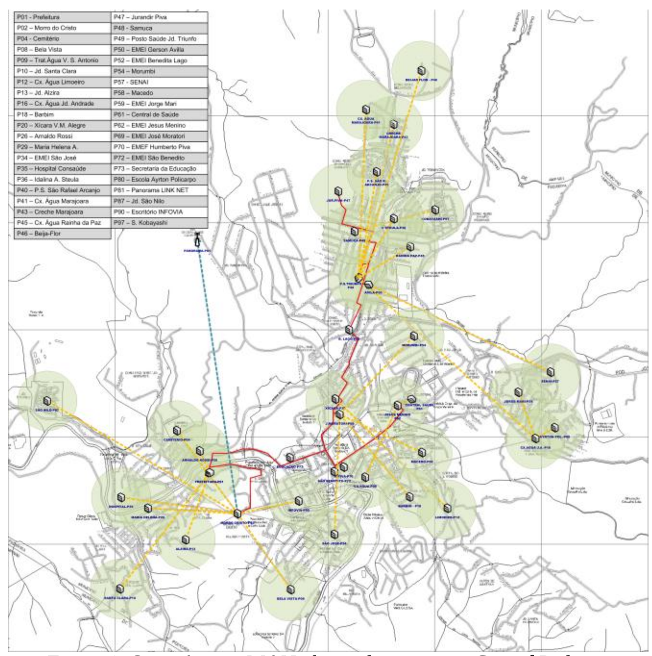

Figure 1. Open Access MAN physical structure – City of Pedreira.

The yellow dotted lines show the radio enlacements (IEEE 802.11a), where the light green circles are the wireless coverage areas for connecting the citizens to the Internet/network (IEEE802.11 b/g/n). The network is based on the Ethernet standard, and the communication protocol employed is the TCP/IP.

The main objective on implementing the VoIP systems in the Open MANs is the cost reduction of calls once the voice traffic happens on the pre-existing data network. The IP connections (VoIP to VoIP) are free of charge. VoIP calls to conventional telephones will have a decrease in the billing charge. The IP telephony in the Open Access MANs can offer a residential extension through which the citizens can talk to one another at no cost.

Based on the statistics framed in [17], the utilization of VoIP extensions for intra-communication of buildings linked to public administration has generated a 76% savings in the city hall telephone bills, when compared to traditional telephony.

City Hall of Pedreira has adopted the VoIP technology to interlink all the public facilities. The configuration of the IP Telephony network follows the structure as displayed in the Figure 2.

III. IPDR CLASSIFICATION

The entire set of IPDR gathered needs to be classified. Categorizing an IPDR is basically to say what happened to it as the call went on. It is to create a taxonomy (from the Greek tassein = classify and nomos = rule, law). The taxonomy varies from system to system, that is, for mobile telephony there are events, which are different from fixed telephony and from VoIP. For instance: for a system based on VoIP it is not possible to single problems out in a given station ahead, once in an IP network the traffic may follow distinctive paths to reach their destinations. In the fixed telephony there will not be Radio Stations Bases, RF blackout, common events that usually happens in Cellular Systems. Besides all that, there are always common events among different systems, such as: completed calls, trunk congestion, busy lines, no answer, and wrong dialing.

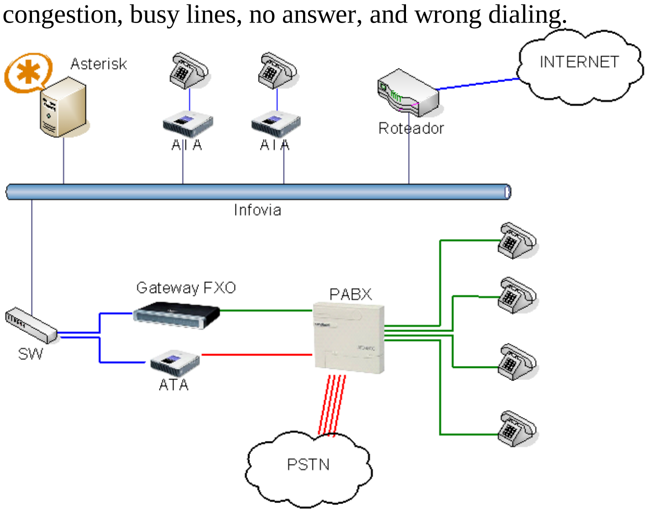

Figure 2. Basic configuration of VoIP in the Open Access MAN of Pedreira.

Every IPDR is submitted to classification which is done according to the pieces of information contained in the fields of the tickets. One of the contributions in this work was the categorization, which led to the taxonomy of IPDR tickets.

As previously mentioned, to classify a call is like attaching a label to each ticket with information about the call destination. It is possible to create a large number of events to classify the tickets. Each one can be divided into sub-events, that is, sub-divisions which reflect the peculiarities of each event. An IPDR field of outstanding relevance in the creation of taxonomy is the field related to “call status”. This field reveals typically four situations:

OK: for calls successfully accomplished.

NOT OK: when the destination could not be found.

TO: when the remote terminal was busy at that time.

FAILED: when some kind of failure happened during the generation of the call.

The “call status” field is known in the conventional telephony as “ending of selection” and indicates what may have occurred to the calls as they left the PABX and were forwarded, or also, events related to the ones coming in to the PABX. This piece of information is of utmost importance in the classification of tickets. Of course, the “ending of selection” field is not the only one to be considered at the moment taxonomy is created. Most of the fields owns relevant information and must be taken in consideration as events and sub-events relative to IPDRs are developed.

Table 2 presents the taxonomy created to describe possible call records.

TABLE 2. CLASSIFICATION FOR IPDRS

Event	Description
CELE	Indicates established calls Local => External
CELI-A	Indicates established call Local => Internal (context of A call)
CELI-A1	Indicates local established calls on extensions.
CELI-A1.1	Indicates local established calls which were terminated suddenly
CELI-A1.2	Indicates local established calls with use of waiting music
CELI-A1.3	Indicates local established calls with extension transference
CELI-A1.4	Indicates local established calls with generation of voice message
CNEE	Indicates external non-established calls
CNEI-A	Indicates internal non-established calls (context of A call)
CNEI-A1	Indicates internal non-established calls, once there was no answer from destination
CNEI-A2	Indicates internal non-established calls due to junction/circuit overflow.
TO	Indicates calls whose destination telephone is busy
FCE-A	Failure occurrence when executing external call (A call context)
FCE-A1	FCE-A due to incorrect dialing
FCE-A2	FCE-A due to channel overflow without feedback of signal/message
FCE-A3	FCE-A due to channel overflow with feedback message
FCE-A4	FCE-A due to channel overflow without feedback signal
FCE-A5	FCE-A during IPDR generation

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The classified tickes will be used to create the baselines. It is possible to create baselines for each type of event or classification. Therefore, there will be a baseline for the number of calls successfully established to an external number per hour, another baseline for the number of calls established successfully internally per hour and so on.

Table 3 contains an example of classified tickets. Comparing both Table 1 and 3 it is possible to see that the unique difference between them resides in the fact that the latter displays a new field where the classification is.

TABLE 3. CLASSIFIED IPDRS

Type	Switch	Start Time	End Time	A Phone Number	...	B Phone Number	Classification
00	35	17:17:25	17:19:58	22221056		22221089	CELE-A
00	35	17:17:28	17:17:35	22221087		38932221	FCE-A2
00	2	17:17:30	17:28:01	22221045		22221007	CELE-A
00	35	17:17:31	17:18:33	22221009		97435330	CELE-A
00	35	17:17:31	17:21:04	22221033		22221029	CELE-A

IV. BASELINES

With the continuous increase in demand for telecommunication services, more and more necessary is to automate the management of networks in order to optimize the resources, reduce costs, prevent from service unavailability, detect failures and avoid bottlenecks. Besides that, it is necessary to have a reliable network for providing latency sensitive services, as it is the case of VoIP technology. We do believe a far-reaching component for the automation of networks is the establishment of baselines. They stand for the natural behavior profile of the network. The baseline supplies subsidies for the administrator to make more accurate decision on management abnormalities or any other troubles that might be going on.

This work, as previously mentioned, proposes the building of baselines relative to VoIP calls by making use of the IPDRs. The process of generating the baselines begins when a user makes a VoIP call. This call is processed and after that an IPDR is generated. The IPDR, then, is stored in a database. Next, the tickets are classified according to this taxonomy created. Once the tickets are classified, they can be used to build the baselines.

Baselines have three dimensions: event x element x time. The baselines can reveal the various behaviors (events) of the network, such as overflowing, completed calls, transferences, busy lines, wrong dialing, etc. Beyond reflecting all these network behaviors, the baseline can be developed on the basis of all components of the network, for instance: telephone number, telephone prefixes, area codes, physical resources (extensions, junctions, PABX stations, and gateways). It is also possible to work with temporal representations like hourly, daily, weekly, monthly and annual periods.

It is meaningful to emphasize the IPDR utilization potential, for any of these three combinations can be taken to build a baseline. This leads to a very substantial flexibility which results in versatility/efficiency to manage the system.

V. CREATION OF BASELINES

This section shows some examples of baselines that were created. To create the baselines we have used IPDRs relative to the commercial time, considering that, at that time, the city hall staff was on duty and, therefore, making the large number of calls.

The Figure 3 shows the baseline created to estimate the amount of calls made throughout the day. This Figure shows the profile of telephone usage. As it can be seen, the results demonstrate a good adjustment between the baseline and the real data, which are data related to the subsequent day, at the end of the sample taken to develop the baseline. The sample to create the baseline took a four commercial-week time, that is, from Monday to Friday from 8 am to 5 pm. Also, regarding to this Figure, it is possible to see that the biggest concentration of calls occurs between 11 am and 2 pm.

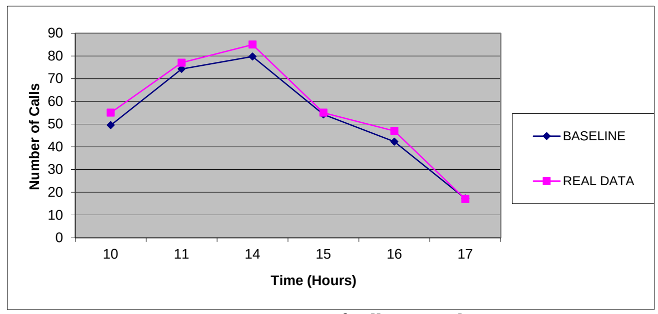

Figure 3. Amount of calls in one day.

Figure 4 shows a comparison between the baseline of local established calls, internal network (CELI-A) and its real traffic. Around 2:00 pm, there was a peak of internal calls successfully established, and not predicted by the baseline. Once they are successfully established calls, this behavior deviation is somehow beneficial to the network. It is not a problem since there was an increase in the volume of completed calls. Anyway, it is a behavior to be investigated.

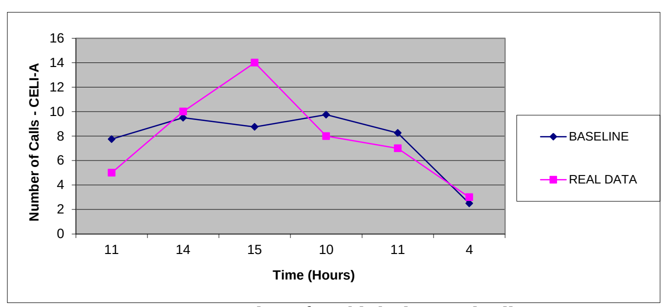

Figure 4. Baseline of established internal calls.

Figure 5 shows the baseline created to demonstrate the behavior of established calls addressed to PSTN(Public Switch Telephone Network). This type of baseline can supply interesting pieces of information relative to calls, because in any PSTN problem it will have a decline in the amount of established calls. This helps detect problems in the network operators so that it can take pro-active action in order to reestablish the service. It is important to evidence that the baselines can give the possibilities to find out the problems in interconnected networks to ours, even if we do not have any management power on those networks.

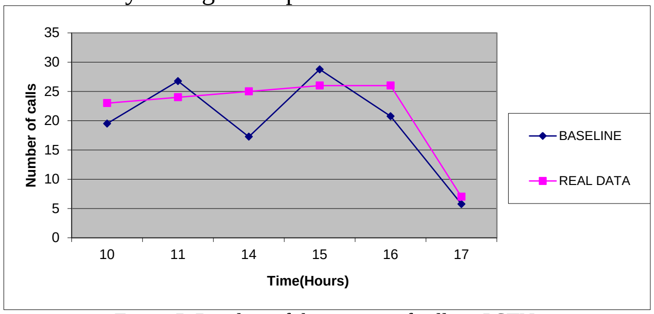

Figure 5. Baseline of the amount of calls to PSTN.

Another interesting approach to the construction of baselines is to analyze the internal telephonic traffic. In the Figure 6 the calls addressed to the Board of Educational phone extension lines were a source for the creation of this baseline. Looking at the curves it is possible to realize a good adjustment between the baseline and the curve that represents the real traffic. This baseline is shown to highlight the potential of this methodology. We can go from a specific extension to an area code (telephone number) of a municipality or state. It is possible to choose either physical elements or logical ones.

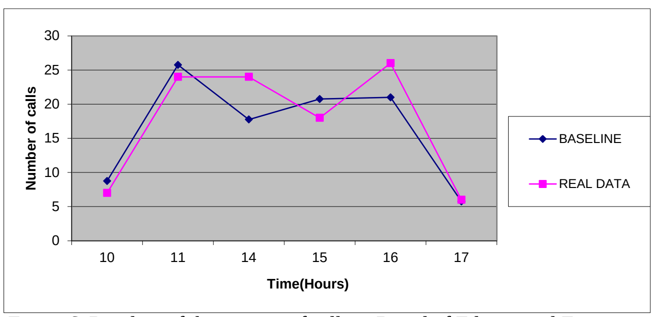

Figure 6. Baseline of the amount of calls to Board of Educational Extension lines.

The baseline in Figure 7 stands for the mapping of internal calls not established because of troubles in the exit junction (CNEI-A2). According to comparison between the baseline and the real curve, it is possible to identify a big deviation after 3 pm in the day analyzed. Such deviation means a problem, as there was excessive degradation, that is, a remarkable increase of uncompleted calls due to malfunctions in the exit junctions.

We are casting algorithms that can be used to detect possible flaws going on the network. In [9], Breda and Mendes, it was researched algorithms that were being employed in the detection of malfunctions based on the utilization of CDRs (Call Detail Records) as a source of information. As it was already explained, the CDR is for fixed/mobile telephony the same IPDR is for VoIP telephony. The advantage of using algorithms is the assurance that the indicated warnings are true. This guarantee is a probabilistic value established by the network administrator. It is reached by means of the adoption of a probabilistic model. In [9], Breda and Mendes, it is explored algorithms that make use of Binomial, Normal and Poisson distributions with guarantee of 99.99999% that the warnings generated are true, that is, they have a root cause. This guarantee means that for every million warnings generated, there is the likelihood of one false-positive warning. A false-positive warning is defined as the one that, despite having been generated, it does not end to be a problem, as it does not have a root cause in the system.

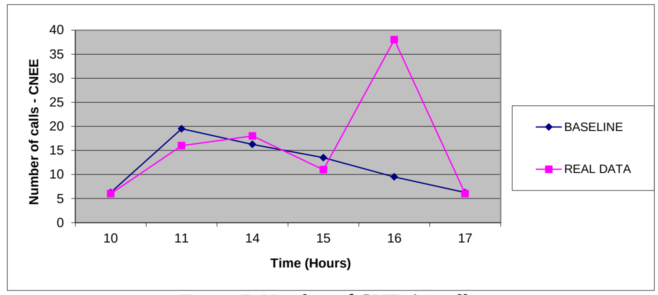

Figure 7. Number of CNE-A2 calls.

VI. CONCLUSION

Our main goal was the construction of a management model on the VoIP technology based on baselines which are put together from a database made up of IPDRs. The baselines feature the IP telephonic traffic, generating a kind of "signature" of the behavior of the system components. Such "signature" can be faced with the current behavior of the components, in a way that makes possible to infer the existence of problems affecting the network performance. Although we have taken data from a metropolitan network, this methodology can be applied to any kind of network, since it has IPDR tickets. Advancing a little bit more, we have got the conclusion that such methodology can be employed in any network, since it has logs, tickets, SNMP packs, that is, logs that portrait one or more events of the system elements.

The classification of the IPDRs has provided a vast gamut of possibilities in the creation of baselines, for instance, the amount of interurban calls made in a given sector, or the amount of international calls originated from a specific extension. This example can be employed to help with the detection of frauds in the network and also with the definition of consumption profile of users.

Another result that can be considered relevant is that the proposed model deals with VoIP systems management from the point of view of conventional telephony events. The VoIP technology is an application that runs with the TCP/IP protocol, that is, with a network of packs. The management on this network model is structured on SNMP objects and copes with some types of behavior related to those packs. The management we are proposing deals with the VoIP technology from the point of view of a regular telephonic call, that is, with all the outcomes a phone call may have. This is highly relevant as it is a change in the way of looking into the VoIP management.

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This new approach has demonstrated to be very useful and promising, as it allowed the characterization of the traffic based on information coming from the IPDRs. The creation and analysis of the baselines complemented the network management by attributing optimization and agility to the process. The baselines generated from the IPDRs were able to demonstrate that such methodology adds efficiency in the management of the network and can be employed to detect malfunctions.

As a future work in this area, we intend to use our VoIP baseline to apply algorithms for detection of abnormal behavior and failures.

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