2010

How does the power crisis problem affect data management in the Dominican Republic

José Raúl Vélez Díaz

How does the power crisis problem affect data management in the Dominican Republic

By

José Raúl Vélez Díaz

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Networking and Systems Administration

Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

April, 2010

Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

Master of Science in
Networking and Systems Administration

Thesis Approval Form

Student Name: JOSE RAUL VELEZ DIAZ

Thesis Title: HOW DOES THE POWER CRISIS PROBLEM AFFECT DATA MANAGEMENT IN THE DOMINICAN REPUBLIC

Thesis Committee

Name	Signature	Date
CHARLES BORDER Chair		
ARLENE ESTEVEZ Committee Member		
LUTHER TROELL Committee Member		

Thesis Reproduction Permission Form

Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

Master of Science in
Networking and Systems Administration

How does the power crisis problem affect data management in the Dominican Republic

I, José Raúl Vélez Díaz, hereby grant permission to the Wallace Library of the Rochester Institute of Technology to reproduce my thesis in whole or in part. Any reproduction must not be for commercial use or profit.

Date: _April, 2010_ Signature of Author: _JOSE RAUL VELEZ DIAZ_

Table of contents

Abstract

In the last decade, the Dominican Republic has been affected by a power crisis nation wide. In 2008, the crisis reached a deficit of 40% in the generation of power; and the problem seems to go on as no agreement is executed to solve it. The problem is originated from the lack of efficiency of many generators, and debts with the generators companies. An important aspect of the power crisis is the challenge to provide power quality to electronic equipment. Data management can be affected by this problem whenever there is data corruption or lost, and devices are damaged. Data availability is extremely important for a business to maintain operational and competitive. This study shows the reality of middle size enterprises in our country, which are on the need to implement solutions in order to protect their infrastructure. This investigation was performed by interviewing a set of enterprises, and analyzing how business is affected, the level of awareness for power problems, and the solutions commonly used to protect the assets. The results presented that mostly all interviewed enterprises try to invest in power protection and correction mechanisms, much of the time sacrificing investment for business growth. Even devoting a generous part of enterprise budgets to confront the power crisis businesses are not 100% free from the consequence of the power crisis. As seen in the results, many businesses do not count with effective disaster recovery plans, nor business continuity plans. Frequent power problems observed are blackouts, overvoltage, and voltage fluctuations.

Introduction

Power deficiency in Dominican Republic is a problem that our country has had to deal with since long time. Everyday there are power shutdowns all over the country, although some sectors are more privileged than others. For industries and corporations it is essential to think of solutions for power regulation and backup to maintain their operations and protect their equipment. Furthermore, power problems are even present in more developed countries, and this is why this is such an important topic to investigate.

In this study, I research the impacts of power crisis over data management in Dominican Republic and how prepared are Dominican companies to protect their assets. Once in production, many systems can not afford to be down or lose data over energy failure. Therefore, data loss, interruptions and errors are consequences that should be avoided whenever possible.

This study is considerably relevant to enterprises that deal with data management in Dominican Republic by analyzing the problems that our country might have regarding the energetic crisis and how our data centers are suffering the consequences.

Literature Review

In order to prepare for my thesis work, I looked at related works done in the area of energetic problems and data management. These works helped me define the path to take in this investigation study. Moreover, this previous exploration helped me get the appropriate background I needed to perform the study.

The Seven Types of Power Problems is a white paper intended to make us conscious about electrical power problems. These may cause data loss, processes interruption and damage of equipment. In addition, the authors note that there is a problem in describing power problems in a standard way. Therefore, this paper describes seven critical power problems, their causes, their consequences and how to prevent them, or at least how to reduce the damage they can do/or reduce the chances of happening. These problems are:

1. Transient
    1.1. Impulsive
    1.2. Oscillatory
2. Interruptions
3. Sag / Undervoltage
    3.1. Sag
    3.2. Undervoltage
4. Swell / Overvoltage
    4.1. Swell
    4.2. Overvoltage
5. Waveform Distortion
    5.1. DC Offset

5.2. Harmonics
5.3. Interharmonics
5.4. Notching
5.5. Noise

6. Voltage Fluctuations
7. Power Frequency Variations

Basically, the idea of my work began by the suggestion of reading this paper. Generally IT staff does not handle electrical terms properly, nor take into consideration the data loss or data corruption that electrical disturbances might be causing them. Therefore, people in charge of data management around an enterprise might have a misconception of how to provide power quality to the equipment that handles their data. This white paper highlights the consciousness of power quality and how to confront the problem, contributing the achievement of business goals. So, my intention is to take this paper as prime support, investigate deeper about these issues and them proceed to survey some of the Dominican enterprises to see how much they know, and how they confront these problems. More from this paper is included in Appendix B.

Other paper I reviewed also describes power quality. In a project about planning solutions for providing different levels of power quality, Ise, Hayashi and Tsuji, find the necessity to explain diferrent characteristics of power quality. In their paper, they divide the aspects of power quality in three categories: voltage stability, continuity of supplying power, and voltage waveform. According to these aspects, Ise, Hayashi and Tsuji present several solutions to solve power inconvenient; having in consideration three levels of power quality: normal quality, high quality and premium quality. The solutions that they design for each level of power quality are intended to be implemented in their work for the Flexible, Reliable and Intelligent Electrical eNergy Delivery System (FRIENDS).

For their work, Ise, Hayashi and Tsuji present several examples of circuits configurations for each level of power quality with proposals that assure the required compensation of each power event. Moreover, they present the results of performance tests with a simple circuit designed to guarantee various power quality levels to single-phase loads. This paper by Ise, Hayashi and Tsuji helped me raise awareness about possible classifications of power quality and fixes that can be implemented for power problems events. This paper adds more background to the definition of power quality, highlighting its importance to offer consumers satisfying levels for their requirements.

Managing power system efficiency

Jiang and Parashar have presented a system for controlling temperature in data centers and increase processing efficiency, allowing minimizing power utilization. Their approach utilizes sensor networks to track room's temperature, air currents and humidity, which permits maintain controls such as automatic triggers when hot spots are found. The data gathered by this method mades possible to capture information about the entire enviroment in the data center and reactively implement programmed policies. Furthermore, their approach has a second level where the collected data is processed by compute servers. This second level has a proactive management action, where the data is examinated for management strategies and outline enduring policies.

For their work, Jiang and Parashar conducted tests of their experiment aided with the Gridmap/iZone programming system, merging the sensor network collecting mechanism with processing algorithmics. The system was used in a simulation using models for cooling and power intake. The outcome of this experiment showed that

temperature administration is performed in short order, and that in-network management accomplishes minimizing power costs and accelerating real time management reactions.

Administration measures inside data centers, like the one described by Jiang and Parashar, help cut down power intake which translates into costs reduction. Smart administration of the energy load in data centers helps increase equipment lastingness, therefore, reducing chances of failure. This study contributes to my research suggesting a system that could be implemented to optimize power consumption and performance in a data center.

In a work developed by White and Freeman, they define the requirements for choosing a data communications bus for power system management. The design of a protocol must comply with three requirements in order to prove its effectiveness: must be cheap, robust, and timely transmission of information. White and Freeman, stand out that "failures that drive voltages out of tolerance can result in corrupted data". They conduct analysis for data communication busses and provide their suggestions for employing every presented bus. Moreover, data communication busses where compared for use with different administrative power system applications. Power utilization is discussed in this work, which relates to my investigation as we must be aware of all possible points of failure that our systems might have while dealing with power problems. Part of designing correct strategies to defend our systems is getting to know how our systems work.

A report by Jennings comments about proposed measures to optimize energy consumption in data centers. These measures are longed to be part of a future implemented legislation. The set of standards are based on the growing power consumption in IT infrastructures, defining best practices for reducing power intake. Jennings describes how resources can be rethought for optimizing utilization. However, the article states that, at the moment, not so many companies are enthusiastic about

putting their hands in these standards. This is due to data breaches that may result from auditing in hands of some private consultant practices. Problems of power distribution in data centers are less complex to resolve if there are a set of best practices to follow; in addition, power consumption is reduced, translating into costs cutback. These practices can add to my work solutions to improve power management in order to reduce power problems. Besides, generation of backup power for maintaining business continuity is eased.

With the power crisis, powering air conditioning systems might result into a challenge. In an article by Costanzo, he addresses Andrew Fanara, which is the team head for Energy Star product development, noting this important fact: "Heat is the No. 1 reason for the failure of electrical products". He also shares that power and cooling are the top two problems faced by IT operators, according to a survey performed by the IT consulting firm Robert Frances Group. Costanzo also noted the impact of virtualization, where the optimized use of servers reduces energy consumption, therefore being easier to energize for business continuity purposes.

Past experiences awake awareness

Two decades ago, an article described how a company requested the design and implementation of a system that fulfilled their need for power supervision in the provisioning to their data centers. This article, by Lockard, explained how Bell of Pennsylvania was having power problems due to transients. To solve their problem they opted for the solution of an uninterruptible power supply supported by a complex power monitoring system. In the article, Lockard reviews the requirements of the company and the processes that they went through in order to implement the system. After the system

deployment, Bell of Pennsylvania could easily locate electrical problems, resolve their cause, and apply resolutions to prevent subsequent occurrences. This article highlights that, since two decades ago, there is evidence of the need to assure power quality administration in data centers. As stated in the article, one of the first steps to resolve a power problem involves determining if the problem was created within facilities, or it is a problem in the provisioning. In my work, I try to get this primary point to the attention of data center managers, and every person that is responsible for equipment of data processing; that is, that they must be aware of providing quality power to their facilities.

In an article about IT managers' experience in a blackout during 2003, Thibodeau talks about backup strategies and repercussions of the disaster. The presented data in the article is based from a survey performed to enterprises in the affected zone and the surrounding areas. Between the actions taken after the blackout, there were plans about testing backup power equipment, providing additional training, and plan existing disaster recovery plans. From the blackout, it was revealed that there was deficiency in the training of many companies' staff. Unaffected companies responded to the disaster too, by planning to perform real-time backup to improve their security. Calculated consequences from surveys yield that 13% of affected companies reported losses between US$100,000 up to US$10 million. The majority determined that had losses less than US$10,000. Looking at how adversity can happen and effortlessly take down a company encourages implementing best practices to protect assets. Power problems happen constantly in Dominican Republic, and my research reflects how companies are facing these issues.

Maness discusses lessons learned in an article where he points out which can be the consequences of worst-case situations, and what preventions can be arranged to avoid them. As described in the article, a proper implementation should be a widespread disaster recovery arrangement; where disaster recovery plans ought to extensively cover system resources, data centers, remote offices, and all computing infrastructure.

Furthermore, disaster recovery plans must aim to protect branch offices as well as company's central offices. Maness states that "operational downtime is costly to businesses and unacceptable to customers". Disaster recovery plans must be set and reachable at all times; a company is in jeopardy if it does not count with it. In a success history commented by Maness, a major airline with a proper planning counts with two data centers, having data replication, synchronously mirroring data ten miles away. Their setting includes power input from different power grids, several diesel generators, various UPS systems, and a natural gas backup system in their secondary office. This scenario have provided the airline with a robust setting enough to protect their business continuity. The article also presents a study conducted by VERITAS Software, where the outcome highlighted that a significant sector of the business has been motivated to prepare a disaster recovery plans because of terrorism threats. Maness also comments that periodical tests and updates of plan procedures are indispensable, but a significant number of companies do not follow this good practice. Furthermore, Maness states that full backups, absolute automated and redundant system are necessary to protect data assets. As showed in this article, a company must be prepared with a full round plan for business continuity. My work is based in the idea of exploring the part of power quality intake in both, disaster recovery and business continuity, guaranteeing data integrity.

Mearian reports in an article that IT departments were better prepared for the blackout suffered in Manhattan and New Jersey back in 2003, as improvements were made after the September 11, 2001 attack. This blackout caused that many enterprises ran their disaster recovery plans. A representative from an interviewed affected enterprise informed that he performed data backup as precaution to assure business continuity in case another branch office had to take over. Another enterprise reported the use of crisis management teams, to evaluate the situation. The solution that a university implemented was to take data snapshots, as soon as power started failing, so they could restore their data as updated as they could. It is reported that disaster recovery plans usually include the use of diesel generators to protect from power interruptions. Furthermore, with the

utilization of data replication for backup, operations can be resumed from a site in an unaffected zone. As shown in the article, lessons learned can be easier to correct in an update to an implemented disaster recovery plan. Mearian notes that a negative consequence from a blackout can be that important processes are interrupted if a plan for proper backup power is not implemented. Power outage in Dominican Republic is a common problem that all business must issue. Protection against power interruptions, power distortions, and others, must be implemented in disaster recovery plans. My investigation digs into this problem, presenting most common problems and most implemented solutions by Dominican Republic middle size enterprises.

In another article by Mearian, he documents the consequences of the August 2003 blackout, as IT executives reinforced their planning to protect IT deployments. Lessons learned descrived in the article undertake projects to reinforce networks. Upon the improvements made by interviewed enterprises, solutions vary between upgrade network connections, add ISP redundacy, use data replication between several IT premises, include IT infraestructure in backup generator circuits, have premises located in separate power grids, increase the amount of diesel fuel stored, among others. A recommended good practice to implement is to extend the amount of tests performed periodically, i.e. monthly tests of backup generators, under complete systems load. Mearian notes that no matter how good a plan is, it is easy to overlook a small detail. In my research, issues with power supply are investigated, presenting a general idea of how enterprises in Dominican Republic plan for protecting their data. Additionally, points for potential improvement are identified.

One year after the blackout of August 2003, Khanna reports consequences and stories from those affected. The article comments how, even thought afflicted business had continuity plans and disaster recovery plans, many of them found themselves looking at weakness in their strategies. Reported losses, showed the importance that represent having business continuity plans and disaster recovery plans in place. Between the

measures taken, some of those affected planned in preparing off site workplace, to relocate business in case of emergencies. Moreover, other measures were reinforcement of their backup power supply. With all these reports from the consequences of the mentioned blackout, it is outstanded how important is for a business to know its weaknesses and to be prepared. Hence, my investigation provides a background of what is the situation regarding business preparation against power problems in Dominican Republic, and offer incentive to improve their infrastructure.

In an article concerning disaster recovery plans and protection of IT assets, Osborne writes about the experience of a company, VERITAS Software Canada, that provides solutions for protecting and administrating data. Several situations from this company's customers are presented. The article stresses the importance of a disaster recovery plan along with business continuity plan. Furtheremore, it is pointed that many businesses are caring to implement them as experiences, from September 11, 2001 and August 2003 blackout in Ontario and parts of the US, have made more conscious. A representant from VERITAS Software Canada says that according to the targeted objective, there are different solutions that can accommodate to a client's infrastructure. Factors to consider while choosing an appropriate recovery product are the recovery point objective (RPO) and the recovery time objective (RTO). Osborne mentions that, between the proposed solutions, a business should count with data backup and recovery systems. Data replication and clustering are used being used in the most updated systems. Moreover, Osborne affirms that in every planning of disaster recovery is necessary the consideration of future growth of the business. This article remarks the importance of knowing the assets to protect in a business, and the importance of planning prevention to avoid data losses or corruption. My work has as objective to note current flaws in how Dominican Republic enterprises confront common problems in the energy supply for equipment that manages their data. In the results of my investigation are presented how Dominican Republic middle size enterprises see the importance of disaster recovery plan and business continuity plan, from the point of view of power provisioning.

Preventing by planning ahead

Power management company, Eaton Corporation, shares some useful rules to follow as best practices for defense against power problems. Their first advice is to identify the possible threats. No matter what the probabilities are, incidents can happen and cause considerable losses to an enterprise. Their second advice is to think about what assets can be compromised in case a disaster occurs; even small companies made investments in computer equipment and applications to run their business. Another tip is to do not overlook a backup system or continuity plan just because of the size of the company. All companies are vulnerable if they are not properly protected. Also, Eaton recommends treating all IT infrastructures as data centers; implementing rules and regulations are not optional according to the size of the business. Among considerations Eaton lists: power distribution, power protection, thermal administration, cable organization, flexibility and monitoring. Finally, their last advice is to evaluate the company infrastructure, in order to identify the appropriate protection needed. By having these topics in mind, Eaton assures, a company can diminish the chances of being affected by a problem in their power systems.

The situation in Dominican Republic

To provide a general background of the situation regarding the energetic crisis, I have researched for articles that define the electricity problem in Dominican Republic. Power in this country is provided by three electricity generator companies: EDENORTE, EDESUR, and EDEESTE, being the first two managed by the state, and the latter private.

According to a source, the Dominican energetic problems have been present since 1999. However, many agree that the problem goes back long before.

Even though, there have been several suggestions to resolve the energetic crisis in Dominican Republic, as the one suggested in the article "Proponen modelo para solucionar crisis energética", the collection and distribution of the service has always been a problem. The collection of the power service in Dominican Republic is an issue that has resulted into the state subsidizing the difference of the consumed electricity and the payments by consumers. On the other side, the government claims that the energetic crisis is due to the lack of generation of power from the generator companies.

The energetic crisis in Dominican Republic reached a 40 percent deficit in the generation of power in 2008, as reported in article "Generadoras eléctricas operaban con déficit". The problem is caused by the lack of fuel and service outage due to maintenance. But the trouble also comes from the absence from the national government to pay to the electricity generator company. There have been several delays in the payments according to the latter. The debt was reported to be more than 400 millions of dollars, at that moment. The electricity generator company threatened with suspending its services if the dept was not pay. Blackouts have been the cause of several popular protests, and several business representatives claimed that damages caused from blackouts have them on the brink of ruin.

According to the article "República Dominicana a las puertas de crisis energética", in 2009 only a 71 percent of the power demand is being covered in Dominican Republic. Power generators are not working at their full capacity due to the lack of fuel, having as consequence blackout in most of the provinces in our country.

Repetitive blackouts of up to 20 hours were reported in the article “Se intensifica la crisis energética” by Santana. Several protests against the bad service took place in many zones of the north region of the Dominican Republic, according to the article.

The president of the Manufacturers’ Association of the Northern Region (AIREN, according to the acronym in Spanish) claims that it became an extreme necessity to resolve the energetic crisis, in order to diminish the consequences of the international economic crisis in Dominican Republic. The president stated that the electricity problem affects the whole nation, and that national development is blocked.

Various sectors have demanded the government to resolve the problems with power generation and distribution. In the article “Piden Gobierno buscar opciones”, the association Foro Social Alternativo asks for a resolution for this problem, and for the implementation of methods to reduce the high rate of the electric consumption. The high rate charged to electricity causes that the most deprived steal this service, having as consequence of a bigger problem. The association mentions that the law 112-00 about hydrocarbons in Dominican Republic frees electric generators of taxation, which the latter have taken advantage of this law to enrich themselves. This association claims that losses in the production sector of the country and households are greater than 200 millions of Dominican pesos.

In the article “Piden políticas”, Bonilla commented a recent forum were topics for resolving the energetic crisis in the Dominican Republic were discussed. The use of renewable energy as a solution was greatly discussed, along with planning for making tests using this type of systems. Also, programs for energy saving and constant monitoring of the power sector were talk about.

In the article “El Cibao necesita más energía”, Severino writes about the problems with power generators in the north zone of Dominican Republic. Severino described how it is urgent to provide for the lack of generators, as the north zone is one of the principal areas of industrialization and production in the country.

In a recent article, the Corporación Dominicana de Empresas Eléctricas Estatales (CDEEE) made an announcement saying that blackouts are going to be reduced as several generators that were out of service are going to be reintegrated to the system. With this change, 80 percent of the demanded power is going to be covered. Moreover, the representative from the CDEEE said that public companies are going to be required to reduce their power consumption, in order to contribute to the problem’s solution. The CDEEE stated that problems with electricity are due to a delay in the fuel distribution, and to the breakdown of several generators. In addition, it was noted that more than 20 hydroelectric generators have been out of the system, and a number of important electric generators have stayed shut down because of the government debts. The representative affirmed that there was a debt of more than 200 millions of Dominican pesos that was due at the end of March 2010.

Severino comments about the state of several electricity generators in Dominican Republic, as well as reasons of recent repetitive blackouts, in the article “Largos apagones”. Complaints about blackouts have increased lately as several provinces have been experiencing long periods of time without electric service. Many are the reasons that a great number of generators are out of service: maintenance, heat, failure, lack of fuel, among others. To try to diminish the problem, even generators that are not efficient have been turn on. Another problem is the low level of water in reservoirs in order to give enough power to hydroelectric generators. The lack of generation seems to be the main cause in recent blackouts. It is also noted the high cost for generation, together with a tradition of not paying for the received service, which stops the planning for new and efficient generators.

In the article “Crisis eléctrica espanta inversión”, a Dominican engineer expresses that investments in the country have been discouraged as a result of the power problem. In this article, it is noted that many factories are barely used as storage for distribution of imported goods. The engineer also observes that there is no action plan in way of implementation in order to resolve the electricity problem. The problem causes that the competitiveness of the country becomes lower every day.

In the article “La crisis eléctrica es”, Severino comments about how the productivity of small and medium enterprises is the most affected by the power crisis in Dominican Republic. Given that with a limited capital, often these businesses are forced to invest in generators instead of updating equipment or supplying themselves with new resources. It is notable the difference for small and medium enterprises that have to compete with others business in Central America, which pay a much lower rate for the power service, and do not have to invest in extra power generators to meet business’ requirements. In the article it is also highlighted the case of enterprises that do not count with enough resources for a second backup generator. For these ones, blackouts often mean long work hours lost.

Methodology

This work analyzes the consequences that energetic crisis has had in data management in the Dominican Republic. In order to cover the subject appropriately, I have interviewed a set of representants from middle size enterprises that handle considerate amount of data over daily labor.

First, to prepare the interviews, a basic research was conducted to analyze the most frequent electric problems in the Dominican Republic. This basic research consisted in meeting with some colleagues that have had some experience with power problems in the Dominican Republic, colleagues that work in the local power provider company and newspaper articles.

As well, while preparing the interview process, I listed the requirements that the enterprises to interview had to meet, and proceeded to select which ones were going to be in the sample. For this investigation I used a sample of convenience. Given that most enterprises are not willing to participate in surveys or interviews that reveal their internal logistics, I selected enterprises were known colleagues work at, enterprises were I could reach to a person that could participate in my interview, and were able to trust in the purpose of this study. Another condition established was that it ought to be a middle size enterprise that needs to manipulate considerable data processes around the enterprise. These data processes might include data access, data saving, data updates, or executing backups. For this investigation I have interviewed a total of seven enterprises.

When I prepared for the interviews, I selected the questions I had to ask so the outcome information could be as complete as possible. The survey consisted of a series of nineteen questions that cover how the business is affected, staff preparation, how its consequences are spread and measures taken to control any effect that a power trouble might generate. The questions outline can be found in the appendix A of this work.

After I got the results of my interviews, the next step was to analyze the outcome by evaluating how prepared are Dominican enterprises for preventing that the energetic crisis causes them problems regarding data management. Following this evaluation, I developed a list of suggestions that enterprises should follow in order to prevent that their data management is affected by power problems.

Deliverables

The target used in my interviews consisted of middle size enterprises located in Santiago, Dominican Republic. Most of these enterprises whether have branch offices located in other provinces, or they have link connections to other countries where they provide service. The seven enterprises that are part of the universe for my interviews in this investigation have the following profiles:

- Electronics supplier store located in Santiago with branch offices in Santiago and Santo Domingo. This business counts with own edifications, for which they have had to implement power backup systems to support whenever the local power distribution company fails. Whenever a power failure occurs, processes are delayed due to the lack of comunication with databases and systems.

- Company dedicated to offer service to other companies and individuals in the area of web services, such as mail, hosting and domains. The company needs to maintain connections with other data centers located worldwide. This business, located in Santiago, has its own edification, and it is provided with its own backup power system.

- Company, located in Santiago, dedicated to offer support remotely to the data processing unit department of a financial company. The company in Santiago is located in a commercial mall, which provides to its modules an electric diesel generator, as a second power supply source. Internally, the business counts with Uninterruptible Power Supplies (UPSs) to sustain during hangover of primary (from the local service provider) and secondary power provision systems.

- Telecom located in Santiago, which offers personal and corporative Voice over Internet services. Has branch offices located in Santiago and a few other provinces in Dominican Republic, as well as interconnection with other service providers, locally and internationally. Offices are located in commercial malls.

- Manufacturing plant located in Santiago, which depends on availability of work hours in order to be a profitable business. This business owns its infrastructure, and needs to provide all its maintenance and protection.

- Cultural development and promotional center located in Santiago. Counts with its own installations in order to provide services of investigation, exhibition, activities' promotion, among others. Counts with its own resources to protect assets and provide its infrastructure preservation.

- Contact center located in Santiago, Dominican Republic. Provides outsourcing services internationally, offering outbound and inbound campaigns as well as other support operations. Placed in a commercial mall, with own backup power systems and protection.

This study yields results of how information officers are aware of preventions, measures taken, and most common power problems that they should be able to confront. The interviews were performed in March 2010. Description of all the outcomes of the interviews is provided in this section.

Significance of data availability

When asked about keeping data availability 24/7, interviewees described the importance to keep this true for their businesses:

An electronics supplier representative responded that the availability of data is extremely important because it must be on hands for billing systems, inventory, and to provide security at the time of any sale. Moreover, they have branches that are connected to servers in the main office, so data links must be accessible at all times. Furthermore, when using remote connections to servers it is the most evident that data must be obtainable at all times; "ten minutes without server is chaotic" the interviewee commented.

Other interviewed, from an enterprise dedicated to Internet related services, mentioned that their data availability is more than vital; if they do not have uninterruptible power, they can not offer their services. They say that in an extreme situation, they could last only as long as 24 hours without being operational.

A company that works with financial reports said that it is very important to have their data accessible because the entire data processing department depends on their continuous availability with remote connections. The interviewed described that theoretically they are not allowed to have any downtime, but at reality, they are given approximately an hour maximum to try to fix a problem; otherwise, if the time is exceeded, they have to search for other contingency measures.

Another interviewed enterprise was a voice service provider. The interviewee stated that data availability is 100% important because the data about the customers needs to be handy at all times. They said that there is no room for unavailability, as they are a telecom. Whenever they have a disaster to confront they need to be up in less than half hour.

A manufacturing facility that works 24/7, when asked about importance of their data availability, answered that it is very important; having only allowed a few hours to respond for any issue.

A cultural development center stated that data availability is very important for them. They always have people connecting through VPN, visiting their web page, using their e-mail platform via webmail, and so forth. In addition, there are always people using their online catalog of music, books and cultural activities. They have established that their down time could only be as much as 3 hours per year.

The last interviewee was a contact center which declared that, as a 24/7 company, their data should be available at any time. Even 10 minutes of being out of service has a high cost for the operations. By the last calculus made by the company, it was show that they cannot be out of service for more tan 4 hours.

Actual power problems

Blackouts are common for the interviewed electronics supplier, in last days having problems twice a day. However, the interviewee commented that, in average, there is a blackout once a week. The person in place described that there is an inverter present in the company which has been presenting failures, and affecting network connections. The interviewee said that the proper level of importance have not been given to this kind of issues. Besides, those affected do not report the problems as they should. Even though, the personnel responsible for administration of IT is considered highly qualified; having as well the facility to obtain the proper equipment for protection.

As for the enterprise dedicated to Internet related services, they set as example that before they had implemented a reliable solution for continuous backup of data, they were victim of data loss, and lost of equipment including: PCs, servers, and air conditioning units. Nevertheless, at the moment they are better prepared.

The company that provides support to a financial reports company commented that their office is located in a commercial building, which is provided with an electric generator. However, the generator has a transition process between itself and the income from the electric company provider. At the time of this transition, the IT infrastructure depends on uninterruptible power supplies (UPS) to maintain a constant power delivery. The situation worsens in the case where the electric service company providing electricity is not constant; these variations tend to make their backup equipment to be damaged or not effective.

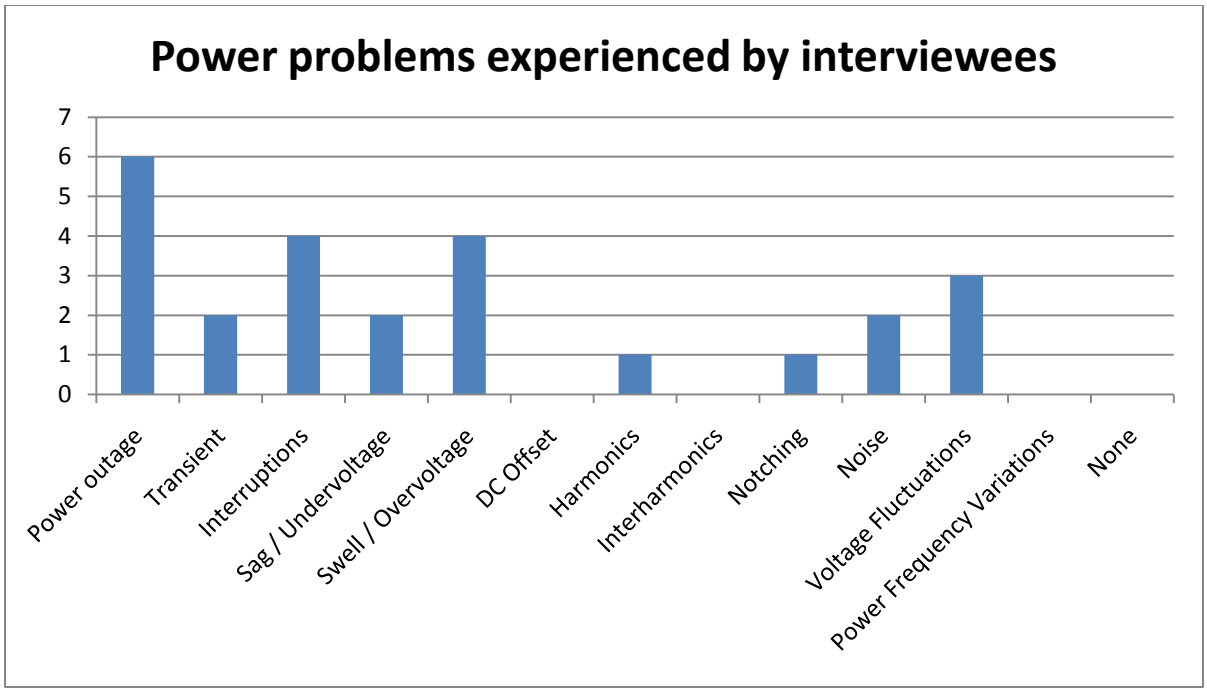
The manufacturing facility noticed that in recent months, they have had frequent energy problems due to power outages, but these have not been of long duration. For this kind of problem they say to be repaired, yet some implementations could take place.

As well, the voice service provider commented that often, electricity has a lot of outages and they have to rely on inverters and plants for hours. Despite the inconveniences, the interviewed affirmed that they have no problem confronting this kind of issues.

The cultural development center interviewed shared that the biggest problem they had was with the T1 Data router. The serial interface kept going down and up for several times, until once for all it stop coming up. The problem was caused by a voltage fluctuation that damaged the mother board of the router. The person in place stated that even though they are prepared, some implementations could be made to improve their protection.

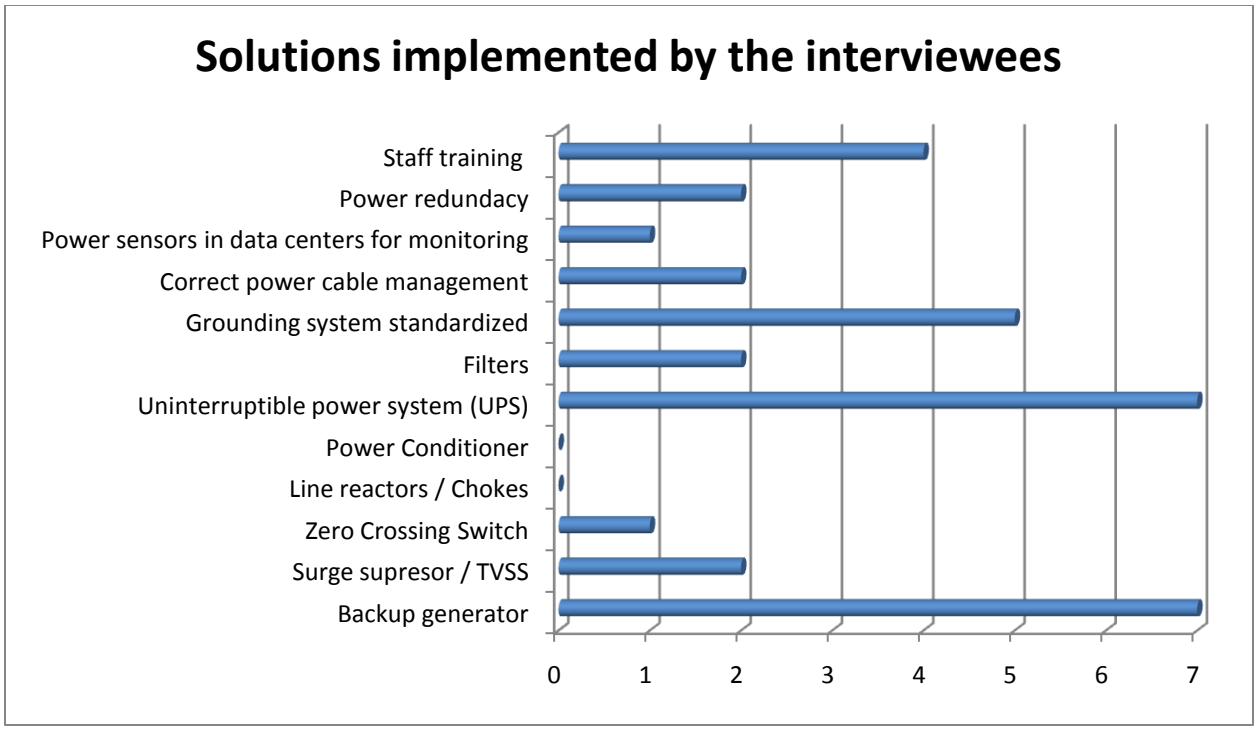
As for the opinion of the contact center representative, the person explained that electrical problems happen all the time. Either they have to face blackouts or have low voltage. While describing how capable of overcoming these issues, the person stated that their current structure works fine by now.

The most common power problems, that the interviewees know that might be experiencing their companies' power intake, are shown next:

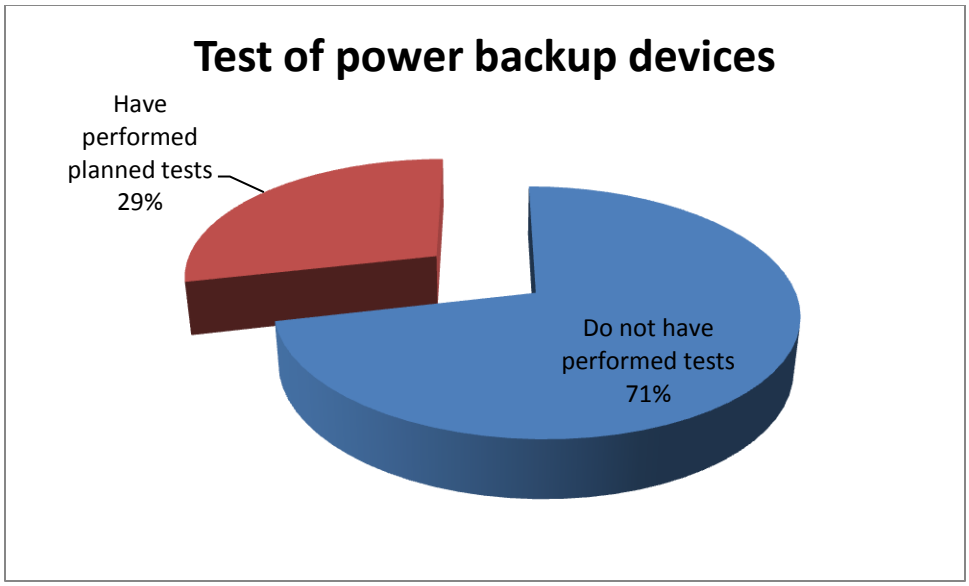


Many of the interviewees confessed that besides the power problems they could report to have attested, there are others that might be present, as extensive studies have not been conducted.

Upon measures taken to protect their data infrastructure, the interviewees shared to have implemented the following solutions:



When asked about testing backup power devices the outcome presented that most of the enterprises only realize the state of their equipment when perturbations occur. Only two out of seven, affirmed to test their back power devices.



Business continuity plan

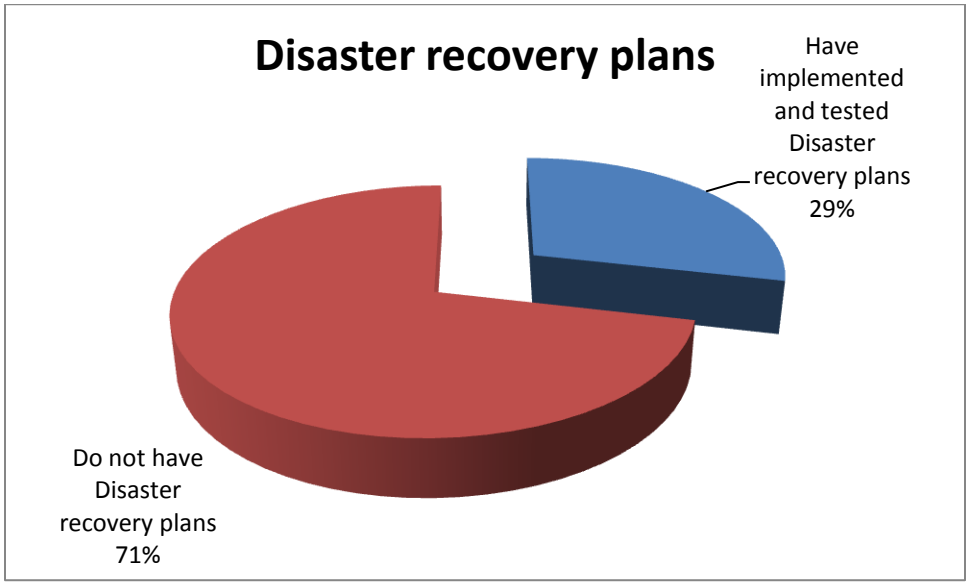
Some of the interviewees commented that even though they do not formally have a business continuity plan available, they count with some solutions that help them maintain operational. Among the measures taken by these companies, to confront power problems in business continuity plans, are deviation of load, troubleshooting in the shortest possible time, UPS for stations, a general UPS, diesel generator, and provide electric maintenance.

Almost half of the interviewees that own a business continuity plan affirmed that they have tested the section of their business continuity plans that covers power problems. One of them stated that they “have developed several scenarios that include the lost of power and the steps to work around them”. Comments in whether their companies should improve their business continuity plan, just almost half interviewees agreed that

they should; since the serious energy problems in our country, businesses are affected easily.

Disaster recovery plan

Most of the interviewees in the sample for this investigation affirmed that their enterprises do not have disaster recovery plans available. Just two out of seven responded to have a disaster recovery plan in place, and they claim that it has been properly tested.



Problems in the premises of service providers

In case of a wide spread outage, the power problems of an ISP might affect business continuity. According to the results of my interviews, most of them agree that the information coming from service providers is almost null. There is not a formal communication explaining what happened, nor when service will be restored. One of the interviewees clarifies that he understands the lack of communication in case of occurred faults, as a reason for maintain confidentiality of service providers.

Normally, service providers in Dominican Republic do not respond to their customers properly when breakdowns occur by giving any type of communication. If there is a significant downtime in regular services, they make some promotions in order to compensate their customers. Although, at enterprise levels, service providers might behave more responsible. In case of interconnecting service provider companies, problems are notified right away according to protocols, including response times and briefs explanations of occurred events. Most of interviews agree that whenever service providers have issues in their premises, they resolve them in a timely manner.

Conclusions

According to the outcome from the interviews completed for this work, power quality readiness for maintaining data accessible, and securely saved, is extremely important. Electronic data has become each day more critical to businesses. Essential processes of business depend on having data available and being able to work with it. Downtime costs affect negatively any company and might leave them out of business.

The power crisis in Dominican Republic have forced middle size enterprises to implement solutions to feed and protect their electronic assets, whenever the local power supplier fails to deliver. Blackouts are constant in our country, and continuously cause equipment failures, operations delay, and data loss.

In order to assure that data management is not affected, IT equipment must be provided with efficient and reliable electricity supply. A good practice is to have a power consultant to evaluate the level of power protection needed, in order to provide equipment with power quality. The power consultant must be able to determine which types of power problems are present in the premises of the client. Moreover, the cause of this problem should be determined, in order to provide the best solution for the business in question. Among the most common equipment to guarantee power quality are: Uninterruptible Power Supplies, power conditioners, voltage regulators, batteries, backup generators, and adequate cooling systems. In appendix C are described the most common solutions that help provide power quality intake to equipment.

Furthermore, a business must count with Disaster recovery and Business continuity plans in place. These should be tested periodically, and updated. Backup test should be designed not to disrupt the business continuity. Also, concurrent maintenance to equipment must be completed within a power protection plan. Automated tools should be used in Disaster recovery and Business continuity plans to prevent human faults, and complete processes timely.

Protecting data in a business, from any type of power problem, is a matter of following good practices, being correctly advised, and implementing proper solutions.

References

Bonilla, Teofilo. “Piden Gobierno Buscar Opciones para Erradicar la Crisis Energética.” *El Nacional.* Economía. Santo Domingo. N.p. 10 Apr. 2010. Web. 26 Apr. 2010.

---. “Piden Políticas para Enfrentar Crisis Energética.” *El Nacional.* Nacional. Santo Domingo. N.p. 20 Jan. 2010. Web. 26 Apr. 2010.

“CDEEE Dice Habrá Menos Apagones.” *El Nacional.* Nacional. Santo Domingo. N.p. 9 March 2010. Web. 26 Apr. 2010.

Costanzo, Chris. "Data Centers Generating a Host of Energy Issues." *American Banker* 18 Jul 2006, Research Library, ProQuest. Web. 7 Apr. 2010.

“Crisis Energética en República Dominicana.” *Ministerio de Economía y Finanzas, República de Panamá*. N.p. n.d. Web. 26 Apr. 2010. <http://www.mef.gob.pa/Cope/pdf/Crisis%20energ%E9tica%20en%20R%20Dominicana.pdf>.

"Eaton Identifies Five Best Practices To Protect IT Infrastructure Against Seasonal Power Problems." *Business Wire* 17 August 2009 ABI/INFORM Dateline, ProQuest. Web. 7 Apr. 2010.

Gabel, David. "Systems Safeguard - Part I: Don't Be Left in the Dark - Power-Protection Devices Help Keep Your Data Center Up and Running." *Computer Decisions* 9 Apr. 1985: ABI/INFORM Global, ProQuest. Web. 7 Apr. 2010.

"Generadoras Eléctricas Operaban con Déficit de un 40 por Ciento de Energía, Población al Grito por Apagones." *lanaciondominicana.com*. Santo Domingo. N.p. 27 Nov. 2008. Web. 26 Apr. 2010.

Harrison, Ben. "Protecting Communications Systems with Backup Power Can Be a Creative Effort." *Telecommunication Products & Technology* 1 Jul 1984: ABI/INFORM Global, ProQuest. Web. 7 Apr. 2010.

Ise, T.; Hayashi, Y.; Tsuji, K.; , "Definitions of Power Quality Levels and the Simplest Approach for Unbundled Power Quality Services," *Harmonics and Quality of*

Power, 2000. Proceedings. Ninth International Conference on , vol.2, no., pp.385-390 vol.2, 2000. <doi: 10.1109/ICHQP.2000.897711>

Jennings, Cath. "Datacentre Energy Under Scrutiny." *Computer Weekly* 17 Feb. 2009: ABI/INFORM Trade & Industry, ProQuest. Web. 4 Apr. 2010.

Jiang, N.; Parashar, M.; , "Enabling Autonomic Power-Aware Management of Instrumented Data Centers," *Parallel & Distributed Processing, 2009. IPDPS 2009. IEEE International Symposium on* , vol., no., pp.1-8, 23-29 May 2009. <doi: 10.1109/IPDPS.2009.5160976>

John Schwartz. "Disaster Plans Get New Scrutiny After Blackout." *New York Times* 19 Aug. 2003, Late Edition (East Coast): ProQuest National Newspapers Premier, ProQuest. Web. 7 Apr. 2010.

Joseph Seymour, Terry Horseley. “The Seven Types of Power Problems.” *White paper #18*. APC.

Khanna, Poonam. "Blackout Shines Light on Need for Business Continuity Plan." *Computing Canada* 10 Sep. 2004: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

Lockard, Ray W.. "Making a Power Play." *Telephony* 4 Jun 1990: ABI/INFORM Global, ProQuest. Web. 7 Apr. 2010.

Maness, Bob. "Preparing for Worst-Case Scenarios in the Data Center: Lessons Learned." *Computer Technology Review* 1 Sep. 2003: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

Mearian, Lucas. "Disaster Recovery Plans Put to the Test; Users Report Resilient Systems." *Computerworld* 18 Aug. 2003: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

---. "One Year Later, IT Prepares for Next Disaster." *Computerworld* 2 Aug. 2004: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

Menn, Joseph, and Quinn, Michelle. "Power Outage Shuts Down Websites; A San Francisco Data Center's Supposedly Crash-Proof System Puts Customers in the

Dark: [HOME EDITION]." *Los Angeles Times* 25 Jul 2007, Los Angeles Times, ProQuest. Web. 7 Apr. 2010.

Moad, Jeff. "The Uninterruptible Power Problem." *Datamation*: International 1 Aug. 1991: ABI/INFORM Global, ProQuest. Web. 7 Apr. 2010.

"New AFCOM Data Center Industry Survey Shows Effects of August Blackout on Nation's IT Grid." *PR Newswire* 15 September 2003 ABI/INFORM Dateline, ProQuest. Web. 7 Apr. 2010.

Osborne, Toby. "Protect your Data." *Summit* 1 Sep. 2004: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

Plasencia, Aleida. "Crisis Eléctrica Espanta Inversión hacia Centroamérica." *Hoy digital*. El país. Santo Domingo. N.p. 24 Feb. 2010. Web. 26 Apr. 2010.

"Presidenta AIREN Dice Crisis Energética Complica Sectores Productivos." *DiarioDigitalRD.com*. Servicios de Noticias. Santo Domingo. n.d. Web. 26 Apr. 2010.

"Proponen Modelo para Solucionar Crisis Energética." *DiarioLibre.com*. Diario Libre. Santo Domingo. 22 Jan. 2009. Web. 26 Apr. 2010.

"República Dominicana a las Puertas de Crisis Energética." *Revista Summa*. N.p. 15 Oct. 2009. Web. 26 Apr. 2010.

Santana, Ricardo. "Se Intensifica la Crisis Energética en la Región del Cibao." *Listindiario.com*. La república. Santo Domingo. N.p. 17 Nov. 2009. Web. 26 Apr. 2010.

Severino, Jairon. "El Cibao Necesita más Energía con Urgencia." *Listindiario.com*. Economía & Negocios. Santo Domingo. N.p. 16 Feb. 2010. Web. 26 Apr. 2010.

---. "La Crisis Eléctrica es más 'Cruel' con Pymes." *Listindiario.com*. Economía & Negocios. Santo Domingo. N.p. 4 March 2010. Web. 26 Apr. 2010.

---. "Largos Apagones por la Sequía y Fallas Técnicas." *Listindiario.com*. Economía & Negocios. Santo Domingo. N.p. 19 March 2010. Web. 26 Apr. 2010.

Thibodeau, Patrick. "Blackout Experience Yields Divergent Backup Strategies." *Computerworld* 22 Sep. 2003: ABI/INFORM Global, ProQuest. Web. 4 Apr. 2010.

Tim Akers, Vice president, AT&T. "Businesses Must be Prepared for Future Blackouts: [Chicago Final Edition]." *Chicago Tribune* 31 Aug. 2003, Chicago Tribune, ProQuest. Web. 7 Apr. 2010.

White, Robert V.; Freeman, Dave; , "Data Communications Issues for Power System Management," *Applied Power Electronics Conference, APEC 2007 - Twenty Second Annual IEEE* , vol., no., pp.1188-1199, Feb. 25 2007-March 1 2007. <doi: 10.1109/APEX.2007.357666>

Appendices

Appendix A

OUTLINE QUESTIONS USED IN THE INTERVIEW PROCESS

The following questions are intended for the interview proccess from the research of power problems that affect a company's data management in Dominican Rebuplic. The name of your company will not be appearing in the submitted documents of the research, therefore the information you provide will be kept anonymous. Las siguientes preguntas tienen como propósito formar parte del proceso de entrevistas para la investigación de como problemas energéticos varios pueden afectar la administración de datos en una empresa en República Dominicana. El nombre de su empresa no aparecerá en los documentos entregados de la investigación; la información que usted provea será mantenida anónima.

OUTLINE QUESTIONS

1. How important would you say is for your organization to maintain your data available 24/7? (Please describe) Qué tan importante diría usted que es para su organización mantener disponibilidad de sus datos 24/7?

1.1. How much time can your business afford to be out of service? Qué tanto tiempo podría su negocio permitirse estar fuera de servicio?

2. In your own words, can you describe the power problems situation in your company? Regarding how often have you found yourself having an inconvenience caused by a power problem. (Please describe) En sus propias palabras, podría describir la situación actual de problemas energéticos en su compañía? En cuanto a que frecuencia se encuentran teniendo algún inconveniente causado por algún problema energético.

2.1. At the moment, how prepared would you say your company is to confront the type of problems you might have? (Please select one) En la actualidad, qué tan preparada diría usted que está su empresa para confrontar los tipos de problemas energéticos que podrían tener?

- ○ Very good prepared. / Muy bien preparados.
- ○ We are fine by now. / Bien, por el momento.
- ○ Prepared but some implementations could take place. / Preparados, pero algunas implementaciones serían oportunas.
- ○ Not prepared. / No preparados.

3. What are the most common power problems that you know you might experience in your company? (Please select all that apply) (Observe attached Table 1 for reference) Cuáles son los problemas energéticos que mas comúnmente podrían experimentar en su compañía? (Favor observar Tabla 1 anexa, para resumen de definiciones de cada evento de problema energético)

- □ Power outage / Interrupción del suministro eléctrico (Apagones)
- □ Transient (Impulsive or Oscillatory) / Transitorios (Impulsivo o Oscilatorio)
- □ Interruptions / Interrupciones instantáneas
- □ Sag / Undervoltage / Caídas de voltaje / Subtensión
- □ Swell / Overvoltage / Aumentos de voltaje / Sobretensión

- □ Waveform Distortion: / Distorsión de la forma onda
  - □ DC Offset / Desplazamiento por corriente continua
  - □ Harmonics / Distorsión armónica
  - □ Interharmonics / Distorsión de las interarmónicas
  - □ Notching / Corte intermitente
  - □ Noise / Ruido
- □ Voltage Fluctuations / Fluctuaciones de voltaje
- □ Power Frequency Variations / Variaciones de la frecuencia eléctrica
- □ Not so sure, but definetely experiencing one or more of the above / No estoy seguro, pero definitivamente uno o más de los anteriores
- □ None / Ninguno

3.1. What measures have your company taken to protect against any power instability? (Please select all that apply) Cuáles medidas ha tomado su compañía como protección contra cualquier inestabilidad energética?

- □ Backup generator / Generador de respaldo
- □ Surge supresor / TVSS (Transient Voltage Surge Supresor) / Supresores de sobrevoltage transitorio
- □ Zero Crossing Switch / Interruptor de cruce por cero
- □ Line reactors / Chokes / Reactores/bobinas de choque
- □ Power Conditioner / Acondicionador de energía
- □ Uninterruptible power system (UPS) / Sistema de alimentación ininterrumpida
- □ Filters / Filtros
- □ Correct grounding system / Sistema de tierra normalizado
- □ Correct power cable management / Cables eléctricos de acuerdo a normas de buenas prácticas
- □ Power sensors in data centers for monitoring / Sensores de electricidad para monitoreo en los data centers
- □ Power redundacy (separate power grids, several diesel generators, and several

UPS systems) / Redundancia de suministro energético (separación de las redes de suministro eléctrico, más de una planta eléctrica, varios sistemas de UPS)

- □ Staff training or orientation on procedures to manage a power outage / Entrenamiento del personal para proceder en caso de fallas eléctricas

3.2. Have your backup power devices have been tested by your company? Su compañía ha sometido a pruebas los dispositivos para respaldo de energía?

_____

4. Does your company have a business continuity plan? Su compañía cuenta con un plan de continuidad del negocio?

- ○ Yes
- ○ No (If you do not, please continue with question #5)

4.1. Does it include procedures for managing power problems? Can you provide details? Este plan incluye procedimientos que tratan los problemas energéticos? Puede usted proveer detalles?

_____

4.2. Have you tested the section of your business continuity plan that covers power problems? Han probado la sección del plan de continuidad del negocio que cubre los problemas energéticos?

- ○ Yes
- ○ No

4.3. Do you think you should have a more aggressive business continuity plan, regarding power problems? Piensa usted que su compañía debería tener un plan de continuidad del negocio con un enfoque mas agresivo, en cuanto problemas energéticos?

_____

5. Does your company have a disaster recovery plan? Su compañía cuenta con un plan de recuperación de desastres?

- ○ Yes
- ○ No (If you do not, please continue with question #6)

5.1. Does it include procedures for managing power problems? Can you provide details? Este plan incluye procedimientos que tratan los problemas energéticos? Puede usted proveer detalles?

_____

5.2. Have you tested the section of your disaster recovery plan that covers power problems? Han probado la sección del plan de recuperación de desastres que cubre los problemas energéticos?

- ○ Yes
- ○ No

5.3. Do you think you should have a more aggressive disaster recovery plan, regarding power problems? Piensa usted que su compañía debería tener un plan de recuperación de desastres con un enfoque mas agresivo, en cuanto problemas energéticos?

_____

6. In case of a wide spread outage, what do you know about the power problems of your ISP? (Please describe) En caso de un apagón eléctrico general, que información le provee su suplidor de Internet e interconexiones?

_____

6.1. In similar situation, what about other companies that you might depend on to manage your data resources? (Please describe) En situaciones similares, que hay acerca de otras compañías de las cuales usted pueda depender para administrar sus recursos de datos?

_____

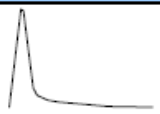
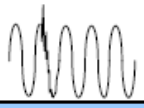
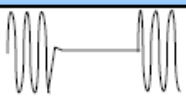
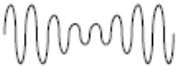
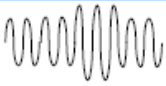
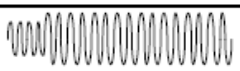
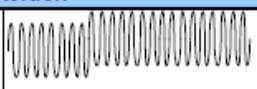
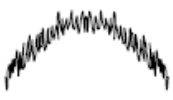
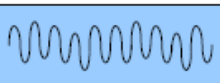
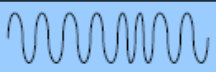
6.2. Do these companies have any policy regarding informing you about their power difficulties and how they protect your service? (Please describe) Se acogen estas compañías a alguna política de comunicación acerca de sus dificultades con problemas energéticos y sobre como aseguran el servicio que les proporcionan?

_____

6.3. How confident are you in the service availibility that these companies provide you? Que tan confiada está su compañía en la seguridad que ofrecen estos proveedores de servicios?

_____

TABLE 1. Summary of disturbances. The seven types of power problems, APC, White paper #18.

Disturbance Category	Wave Form	Effects	Possible Causes	Possible Solutions
1. Transient				
Impulsive		Loss of data, possible damage, system halts	Lightning, ESD, switching impulses, utility fault clearing	TVSS, maintain humidity between 35-50%
Oscillatory		Loss of data, possible damage	Switching off inductive/capacitive loads	TVSS, UPS, Reactors/Chokes, Zero Crossing Switch
2. Interruptions				
		Loss of data, possible damage, shutdown	Switching, utility faults, circuit breaker tripping, component failures	UPS
3. Sag / Undervoltage				
Sag		System halts, loss of data, shutdown	Startup loads, faults	Power Conditioner, UPS
Undervoltage		System halts, loss of data, shutdown	Utility faults, load changes	Power Conditioner, UPS
4. Swell / Overvoltage				
Swell		Nuisance tripping, equipment damage/reduced life	Load changes, utility faults	Power conditioner, UPS, ferroresonant "control" transformers
Overvoltage		equipment damage/reduced life	Load changes, utility faults	Power conditioner, UPS, ferroresonant "control" transformers
5. Waveform Distortion				
DC Offset		Transformers heated, ground fault current, nuisance tripping	Faulty rectifiers, power supplies	Troubleshoot and replace defective equipment
Harmonics		Transformers heated, System halts	Electronic loads (non-linear loads)	Reconfigure distribution, install k-factor transformers, use PFC power supplies
Interharmonics		light flicker, heating, communication interference	Control signals, faulty equipment, cycloconverters, frequency converters, induction motors, arcing devices	Power Conditioner, Filters, UPS
Notching		System halts, data loss	Variable speed drives, arc welders, light dimmers	Reconfigure distribution, relocate sensitive loads, install filters, UPS
Noise		System halts, data loss	Transmitters (radio), faulty equipment, ineffective grounding, proximity to EMI/RFI source	Remove transmitters, reconfigure grounding, moving away from EMI/RFI source, increase shielding, filters, isolation transformer
6. Voltage Fluctuations		System halts, light flicker	Intermittent operation of load equipment	Reconfigure distribution, Relocate sensitive loads, Power Conditioner, UPS
7. Power Frequency Variations		Synchronous equipment failure, No effect on IT equipment	Standby generators ineffectively governed	Upgrade generator governor

Appendix B

POWER QUALITY PROBLEMS

Power quality is defined by any disturbance that changes the waveform input of any electrical equipment. As described in the white paper The Seven Types of Power Problems, "in a perfect world, commercial ac power appears as a smooth, symmetrical sine wave, varying at either 50 or 60 cycles every second (Hertz – Hz) depending on which part of the world you are in." In this section, it is described the most common power disturbances that might cause program interruptions and data corruption.

Impulsive Transients

An impulsive transient is an instantaneous high peak in the electrical signal that elevates its voltage. This disturbance can be whether in a positive or in a negative direction. An example of this disturbance can be observed in the following image:

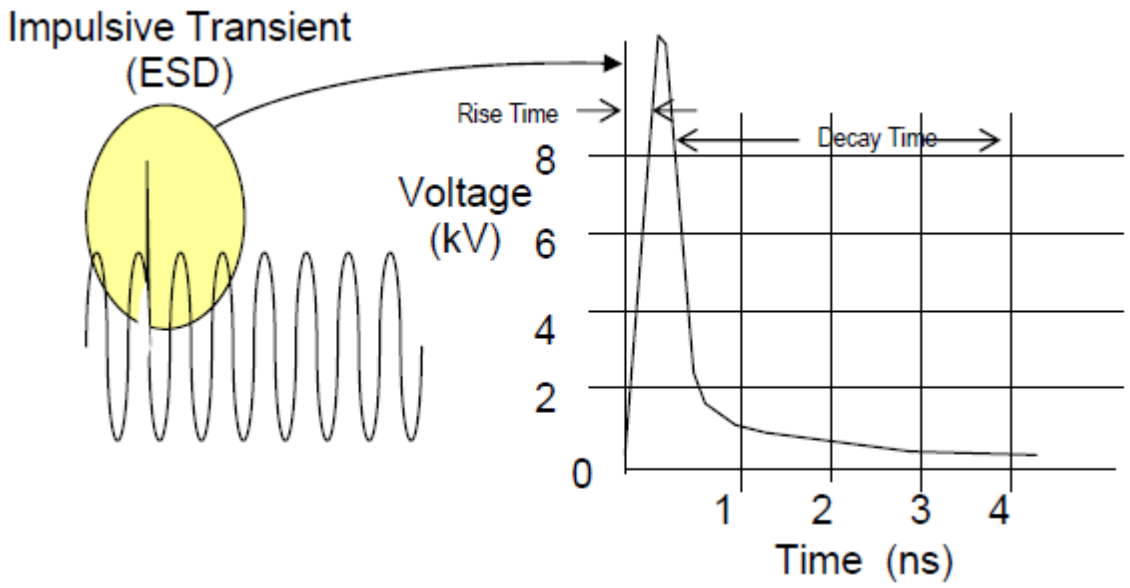


*Image from "The seven types of power problems, APC, White paper #18".

APC lists that an impulsive transient can be caused by lightning storms, poor grounding, switching of inductive loads, utility fault clearing, and Electrostatic Discharges (ESD). In addition, the effects include data loss or corruption, and physical harm of equipment. The solution of this king of problem is to use Transient Voltage Surge Suppressors (TVSS). To prevent ESD, it is advised to provide air conditioning of data centers to control temperature and moisture. Likewise, to maintain the human body grounded it is recommended the use of wrist straps, antistatic mats and desktops, and antistatic footwear, providing a correct wiring to the ground of the building.

Oscillatory Transients

An oscillatory transient is a sudden boost in the electrical signal that becomes smaller fluctuating among positive and negative limits. This problem can occur in the signal's current, voltage, or both. An example can be seen in the image:

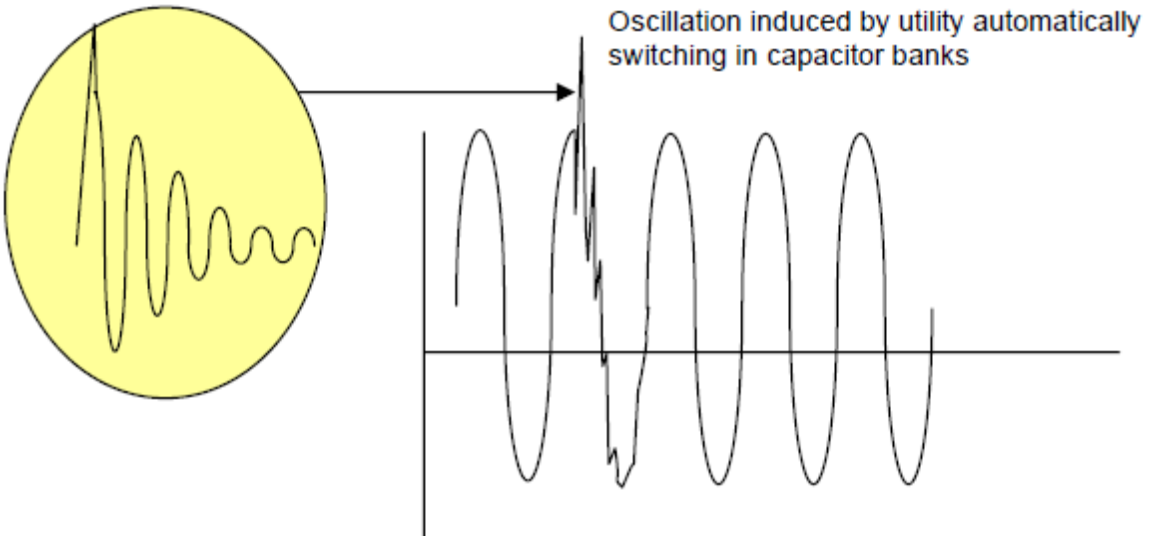


*Image from "The seven types of power problems, APC, White paper #18".

Origin of this type of problem include turning off inductive or capacitive loads, and might cause trouble to electronic equipment. To solve this difficulty it is used line reactors or chokes, and Zero Crossing switches. However, sometimes an Uninterruptible Power Supply (UPS) could be enough to solve oscillatory transients.

Interruptions

An interruption occurs when there is a complete absence of voltage or current in the electrical signal. There are various reasons for this problem, which is caused when there is any kind of disturbance in the electrical supply grid. The reason can be an accident, an animal, critical weather, equipment malfunction, among others. A power interruption can result into disruption, harm or downtime of electrical equipment. The following image presents an example of an interruption:

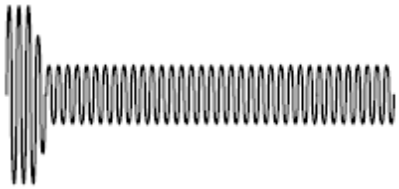
To prevent this problem it is recommended to provide maintenance of general machinery. Also, the use of solutions such as UPS and generators help reduce the impact of interruptions.

Sag

A sag is a momentary diminution of the AC voltage in an electrical wave. The most common causes of sags are system errors, and the startup of intense loads of currents. A sag can cause data corruption, and might produce minor damage to equipment. As well as interruptions, equipment can be protected against sags with the use of UPS and motor generators. An example of how a sag can be represented can be observed in the next image:

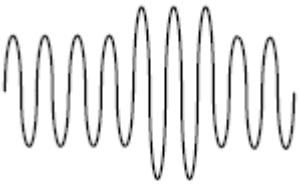
Undervoltage

An undervoltage is a drop in the voltage level of an electrical signal. It is also known as a “brownout”. This problem can produce equipment overheating. To correct this type of difficulty it is advised the use of UPS and power conditioners. The following graphic illustrates an undervoltage:



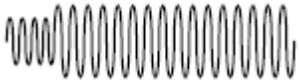
Swell

A swell is momentary increase of the AC voltage in an electrical wave. This problem can be caused by the stop of strong loads of currents, the connection of high impedance loads, or an error of a single phase in a three-fase system. The results of this problem include data corruption, system damage, deterioration of electrical contacts, and insulation deterioration. Resolving this type of problem include the use of UPS, power line conditioners, and ferroresonant control transformers. This image shows a representation of a swell:



Overvoltage

An overvoltage is a long term boost of the voltage level in an electrical signal. It can be produced in systems where the amount of loads is reduced and the system is not balanced to only provide the power needed. Overvoltage can be corrected with the use of UPS or power line conditioners. As well, a correction of the input power of the facilities can solve the problem. Overvoltage can produce overheating of electrical equipment. The following graphic represents an overvoltage:



DC Offset

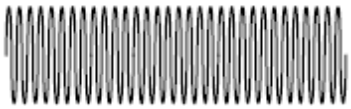
This problem occurs when a direct current (dc) is induced into an electrical signal causing a waveform distortion, which overheats and saturates transformers. A dc offset problem can be resolved by replacing the malfunctioning engine that generates the problem. An example representing the dc offset problem can be seen in the image:

Harmonics

This problem is a distortion of the electrical waveform which is corrupted by frequencies that are multiples of the original waveform. This problem produces equipment overheating, and can be resolved with k-rated transformers, reconfiguring distribution, and use of harmonic filters. An example of this disturbance can be observed in the following image:

Interharmonics

Interharmonic waveform distortion is a problem commonly generated by a signal infringed on the supply voltage by an electrical device. Common consequences of this type of problem include visual flickering of displays and incandescent lights, heat, and communication interference. Interharmonics distortions can be resolve with the use of filters, line conditioners, and UPS. The following graphic represents interharmonic waveform distortion:



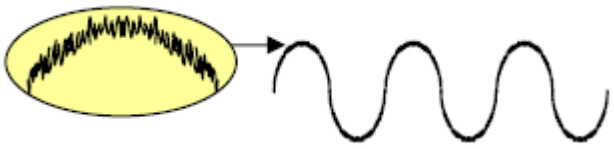
Notching

A periodical voltage interruption is called notching, which can cause data loss, data communication troubles, and system interruptions. To solve this kind of problem it can be either removed the origin of the problem, or implement UPS systems and filters. An example of this disturbance can be observed in the following image:

Noise

Noise is a non-desired voltage or current imposed in the voltage or current of an electrical signal. It is originated from electronic equipment, and can provoke data inaccuracy, system failure, among others. There are several methods to control this problem. The most common solutions are implementation of UPS, use of grounded and

shielded isolation transformer, change place of the interfering source, use noise filters, and increase shielding. An example of how noise can be represented can be observed in the next image:



Voltage fluctuations

A voltage fluctuation is a sequence of random small changes in the voltage amplitude of an electrical signal. This problem is generally originated by arc furnaces, and can be solved by relocating equipment, or implementing UPS or power line conditioning. The following graphic illustrates an example of voltage fluctuation:

Frequency variations

Frequency variation is a problem in the electrical signal, where its frequency is altered. IT equipment is not sensitive to this kind of problem. However, motor and sensitive devices that depend on the input frequency of power can be affected by this problem. This is solved by providing maintenance to the faulty equipment generating the problem. The next image represents a frequency variation:

Appendix C

SOLUTIONS FOR POWER QUALITY

In this section it is provided a brief documentation of the most common solutions and best practices to help protect equipment and correct some power quality problems.

Uninterruptible Power Supply (UPS)

The primary function of a UPS is to provide energy as a power source, for a momentary period of time, whenever the primary power source fails. It also protects from transient spikes, and allows for shutting equipment down appropriately in blackouts. There are several categories of UPS depending of what asset is needed to protect. For workstations, standby UPS offer protection to PCs by switching to a second power source (its backup battery) when it is detected any problem with the primary power source. For critical equipment protection, such as data rooms, it is used line-interactive UPS, which control voltage up or down as needed, and provide noise filtering. In case of mission critical equipment protection there are double-conversion UPS. These ones provide power quality by isolating the powered equipment.

Line conditioner

Line conditioners are devices that protect against undervoltages, overvoltages, and some waveform distortions, in order to provide power quality. Line conditioners clean the electrical signal from interference and regulate voltage. A good quality designed line conditioner uses internal filter banks, which isolate power outputs.

Moreover, it must offer noise repression of 40db or higher, as well as high heat dissipation.

Transient voltage surge suppressor (TVSS)

TVSS are specialized equipment used to protect against highvoltage and transients. There is a classification for the use of TVSS as defined by the standard IEEE C62.41. According to this standard, suppressors type A are installed at the final point where the equipment to be powered is located. Type B suppressors are installed as protection to devices that distribute power within a facility. And finally, type C suppressors are used as primary protection where the external power grid source is located. To acquire a TVSS system it must be taken into consideration the classification defined by ANSI/IEEE C62.41, the level of exposure to the problem, the voltage level, and so forth. A TVSS system must match its maximum continous operating voltage greater than the system voltage that it is going to work with. As well, it must be considered the total lightning energy that the device can absorb, also known as kA rating.

Air conditioning

Electrical equipment needs protection from overheating and humidity. A good design of air conditioning, heating and ventilation system is advised in order to provide correct climate in a servers' room. The design for the cooling system varies according to the edification. It is common the use of floor and ceiling plenums for air circulation. Temperature, air distribution and humidity can be monitored by sensors and controled by computers to maintain adequate environments in server rooms. Likewise, virtualization is a really good solution to reduce heat in a server's room, and reduces power utilization.

Grounding

Grounding must comply with standard TIA/EIA-942 in order to protect any data equipment adequately from electrostatic discharges, interference, as well as protection for personnel. TIA/EIA-942 is a telecommunications infrastructure standard for data centers. It defines that it must be used a grid copper strip and 6 AWG insulated wire to connect cabinets and racks, as well as any other necessary device.