

**June 29, 2009 Incident Review**  
**Dallas Fort Worth Data Center**  
**Review Dated: July 8, 2009**

The purpose of this document is to capture the events and subsequent response to the incident that took place in the DFW datacenter on 29 June, 2009.

## **I. Executive Summary**

On 29 June, an area of the Rackspace DFW Datacenter experienced a power outage that impacted customer equipment between approximately 3:15 PM CDT and 4:15 PM CDT. Several components of the datacenter infrastructure were involved in the outage, including the generators, the uninterruptible power supply (UPS) and several pieces of the electrical infrastructure.

Immediately following the restoration of power to the impacted area, Rackspace engaged equipment vendors, third-party advisors and its data center engineering team to conduct a root cause analysis of the events that precipitated this incident. Actions have been taken to remediate several issues. The primary issues involved were:

- Failure of the four generators in generator bank A to properly synchronize with the UPS systems and ultimately the generators failed to handle the electrical load.
- Failure in portions of the electrical infrastructure, which prevented the transfer of the electrical load between different power sources

Rackspace believes it has identified the root causes behind the failures. They are summarized here:

- Quality of power among the generators and from the generators to the UPS battery cluster caused the synchronization failure of the generators
- Switches in the electrical infrastructure (i.e. Pad Mounted Switch) failed to perform to specification

Corrective actions have been taken on the generators, UPS and primary utility feeder breaker. There will be ongoing and preventative maintenance and remediation activities, as well as a number of process and leadership changes which will further strengthen the quality of the data center infrastructure and operations.

## **II. Incident Timeline, 29 June**

- **1:51 p.m. CDT** – The DFW datacenter lost utility power to its chiller plant and UPS clusters A, B, C, D, E and F in DFW Phases I and II. All back-up systems performed as designed and the electrical load was supported by UPS batteries while generators supporting the chiller plant and the UPS clusters came on-line as designed.
- **2:35 p.m. CDT** – The A bank of generators that supports UPS clusters A, B, and E began experiencing a synchronization failure. This condition escalated and subsequently prevented the generators from holding the electrical load for UPS clusters A, B and E. The Facility Engineering team could not resolve the generator bank A issues and attempted to engage the secondary utility feeder. This attempt failed due to an issue in the Pad Mounted Switch (PMS), which allows the transfer to the secondary utility feeder. When the A bank generators failed, the UPS batteries came back on line automatically to support the electrical load for UPS clusters A, B and E until approximately 3:15 PM. The B bank of generators and the chiller plant generators continued to perform as designed without customer interruption.

During this time, Facility Engineering had begun the process of by-passing UPS clusters A and B as they believed generator bank A would support clusters A and B without experiencing synchronization issues if cluster E was left off line. This process involved routing power across a maintenance bus. The maintenance bus isn't used for utility power. While the team was working on the maintenance bus transfer, utility power was returned to the primary utility feeder.

- **3:15 p.m. CDT** – The batteries in UPS clusters A, B and E completely discharged and all equipment receiving power through those UPS clusters experienced an interruption in service. This occurred because we could not switch over to the secondary utility feeder and because we could not stabilize the generators supporting UPS clusters A, B or E. All other parts of the data center continued to operate without impact, including the chiller plant and UPS clusters C, D and F. Phase III of the DFW data center was not impacted.
- **3:58 p.m. CDT** – The primary utility feeder was restored and UPS cluster E came back up, in by-pass automatically. At this point, because the load required from the A bank generators no longer included cluster E the Facility Engineering team was able to successfully bring UPS clusters A and B back up, on generator power, without battery back-up.
- **5:37 p.m. CDT** – Batteries for UPS clusters A, B and E were recharged and cluster B was moved to back primary utility power. At this time, cluster A required a repair to one of the four UPS modules (module 2) so the cluster remained on generator power. Only 3 modules are required for UPS cluster A to perform.
- **7:40 p.m. – 7:45 p.m. CDT** – The A bank generators now supporting only UPS cluster A began to experience synchronization issues, forcing a transition back to utility prior to the repairs on UPS cluster A, module 2 being completed.
- **8:55 p.m. – 9:00 p.m. CDT** – Repairs to module 2, in UPS cluster A, were completed and tested and the module was brought back on-line to restore N+1 redundancy in UPS cluster A.

### **III. Diagnosis and Remediation**

Rackspace has undertaken a number of repairs and proactive maintenances in response to this incident. This is a summary of completed activities and future maintenance plans:

#### **Generator and UPS Systems: Testing and Findings**

The disruptions experienced on 29 June were the result of the 4 generators in bank A failing to synchronize and going into an unacceptable excitation state which led to the A bank generators failing to carry the electrical load. Rackspace has narrowed the root cause of the excitation failure to power quality. When power quality is poor, the voltage and current are not aligned, causing stress on the generators and ultimately the inability to synchronize properly. Rackspace conducted a number of maintenances and tests on the generators and UPS systems to address the power quality issues. The following are the key maintenance activities Rackspace conducted:

1. During off-peak hours on 30 June through 1 July, Rackspace and its vendors placed power meters on the input side of all UPS cluster systems for generator banks A and B, in order to collect and compare detailed power information. Data was collected for both utility and generator settings on the UPS clusters to identify any discrepancies.
2. Incorrect settings on the UPS input filters were found to be a contributing factor to the power quality and synchronization issues between the UPS systems and the generators. The DFW generator bank A UPS units were previously programmed to drop out all input filters any time the generators are in use, causing additional stress on the generators. These settings were found to be inconsistent with the settings for generator bank B's UPS units. Measurement of the power quality of the UPS units confirmed that there was a high amount of distortion in the UPS power input for generator bank A which supports UPS clusters A, B and E.
3. During off peak hours on 2 July, Rackspace's vendor load tested generator bank A supporting UPS clusters A, B and E to validate generator performance under simulated load conditions. During the maintenance, Rackspace was able to take detailed readings on the control parameters and load sharing settings. The vendor discovered an unusually high amount of noise on the electrical lines that send signals to the four generators in bank A, instructing them how to share the electrical load. Upon investigation, it was discovered that firmware among the three generators was inconsistent, due to a maintenance failure. Additionally, the wrong kind of wire had been used to connect the generators and the wire was also incorrectly grounded.

The resulting failure of the A bank generators was the result of the accumulation of the factors described above, exacerbated by the recent and significant use of the A generator bank.

#### **Generator and UPS Systems: Remediation Actions**

1. The logic controlling the input filters for the UPS systems was modified so that filters will be applied or removed as the load on the UPS increases or decreases, respectively.
2. The controls for generator bank A were re-wired and grounded.
3. Firmware was updated for all generators in bank A as per the manufacturer's specification.

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Following these changes, testing on 3 July showed that all of the above issues had been eliminated and that the generators and UPS systems were functioning properly. Due to the successful outcome of the maintenance on generator bank A, Rackspace proactively updated generator bank B.

### **Pad Mounted Switch**

The function of the Pad Mounted Switch is to direct power from the utility feeder to each transformer which leads to the Datacenter. The #8 Pad Mounted Switch failed when the datacenter team attempted to move from the failing generator bank to the secondary utility feeder. During the investigation it was discovered that the mechanical linkage in the Pad Mounted Switch would not engage despite the fact that the switch had been maintained in accordance with manufacturing guidelines.

**Remediation Plan:** Parts are on order and are expected to be available during the week of 6 July. Repairing the switch will require that Rackspace move UPS cluster F, supported by generator bank B, to generator power during a scheduled maintenance window. This repair has tentatively been scheduled during the latter half of the week beginning 6 July.

### **Utility Breaker Maintenance**

During the event investigation, the Facility Engineering team discovered that the utility feeder breakers had not been adjusted to properly reflect the increased power requirements of the facility which had recently been increased to 12MW.

**Remediation Actions:** During off-peak hours on 3 July, Rackspace's utility provider adjusted the settings of the feeder breaker for both primary and secondary feeders to better match the power requirements of the facility.

### **Systemic Operating Changes**

Throughout the course of recent events, Rackspace has taken steps to remediate the current issues and mitigate future issues by leveraging third party experts and vendors, making organizational changes and evaluating the efficacy of processes used in data center operations. That work will continue over the coming months, however, the following systemic changes have been made:

#### **Resources Leveraged in Diagnosis and Remediation Activities:**

- Eaton Electrical – Electrical Infrastructure Vendor
- Cummins – Generator Vendor
- Oncor – Utility Provider
- Eaton Powerware – UPS Battery Cluster Vendor
- Consultant from M.I.T
- Consultant from a tier-one datacenter operator
- Rackspace Facility Engineers from DFW and other Rackspace data center facilities

#### **Operating Changes Going Forward (Completed or In Progress):**

- Organization
  - Changed DFW data center and US data center leadership
- Process
  - Reviewing all internal maintenance records and processes to ensure Rackspace meets and/or exceeds the manufacturer's recommended maintenance plan for infrastructure

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- Changing our internal change management policies to ensure multiple parties are involved in the design, review and acceptance of future maintenance activities
- Engaging the equipment manufacturers and service providers to inventory previous maintenance activities and provide forward-looking maintenance plans
- Improving the communication process to Customers regarding standard datacenter maintenance events and incidents
- System
  - As referenced in the above document, Rackspace, in addition to the immediate incident response, has proactively replaced several components of the datacenter infrastructure (i.e., UPS battery clusters)

#### **IV. Dallas/Ft. Worth Data Center Power Structure Overview**

The data center is composed of several key pieces of equipment and associated electrical infrastructure. Major components are described below:

- DFW Phases I and II have two separate utility feeds (primary and secondary). The utility feeds are on separate sub-stations.
- Shifting between the two utility feeds is accomplished by the Pad Mounted Switches
- DFW Phase I and II are supported by two separate banks of generators that power the UPS clusters.
- Changing between utility feed and generator feed is accomplished by the Automatic Transfer Switch (ATS).
- Generator bank A and the primary utility feed deliver power to an Uninterruptible Power Supply (UPS) with three UPS clusters (A, B and E) via a power bus.
- Generator bank B and the primary utility feed deliver power to an Uninterruptible Power Supply (UPS) with three UPS clusters (C, D and F) via a power bus.
- The Uninterruptible Power Supply (UPS) clusters are batteries that maintain power during the shift between utility and generator power. The UPS clusters target 20-40 minutes of power in the absence of utility or generator power
  - Each UPS cluster has four modules
  - Each module has four strings of batteries
  - Each string has forty batteries
  - Each UPS cluster has between ten to fourteen Power Distribution Units (PDUs).
- Each PDU supports approximately forty cabinets, which include servers and other devices.
- Cabinets have redundant connections to separate PDUs.

This data center infrastructure has been built with redundancy to allow for standard operation in the event of failed components.

- Rackspace can lose one utility feed and still be powered by generators or the other utility feeder (N+1)
- Rackspace can lose one generator in the generator bank and still power all three UPS clusters (N+1)
- Rackspace can lose one module in any individual UPS cluster and still power the attached PDUs and associated cabinets (N+1)

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