

# Short Paper: Troubleshooting Distributed Systems via Data Mining

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## Abstract

*Through massive parallelism, distributed systems enable the multiplication of productivity. Unfortunately, increasing the scale of available machines to users will also multiply debugging when failure occurs. Data mining allows the extraction of patterns within large amounts of data and therefore forms the foundation for a useful method of debugging, particularly within such distributed systems. This paper outlines a successful application of data mining in troubleshooting distributed systems, proposes a framework for further study, and speculates on other future work.*

## 1 Introduction

Distributed systems are multiplicative tools: they multiply the ability of a user to perform useful work, but they also multiply the ability to make a mess. Consider the following common scenario: a user submits one million jobs to a system consisting of thousands of CPUs. After working on the jobs for some time, the system reports completion. However, the user unhappily discovers that a large fraction of the jobs have failed! How would an end-user even begin to sort out this mess? This is not merely an academic exercise. Regular users of large distributed systems are accustomed to these occurrences, particularly in the development stages of a system. For example, Grid3 [7] has reported a thirty percent failure rate for some categories of jobs.

Why do unexplained failures of this type occur at large scale? There are many different kinds of failure that are difficult to disentangle. First, a given job may not necessarily be compatible with arbitrary machines. Obviously, most jobs require a particular CPU and operating system. More subtly, users may not be aware that a particular job requires certain tools or libraries to be installed on the operating system. Other failures may be due to administrative activities: the firewall rules on a cluster might be adjusted, or a user may be denied access to resources previously available. Finally, some failures are due to pure chance: a cosmic ray disrupts a stored value, and the program crashes.

We propose that data mining techniques can be applied to the problem of large scale troubleshooting. If both jobs and the resources that they consume are annotated with structured information relevant to success or failure, then classification algorithms can be used to find properties of each that correlate with success or failure. In the one-million jobs example above, an ideal troubleshooter would report to the user something like: *Your jobs always fail on Linux 2.8 machines, always fail on cluster X between midnight and 6 A.M, and fail with 50% probability on machines owned by user Y.* Further, these discoveries may be used to automatically avoid making bad placement decisions that waste time and resources.

We hasten to note that this form of data mining is not a panacea. It does not explain *why* failures happen, or make any attempt to diagnose problems in fine detail. It only proposes to the user properties correlated with success or failure. Other tools and techniques may be applied to extract causes. Rather, data mining allows the user of a large system to rapidly make generalizations to improve the throughput and reliability of a system without engaging in low level debugging. These generalizations may be used later at leisure to locate and repair problems. In addition, the problem of distributed debugging, with its unique idiosyncracies and dynamics, lends itself as a compelling application for data mining research. Standard off-the-shelf methodologies might not be directly applicable for large, dynamic, and evolving system. It is desired to implement techniques that are capable of incremental self-revision and adaptation. The goal of our paper is to serve as a proof-of-concept and identify venues for compelling future research.

## 2 Proof of Concept

We have created a proof of concept of this idea by analyzing jobs submitted to an active Condor [9] pool of 250 machines with a wide variety of properties and several active users. To apply data mining, we must use the information available from this pool to determine attributes. Experiments must then be performed to validate that data mining is useful in distributed systems troubleshooting.

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