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Efficient failure prediction in autonomic networks based on trend and frequency analysis of anomalous patterns

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SUMMARY

We describe an efficient failure prediction system based on new algorithms that model and detect anomalous behaviors using multi-scale trend analysis of multiple network parameters. Our approach enjoys many advantages over prior approaches. By operating at multiple timescales simultaneously, the new system achieves robustness against unreliable, redundant, incomplete and contradictory information. The algorithms employed operate with low time complexity, making the system scalable and feasible in real-time environments. Anomalous behaviors identified by the system can be stored efficiently with low space complexity, making it possible to operate with minimal resource requirements even when processing high-rate streams of network parameter values. The developed algorithms generate accurate failure predictions quickly, and the system can be deployed in sa distributed setting. Prediction quality can be improved by considering larger sets of network parameters, allowing the approach to scale as network complexity increases. The system is validated by experiments that demonstrate its ability to produce accurate failure predictions in an efficient and scalable manner. Copyright © 2013 John Wiley & Sons, Ltd.

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1. INTRODUCTION

As information technology (IT) infrastructure and its interconnecting telecommunication networks evolve over time, they become ever larger and more complex. This creates the need for a scalable fault management strategy wherein failure prediction techniques play a critical role. Failure prediction, in turn, requires a fundamental understanding, i.e. models, of the behaviors of complex heterogeneous systems. Models of such systems, in turn, require the collection and mining of vast amounts of real-time state information. In present-day networks, such performance and state information is often not directly available and must be synthesized to create models of ensemble behavior [1–3].

In light of these shortcomings, the concept of an *autonomic network* has emerged. Autonomic networking follows the concept of autonomic computing, an initiative started by IBM in 2001 [4]. We shall use this term here to refer to any network that is self-configuring and self-managing, on the basis of real-time performance and state information. Already, networks are increasingly service-aware. Network clients specify not only content pertaining to a service, but service characteristics as well. Contemporary examples include quality of service (QoS) requirements and service-level agreements (SLAs) which allow network resources to be used optimally towards service delivery. Network design is thus moving towards self-configuring and managing to overcome the shorter technology life cycle and the rapidly growing complexity of the technology, services and network infrastructure. Future networks are envisaged as autonomic and service-aware, orchestrating guarantees of reliability,

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