Analysis and Modeling of Time-Correlated Failures in Large-Scale Distributed Systems

Fault tolerance

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Outline

• Introduction
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• Method description
• Analysis (of autocorrelation)
• Modeling
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Motivation

Increased complexity, higher failure rates

Failure models for building fault-tolerance mechanisms are required

Previous work focuses on failure models that assume the failures not to be correlated

Not so realistic! Ex: peak failure periods
Goals

Investigate time correlation between failures
- Observing peaks
- Detecting patterns

Create a model to describe failure (peaks) and enable failure prediction
Method

19 failure traces from diverse large-scale DS are used.

Analysis
Use the autocorrelation function (ACF) for each trace

Modeling
Use Maximum Likelihood Estimation (MLE) to match certain well-known probability distributions to the empirical data
Autocorrelation Function (ACF)

- measures the degree of correlation of the failure time series data with itself during different time lags.
- Takes values in the interval abs[0, 1]
- 1 means high correlation, 0 means failures are random or periodic
- High autocorrelation
Analysis of Autocorrelation [3/4]

- Visible patterns
Results show that most of the systems, 16 out of 19, exhibit strong correlation from small to moderate time lags.

In addition, peak patterns are visible in many of them.

This helps predictability.
The model comprises four parameters:

- Peak duration
- Time between peaks (inter-peak time)
- Inter-arrival time of failures during peaks
- Failure duration during peaks
Two steps:
Establish what is a peak
  • Use a threshold $\mu + k\sigma$

Extract model parameters and find a good fit among well known probability distributions
Example:
Once established the way the model is designed, it has to be generated.

It should characterize all the 19 investigated systems

Create an Average System Model (ASM)!
ASM creation comprises 2 steps:

• For each combination of system and parameter we specify the best fitting candidate distribution.

• For each parameter we pick the best fitting candidate among the different systems.
After defining the best fitting distributions, each data set is fit independently to find the set of best fit parameters.

Not all parameters can be fit into the model, this depends on the system...
Results show that for all parameters either lognormal or Weibull distributions provide a good fit for the ASM.

An investigation of the fraction of downtime during peaks and the # of failures during peaks shows that on average 50% - 90% of downtime is caused by failures during peaks.
This study assesses the presence of time correlated failures

Proposes a more realistic model which takes into consideration this correlation

Claims to give an appropriate model which is able to predict 50% - 90% of the downtimes.
Questions?