DataCenter.ai
A Predictive Analytics Framework for Modern Data Center, and
A Case Study for Disk Failure Prediction

Yuming Ma
Architect, Cisco Cloud Services

Eric Chen
CEO, ProphetStor

March 21, 2017
Trend of Data Center Management

- Reactive
- Preventive
- Predictive
- Proactive

Automate storage operation by artificial intelligence and eliminate human cost.
Data Center Component Failure

• Data center component failure is normal and regular
• Unmanaged failure can cause cascading disaster
• Data center components has tons of data generated
• How to use the data for better management and operation?
  • Data can be used to build analytics
  • Analytical intelligence improves management and operation
Data Center Usage

• A McKinsey study in 2008 pegging data-center utilization at roughly 6 %.

• An Accenture paper from 2011 sampling a small number on Amazon EC2 machines finding 7 percent utilization over the course of a week.

• A Gartner report from 2012 putting industry wide utilization rate at 12 %.

• The 2014 Data Center Efficiency Assessment from the NRDC has found that US data center utilization at 12 to 18 %.

• How to improve data center efficiency?
The challenges of the data center operation that DataCenter.ai aims to solve

- Workload resource allocation waste
- Over-committed computing resources
- Over-heated components
- Component sudden failure
- Disk sudden failure
- Disk performance degradation
- Disk size bloat
How can we do better?
Storage Cluster Monitoring and Analytics

- Three types of data: events, metrics, logs
- Data collected from each node
- Data pushed to monitoring portals
- In-flight analytics for run-time RCA
- Predictive analytics for proactive alert
- Plugin to synthesize data for cluster level metrics and status
### Data Sources

#### Data Centers

<table>
<thead>
<tr>
<th>Data Center</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload</td>
<td>...</td>
</tr>
<tr>
<td>Computing resources</td>
<td>...</td>
</tr>
<tr>
<td>Network resources</td>
<td>...</td>
</tr>
<tr>
<td>Storage resources</td>
<td>...</td>
</tr>
</tbody>
</table>

#### Metadata Collection
- Log
- Metrics
- Event
Stream Analytics

Storm Topology

Storm Topology

kafka

kafka
Predictive Analytics

- Metrics
- Logs
- Events

Machine learning

Predict failure and resource consumption

Provide resource allocation and replacement plan

- Storage
- Hyper-converged
- Application Server
AI/Machine Learning Algorithms

- Predict
- Prescription

- Time-series prediction
- Anomaly detection
- Real-time alerting
- Resource allocation plan
- Workload operation plan
- Hardware replacement plan
Datacenter.ai Framework
A Storage Case Study for Disk Failure Prediction
Disk Failure Scenario in Ceph

• Unmanaged disk failure:
  • Disk failed
  • OSD daemon dies
  • OSD is down and out
  • A new OSD was selected for data replica
  • Copy objects from existing replicas to new OSD
  • Find and Replace the failed disk
  • Copy objects again

• Managed disk replacement:
  • Set osd noout
  • Mark OSD out
  • Shutdown OSD
  • Replace disk and start OSD
  • Copy objects from existing replicas to new disk
DiskProphet provides monitoring, prediction, and prescription.

**Input Data**
- SMART data
- Disk performance data
- Host metrics

**Metrics data store**

**Output**
- Failure disk prediction
- Slow disk prediction
- Abandon disk prediction
- Disk replacement plan
- Interaction
  - Dashboard
  - REST API

**ETL**

**Pre-process**
- Machine Learning
- Predictive Analysis
- Fuzzy Logic
- Deep Learning

**Analytics**
- Apache Spark

**Apache Spark**
- InfluxDB
- Neo4J

**DiskProphet**

**Interaction**
- Dashboard
- REST API
SaaS and on-Prem Model
Prediction Process
Multilayer Perceptron (MLP) is used to predict life expectancy of disks

Collect data from disks
- Performance data
- S.M.A.R.T data
- Size (available size and total capacity data)
- Device metadata (vendor, model)

Bern
Day range
#1: 0 ~ 90 days
#2: 90 ~ 180 days
...
#12: 1080+ days

Model life expectancy model

Predict life expectancy

SSD #42's life expectancy is #4 bin (i.e. 360 ~ 450 days)

Periodically update model with updated data set
Support Vector Machine (SVM) is used to predict near-failure likelihood

Collect data from disks
- Performance data
- S.M.A.R.T data
- Size (available size and total capacity data)
- Device metadata (vendor, model)

Historical data of good disks

Model near-failure likelihood

Periodically update model with updated data set

Historical data of failure disks

Predict near-failure likelihood

There is an 84% chance SSD #53 will be failure in the next 14 days => Likely
DiskProphet predicts life expectancy and near-failure likelihood of disks

<table>
<thead>
<tr>
<th>Disk</th>
<th>Near-Failure likelihood</th>
<th>Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD3215</td>
<td>Very likely</td>
<td>0 ~ 30 days</td>
</tr>
<tr>
<td>WD3015</td>
<td>Likely</td>
<td>30 ~ 60 days</td>
</tr>
<tr>
<td>ST400D5</td>
<td>Unlikely</td>
<td>180 ~ 210 days</td>
</tr>
</tbody>
</table>
DiskProphet provides the replacement plan by combing the disk failure and performance prediction

Input data
- SMART
- Disk Performance
- Host Performance

Disk failure prediction
- Failure likelihood of SSD #2 within the next 7 days is “very likely”
- IOPS prediction
  - Predictive lowest loading of next 24 hours

Plan the replacement of SSD #2 at 2am
Dash Board

**HOST SUMMARY**

<table>
<thead>
<tr>
<th></th>
<th>Disk Name</th>
<th>Life Expectancy (day)</th>
<th>Near-Failure Prediction</th>
<th>Disk Vendor</th>
<th>Disk Type</th>
<th>Disk Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-11-09 01:25:47</td>
<td>/dev/sde</td>
<td>720 ~</td>
<td>Unlikely</td>
<td>Micron</td>
<td>SSD SAS</td>
<td>MICRON S630DC-480</td>
</tr>
<tr>
<td>2016-11-09 01:25:47</td>
<td>/dev/sdb</td>
<td>720 ~</td>
<td>Unlikely</td>
<td>Micron</td>
<td>SSD SAS</td>
<td>MICRON S630DC-480</td>
</tr>
<tr>
<td>2016-11-09 01:25:47</td>
<td>/dev/sdc</td>
<td>720 ~</td>
<td>Unlikely</td>
<td>Micron</td>
<td>SSD SAS</td>
<td>MICRON S630DC-480</td>
</tr>
<tr>
<td>2016-11-09 01:25:47</td>
<td>/dev/sdd</td>
<td>720 ~</td>
<td>Unlikely</td>
<td>Micron</td>
<td>SSD SAS</td>
<td>MICRON S630DC-480</td>
</tr>
</tbody>
</table>
Test results
AI Training

Backblaze Training data

2013/4/10 ~ 2015/12/31

DiskProphet

Disk Failure Prediction Model
Prediction Testing

Backlaze Testing data
2016/6/1 ~ 2016/9/30

DiskProphet

Disk Failure Prediction Report

<table>
<thead>
<tr>
<th>Disk</th>
<th>Near-Failure likelihood</th>
<th>Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD3215</td>
<td>Very likely</td>
<td>0 ~ 30 days</td>
</tr>
<tr>
<td>WD3015</td>
<td>Likely</td>
<td>30 ~ 60 days</td>
</tr>
<tr>
<td>ST400D5</td>
<td>Unlikely</td>
<td>180 ~ 210 days</td>
</tr>
</tbody>
</table>
Daily prediction accuracy

On Backblaze dataset: 1/1/16 ~ 3/31/16
Average accuracy rate is 96.1%
DataCenter.ai automates the operation of the software-defined data center
Thank You

Yuming Ma: yumima@cisco.com
Eric Chen : eric.chen@prophetstor.com