PMC: A Performance Monitoring system for Clusters

Moreno Marzolla
Email marzolla@dsi.unive.it
Web: http://www.dsi.unive.it/~marzolla

Dip. Informatica, Università di Venezia
BaBar Farm @ INFN Padova

- ≈150 2xPIII 1.26GHz Machines, 1GB Ram, RH Linux 7.2
- Tape Library with a capacity of ~70TB not compressed;
- Network switch, UPSes, Environmental conditioning system,
...
Monitoring Requirements

- **Hardware Status**
  - Machine Crashes, disk crashes, CPU temperatures, disk/partitions overflows...

- **Processes status**

- **Environmental conditions**
  - Humidity, Temperature, UPS status...

- **System administrators should be notified as soon as a problem occurs**
  - Some automatic action should be taken when possible (e.g., shut down the machines if overheated).
Other requirements

• The monitoring system should also be:
  - **Scalable**
  - Efficient (little resources requirement)
  - Flexible and customizable
  - **Easy to configure**
  - Should be able to operate in *batch mode* (as a regular UNIX daemon, no GUI)
  - Should be able to observe different quantities with different granularities
    • eg, CPU utilization sampled every 5 seconds, CPU temperature sampled every minute, ...
Some existing monitoring tools

- There are *many* of them:
  - MRTG  http://people.ee.ethz.ch/~oetiker/webtools/mrtg/
  - Ngop  http://www-isd.fnal.gov/ngop/
  - Netsaint/Nagios  http://www.nagios.org/
  - Ganglia  http://ganglia.sourceforge.net/
  - RemStats  
    http://silverlock.dgim.crc.ca/remstats/release/index.html
  - Cricket  http://cricket.sourceforge.net/
  - GxSNMP  http://www.gxsnmp.org/
  - ... (add your own here)
What's wrong?

- We examined some publicly available monitoring tools.
  - Also organized a workshop in Padova with vendors and other people from the HEP community
- Many of them were not suited to us:
  - Not scalable
  - Require their own daemons running on the monitored hosts
    - Can't install a daemon on a network switch, or on a tape library
  - Hard to configure
    - In many cases we gave up without trying the program.
  - Poorly implemented
Architectural sketch

User Interface

User Interface

User Interface

Monitor

Collector

Collector

Observer

Observer

Observer

Observer

Observer

Observer

Hardware

Hardware

Hardware

Hardware

Hardware
The Observer

- The Observer must be able to collect statistics on any networked equipment
- We decided to use **SNMP (Simple Network Management Protocol)**
  - It is a well-known protocol
  - It is implemented by virtually every vendor
  - It is reasonably simple yet powerful
  - A very good open source implementation is available on Unix/Linux platforms
  
More on SNMP

Manages Resources

SNMP Managed Objects

SNMP Messages

Network Protocol

IP

UDP

SNMP

GetRequest

GetNextRequest

SetRequest

GetResponse

Trap

GetRequest

GetNextRequest

SetRequest

GetResponse

Trap

LAN/WAN

W. Stallings, *SNMP, SNMPv2, SNMPv3 and RMON 1 and 2*, 3rd edition, p. 81
The Collector/Monitor (PMC)

• Asynchronous (nonblocking) parallelized SNMP Polling;
• XML-based configuration file;
• The RRDTool package is used to store data and produce graphs
  – Old data have lower resolution than recent ones.
  – Round Robin Databases have known maximum size.
  – Graphing capabilities are provided by the library.
• Dynamic generation of HTML pages using XSLT stylesheets.
Architecture

XML Configuration File

<?xml version="1.0" standalone="no"?>
<!DOCTYPE monitor SYSTEM "monitor.dtd">
<monitor>
  ...
</monitor>

Monitored Hosts

PMC

HTTPD

Status

Stylesheets

XSLT Stylesheet 1

XSLT Stylesheet 2

HTML Pages

HTML Page 1

HTML Page 2

Host 1

Host 2

Host n
Example of XML Configuration File

```xml
<?xml version="1.0" standalone="no"?>
<!DOCTYPE monitor SYSTEM "monitor.dtd">

<monitor numconnections="20" asclogfile="/monitor/asc.log"
    httpdlogfile="/dev/null" rrddir="/monitor"
    htmldir="/monitor/html" ascverbosity="3">
    <host name="localhost">
        <description>This machine</description>
        <miblist>
            <mib id="cpuUser" name=".1.3.6.1.4.1.2021.11.50.0" type="COUNTER">
                <archives>
                    <rra cf="AVERAGE" granularity="60" expire="604800"/>
                </archives>
            </mib>
        </miblist>
    </host>
</monitor>
```
Example of XML Status Dump

```xml
<?xml version="1.0"?>
<hosts>
  <host name="localhost" status="NR">
    <mibs>
      <mib id="availSwap" lastUpdated="1018016033">1052248.000000</mib>
      <mib id="totalSwap" lastUpdated="1018016033">1052248.000000</mib>
      <mib id="totalMem" lastUpdated="1018016033">917080.000000</mib>
      <mib id="cachedMem" lastUpdated="1018016033">7128.000000</mib>
      <mib id="bufferMem" lastUpdated="1018016033">35052.000000</mib>
      <mib id="sharedMem" lastUpdated="1018016033">0.000000</mib>
      <mib id="freeMem" lastUpdated="1018016033">833800.000000</mib>
      <mib id="cpuSystem" lastUpdated="1018016033">137587.000000</mib>
      <mib id="cpuUser" lastUpdated="1018016033">13581.000000</mib>
      <mib id="tempCpu2" lastUpdated="1018016033">24500.000000</mib>
      <mib id="tempCpu1" lastUpdated="1018016033">25000.000000</mib>
      <mib id="tempMB" lastUpdated="1018016033">33000.000000</mib>
    </mibs>
  </host>
</hosts>
```

Moreno Marzolla
Sample HTML Output

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25%</td>
<td>25%-50%</td>
<td>50%-75%</td>
<td>&gt; 75%</td>
<td></td>
</tr>
</tbody>
</table>

Farm Overview

Machines are listed in alphabetical order. The meaning of the box colors is the following:

- bbr-cluster02  
- bbr-cluster03  
- bbr-cluster04  
- bbr-cluster05  
- bbr-cluster06  
- bbr-darmac07  
- bbr-darmac08  
- bbr-darmac09  
- bbr-darmac10  
- bbr-darmac11  
- bbr-darmac12  
- bbr-darmac13  
- bbr-darmac14  
- bbr-export01priv  
- bbr-export02priv  
- bbr-farm001  
- bbr-farm002  
- bbr-farm003  
- bbr-farm004  
- bbr-farm005  
- bbr-farm006  
- bbr-farm007  
- bbr-farm01  
- bbr-farm02  
- bbr-farm03  
- bbr-farm04  
- bbr-farm05  
- bbr-farm06  
- bbr-farm07  
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- bbr-farm62  
- bbr-farm63  
- bbr-farm64  
- bbr-farm65  
- bbr-farm66  
- bbr-farm67  
- bbr-farm68
Sample HTML Output
What we are monitoring

- **CPU Utilization**
  - User/System/Idle
- **Disk I/O**
  - Not perfect due to kernel limitation
- **Network I/O**
- **Temperature of the CPUs**
  - On some machines only. Problem with IBM Service Processor locking the SMbus
- **Load Average**
- **Network I/O and link errors on the switch**
What we concluded so far

- Monitoring a large computing cluster is a highly nontrivial task.
- Many available monitoring tools exist, but many of them are not adequate for large distributed systems.
- We are building a general-purpose SNMP and XML-based monitoring tool.
- A prototype exists and is working
  - ...but see next slide
Problems and to-do list

- Alarms are not implemented yet
  - Hope to do so Really Soon™
- Facing scalability problems
  - Each SNMP variable is stored in a RR Database…
  - …So we have > 4000 RR Databases right now, to update every 10 seconds
  - The monitor machine “freezes” during the updates
- Occasional crashes
  - Probably caused by a bug in the HTTP server code
  - We are going to replace that code with a lightweight HTTP server library (SWILL)