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LDMS Version 3 Tutorial https://github.com/ovis-hpc/ovis

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04/2017

SAND2017-5153 O

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

About this document

- This is a sub-selection of materials from an LDMS tutorial. The full tutorial includes VM's with an LDMS installation. The VM is not here, however the run scripts from the exercises are included.
- If you install LDMS on your system, you can then use these scripts as models and work through the exercises.

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Resources

- Documentation (Building, Using)
    - https://github.com/ovis-hpc/ovis/wiki
- Source Code
    - https://github.com/ovis-hpc/ovis
    - git clone https://github.com/ovis-hpc/ovis.git
- Publications:
    - https://ovis.ca.sandia.gov

Tutorial Format

Overview of the Lightweight Distributed Metric Service (LDMS)

- Introduction to HPC monitoring
- Overview of the LDMS framework
  - LDMS architecture description

Setup

- Environment setup description and verification
- Introduction to support programs and helper scripts for use in lab work

Hands-on labs Instructor walk through and facilitated student exploration

- Lab 1: Samplers
  - Sampler startup and local and remote verification
- Lab 2: Aggregators
  - Aggregation startup and verification using sampler
  - Aggregation of all other attendees' samplers
- Lab 3: Dynamic configurations and resilience
- Lab 4: Storing data in CSV stores
- Lab 5: Calculating derived data and saving to a CSV store
- Lab 6: Storing the data in an SOS database
- Lab 7: Exploring data in an SOS database
- Lab 8: Data analysis and Visualization from an SOS database

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Introduction to HPC Monitoring

- Canonical Monitoring Goal: Real-time troubleshooting (e.g., nodes down, out of memory, resource congestion)
- HPC monitoring concerns:
  - Impact on running applications
  - How to aggregate data from different sources for analysis.
    - Network, filesystem, CPU utilization, memory utilization
  - What analyses would be meaningful.
    - e.g., What raw and derived data would indicate performance-impacting network congestion.
  - How to process large amounts of data in real-time
- As a result, canonical system monitoring:
  - Typically performed at intervals of minutes
  - Analyses largely consists of detecting monitoring values exceeding pre-defined thresholds
  - Data is unsuitable for gaining significant insights into application performance problems

Monitoring Can Enable Resource-Aware Computing

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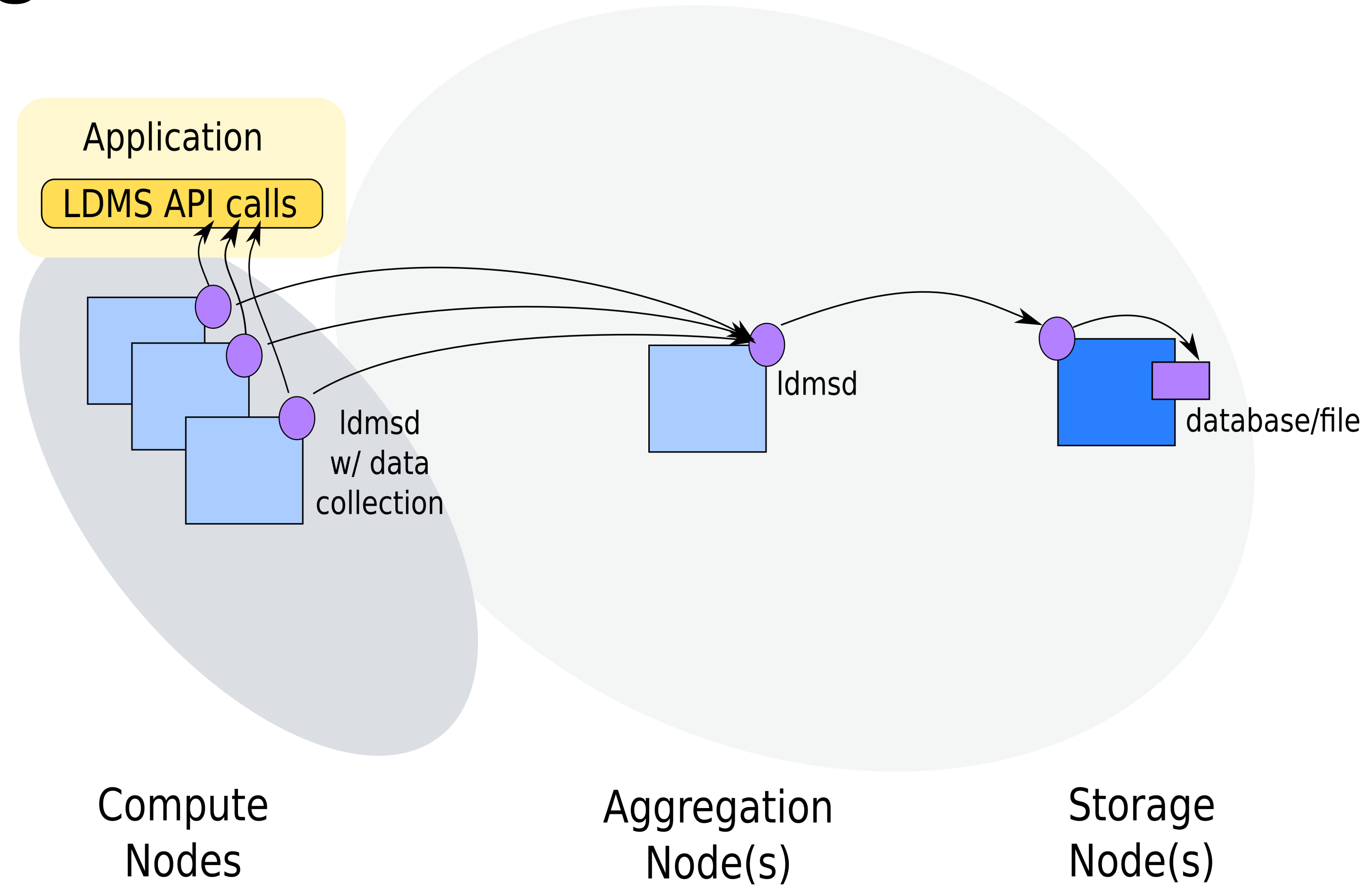
Lightweight high-frequency continuous run-time monitoring, analysis, and feedback could enable:

- Faster problem detection, including component-specific issues based on a particular component's known behaviors and environment (e.g., thermal variations)
- Insight into a large-scale application's use of resources under *production* conditions, including contention from other applications
- Dynamic application-to-resource mapping based on application needs and system state
- Co-scheduling of applications based on contention for shared resources
- Dynamic system operations based on a data center's power demands, temperature etc.

LDMS Overview

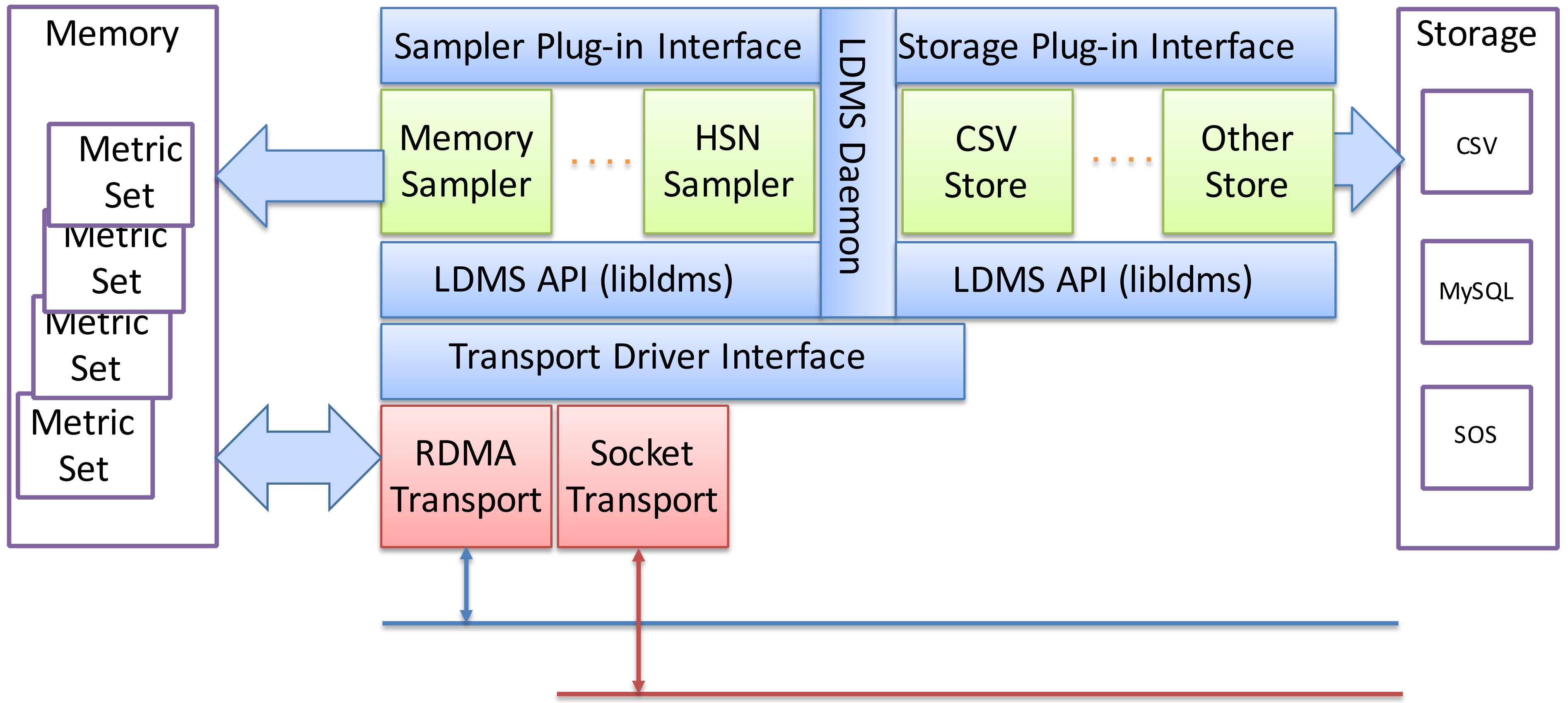
- What is the Lightweight Distributed Metric System (LDMS)?
  - Collect numeric data
  - Move and aggregate data
  - Store data
  - Analyze data
    - Troubleshooting
    - Optimization
    - Inform future designs
- Typical use case descriptions
- Supported technologies
  - Linux on all but IBM Blue Gene platforms
- Sources of code, information, and support

Lightweight Distributed Metric Service (LDMS) High Level Overview

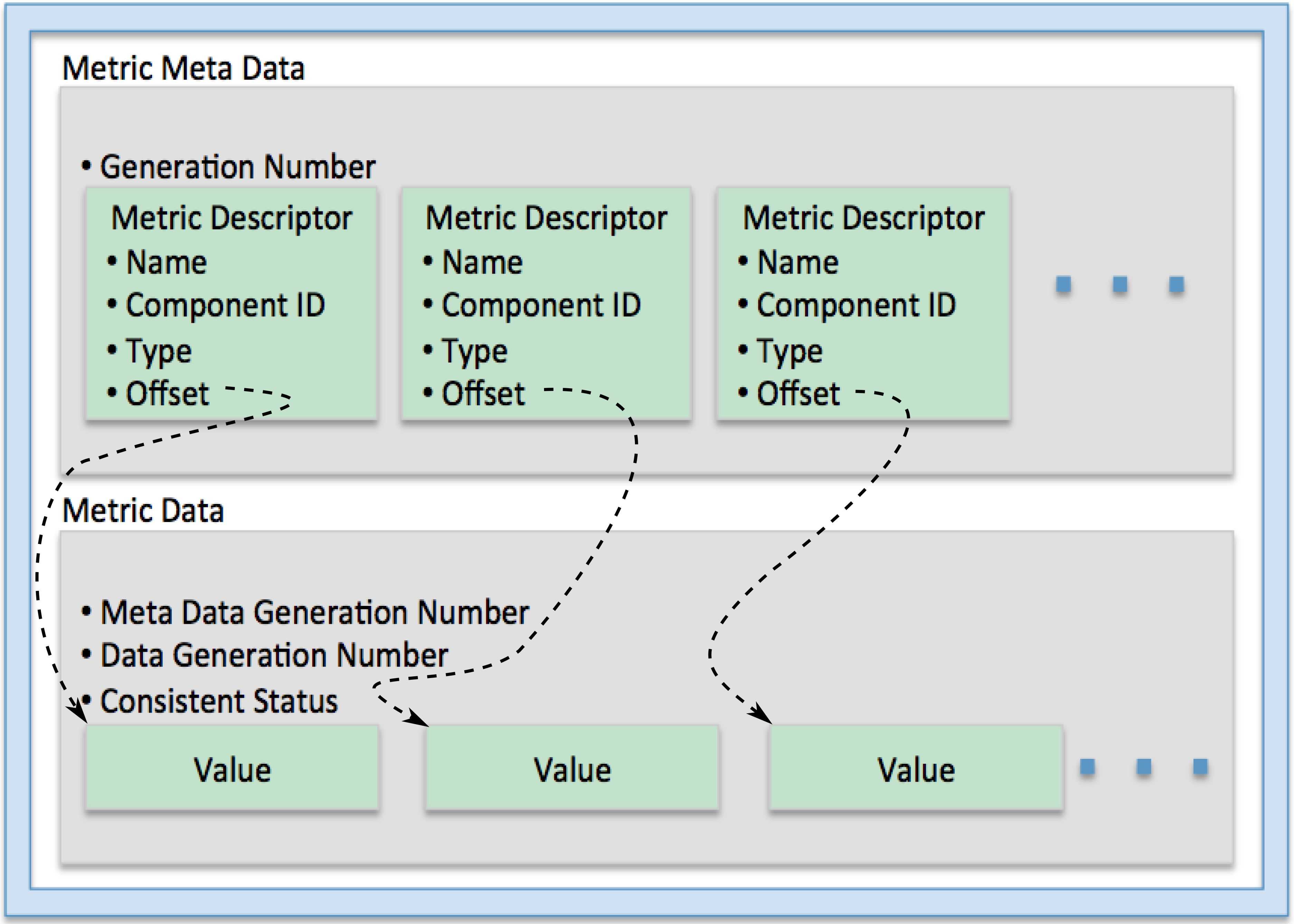


* Only the current data is retained on-node

LDMS Plugin Architecture



Metric Set Memory



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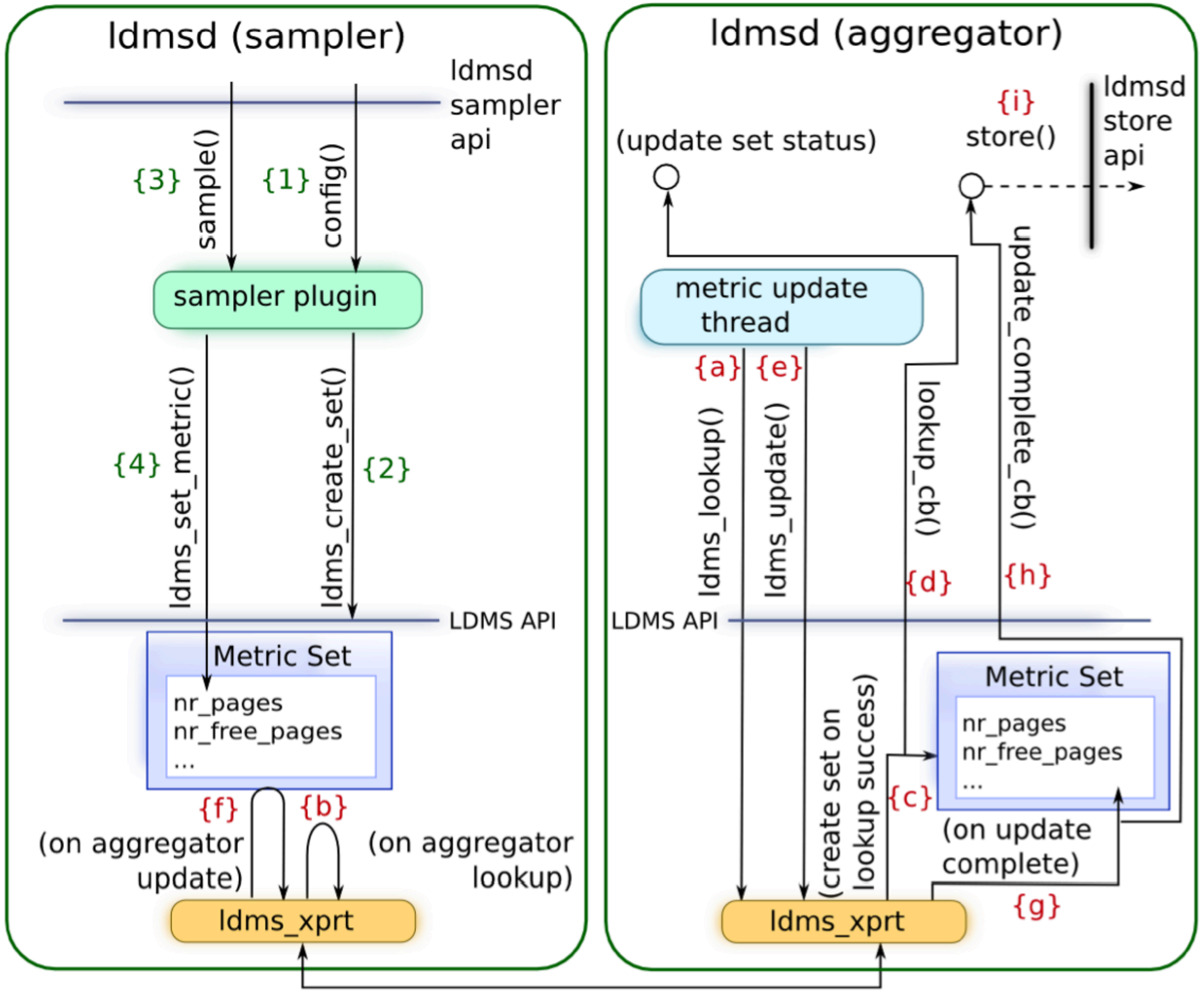
Data Flow



ldmsd (sampler)
ldmsd sampler api
{3} sample()
{1} config()
sampler plugin
{4} ldms_set_metric()
ldms_create_set() {2}
LDMS API
Metric Set
nr_pages
nr_free_pages
...
{f}
{b}
(on aggregator update)
(on aggregator lookup)
ldms_xprt
ldmsd (aggregator)
(update set status)
{i}
store()
ldmsd store api
metric update thread
{a} {e}
ldms_lookup()
ldms_update()
lookup_cb()
update_complete_cb()
{d}
{h}
LDMS API
(create set on lookup success)
{c}
Metric Set
nr_pages
nr_free_pages
...
(on update complete)
{g}
ldms_xprt

Supported platforms and networks

- Platforms
  - Rhel 6 and 7
  - SLES 11 & 12
  - Ubuntu
  - Cray XE6, XK and XC
- Transports
  - Socket
  - Cray ugni
    - Aries
    - Gemini
  - RDMA
    - Infiniband
    - iWarp

Build dependencies

- Typical compute node environment
  - Autoconf >=2.3, automake, autotool
  - Libevent2-devel >=2.0.31
  - OpenSSH-devel
- End use hosts (monitor cluster, special aggregation hosts, etc.)
  - Python
    - 2.6 with the argparse module
    - 2.7
  - Swig
  - Doxygen for documentation

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LDMS Installation methods

- Manually install using autoconf and automake
- Deployment using RPM

Note: For this demo, LDMS is pre-installed on student VMs in /opt/ovis.

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Getting started: Log in and set up your environment

```
ssh –Y ovis_public@XXXXXXX
$ ovis_public@XXXXXX's  password: *******
ovis_public@ovis-demo-login  ~                                    [sshd:]
$ ssh –Y ovis_public@ovis-demo-01
```

Note: "/home/ovis_public/demo/ldmsd/env/ldms-env.sh" is used to set up LDMS environment

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

VM directory structure

- VMs include source code, scripts and configuration files for every exercise, helper mini-applications for use in the exercises, and supporting visualization tools (e.g., gnuplot).
- Directory structure:
  - source-code/
    - ldms/ source code of LDMS latest release version
    - util/ utility codes for use in the examples
  - data/ Pre-collected numeric data and log message data
    - ldms-data/ Released numeric data from NCSA BlueWaters
      - csv A subset of Blue Waters data in the CSV format
  - demo/
    - ldmsd/
      - conf/ Configuration files used in the LDMS demo
      - data/ Place holders for the to-be-stored LDMS data
      - env/ Scripts to setup environment variables
      - scripts/ Helper scripts to deploying LDMS daemons

Note: VM's not in the release materials. Additional configuration scripts in the associated tarball

Getting started: Set up and verify your Environment

- System env. var.
  - PATH = ${OVIS_HOME}/bin/:${OVIS_HOME}/sbin/:${PATH}
  - LD_LIBRARY_PATH = ${OVIS_HOME}/lib/:${LD_LIBRARY_PATH}
  - PYTHONPATH = ${OVIS_HOME}/lib/python2.7/site-packages/:${PYTHONPATH}
- LDMS env. var.
  - ZAP_LIBPATH = ${OVIS_HOME}/lib/ovis-lib
  - LDMSD_PLUGIN_LIBPATH = ${OVIS_HOME}/lib/ovis-ldms
- LDMS authentication
  - LDMS_AUTH_FILE = <path to file with your shared secret>
    - Permissions 600
    - Format: secretword=<8 or more characters> (e.g. secretword=mylittlesecret)

NOTE: ${OVIS_HOME} =/opt/ovis in this example

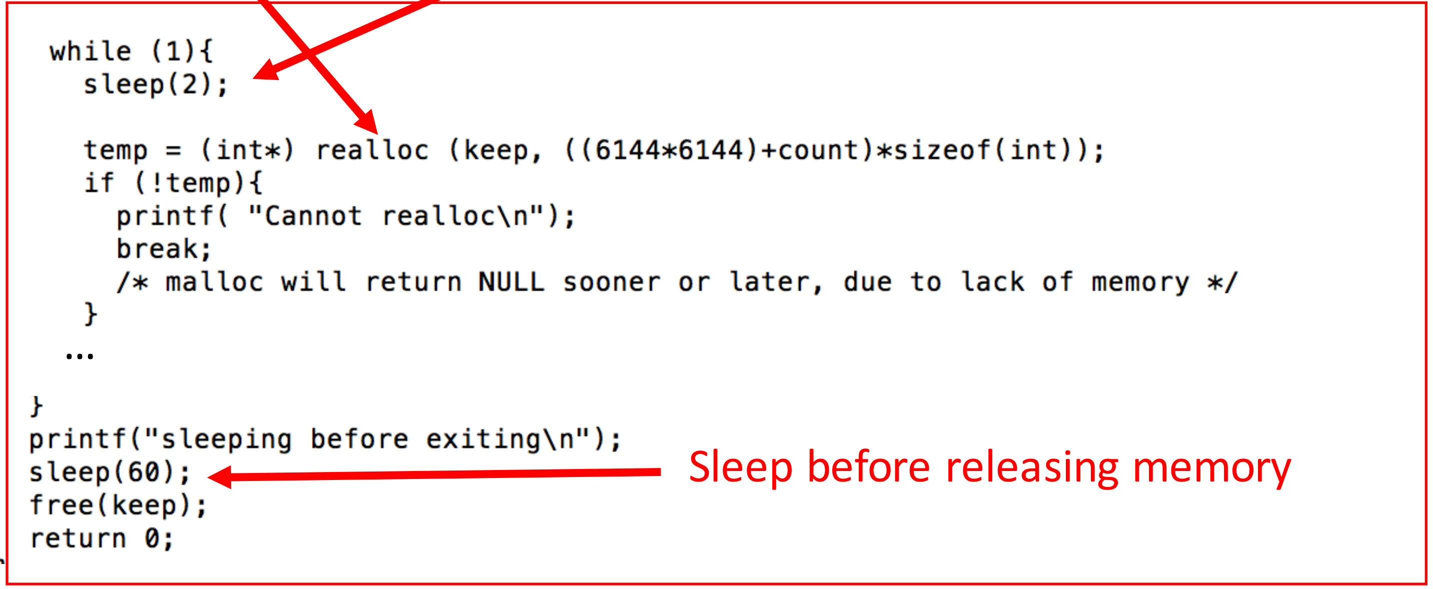
Note: VM's not in the release materials. Additional configuration scripts in the associated tarball

Test code: memeater.c

- Memeater code which repeatedly allocs mem. Run with LDMS to see changes in memory utilization values reported in /proc/meminfo.
- Located at /home/ovis_public/source-code/util/memeater.c. Compile with cc.

Periodically increase memory allocated

Sleep between alloc. Change this wrt sampling frequency.



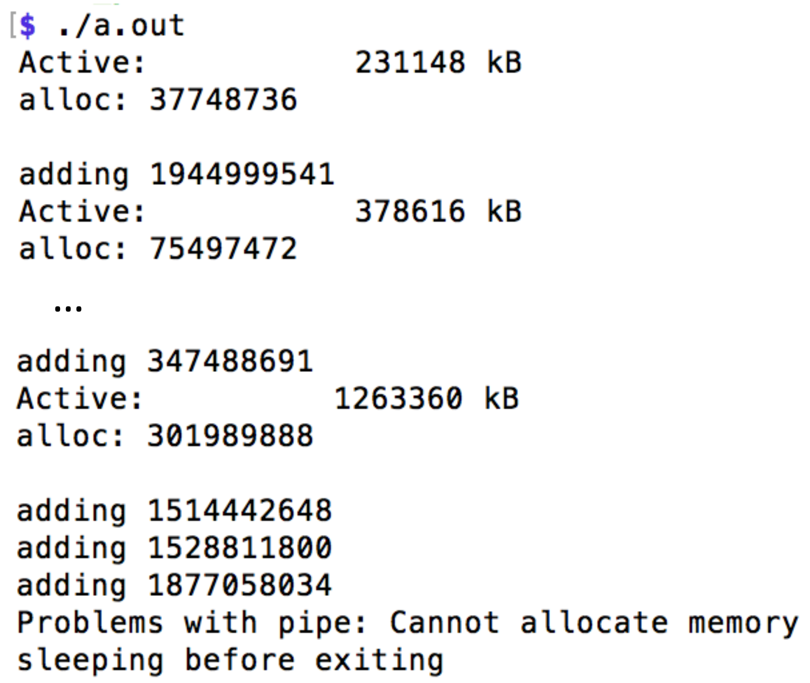
```
 while (1){
   sleep(2);

   temp = (int*) realloc (keep, ((6144*6144)+count)*sizeof(int));
   if (!temp){
     printf( "Cannot realloc\n");
     break;
     /* malloc will return NULL sooner or later, due to lack of memory */
   }
  ...

}
printf("sleeping before exiting\n");
sleep(60);
free(keep);
return 0;
```

Sleep before releasing memory

./a.out



```
$ ./a.out
Active:             231148 kB
alloc: 37748736

adding 1944999541
Active:             378616 kB
alloc: 75497472

  ...

adding 347488691
Active:            1263360 kB
alloc: 301989888

adding 1514442648
adding 1528811800
adding 1877058034
Problems with pipe: Cannot allocate memory
sleeping before exiting
```

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Lab Exercises

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

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LAB 1: Samplers

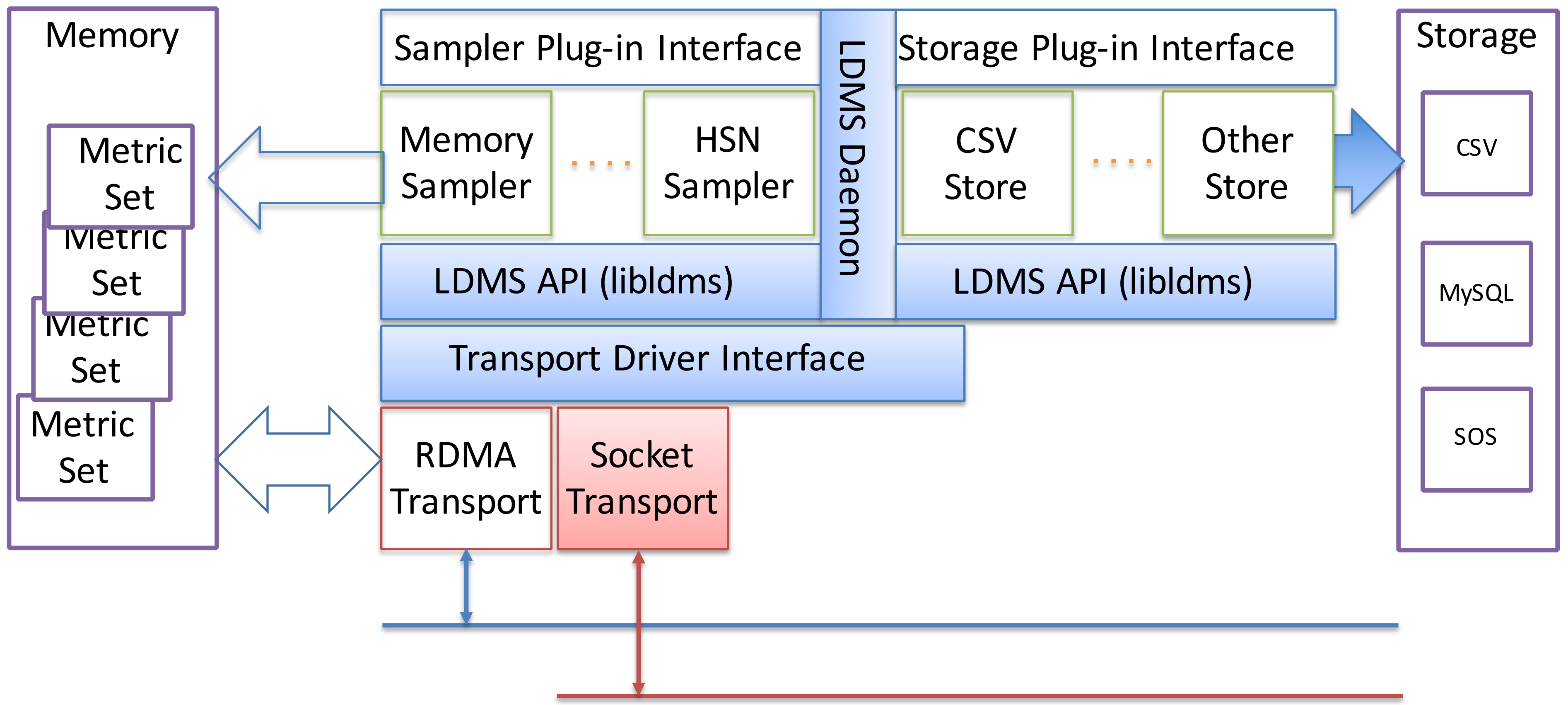
Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Start and configure a LDMS daemon

Lab Goals:

- Basic LDMS daemon startup and configuration flags/args
  - Manual and run-time configuration options
  - Output options
    - Log files and log levels
    - Debug information
  - man pages
    - man /opt/ovis/share/man/man8/ldmsd.8 – opens ldmsd man pages
    - man /opt/ovis/share/man/man8/ldmsd_controller.8 – opens “ldmsd_controller” man pages
- Use of ldms_ls utility as a diagnostic tool
  - man pages
    - man /opt/ovis/share/man/man8/ldms_ls.8 – opens ldms_ls man pages

LDMS Plugin Architecture



Start a LDMS daemon

- Start ldmsd

```
ldmsd -x sock:10001 -l sampled.log -S sampled.sock -r sampled.pid –
p 20001
```

- `-x:` Transport : listening port
- `-l:` Specify the log file path and name
- `-S:` Specify the Unix domain socket for communication with ldmsctl or ldmsd_controller
- `-r:` Specify where to write the pid file
- `-p:` Specify the listener port for remote configuration

Note: The log and Unix domain socket names are just strings. We use “samplerd” here to denote those being used by a ldmsd that will be running “samplers” as opposed to performing aggregation.

Check to see if ldmsd is running

- Using ps

```
ps auxw | grep ldmsd | grep –v grep
```

  - Returns something like: “ovis_pu+ 3582 0.0 0.1 401604 2204 ? Ssl 12:51 0:00 **ldmsd** -x sock:10001 -S samplerd.sock“ if running
  - Returns: blank line if not running
- Using ldms_ls

```
ldms_ls –h localhost –x sock –p 10001
```

  - Returns: “Connection failed/rejected.” if ldmsd specified does not exist
  - Returns: blank line if the ldmsd specified exists but has no metric sets configured

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Exercise: Run ldmsd

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Manually load and configure a sampler plugin

Lab Goals:

- Basic sampler plugin operation
  - Manual dynamic configuration using the "ldmsd_controller" utility
  - Static configuration using a configuration file
  - man pages
    - man /opt/ovis/share/man/man7/Plugin_meminfo.7 – opens meminfo plugin man pages
    - man /opt/ovis/share/man/man7/Plugin_vmstat.7 – opens vmstat plugin man pages
- Use of ldms_ls utility as a diagnostic tool
  - man pages
    - man /opt/ovis/share/man/man8/ldms_ls.8 – opens ldms_ls man pages

Configure LDMS daemon Sampler Plugin(s)

- Load the “meminfo” sampler plugin
- Configure loaded “meminfo” sampler plugin
  - Give the set name (instance)
  - Give the node name (producer)
  - Give the component ID
  - Plugin-specific arguments
- Start sampler plugin with a particular sampling interval and offset

optional

Connect ldmsd_controller to an ldmsd

- Set up “ldmsd_controller” connection to the aggregator over socket

```
$ldmsd_controller --host localhost --port 20001
--auth_file ~/.ldmsauth.conf
```

```
Welcome to the LDMSD control processor
localhost:20001>
```

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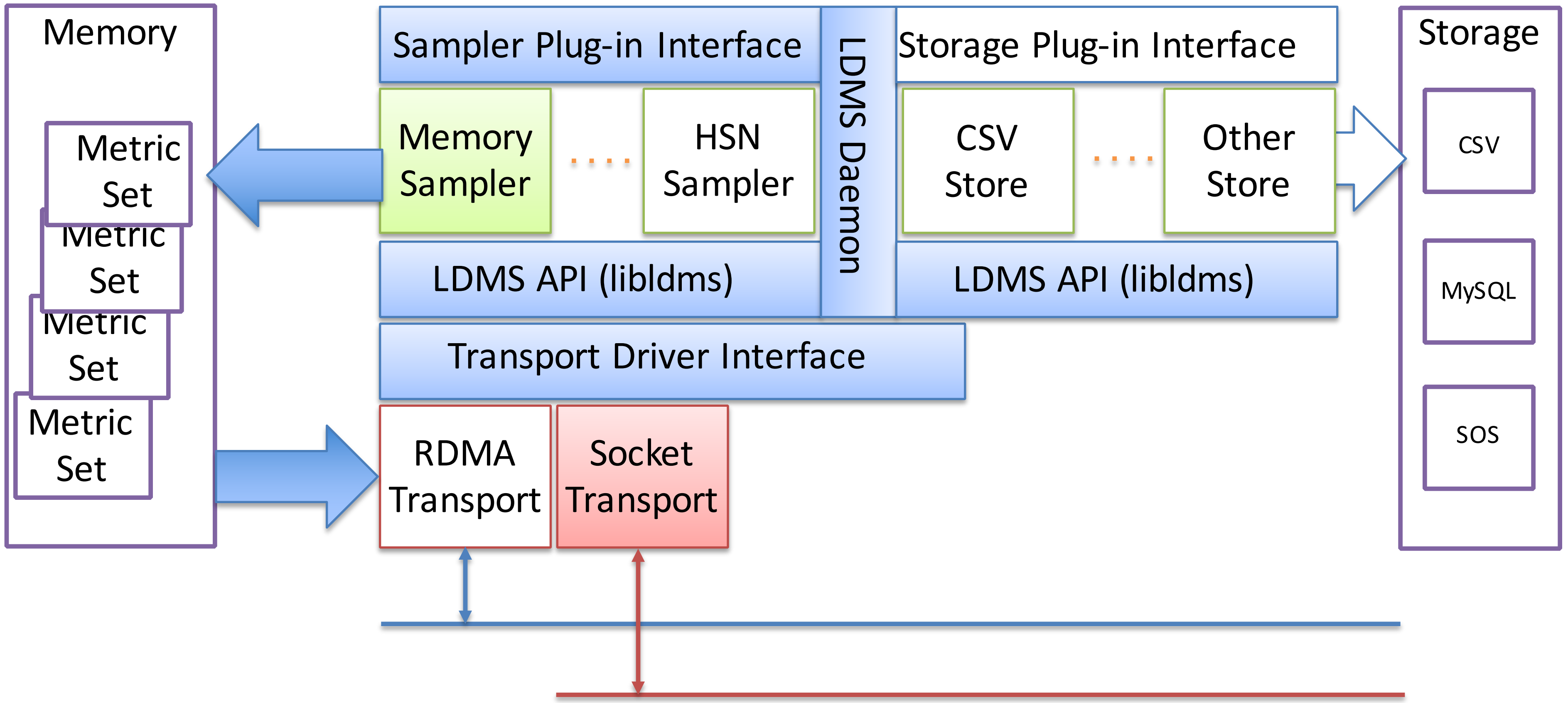
Exercise: Connect to ldmsd with ldmsd_controller

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

LDMS Plugin Architecture



Interactive Configuration using the ldmsd_controller

- Load the “meminfo” sampler

```
localhost:20001> load name=meminfo
```

- Configure the “meminfo” sampler

```
localhost:20001> config name=meminfo
                 producer=<$HOSTNAME>
                 instance=<$HOSTNAME>/meminfo
                 component_id=<host number>
```

Query current sets on an LDMS Daemon using “ldms_ls”

- Use ldms_ls to query the current sets available on an LDMS daemon

```
$ ldms_ls -h localhost -x sock -p 10001
```

```
ovis-demo-01/meminfo
$
```

Get the set information before starting the “meminfo” sampler

```
$ ldms_ls -h localhost -x sock -p 10001 -v ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: inconsistent, last update: Wed Dec 31 18:00:00 1969 [0us]
  METADATA --------
    Producer Name : ovis-demo-01
    Instance Name : ovis-demo-01/meminfo
      Schema Name : meminfo
             Size : 1904
     Metric Count : 45
               GN : 2
  DATA ------------
        Timestamp : Wed Dec 31 18:00:00 1969 [0us]
         Duration : [0.000000s]
       Consistent : FALSE
             Size : 400
               GN : 1
  -----------------
```

Query current metric values before starting the “meminfo” sampler

```
$ldms_ls -x sock -p 10001 -l ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: inconsistent, last update: Wed Dec 31 18:00:00 1969 [0us]
M u64           component_id                                    1
D u64           job_id                                          0
D u64           MemTotal                                        0
D u64           MemFree                                         0
D u64           MemAvailable                                    0
D u64           Buffers                                         0
D u64           Cached                                          0
D u64           SwapCached                                      0
D u64           Active                                          0
D u64           Inactive                                        0
…
```

Start the “meminfo” sampler

- Start the “meminfo” sampler

```
localhost:20001> start name=meminfo interval=1000000
offset=0
```

- This starts the sampler updating the metric values every 1 second

Get the set information

```
$ ldms_ls -x sock -p 10001 -v ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: consistent, last update: Fri Feb 10 12:46:55 2017 [3486us]
  METADATA --------
    Producer Name : ovis-demo-01
    Instance Name : ovis-demo-01/meminfo
      Schema Name : meminfo
             Size : 1904
     Metric Count : 45
               GN : 2
  DATA ------------
        Timestamp : Fri Feb 10 12:46:55 2017 [3486us]
         Duration : [0.000068s]
       Consistent : TRUE
             Size : 400
               GN : 259
  -----------------
```

Query current metric values

```
$ldms_ls -x sock -p 10001 -l ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: consistent, last update: Fri Feb 10 12:50:25 2017
[4156us]
M u64        component_id                              1
D u64        job_id                                    0
D u64        MemTotal                                  1884188
D u64        MemFree                                   828244
D u64        MemAvailable                              1639232
D u64        Buffers                                   948
D u64        Cached                                    915992
D u64        SwapCached                                0
D u64        Active                                    84336
D u64        Inactive                                  891196
…
```

Check source for reference

```
$ cat /proc/meminfo
MemTotal:        1884188 kB
MemFree:          828420 kB
MemAvailable:    1639912 kB
Buffers:             948 kB
Cached:           916396 kB
SwapCached:            0 kB
Active:            85144 kB
Inactive:         890212 kB
Active(anon):      58272 kB
Inactive(anon):     8372 kB
Active(file):      26872 kB
Inactive(file):   881840 kB
```

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Exercise: Manual sampler configuration

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

- Kill all of your ldmsd in preparation for the next section

```
$pkill ldmsd
```

- Kill a particular ldmsd

```
• ps auxw | grep ldmsd | grep –v grep
ovis_pu+  3582  0.0  0.1 401604  2204 ?        Ssl  12:51   0:00 ldmsd -x
sock:10001 -S samplerd.sock
• kill 3582
```

- Check to make sure it is dead

```
$ ps auxw | grep ldmsd | grep –v grep
```

Start ldmsd and sampler plugin using a configuration file

- ldmsd can be started using a configuration file
    - Syntax is identical to that used for manual configuration
    - Can be used to run and configure BOTH sampler and aggregator ldmsd
- Sample configuration file for meminfo example:

```
$cat /home/ovis_public/demo/ldmsd/conf/simple_sampler.conf
load name=meminfo

config name=meminfo producer=<$HOSTNAME> instance=<$HOSTNAME>/meminfo
component_id=<host number>

start name=meminfo interval=1000000
```

- Run ldmsd using this configuration file

```
$ldmsd -x sock:10001 -l samplerd.log -S samplerd.sock -c
/home/ovis_public/demo/ldmsd/conf/simple_sampler.conf
```

Query current metric values

```
$ldms_ls -x sock -p 10001 -l ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: consistent, last update: Fri Feb 10 12:50:25 2017 [4156us]
M u64        component_id                  1
D u64        job_id                        0
D u64        MemTotal                      1884188
D u64        MemFree                       828244
D u64        MemAvailable                  1639232
D u64        Buffers                       948
D u64        Cached                        915992
D u64        SwapCached                    0
D u64        Active                        84336
D u64        Inactive                      891196
…
```

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Exercise: Static sampler configuration

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Configuration Tools Summary

Dynamic/manual configuration (remote or local)

- ldmsd_controller – Python script that can connect to a ldmsd via a configured network socket or a local Unix Domain Socket

Static configuration (local)

- Configuration file – loaded at ldmsd run time

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Configuration option and tool.

- CMD line configuration –c
- ldmsctl
  - C interface to configure LDMSD.
  - Only for sampler daemon
- ldmsd_controller
  - Python interface to configure LDMSD.
  - Connect to an LDMSD using UNIX domain socket (local) or socket (remote).
  - Auto-completion
  - Command help
- More details can be found at https://www.opengridcomputing.com/wordpress/index.php/ovis-3-3-user-guide/#ldmsd-config

Start ldmsd_controller

- Connect with UNIX domain socket

```
ldmsd_controller --sockname samplerd.sock
```

- Connect with socket

```
ldmsd_controller --host localhost --port 20001
--auth_file ~/.ldmsauth.conf
```

ldmsd_controller: Get command list

```
samplerd.sock> help
```

```
Documented commands (type help <topic>):
========================================
EOF        prdcr_del          stop              udata              version
add        prdcr_start        store             udata_regex
config     prdcr_start_regex  strgp_add         updtr_add
env        prdcr_stop         strgp_del         updtr_del
help       prdcr_stop_regex   strgp_metric_add  updtr_match_add
include    quit               strgp_metric_del  updtr_match_del
info       say                strgp_prdcr_add   updtr_prdcr_add
load       shell              strgp_prdcr_del   updtr_prdcr_del
loglevel   source             strgp_start       updtr_start
logrotate  standby            strgp_stop        updtr_stop
prdcr_add  start              term              usage
```

Definitely use for samplerd
Definitely use for aggregators
Use to load and config plugin
Get help and daemon status

ldmsd_controller: command help

```
samplerd.sock> help prdcr_add
```

```
Add an LDMS Producer to the Aggregator
Parameters:
name=     A unique name for this Producer
xprt=     The transport name [sock, rdma, ugni]
host=     The hostname of the host
port=     The port number on which the LDMS is listening
type=     The connection type [active, passive]
interval= The connection retry interval (us)
```

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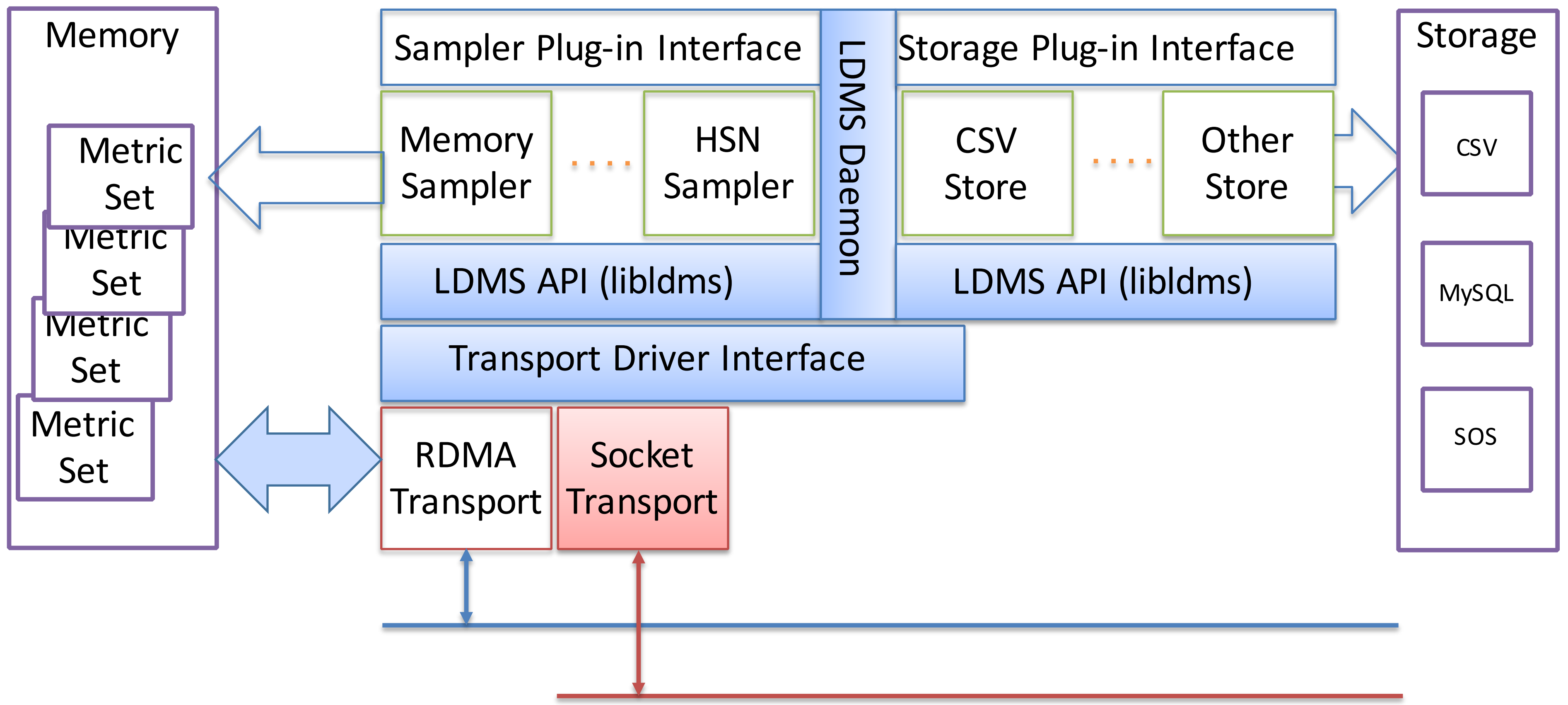
LAB 2: Aggregators

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

LDMS Plugin Architecture



Configure a LDMS daemon (ldmsd) to Aggregate metric set(s)

Goals:

- Add list of connections to sampler ldmsd’s
- Start the connections
- Create an Update policy
  - How often to get a metric set’s update
  - From which sampler ldmsd’s to aggregate
- Start the Update policy

Start an ldmsd that will be used for aggregation

- Start LDMSD

```
ldmsd -x sock:10002 -m 10M -l aggd.log -S aggd.sock -p 20002
```

- `-x:` transport : listener port
- `-m:` Allocate set memory for aggregated metric sets (default: 512K)
- `-l:` Specify the log file path
- `-S:` Specify “Unix Domain Socket” name used for local configuration
- `-p:` Specify the listener port for remote configuration

Interactive aggregator configuration

- Set up "ldmsd_controller" connection to the aggregator over socket

```
$ldmsd_controller --host localhost --port 20002
--auth_file ~/.ldmsauth.conf
```

```
Welcome to the LDMSD control processor
localhost:20002>
```

Simple Aggregator Configuration

- Configure the aggregator to aggregate the “meminfo” set from the sampler daemon

```
localhost:20002> prdcr_add name=bar host=$HOSTNAME port=10001 xprt=sock
type=active interval=20000000

localhost:20002> prdcr_start name=bar
```

- name: policy tag
- host: hostname of the sampler daemon
- port: Listener port of the sampler daemon
- xprt: Transport the sampler daemon listens on
- type: Always “active”
- interval: Re-connect interval

Plugin status (on agg after started prdcr but before updtr)

```
localhost:20002> status
```

```
Name             Host             Port         Transport    State
---------------- ---------------- ------------ ------------ ------------
localhost        localhost               10001 sock         CONNECTED
    ovis-demo-i03/meminfo meminfo            READY
Name             Interval     Offset       State
---------------- ------------ ------------ ------------
Name             Container        Schema           Plugin           State
---------------- ---------------- ---------------- ---------------- ------------
```

Query current metric values on the aggregator

```
$ldms_ls -h localhost -x sock -p 10002 -l
```

```
ovis-demo-01/meminfo: inconsistent, last update: Wed Dec 31 18:00:00 1969 [0us]
M u64        component_id                                  1
D u64        job_id                                        0
D u64        MemTotal                                      0
D u64        MemFree                                       0
D u64        MemAvailable                                  0
D u64        Buffers                                       0
D u64        Cached                                        0
D u64        SwapCached                                    0
D u64        Active                                        0
D u64        Inactive                                      0
…
```

Simple Aggregator Configuration

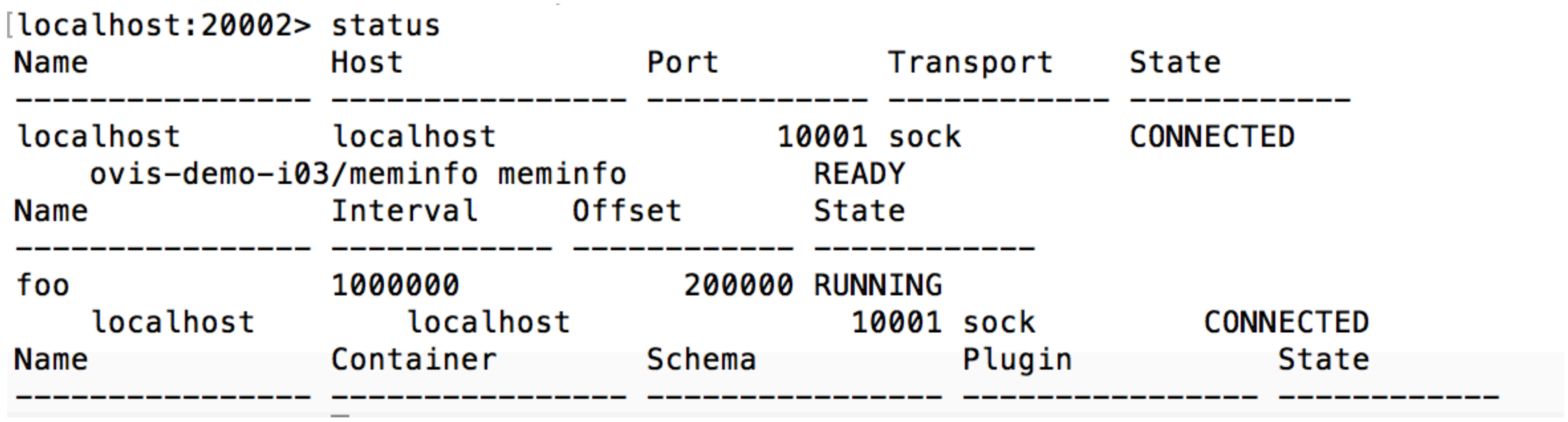
- Configure the aggregator to update the "meminfo" set

```
localhost:20002> updtr_add name=foo interval=1000000 offset=200000
localhost:20002> updtr_prdcr_add name=foo regex=.*
localhost:20002> updtr_start name=foo
```

- **name:** policy tag
- **interval:** update interval (in usec)
  - Example: interval=1000000 means aggregate every 1 seconds
- **offset:** Target (in us) from <epoc sec>.000000
  - Example: offset=10000 means aggregate every <interval> seconds at 10ms into the second.
- **regex:** regular expression to match the target producers tag(s)

Plugin status (on aggregator after started prdcr and updtr)

```
localhost:20002> status
```



```
localhost:20002> status
Name             Host             Port         Transport    State
---------------- ---------------- ------------ ------------ ------------
localhost        localhost               10001 sock         CONNECTED
    ovis-demo-i03/meminfo meminfo              READY
Name             Interval     Offset       State
---------------- ------------ ------------ ------------
foo              1000000            200000 RUNNING
    localhost        localhost               10001 sock         CONNECTED
Name             Container        Schema           Plugin           State
---------------- ---------------- ---------------- ---------------- ------------
```

Query current metric values on the aggregator

```
$ldms_ls -h locahost -x sock -p 10002 -l ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: consistent, last update: Fri Feb 10 12:50:25 2017 [4156us]
M u64          component_id                                  1
D u64          job_id                                        0
D u64          MemTotal                                      1884188
D u64          MemFree                                       828244
D u64          MemAvailable                                  1639232
D u64          Buffers                                       948
D u64          Cached                                        915992
D u64          SwapCached                                    0
D u64          Active                                        84336
D u64          Inactive                                      891196
…
```

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Exercise: Validate manual configuration and aggregation from sampler

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Start ldmsd and aggregation using a configuration file

- ldmsd can be started using a configuration file
  - Syntax is identical to that used for manual configuration
  - Can be used to run and configure BOTH sampler and aggregator ldmsd
- Sample configuration file for meminfo example:

```
$cat /home/ovis_public/demo/ldmsd/conf/simple_aggregator.conf
    prdcr_add name=localhost host=$HOSTNAME port=10001 xprt=sock type=active
    interval=20000000
    prdcr_start name=localhost
    updtr_add name=foo interval=1000000 offset=200000
    updtr_prdcr_add name=foo regex=.*
    updtr_start name=foo
```

- Run ldmsd using this configuration file

```
$ldmsd -x sock:10002 -l aggd.log -S aggd.sock -c
/home/ovis_public/demo/ldmsd/conf/simple_aggregator.conf
```

Query current metric values

```
$ldms_ls -x sock -p 10002 -l ovis-demo-01/meminfo
```

```
ovis-demo-01/meminfo: consistent, last update: Fri Feb 10 12:50:25 2017 [4156us]
M u64        component_id                             1
D u64        job_id                                   0
D u64        MemTotal                                 1884188
D u64        MemFree                                  828244
D u64        MemAvailable                             1639232
D u64        Buffers                                  948
D u64        Cached                                   915992
D u64        SwapCached                               0
D u64        Active                                   84336
D u64        Inactive                                 891196
…
```

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Exercise: Validate static aggregator configuration and aggregation from sampler

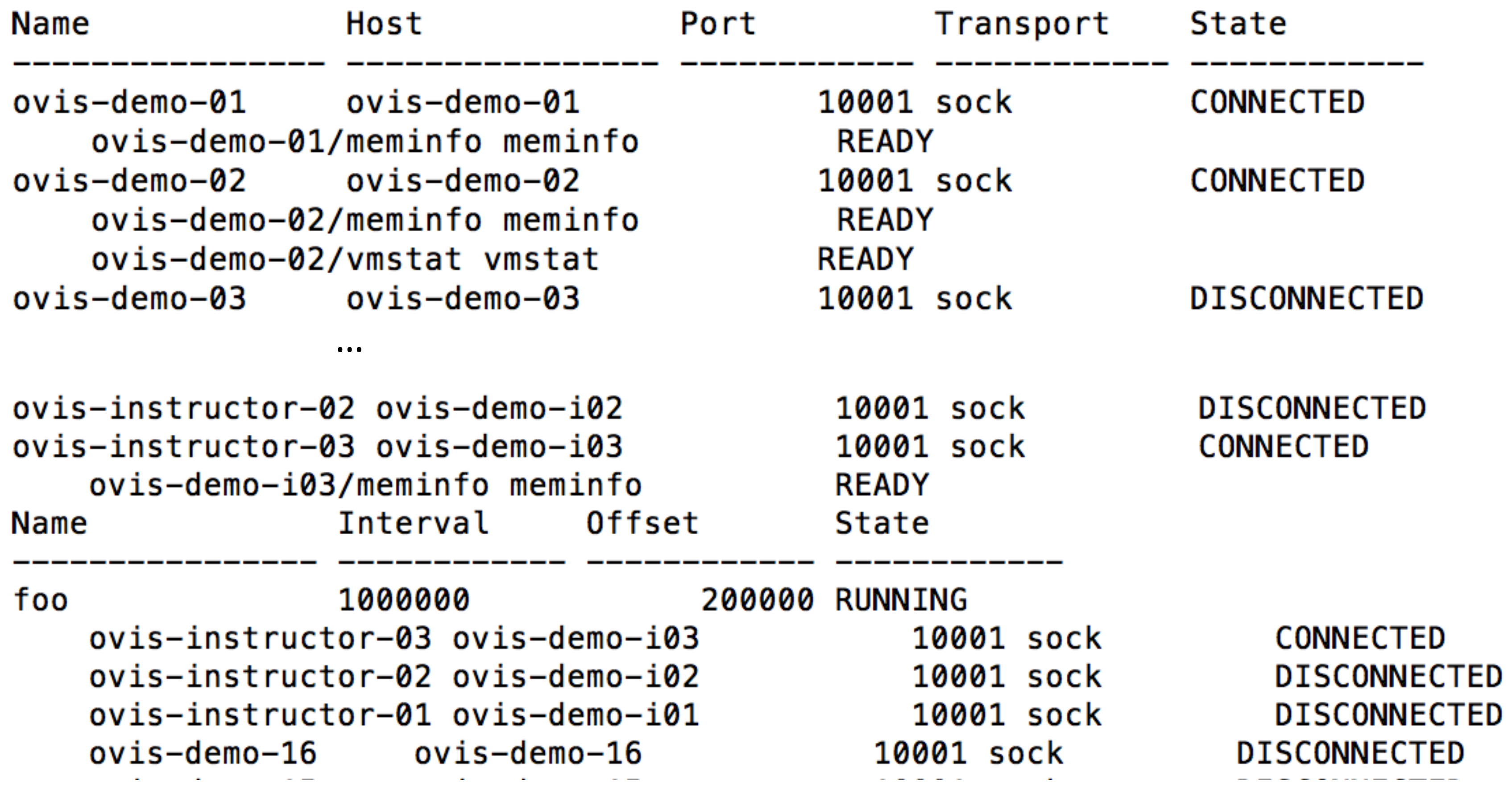
Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Aggregate from student VMs

- Kill aggregator ldmsd
- Restart ldmsd using “-c students_all_aggregator.conf”
- Kill aggregator ldmsd
- Restart ldmsd using “-c students_subset_aggregator.conf”

Plugin status (on aggregator from all students)

```
localhost:20002> status
```



```
Name             Host             Port         Transport    State
---------------- ---------------- ------------ ------------ ------------
ovis-demo-01     ovis-demo-01            10001 sock         CONNECTED
    ovis-demo-01/meminfo meminfo          READY
ovis-demo-02     ovis-demo-02            10001 sock         CONNECTED
    ovis-demo-02/meminfo meminfo          READY
    ovis-demo-02/vmstat vmstat           READY
ovis-demo-03     ovis-demo-03            10001 sock         DISCONNECTED
                 …

ovis-instructor-02 ovis-demo-i02          10001 sock         DISCONNECTED
ovis-instructor-03 ovis-demo-i03          10001 sock         CONNECTED
    ovis-demo-i03/meminfo meminfo         READY
Name             Interval     Offset       State
---------------- ------------ ------------ ------------
foo              1000000            200000 RUNNING
    ovis-instructor-03 ovis-demo-i03          10001 sock         CONNECTED
    ovis-instructor-02 ovis-demo-i02          10001 sock         DISCONNECTED
    ovis-instructor-01 ovis-demo-i01          10001 sock         DISCONNECTED
    ovis-demo-16     ovis-demo-16            10001 sock         DISCONNECTED
```

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Exercise: Validate static aggregator configuration and aggregation from sampler

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

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LAB 3: Dynamic Changes and Resilience

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Dynamic Configuration Changes

- Dynamic configuration
  - Sampler daemons
    - stop sampler plugins
    - start with different intervals
  - Aggregator daemons
    - stop prdcr/updtr/strgp
    - remove prdcr/updtr/strgp
    - change interval

Dynamic Changes and Robustness

- On-the-fly additions of samplers will be discovered by the aggregating ldmsd
  - **Exercise** – one student will add the vmstat sampler via ldmsd_controller to his running ldmsd. All others will see it appear in their aggregators which are collecting from that sampler.
  - **Exercise** – one student will stop his meminfo sampler via ldmsd_controller in his running ldmsd. All others will see in ldms_ls timestamp output that that student's metric set ceases to update.
  - **Exercise** – the same student will restart his meminfo sampler via ldmsd_controller in his running ldmsd. All others will see in ldms_ls timestamp output that that student's metric set resumes updating.
- Samplers and Aggregators can be started in any order
- LDMS collection and transport topologies are robust to Samplers and Aggregators being killed and restarted
  - **Exercise** – one student will kill his ldmsd sampler. All other students will see in ldms_ls timestamp output that that student's metric set ceases to update
  - **Exercise** – the same student will restart his ldmsd sampler. All other students will see in ldms_ls timestamp output that that student's metric set resumes updating.

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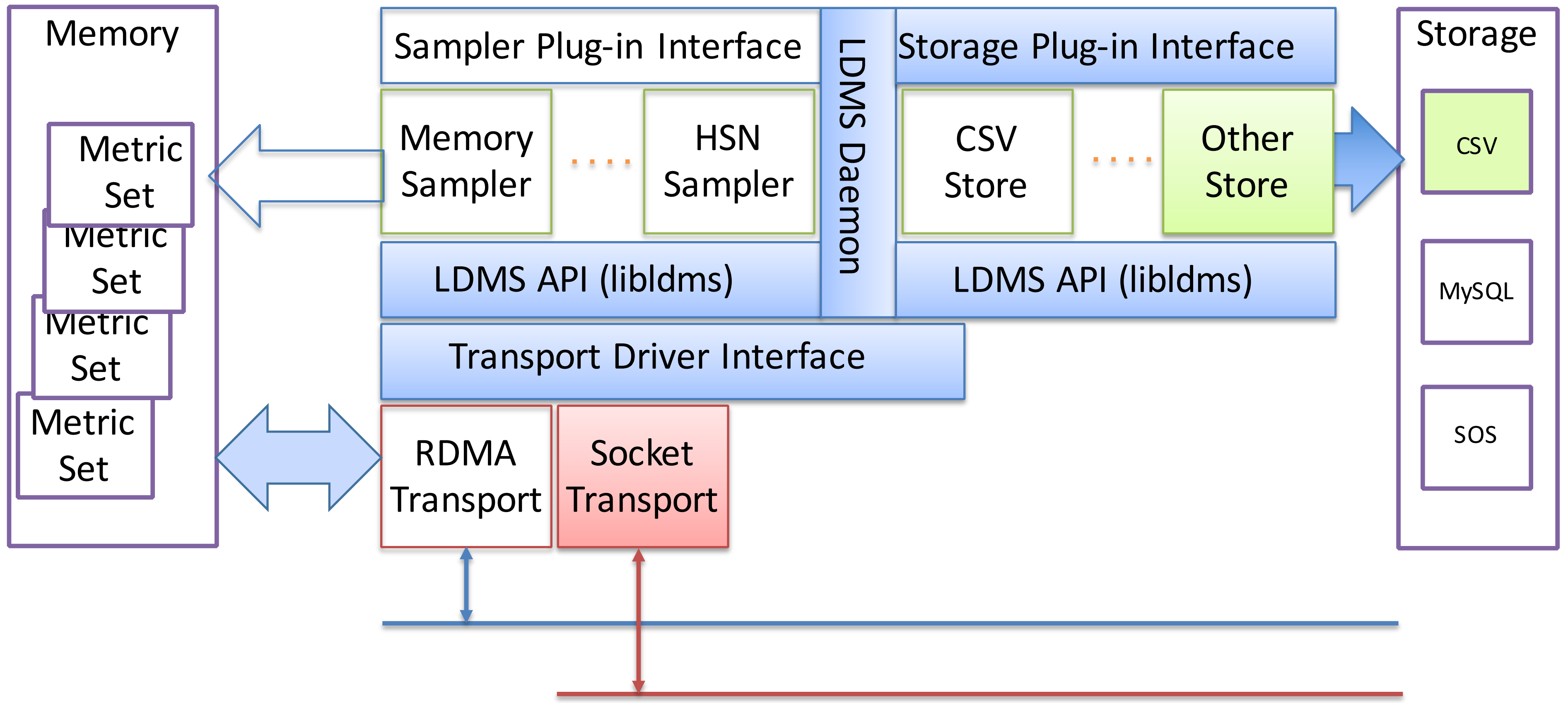
LAB 4: Storing data in CSV stores

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

LDMS Plugin Architecture



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Storing data to csv file(s)

- Goals:
  - Configure a csv store with ldmsd_controller
  - Configure a csv store with configuration file
  - Store options

- Example output:

```
#Time,Time_usec,ProducerName,component_id,job_id,MemTotal,MemFree,MemAvailable,Buffers,Cached,SwapCach
ed,Active,Inactive,Active(anon),Inactive(anon),Active(file),Inactive(file),Unevictable,Mlocked,SwapTotal,SwapFree,Dirt
y,Writeback,AnonPages,Mapped,Shmem,Slab,SReclaimable,SUnreclaim,KernelStack,PageTables,NFS_Unstable,Bounce,
WritebackTmp,CommitLimit,Committed_AS,VmallocTotal,VmallocUsed,VmallocChunk,HardwareCorrupted,AnonHugeP
ages,HugePages_Total,HugePages_Free,HugePages_Rsvd,HugePages_Surp,Hugepagesize,DirectMap4k,DirectMap2M

1487105964.002482,2482,ovis-demo-09,9,
0,1884188,571028,1688632,0,1212004,6108,104536,1122496,8276,8580,96260,1113916,0,0,839676,793956,420,0,1
0552,24812,1796,52124,40104,12020,1792,3280,0,0,0,1781768,387984,34359738367,7216,34359728128,0,2048,0,0,
0,0,2048,47040,2050048

1487105963.002583,2583,ovis-demo-02,2,
0,1884188,1665280,1671132,948,107512,0,71540,80920,44128,8308,27412,72612,0,0,839676,839676,0,0,44000,222
64,8436,35680,24304,11376,1600,2940,0,0,0,1781768,296444,34359738367,7216,34359728128,0,6144,0,0,0,0,2048,
34752,2062336

1487105963.001964,1964,ovis-demo-08,8,
0,1884188,1623168,1644996,948,129700,0,89312,101956,60788,8332,28524,93624,0,0,839676,839676,0,0,60620,23
912,8500,36456,24608,11848,1872,4364,0,0,0,1781768,403252,34359738367,7216,34359728128,0,16384,0,0,0,0,20
48,44992,2052096
```

Aggregator Configuration to store metric set data using CSV store

- Configure the aggregator to store the "meminfo" set to a csv file using ldmsd_controller
    - Load the store_csv plugin
    - Configure the plugin

```
$ldmsd_controller --host localhost --port 20002 --auth_file ~/.ldmsauth.conf
localhost:20002> load name=store_csv
localhost:20002> config name=store_csv path=/home/ovis_public/demo/ldmsd/data
action=init buffer=0
```

- name: plugin name
- path: Path to the base directory for the csv file container. This directory must pre-exist.
- action: 'init' to initialize the plugin (*other actions will not be described in this tutorial*)
- buffer: '0' to disable buffering
- man page:
    - man /opt/ovis/share/man/man7/Plugin_store_csv.7 – opens store_csv plugin man pages

Aggregator Configuration to store metric set data using CSV store

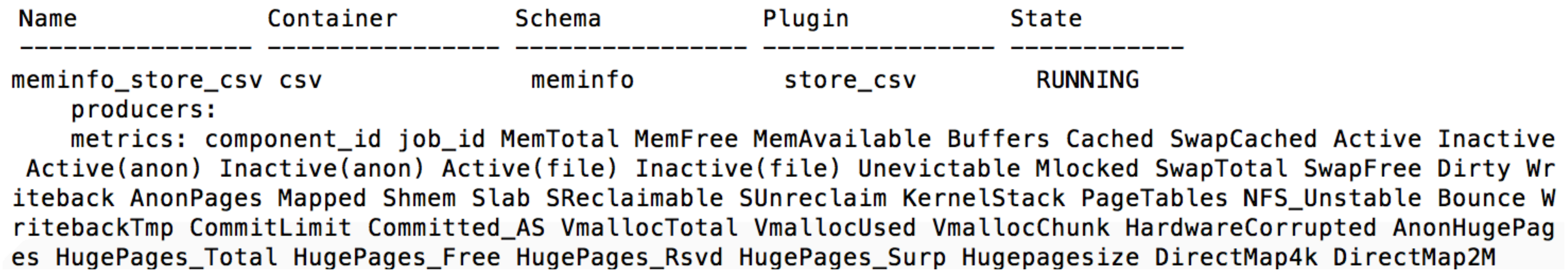
- Configure the aggregator to store the “meminfo” set to a csv file.

```
localhost:20002> strgp_add name=meminfo_store_csv
plugin=store_csv container=csv schema=meminfo
localhost:20002> strgp_start name=meminfo_store_csv
```

- name: storage policy tag
- plugin: store plugin used for storing metric set data
- container: the storage backend container name. For csv, this is the directory where the output file will go. This will be created.
- schema: metric set schema to be stored

Plugin Status *(store info only)*

```
localhost:20002> status
```



```
 Name               Container          Schema             Plugin             State
 ------------------ ------------------ ------------------ ------------------ ------------
meminfo_store_csv csv                 meminfo            store_csv         RUNNING
    producers:
    metrics: component_id job_id MemTotal MemFree MemAvailable Buffers Cached SwapCached Active Inactive
 Active(anon) Inactive(anon) Active(file) Inactive(file) Unevictable Mlocked SwapTotal SwapFree Dirty Wr
iteback AnonPages Mapped Shmem Slab SReclaimable SUnreclaim KernelStack PageTables NFS_Unstable Bounce W
ritebackTmp CommitLimit Committed_AS VmallocTotal VmallocUsed VmallocChunk HardwareCorrupted AnonHugePag
es HugePages_Total HugePages_Free HugePages_Rsvd HugePages_Surp Hugepagesize DirectMap4k DirectMap2M
```

Examining the CSV file

- The data is saved in: /home/ovis_public/demo/ldmsd/data/csv/meminfo

1. Checking the csv file

```
$ tail –f /home/ovis_public/demo/ldmsd/data/csv/meminfo
```

   - If aggregating from others' vm's, see multiple hosts in the output

2. Data changes:
   - Run the memeater executable

```
$ ./a.out
```

   - Compare the live memeater output with the tail –f values

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Exercise: Store CSV

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Start csv store with a configuration file with advanced configuration options

- Aggregator configuration file at: /home/ovis_public/demo/ldmsd/conf/agg.conf

```
load name=store_csv
config name=store_csv path=/home/ovis_public/demo/ldmsd/data action=init buffer=0
    rollover=120 rolltype=1 altheader=1
strgp_add name=meminfo_store_csv schema=meminfo plugin=store_csv container=csv
strgp_start name=meminfo_store_csv
```

- New configuration options:
  - Rollover by time or size:
    - `rollover=120 rolltype=1` – rolls over every 120 sec. Output file is postpended with epoch timestamp (meminfo.12345)
  - Header in a separate file:
    - `altheader=1`

Start csv store with a configuration file with advanced configuration options

- Uncomment the lines for store_csv only (*not store_function_csv*)
- Kill current aggregator (not the sampler) and Restart aggregator:

```
ldmsd -x sock:10002 -l agg.log -p 20002
     -c /home/ovis_public/demo/ldmsd/conf/agg.conf
```

- Note the file rollover and alternate header

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Exercise: CSV store with a configuration file and advanced configuration options

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

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LAB 5: Calculating derived data and saving to a CSV store

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Storing data to store function csv file(s)

Goals:

- Configure a function csv store with ldmsd_controller
- Configure a function csv store with a configuration file
- Function options

Example output:

```
#Time,Time_usec,DT,DT_usec,ProducerName,component_id,job_id,RAW_ACTIVE,RAW_ACTIVE.Flag
,RAW_MEMTOTAL,RAW_MEMTOTAL.Flag,RATIO100,RATIO100.Flag,  TimeFlag
1487107627.002486,2486,0.999712,999712,ovis-demo-i03,103,0,828068,0,1884188,0,43,0,0
1487107628.002425,2425,0.999939,999939,ovis-demo-i03,103,0,975536,0,1884188,0,51,0,0
1487107629.002402,2402,0.999977,999977,ovis-demo-i03,103,0,975528,0,1884188,0,51,0,0
1487107630.018970,18970,1.016568,16568,ovis-demo-i03,103,0,980228,0,1884188,0,52,0,0
1487107631.002405,2405,0.983435,983435,ovis-demo-i03,103,0,1122996,0,1884188,0,59,0,0
```

Active/Memtotal ratio increasing while memeater runs

Store_function_csv configuration file

Configuration File at /home/ovis_public/demo/ldmsd/conf/fct.conf

```
# SCHEMA NEW_METRICNAME FUNCTION N_MET <METS_CSV> SCALE|THRESH WRITEOUT
meminfo RAW_ACTIVE  RAW  1 Active 1 1
meminfo RAW_MEMTOTAL  RAW 1 MemTotal 1 1
meminfo RATIO100 DIV_AB 2 RAW_ACTIVE,RAW_MEMTOTAL  100  1
```

- Functions: RAW (raw value), Scalar and Vector add/subtract/multiply/divide, threshold checks, min/max
  - man page
    - man /opt/ovis/share/man/man7/Plugin_store_function_csv.7 – opens store_function_csv plugin man pages
- Chain variables for a complex computation
- V3 Limitations (addressed in future versions):
  - u64 cast at all steps. Can use scale to keep precision.
  - Functions are only per instance of a metric set (e.g., cannot combine data from meminfo and vmstat, cannot combine info from different components)
- Output flags: Flag for invalid for every computation and for ageusec

Aggregator Configuration to store metric set data using store_function_csv

- Configure the aggregator to store derived data from the “meminfo” set to a csv file.

```
$ldmsd_controller --host localhost --port 20002 --auth_file ~/.ldmsauth.conf
localhost:20002> load name=store_function_csv
localhost:20002> config name=store_function_csv
path=/home/ovis_public/demo/ldmsd/data buffer=0 ageusec=2000000
derivedconf=/home/ovis_public/demo/ldmsd/conf/fct.conf
```

- ~~action: ‘init’ to initialize the plugin~~
- derived_conf: derived configuration file (can take multiples: csv)
- ageusec: flag when the DT between data points is greater than this value

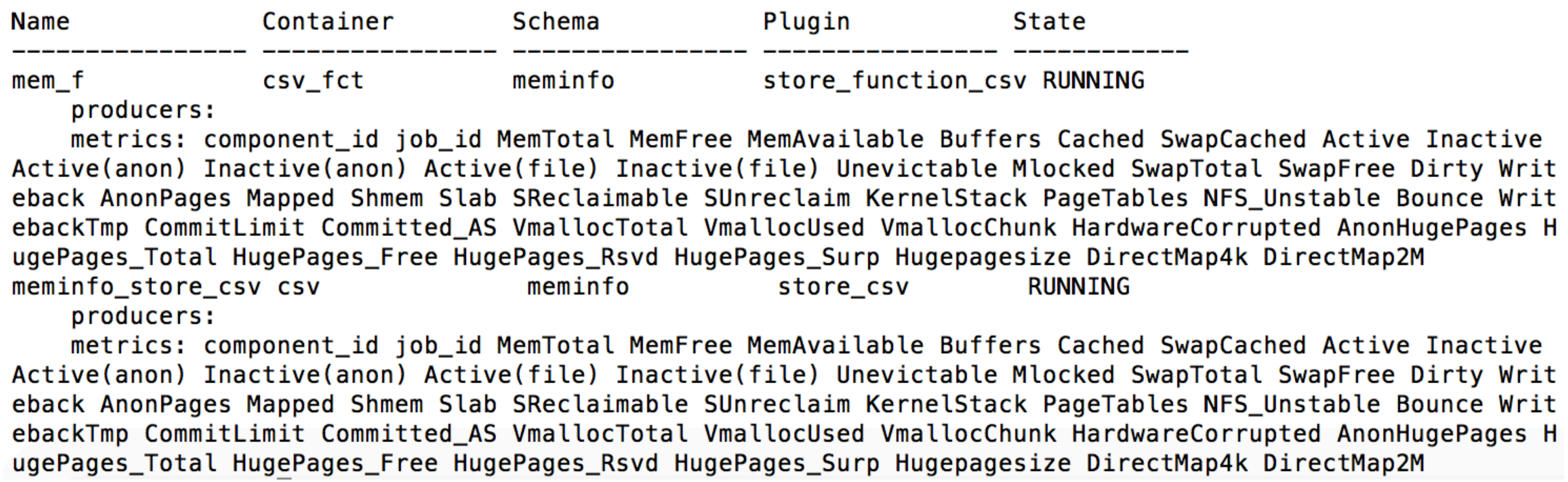
Aggregator Configuration to store metric set data using store_function_csv

- Configure the aggregator to store derived data from the "meminfo" set to a csv file.

```
localhost:20002> strgp_add name=mem_f
plugin=store_function_csv container=csv_fct
schema=meminfo
localhost:20002> strgp_start name=mem_f
```

Plugin Status *(store info only shown)*

```
localhost:20002> status
```



```
Name             Container        Schema           Plugin           State
---------------- ---------------- ---------------- ---------------- ------------
mem_f            csv_fct          meminfo          store_function_csv RUNNING
    producers:
    metrics: component_id job_id MemTotal MemFree MemAvailable Buffers Cached SwapCached Active Inactive
Active(anon) Inactive(anon) Active(file) Inactive(file) Unevictable Mlocked SwapTotal SwapFree Dirty Writ
eback AnonPages Mapped Shmem Slab SReclaimable SUnreclaim KernelStack PageTables NFS_Unstable Bounce Writ
ebackTmp CommitLimit Committed_AS VmallocTotal VmallocUsed VmallocChunk HardwareCorrupted AnonHugePages H
ugePages_Total HugePages_Free HugePages_Rsvd HugePages_Surp Hugepagesize DirectMap4k DirectMap2M
meminfo_store_csv csv              meminfo          store_csv        RUNNING
    producers:
    metrics: component_id job_id MemTotal MemFree MemAvailable Buffers Cached SwapCached Active Inactive
Active(anon) Inactive(anon) Active(file) Inactive(file) Unevictable Mlocked SwapTotal SwapFree Dirty Writ
eback AnonPages Mapped Shmem Slab SReclaimable SUnreclaim KernelStack PageTables NFS_Unstable Bounce Writ
ebackTmp CommitLimit Committed_AS VmallocTotal VmallocUsed VmallocChunk HardwareCorrupted AnonHugePages H
ugePages_Total HugePages_Free HugePages_Rsvd HugePages_Surp Hugepagesize DirectMap4k DirectMap2M
```

Storing derived data to a function store CSV file

- The data is saved at /home/ovis_public/demo/ldmsd/data/csv_fct/meminfo
- Checking the csv_fct file:

```
tail  -f /home/ovis_public/demo/ldmsd/data/csv_fct/meminfo
```

Exercise: Store_function_csv

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Storing derived data to a function store CSV file using the ldmsd configuration file

- Uncomment the lines for store_function_csv (*store_csv lines are still uncommented*)
- Kill current aggregator (not the sampler) and Restart aggregator:

```
ldmsd -x sock:10002 -l agg.log -p 20002
-c /home/ovis_public/demo/ldmsd/conf/agg.conf
```

- Checking the csv_fct file

```
tail  -f /home/ovis_public/demo/ldmsd/data/csv_fct/meminfo
```

- Run the memeater code at same time as storing data:

```
./a.out
```

the memeater executable

compare the live memeater output with the tail –f values

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Exercise: Store_function_csv with configuration file and memeater

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

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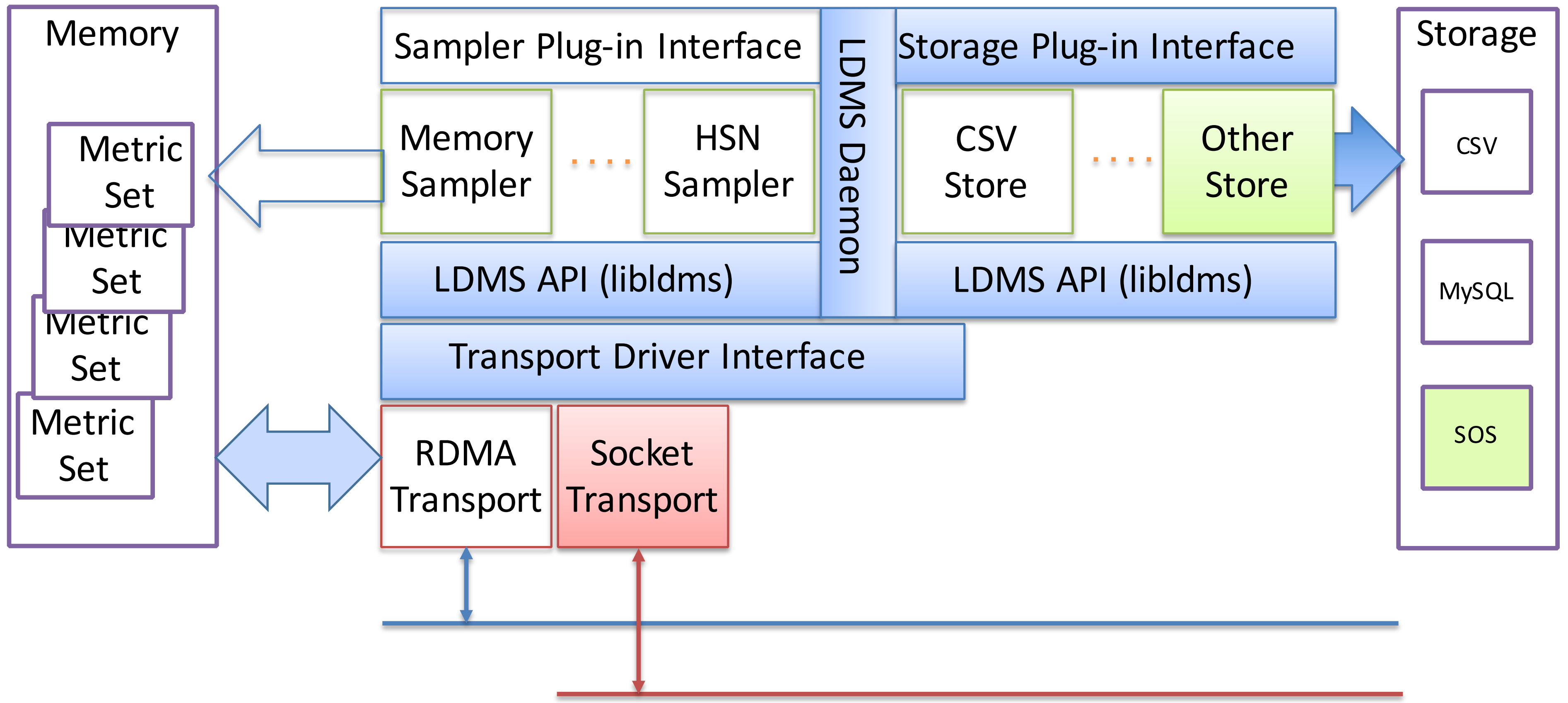
LAB 6: Storing the data in an SOS database

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

LDMS Plugin Architecture



Configure the aggregator’s SOS store plugin

- Steps:
  - Load the store_sos plugin
  - Configure the plugin

```
localhost:20002> load name=store_sos
localhost:20002> config name=store_sos
path=/home/ovis_public/demo/ldmsd/data/sos
```

- name: plugin name
- path: Path to the directory to contain the SOS database

Add a storage policy to save the meminfo data to the SOS store

- Configure the aggregator to store the "meminfo" set to a SOS database.

```
localhost:20002> strgp_add name=meminfo_sos plugin=store_sos
container=meminfo schema=meminfo
localhost:20002> strgp_start name=meminfo_sos
```

- name: storage policy tag
- plugin: store plugin used for storing metric set data
- container: the storage backend container name
- schema: metric set schema to be stored

Use a configuration file to configure the storage back-end

- Edit the configuration file at ~/demo/ldmsd/conf/agg.conf
  - Uncomment the store_sos configuration lines
- Kill current aggregator (not the sampler)
- Restart the aggregator

```
   ldmsd -x sock:10002 -l agg.log -p 20003 \
     -c ~/demo/ldmsd/conf/agg.conf
```

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LAB 7: Exploring data in an SOS database

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

Exercise: Use the SOS tools to explore the database

- sos_cmd
  - Create containers
  - Create and query schema
  - Import and query data
- lmq
  - Plot data stored in the SOS database
- Data visualization on Grafana

Query available schemas in your database

```
$ sos_cmd -C /home/ovis_public/demo/ldmsd/data/sos/meminfo/ -l
```

Container name given at strgp_add

```
schema :
   name      : meminfo
   schema_sz : 4504
   obj_sz    : 408
   id        : 129
   -attribute : timestamp
       type           : TIMESTAMP
       idx            : 0
       indexed        : 1
       offset         : 8
```

```
-attribute : MemTotal
       type          : UINT64
       idx           : 5
       indexed       : 0
       offset        : 48
   -attribute : MemFree
       type          : UINT64
       idx           : 6
       indexed       : 0
       offset        : 56
```

Query data in the SOS database

```
sos_cmd -C /home/ovis_public/demo/ldmsd/data/sos/meminfo  \
            -q -S meminfo  -X comp_time -V timestamp –V component_id  -V MemFree -V Active | less
```

```
timestamp                        component_id       MemFree            Active
-------------------------------- ------------------ ------------------ ------------------
               1487100290.607418                  0            1636160              80120
               1487100300.609416                  0            1636160              80120
               1487100310.611474                  0            1642688              76016
.  .  .
               1487114607.002163                103            1628516              90320
               1487114608.002077                103            1628516              90320
-------------------------------- ------------------ ------------------ ------------------
Records  887636/887636.
```

-q Query the database
-S Schema name
-X index used to order data
-V once for column in the output

Output the data as a CSV file

```
sos_cmd -C /home/ovis_public/demo/ldmsd/data/sos/meminfo  \
            -q -S meminfo  -X comp_time-V timestamp –V component_id  -V MemFree -V Active  -f csv| less
```

```
# timestamp,component_id,MemFree,Active
1487100290.607418,0,1636160,80120
1487100300.609416,0,1636160,80120
1487100310.611474,0,1642688,76016
.   .   .
1487114606.002196,103,1628548,90320
1487114607.002163,103,1628516,90320
1487114608.002077,103,1628516,90320
# Records 889483/889483.
-------------------------------- ------------------ ------------------ ------------------
Records 887636/887636.
```

-q Query the database
-S Schema name
-X index used to order data
-V once for column in the output
-f csv format the output as CSV

Output the data as a JSON file

```
sos_cmd -C /home/ovis_public/demo/ldmsd/data/sos/meminfo  \
             -q -S meminfo  -X comp_time-V timestamp –V component_id  -V MemFree -V Active  -f json | less
```

```
{ "data" : [
{"timestamp" : "1487100290.607418","component_id"  : "0","MemFree" : "1636160","Active" : "80120"},
{"timestamp" : "1487100300.609416","component_id"  : "0","MemFree" : "1636160","Active" : "80120"},
{"timestamp" : "1487100310.611474","component_id"  : "0","MemFree" : "1642688","Active" : "76016"},
{"timestamp" : "1487100320.613736","component_id"  : "0","MemFree" : "1641272","Active" : "77292"},
 .    .    .
{"timestamp" : "1487114606.002196","component_id"  : "103","MemFree" : "1628548","Active" : "90320"},
{"timestamp" : "1487114607.002163","component_id"  : "103","MemFree" : "1628516","Active" : "90320"},
{"timestamp" : "1487114608.002077","component_id"  : "103","MemFree" : "1628516","Active" : "90320"}], "totalRecords" : 890414,
"recordCount"  : 890414}
```

-q Query the database
-S Schema name
-X index used to order data
-V once for column in the output
-f csv format the output as JSon

LAB 8: Data Analysis and Visualization from an SOS database

Note: VM's not in the release materials.
Additional configuration scripts in the associated tarball

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lmq

LDMS tool to plot time-series graphs

Query range of dates available in the database

```
lmq --path /home/ovis_public/demo/data/sos/meminfo \
      --query dates --schema meminfo
```

```
There are data available from 02/13/17 14:47:44 (1487018864.002345) through
02/15/17 21:12:21 (1487214741.002282)
```

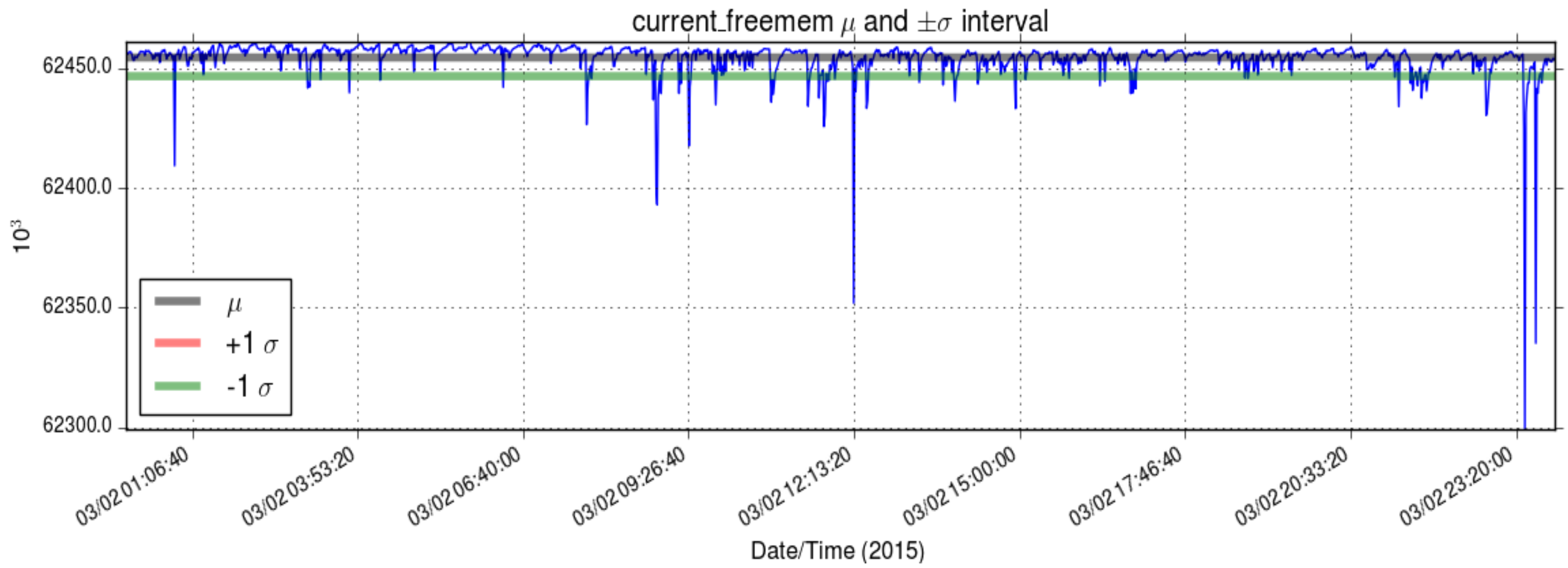
--path	The path to the container
--query	What is being queried
--schema	The schema to query

Exercise: Plot time-series graph of a metric

```
$lmq --path ~/demo/ldmsd/data/sos/meminfo --query data --schema meminfo \
      --metric_name MemFree --component_id 2
```

--path	The path to the container
--query	What is being queried
--schema	The schema to query
--metric_name	The metric data to plot
--component_id	The component data to plot

lmq plot of MemFee of component 2

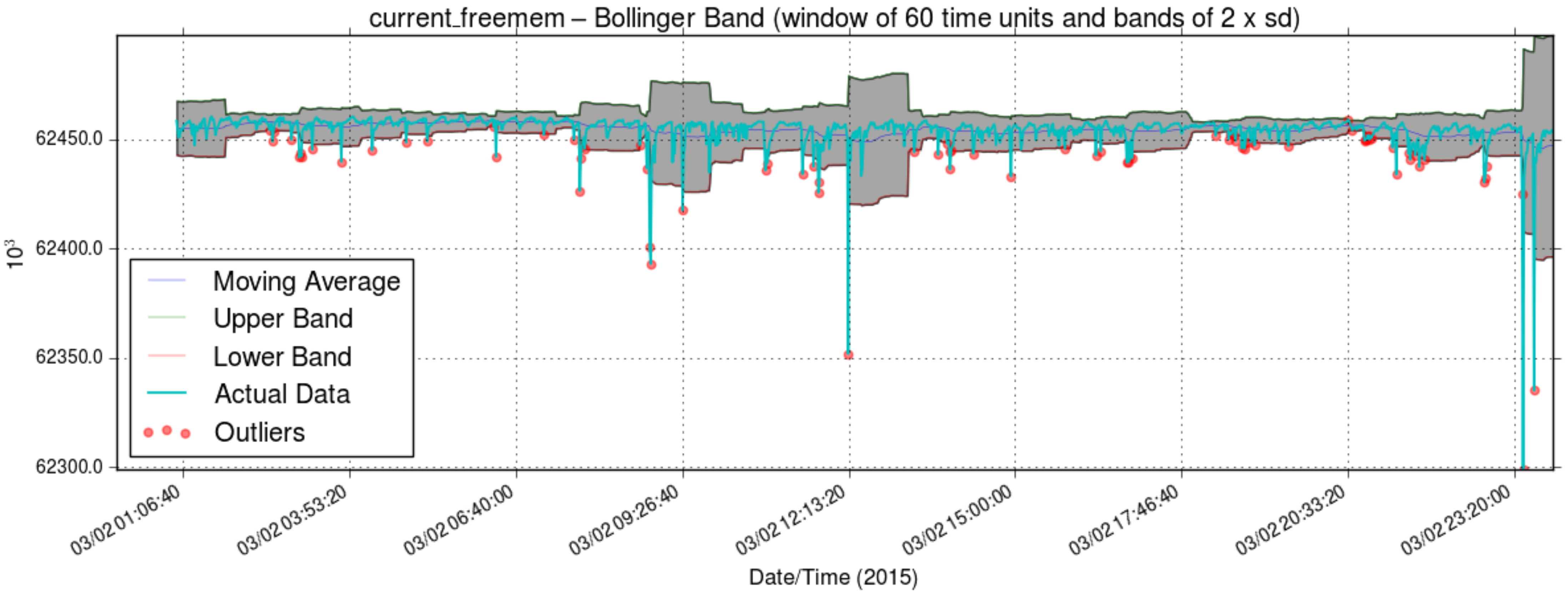


Exercise: Plot a graph showing windowed average, and running windowed variance

```
lmq --path ~/demo/ldmsd/data/sos/meminfo --query data --schema meminfo \
            --metric_name current_freemem  --component_id 2 --bollinger
```

--path	The path to the container
--query	What is being queried
--schema	The schema to query
--metric_name	The metric data to plot
--component_id	The component data to plot
--bollinger	Plot Bollinger bands and outliers

lmq plot of MemFree of component 2


current_freemem – Bollinger Band (window of 60 time units and bands of 2 x sd)
Moving Average
Upper Band
Lower Band
Actual Data
Outliers
10^3
03/02 01:06:40
03/02 03:53:20
03/02 06:40:00
03/02 09:26:40
03/02 12:13:20
03/02 15:00:00
03/02 17:46:40
03/02 20:33:20
03/02 23:20:00
Date/Time (2015)