ACCESS Monitoring and Measurement Service (MMS) Overview
SURA - June 2022
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ACCESS Monitoring and Measurement Service

• Comprehensive framework for CI system management
• Understand and optimize resource utilization and performance
  • Provide instantaneous and historical information on utilization
  • Measure Quality of Service of CI systems and applications
  • Measure and improve job and system level performance
  • Inform computing system upgrades and procurements
• XDMoD (XD Metrics on Demand) tool
  • Analytics Framework for XSEDE/ACCESS
• Open XDMoD*: Open Source version for CI centers
  • Used to measure and optimize performance of HPC centers
  • 250+ academic, governmental, & commercial installations worldwide
  • https://open.xdmod.org/
ACCESS MMS Team

• University at Buffalo – Center for Computational Research
  • Matt Jones, Bob DeLeon, Joe White, Jeff Palmer, Nikolay Simakov, Ryan Rathsam, Gregary Dean, Hannah Taylor, Conner Saeli

• Roswell Park
  • Tom Furlani (PI)

• TACC
  • Bill Barth, Stephen Harrell, Matt Cawood (performance monitoring)

• Tufts
  • Abani Patra (performance monitoring)

• Indiana
  • Jennifer Schopf (Netsage)

• Case Western
  • Vipin Chaudhary (application anomaly detection)

• SDSC
  • Shava Smallen (CloudBank)
Why a CI Monitoring and Measurement Service?

- Monitoring and Audit of NSF funded CI
  - Technology Audit Service (TAS): 2010 – 2015
  - XD Metrics Service (XMS): 2015 – 2022
- The landscape before TAS/XMS
  - Accounting data incomplete and only available quarterly
  - Job level performance data not available
  - No external measure of Quality of Service (QoS)
  - RP reporting to the central database was inconsistent
  - RP quarterly and annual reports done manually
  - CI planning and analysis difficult due to lack of accessibility of historical data (utilization, allocation, etc)
Overall CI Performance Matters

- **CI systems are typically oversubscribed**
  - Improving application or system performance will improve overall job throughput
  - Free’s up otherwise wasted CPU cycles for useful work
- **Small improvements in system performance can have high impact**
  - Every 1% increase in system performance on the resources provided through XSEDE translates into the ability to allocate an additional 101 M CPU hours annually
  - Corresponds to a savings of $5M*

* Assuming a rate of $0.05 per CPU hour
Benefits for Stakeholders

- **PI and End User**
  - Account management, resource selection, application tuning, improved throughput

- **Systems Administrator**
  - System diagnostic and performance optimization, application tuning

- **Computational Scientist and Support Specialist**
  - Tool to facilitate work with end-users to improve job performance and throughput

- **CI Center Director**
  - Comprehensive resource management and planning tool
  - Return on Investment Metrics

- **External Reviewers**
  - Tool for data driven review for verification of best practices and project goals

- **NSF Senior Leadership**
  - Measure the effectiveness of supported programs
  - Inform deployment of future systems to fulfill unmet need
Data/Services Available to ACCESS Tracks

• Job accounting data
• Application performance data
• Allocations data
  • Users, Resources
• Gateways usage data
• Quality of Service data
  • Resource providers
  • Applications
• Job efficiency data
• User data
  • Job efficiency, usage, application performance, ......
• Resource workload analysis
• Data analytics framework
• Networking data
• Workflows
So What’s New?

- **ACCESS MMS Tasks**
  - Data Analytics Framework
  - CI Simulator
  - Monitoring CI Ecosystem
  - Application Power Monitoring
  - Network Integration
  - Value Analytics Realm
  - Open XDMoD Development
  - ACCESS Auditing
  - Service Model
Data Analytics Framework

• Provide analytic framework for direct access to rich depository of performance and utilization data in XDMoD data warehouse
• No reliance on XDMoD web portal
• GUI Built on Jupyter notebooks
• Python and R interfaces for automated workflows and expert users
Data Analytics Framework Prototype

```python
In [15]: # Use the python API to get timeseries usage data from the OnDemand data realm in XDMoD with xdw.DataWareHouse('https://metrics-dev.ccr.buffalo.edu:9002') as x:
   ...:     ondemandusage = x.timeseries(start = '2021-01-17', end = '2021-02-17',
   ...:         realm='OnDemand', metric='user_count', dimension='none')

In [33]: # Add a Day name column
   ...: ondemandusage["Weekday Name"] = ondemandusage.index.strftime("%a")

In [45]: ax = ondemandusage.boxplot(by="Weekday Name")
   ...: ax.set_ylabel('Number of Active Users')
   ...: plt.suptitle(''

Out[45]: Text(0.5, 0.98, '')
```

Center for Computational Research
CI Simulator

- Develop a CI Simulator to model the NSF CI ecosystem
- Can be used to predict the response CI ecosystem to:
  - New CI systems
  - Changes in the operational parameters of existing systems
CI Simulator

• Specific questions can be posed and the CI simulator can provide a quantitative estimate of response of CI ecosystem

• Example use cases
  • Which of the following options would have the greatest impact on reducing the time to science:
    • one large resource,
    • two smaller resources,
    • or additional public cloud resources?
  • Simulating the relative impact of increased gateway resources versus MRI or CC* resources, which can then be used to guide funding decisions.
Monitoring the CI Ecosystem

- Current XDMoD monitoring framework employed to better understand national capacity and capability class CI systems
- However, this represents a continually shrinking fraction of the national computational CI ecosystem which includes:
  - campus-based systems, high throughput computing, science gateways, and public clouds
Monitoring CI Ecosystem

• Development of a monitoring system for CI computational ecosystem
  • national-level CI
  • NSF-funded public cloud usage
  • campus-level CI
  • network utilization
  • workload-type systems (OSG and Gateways)
Application-Level Power Monitoring

• Provide a detailed workload analysis of time to solution versus power consumed for applications
• Useful for new and emerging technologies
  • Will the energy savings realized by a more energy efficient architecture be offset by longer running times for the job mix?
• Application developers can tune their applications to achieve better energy efficiency on different architectures
Application-Level Power Monitoring

- Example: Energy efficiency comparison for NAMD and GROMACS
  - CPU - Intel Gold-6230,
  - GPU - NVIDIA V100
  - Raspberry Pi4 (ARM-based)

GPU versions are faster and more energy efficient
Effective application monitoring requires full stack monitoring from the front-end, user experience, to the back-end CI to provide complete visibility into every aspect of application performance.

- Various layers such as infrastructure, network, logs, containers, databases, and clouds.

Develop machine learning based tools to monitor application performance metrics.

- Develop framework with lightweight agents for real-time monitoring.
- Train models using time-series data from XDMoD.
- Target two widely used applications.
Network Data Integration

- Indiana University – Dr. Jennifer Schopf
- Motivation: Data movement increasingly important for computation, simulation and large-scale experimental facilities
- Use NetSage to track data movement
  - Collect SNMP, flow data, and perfSONAR active testing data
- Use XDMoD to correlate data movement with computational workload
Value Analytics Realm in XDMoD

- Help provide ROI metrics to support campus investment in CI
- XDMoD Value Analytics Realm will correlate system usage with PI funding
- Proposed sources of campus funding data
  - university sponsored programs office
  - direct feeds from NIH, NSF, etc
XDMoD & Open XDMoD Development

• **TACC_Stats development**
  • keep current, add new technologies and new features

• **Additional features including:**
  • Added GPU support
  • Expanded storage metrics
  • On Demand integration
  • ColdFront integration

• **Application Kernel Development**
  • Support for cloud environments
  • Support for workflows
  • Develop Network usage Application Kernel
ACCESS Auditing

- ACCESS MMS will continue carrying out workload analyses on capability and capacity class systems as directed by NSF.
- Similar to analyses carried out by XMS on Blue Waters and NSF Innovative Resources:
Service Model – Data Service

• Embrace the FAIR principles for scientific data
  • **Findable**
    • The ACCESS XDMoD data warehouse will have a searchable metadata index that is both human and machine readable, publishing data and service assets
  • **Accessible**
    • Data warehouse assets will be available through standard REST calls. Metadata will be publicly available (Findable)
  • **Interoperable**
    • Data warehouse exports will made available in commonly used machine readable formats including JSON and CSV
  • **Reusable**
    • MMS encourage reuse of XDMoD’s data assets throughout the research community and will continue to do so
Service Model - ACCESS Tracks

- **Track 1 Allocations Service**
  - Historical CI usage for individual users/projects and overall CI resource usage

- **Track 2 End User Support Service**
  - Provide detailed information about end users historical jobs, workflow and network usage to help support and respond to customers' queries.

- **Track 3 Operations Service**
  - Provide information on ongoing ACCESS operations including QoS metrics

- **Track 5 Technology Translation**
  - Work with Track 5 and ACCESS ACO to determine and implement the proper reporting metrics

- **ACCESS ACO**
  - Provide information to support its management, oversight and coordination of the ACCESS awardees
Federated XDMoD

- Federated XDMoD allows integration of multiple Open XDMoD instances into a single monitoring and reporting entity
- Can monitor each instance separately and/or look at the federation totals
Discussion