# Holistic Measurement Driven System Assessment (HMDSA)

https://hmdsa.github.com/hmdsa

## Exascale-ready operations, improved performance, and balanced system design via comprehensive system monitoring and analysis


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## Answering Key Operational Questions

Is my performance variation due to system conditions or code changes?

How can I know if the system is having problems?

### User

### System Managers & Users

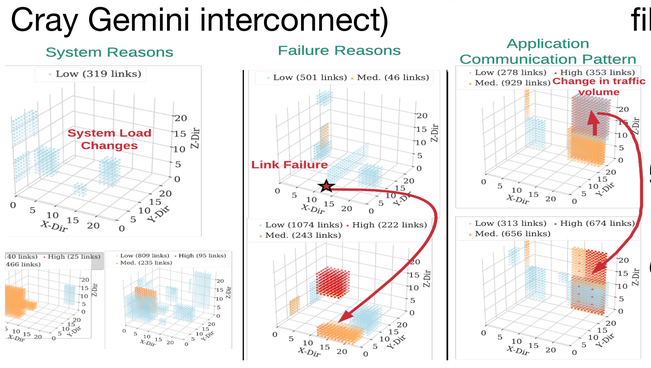
**Capability:** Combined reasoning based on changes in application characteristics (e.g.,MPI message size) and system characteristics (e.g., network congestion) to diagnose cause(s) of performance variation and predict application runtime.

**Figures of merit on Cray Aries interconnect system**

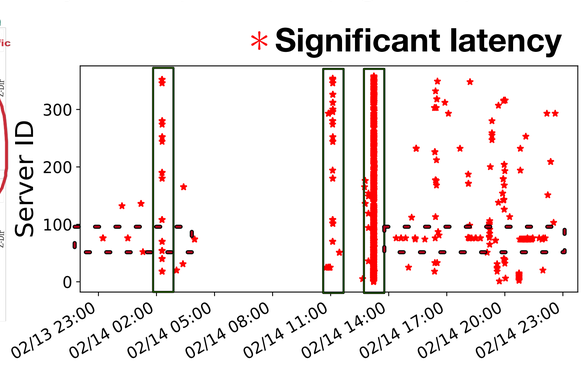
| Job ID | App ID | Node ID | Start Time | End Time | HPages | NW Congest | Mem Score | Anomalies | PAPI Perf | App Perf | Comm Perf |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10399 | CoMD | nid000[53,59] | 2018-09-21 00:28:40 | 2018-09-21 00:30:40 | 0.0 | 1.57 | 0.042 | 0x1 | 0.0 | 0.59 | 0.0 |
| 10398 | lulesh | nid000[60-61] | 2018-09-21 00:19:26 | 2018-09-21 00:22:02 | 0.0 | 0.21 | 0.041 | 0x0 | 0.29 | 1.55 | 0.0 |
| 10397 | CoMD | nid000[53,59] | 2018-09-21 00:19:19 | 2018-09-21 00:21:28 | 0.0 | 0.06 | 0.042 | 0x0 | 0.1 | 0.59 | 0.0 |
| 10396 | CoMD | nid000[21-22] | 2018-09-21 00:19:16 | 2018-09-21 00:21:25 | 0.0 | 2.75 | 0.053 | 0x0 | 0.0 | 0.61 | 0.0 |

Different Cray Aries with competing application, different Aries, same Aries (self-contention)

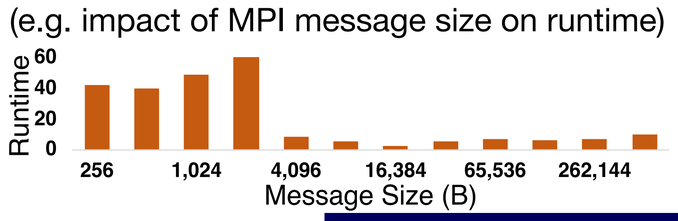
**Capability:** Diagnose network issues using extracted congestion regions (e.g. Cray Gemini interconnect)

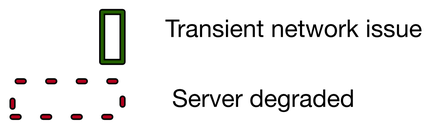



**Capability:** Diagnose file-system issues using periodic latency measurements of file system operations (e.g. write)




**Capability:** Diagnose code-related issues (e.g. impact of MPI message size on runtime)



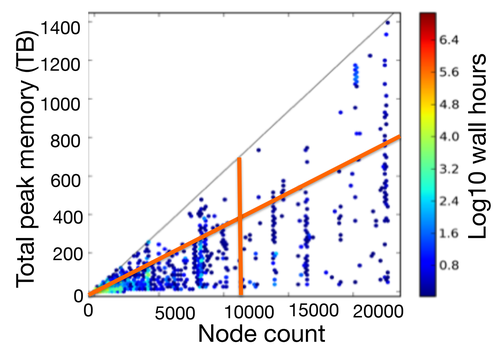




What are the architectural requirements given the site's workload?

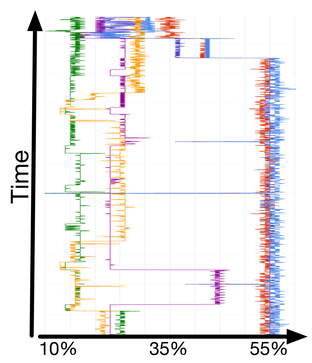
### Architects & Acquisitions Teams

**Capability:** Inform design decisions for future systems

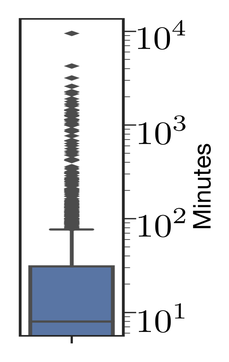
**Insight:** Assessing dynamic range of memory needs for facilities' workflows




**Insight:** Identifying issues with network routing and congestion mitigation procedures




Worst % input queue stall across $X\pm, Y\pm, Z\pm$ directions on Cray Gemini interconnect

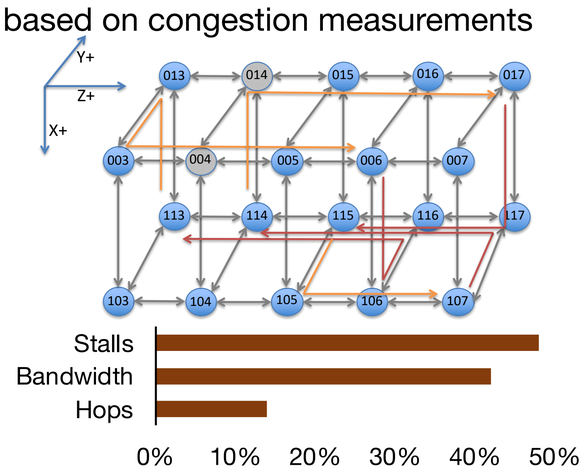



Duration of congestion

How can a system provide more effective and efficient services?

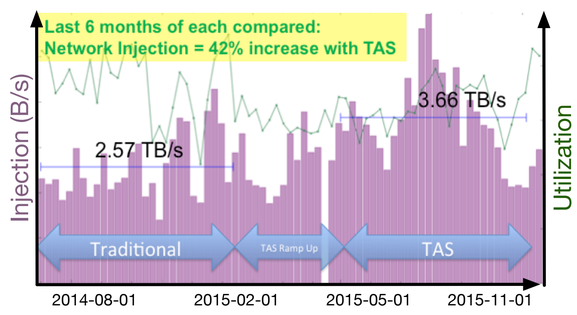
### Architects, System Managers & Support Staff

**Capability:** Dynamic task re-mapping based on congestion measurements




Percentage of congestion time recovered by performing dynamic re-mapping.

**Capability:** Topology-aware scheduling (TAS) based on congestion measurements




Impact of TAS on system performance

## Exascale-ready Features

- **Data-driven and Machine Learning (ML) based mechanisms** for data collection, analysis, and automated runtime feedback and control
- **Scalable APIs** that enable flexible runtime interactivity (e.g., streaming analytics)
- **Platform independent** open-source solutions

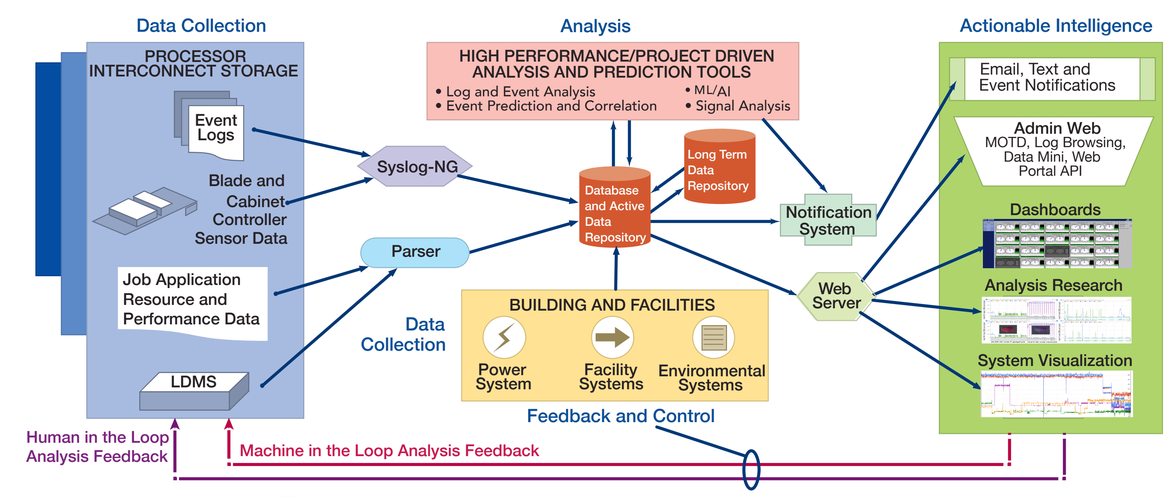
## Significance and Impact

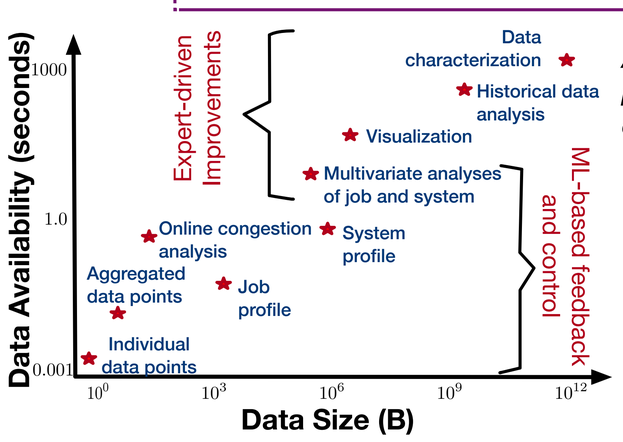
- Enable **highly efficient HPC system usage** and inform future system improvements to produce more science
- Transform **real-time data into actionable intelligence** at runtime

## Key Strengths

- Lightweight, low overhead mechanisms enable high fidelity (e.g. sub-second) synchronized, whole system numeric and event data capture with negligible impact on application runtime
- Discovery and analysis of performance and resilience related phenomena via integrated system logs and numeric data
- Low latency feedback of analysis results to system software, applications, and system managers
- High resolution extraction and classification of phenomena with respect to locality, severity, and temporal extent

## Scalable System Design and Architecture

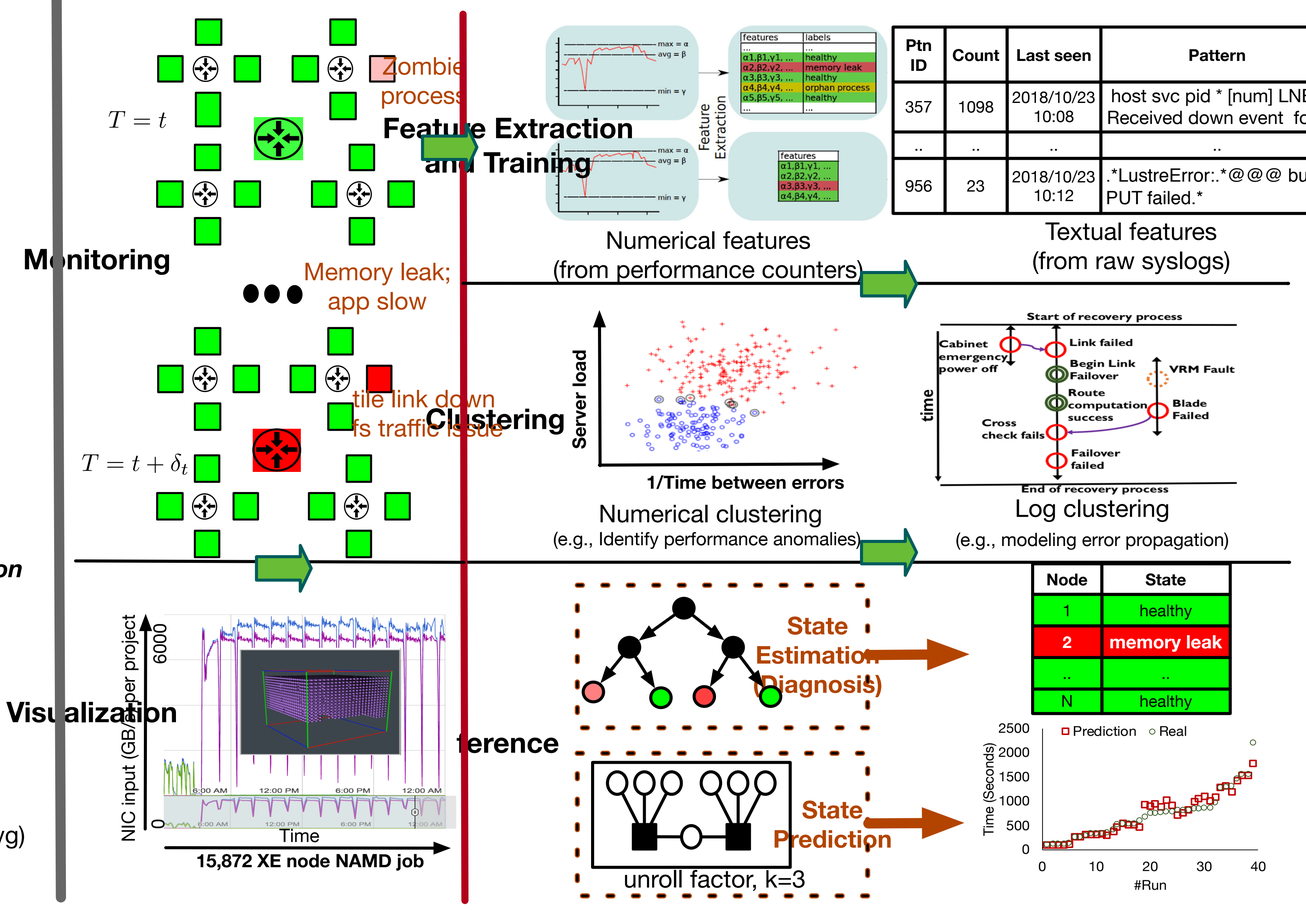



***Architecture supports big data analysis, provenance, and curation. Currently in production on Blue Waters:***

- Real-time collection and processing for 28,000 nodes and all sub-systems
  * Process 20 B datums per day
  * Active storage of 11 trillion datums
- 8,100 active unique log and data event types
  * 50,000 different event types seen to date
  * Up to 1,470M log and data events/day (30M avg)

## Actionable Expert and ML-Driven Analysis




| Ptn ID | Count | Last seen | Pattern |
|---|---|---|---|
| 357 | 1098 | 2018/10/23 10:08 | host svc pid * [num] LNET Received down event for * |
| .. | .. | .. | .. |
| 956 | 23 | 2018/10/23 10:12 | .*LustreError:.*@@@ bulk PUT failed.* |

| Node | State |
|---|---|
| 1 | healthy |
| 2 | memory leak |
| .. | .. |
| N | healthy |