Optimizing Architectures for Multi Mission Archives

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STScI Archive and Data Center

STScI hosts operational archives and data processing for multiple missions
- The big active missions: HST, Kepler, GALEX

MAST: Multi-mission Archive at Space Telescope
- Established in 1997 as NASA’s Optical/UV archive
- Supports both active and legacy missions (IUE, FUSE, EUVE, ...)
- Images (DSS), spectra, catalogs (GSC2), time series
- Community Contributed Products - High Level Science Products (HLSP)
- Currently integrating the Hubble Legacy Archive (HLA)

JWST Science Operations Center in design and development
- Early production phase for the Science instrument Integration and testing Data (SID) Archive – ground test data archive utilizing MAST & HST data archive and distribution system
- Primary mission science data processing and archive operations
Balancing Architecture Goals

Support Mission Requirements
- HRAS (High Reliability, Availability, Serviceability)
- Provide capability to tweak mission dms operations priorities
- Shared costs for multiple mission architecture support
- Plan optimal hardware life cycles through life of mission
- Performance management, continuous and benchmarked

Organizational archive planning for community
- Optimize the usefulness of the FULL archive content for the next generation of archival science research – data mining
- Design systems with flexibility for innovation
- Integration with external archive resources
**MM Architecture Planning Team**

- **HST Architecture Transition Planning Team:**

- **Archive Infrastructure Planning Team (AIPT):**
  - Brian Mclean, Karen Levay, Ron Russell, Bernie Shiao, Mark Kyprianou, Vera Gibbs, Sandy McCarthy

- **JWST SOC and Systems Engineering WG (SEWG):**
  - Joe Pollizzi, Daryl Swade + WG

- **Archive Management Team**
  - Carl Johnson, Rick White, + leads of dms work areas

- **IVOA and VAO**
Innovation
Unified Customizable User Interface – Web 2.0/Visualization
Multi Mission OPS Architecture
Virtualized Architecture

Multi Mission Science Archive Operations

Future

JWST Archive

Kepler Archive

HST Archive

Open Source Unified Science Software

2009 2010 2011 2012 2013 2014

Public Science Archive

News and Outreach

MAST HLA

Virtual Observatory

SAN Upgrade to 8Gb

Network Bandwidth

Service Oriented Architecture

Infrastructure
Architecture supported work areas in STScI data management systems (DMS)

- Data receipt and processing of science and engineering telemetry data
  - Workflow, instrument pipelines, reprocessing for calibration enhancements and higher level science products generation

- Archive Systems for storage and distribution of raw and processed science and engineering data
  - Operational Monitoring, file brokering, safestore, and database systems
  - Science user interface, data retrieval from core archive, help desk

- Science Calibration Software – Instrument team expertise
  - Instrument pipeline steps which perform corrections, combine, and characterizes data

- Data Analysis Tools – distributed software
  - Instrument scientists use to characterize instrument performance
  - End user astronomers generate and visualize results of calibrated data

- Interface and service support for other mission subsystems
  - Planning and Scheduling of Observations
  - Flight Operations Systems, NASA centers
Architectural Tiers

Interleaved system models and views

- Applications – update/modernize functionality of operational systems
- Network Infrastructure and connectivity to the community – increased bandwidth and IOPS
- Compute, database, and application servers – new technology and scaling for increased performance demand, fault tolerance
- Storage Tiers – Internal Private Cloud + External solutions
- External Mirrors – Replication of Holdings
- External Archive Interoperability – Virtual Observatory standards

Big Issues to Address

- Migration of Legacy Systems – full or partial system replacements
- How mission schedules interface with technology life-cycles
- Scaling and Flexibility for Growth - choosing the right path forward
- Who is the customer?
Architecture Development Strategies

- Optimize, innovate, consolidate and balance requirements
- Build working teams across organizational groups that combine the science, software engineering and IT expertise to bridge communications
- Hardware systems share where possible base-lined configurations for consistent deployment and maintenance
- Build dedicated systems to address the requirements for development, test, and operations environments
- Combine architecture solutions....where possible physical and system configurations for common functional systems
- Scalable infrastructure with end-to-end level monitoring
- Engage resource sharing through collaborative partnerships
Storage Architecture - Private Cloud

Storage Area Network (SAN)

- SAN shared infrastructure and EMC storage frameworks - 8Gb fiber channel network – commodity integration support cross platform
- Connectivity of host servers through Host Bus Adapters (HBA) to dual enterprise class switches with multiple fabrics
- Tiered storage: Flash, SATA (files), and Fiber channel (DBs) drives
- Storage File Brokering Systems will be adapted to manage both batch and direct file access
- Developing Total Cost for Ownership (TCO) model understanding
SAN Architecture

### Storage Units

- **HST CX4-480**: 380 TB
- **JWST CX4 - 240**: 213 TB
- **Kepler CX700**: 65 TB
- **HLA CX3-40**: 54 TB

### Total Disk Space in TB - Current

<table>
<thead>
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### Total Usable Space

- **Central Store Virtual Space**: 202 TB
- **Total Usable Space**: 914 TB
Applications architecture considerations

- Design applications which function across distributed servers
  - Load balance core mission functions: ingest, request processing, and reprocessing

- Modernize web technology for the archive user portal services and operations control systems

- Increase development of database services to reduce management of meta files – use data models and mapping

- Shared software and collaborative exchange throughout systems (internal and external)
  - Public Science Archive and Operations Archive
  - Produce and use *open source* software – AURA science software effort

- Key interfaces between archive and workflow systems requires shared file system architectures
  - Application design and file system solutions (GFS-2, NFS, Others)
Virtualized Development Infrastructure

Public Science Archive  Mission Operations

- HLA Apache
  - HLA IIS
  - HLA SQL
  - HLA Processing
- Archive Apache
  - NVO IIS
  - NVO SQL
  - MAST IIS
- HST DADS DEV
  - DADS Stable
  - HST SQL
- SID DADS DEV
  - SID DADS Stable
  - SID SQL
- Public Science Archive
  - Mission Operations
- VMware ESX cluster – Expand as needed
Realized Virtualization Pros

- Ability to map multiple server os environments to single physical node, multi-functional purposed
- Migration and sharing of VM server deployments can be ‘motioned’ across physical nodes for load management
- Storage can be presented across ESX servers to facilitate migrations of servers without data copy
- Tools work well for automated physical to virtual system configuration migrations and vice versa
- Fully configured VM server distribution capability for external locations – OS, DB, APP
- Ideal regression testing system for multi-platform
Realized Virtualization Cons

- **VMWare cpu allocation limits** – slow tech change
  - Testing demonstrated VM does not scale for HT cpus, leads to underutilized processors > 4 core

- **VMWare ESX os limits** storage lun allocation to 2TB, for large scale configuration increased complexity for abstraction layers

- **Raw device mapped luns** may appear on servers not hosting VMS – potential for data corruption

- **VMs** have no awareness of SAN HBAs and therefore cannot use SAN backup
  - Potential bridge of gap with VEEAM still in testing, additional licensing required

- **Licensing and costs** for implementation/core
Public Science Archive

Note 1: Test/Processing hardware identical to Public systems
(a) Test environment same as Public (b) act as backup

Note 2: Clusters will start as failover and transition to load balancing

HLA Footprints, GALEX, Science Catalogs, NVO

Windows cluster

HLA/Archive

Linux cluster

LOAD Balancing

 Apache

 LVS

 Apache

 IIS

 SQL

 Windows cluster

 Add Servers AS NEEDED

HLA/Archive

Test & Processing

Linux cluster

LOAD Balancing

 Apache

 LVS

 Apache

 IIS

 SQL

 Windows cluster

 Add Servers AS NEEDED

PUBLIC

TEST
Operation Archive Architecture Today with Modernized Safestore

FROM: Science Community (thru MAST/HLA)

TO: Science Community

7 Dynamically Re-Configurable Domains (4 currently)

OPUS/Archive OPS

Databases OPS

Code Development

System Test

Database Test

OS/Security Test

SUN FIRE 15K Domain Config

Maxed out - CPUS currently in use - 72
Performance-processor testing

Speed trials

Navtive 710 vs Native 900 and Virt 710

Intel 10:8 cores
Dunnington to Nehalem

8 cpu VM appears not to support Hyperthreading => Native Significantly Outperforms VM
New Operations Server Architecture

Note 1: Test/Processing hardware identical to Operations systems and may function as failover – future clustering options

Note 2: Linux Test and Operations Clusters for distributed and scalable application deployment
Science instrument Integration and Test Data Archive (SID Archive)

- Ground Test Data for JWST detector testing, instruments, and formal observatory test facility
- Virtualized system architecture
  - Initially we planned for dev, test, and ops, yet discovered storage limitations for VMWare allocations to SAN pools
- Production system online - scalable to 200TB archive

DMS design phase beginning

- Data Processing, Archive Systems, Architecture and Calibration Software
- Capacity of Holdings estimated 1-2PB for base calibration
JWST DMS architecture
Mirroring STScI archive holdings

- Evolving models lean toward Public Science Archive cached calibrated data
- Metadata exchange may be simplified by adopting VO data models
- Considering External Cloud solutions for bandwidth

Catalog cross-matching projects

Synergy with other mission archives

JWST archive collaborations are still TBD

Archive Interoperability, innovation, and technology for enabling scientific data mining across distributed networks
Future External Archive Shared Architectures

Public Science Archive

- JWST Science Product Files
- HST Science Product Files
- Science Database
- Archive User Data Access Services

Files/VMs

Metadata

Science Products

- JWST Science Product Files
- HST Science Product Files
- Mirrored Science Database
- Archive User Data Access Services
Mapping to IVOA Architecture - Technical Coordination Group (TCG)

• STScI Public Science Archive VO Components:
  - VAO Fully Searchable Registry
  - Data Provider Services (TAP, ObsTAP, Cone, SIAP, SSAP)
• In development
  - Footprint Service Specification
  - Data Models
  - VAO Work Areas: SEDs, Search Portal, Testing, Operations
  - VOTable Validation Service
  - VOEvent for supernova in Multi-Cycle Treasury ongoing
• JWST formal requirements for DMS to implement IVOA standard data provider Services
Conclusions

_multi mission architectures require shared solutions across the strata of archive systems_

_virtualized solutions work well for dev and distribution_

_common yet flexible infrastructure is key for scalability, performance and maintenance_

_synergy both with internal and external solutions provides opportunity for advancing science return_

_long term planning for technology life cycle peaks ~five years for refresh of architectural components – build systems that can adapt in units rather than full replacement_