1 EXECUTIVE SUMMARY

The University of Nevada, Reno (UNR) is a High Activity Research University moving to a Very High Activity Research University. To attain that goal requires a significant technology infrastructure to support the research. A key component of that infrastructure is an appropriate high performance computing (HPC) capacity. That capacity includes the hardware, software, people, organization and a sustainable strategy to maintain and grow the HPC environment. This plan provides a road map to implement that capacity.

UNR has a modest HPC cluster managed by UNR Central IT and available for the entire campus. Several departments have clusters of varying size acquired and maintained through a patchwork of resources. Others find their high performance computation and storage needs met by use of off premise systems at other universities or from cloud providers. Funding for high performance computing has been sporadic with limited staff and lack of a sustained (and sustainable) coordinated effort. As UNR hires more faculty with both HPC needs and expertise, there is need for a coherent plan moving forward.

The proposal is to implement a Community Condominium HPC infrastructure. It will build from the current UNR HPC environment. The architecture will include three levels of activity: local, Community Condominium, and off premise. Local will be those computing resources with a strong need to remain distributed at local points of research activity. These resources may or may not be available to others across UNR. The Community Condominium will be a centrally located and managed resource for use by the entire UNR campus. Off premise activity will access resources at other institutions or cloud based services to meet needs not addressed through the campus infrastructure.

The Community Condominium HPC business plan will be based on a shared ownership and cost model. It will include three tiers of access depending on need. The tiers include: 1) shared ownership of the system, or 2) chargeback for priority use, or 3) no charge for limited use of the system.

All aspects will be governed by a standing oversight committee composed of stakeholders. This committee, or smaller working groups composed of committee members, will have input and oversight into the system design, sustainable business plan, and policies for management such as determining priorities for use. The committee will report up to the Office of the VPRI and the Office of the CIO. The day-to-day management of the Community Condominium will be the responsibility of UNR Central IT.
This plan assumes a hybrid mix of distributed and central resources on premise and off-premise including hardware, software and personnel.

2 BACKGROUND

2.1 HISTORY

The initial UNR HPC environment was a collaborative effort between Computer Science, Bioinformatics/INBRE, Medical School, and Central IT. The servers were physically located in Central Services and Laxalt Mineral Research buildings. The grid was comprised of Sun Microsystems SunFire (X4100, X4150) computers, storage, and management nodes. System, software and technical administration was provided by one partially dedicated Central IT staff and a temporary (LOA) position. In February 2015, funding provided by the Provost’s office allowed IT to decommission the legacy cluster and approximately 110 servers were removed from service and returned to the original stakeholders. Existing users were migrated to new HPC platform that was comprised of 16 Dell compute servers, a central Dell storage server, and one management server. In June 2015, additional hardware was purchased which included 11 additional Dell servers and a storage expansion array. This purchase further expanded the existing HPC resources available for campus use.

2.2 CURRENT STATUS

2.2.1 Distributed Systems
There are several clusters distributed around the UNR campus. The capacity for computation and storage varies but these are typically modest in size and tailored to specific needs of the research being done at that location. Some of these systems are available for use by others; some are for the exclusive use of faculty and students in the department. These clusters are funded from grants or other opportunistic funding. Staffing varies from students to the researcher and a few instances of dedicated staff. The latter are usually funded on soft money from grants. The distributed systems comprise a patchwork that has met immediate needs, but this is a difficult model to sustain.

2.2.2 Central System
The UNR HPC cluster, commonly referred to as the UNR Grid, currently consists of 432 total processors, comprised of 27 Dell PowerEdge R720/R730 server nodes. Each node has two Intel Xeon 8-core processors, 256 GB RAM, and 1.2 TB virtual RAID hard drive. There are 11 E5-2630 v3 “Haswell” 2.4GHz R730 node processors, and 16 E5-2650 v2 “Ivy Bridge” 2.6GHz R720 node processors.

Five of the R720 servers are each additionally equipped with one NVidia K20m GPU accelerator for CUDA processing capability.

Central storage is a Dell PowerVault 3400 with two MD 1200 expansion arrays. There is 97.4 TB of RAID total storage (35 TB currently unallocated to meet ongoing demands). Storage is presented via one Network File System server currently configured as below:
/scratch – 28.4TB allocated
/home – 6.6TB allocated
Remaining space allocated to O/S and software packages.

2.2.2.1 Services
In addition to hardware installation and maintenance, the HPC primary support position builds and/or installs requested software, provides technical assistance, and collaborates with HPC cluster users in implementing functional solutions.

Some of the software applications are compilers including GCC, GFortran, GHC, MPICH, OpenMPI

Bioinformatics software includes ClustalW, EMBOSS, FASTA, FFTW, Glimmer, GROMACS, HMMER, mpiBLAST, MrBayes, Phylip

For Math and Statistics Octave and R are available.

There are also approximately 20 various chemistry and engineering software titles.

2.2.2.2 IT Operations Staff
John R. Anderson – HPC Server Administrator
Artin Matousian – Linux Server Administrator (backup HPC Administrator)

3 PROPOSED RESEARCH COMPUTING SUPPORT

3.1 Vision
The UNR HPC Services will facilitate research and aid in educational advancement by making leading edge, high-performance computing and visualization available to individual administrative units, as well as multidisciplinary units across campus. It will embrace this disciplinary diversity by creating partnerships that support HPC needs throughout UNR. The tools and services will be available to the entire university community. The objective is to ensure that UNR retains the superior HPC facilities and services needed to enable success in attaining strategic goals.

3.2 Assumptions

1. The current hardware array (cores, memory, storage) described in Section 2 needs to be increased. The specifics will be determined through the governance process described in Section 3.6.
2. The campus network will be upgraded as needed for sufficient access to the HPC resources from all research locations needing those services.
3. The UNR research computing support will be a hybrid of distributed and central resources, on premise and off-premise including hardware, software and personnel. No single entity has or will have all the resources necessary to provide all services to all users.
4. Consolidation of resources for use across departments, disciplines and projects will be a primary guide.
5. Use of consolidated HPC services will be encouraged but voluntary.
6. This plan will be implemented insofar as available resources allow.

3.3 SERVICES

The specific menu of services provided will evolve based on need and available resources. This will include a mix of three services.

- **Technical Infrastructure**: to provide a state-of-the-art local facility that combines substantial computing and storage capabilities to enable projects that require significant computational resources. This includes computer cores, memory, high bandwidth storage and an essential library of software.

- **Consulting Services**: to provide integrated HPC consulting services to UNR researchers. The services are designed to provide a “one-stop shop” solution whereby researchers can receive HPC related grant preparation assistance, project design help, cost effectiveness analysis of locally and externally applicable HPC solutions, and finally project execution services.

- **Utilization of External Resources**: The UNR HPC Services will be open to using the best solution for the individual needs of each project and recognizes that no single solution is optimal for all projects. This will include support (technical and contractual) for access to external HPC resources offered at other universities, government agencies, research consortia, and the private sector (such as Amazon Web Services) to provide the most effective mix of HPC services for each research and scholarly activity.

3.4 ARCHITECTURE: THREE TIERS OF HIGH PERFORMANCE COMPUTING

The architecture will be a hybrid of local resources at the departmental or unit level, centrally housed and managed community resources, and access to external off-premise resources, all with sufficient network capacity to easily move between these three layers.

3.4.1.1 **Local**

Specific, specialized requirements for data collection, analysis, and interim storage as well as dedicated equipment unique to the work being done (e.g. gene sequencer) is expected to reside locally at the unit, department or space allocated to the individual researcher. There will also be individual computing clusters that may stand alone for a variety of reasons (security, proprietary software, compliance, funding restrictions, or other criteria). These resources may or may not be available to the larger campus or a subset of specific departments or researchers. An inventory of these resources will be maintained by Central IT.
This layer of resources will be managed locally. Central IT will provide network connectivity of sufficient bandwidth dependent on need.

The facilities housing this equipment should meet minimum standards for safety and security.

There will also be opportunity for colocation of this hardware in a centrally managed campus data center where security, power and cooling can provide a higher level of reliability.

3.4.1.2 Community Condominium

The UNR HPC Cluster will be a joint investment between Central IT and the UNR research community based on the Community Condominium Computer Model. UNR will make an initial centrally funded investment for a cluster consisting of standard computer nodes and large memory nodes as well as a scalable storage solution that will expand the existing HPC cluster. The research community will contribute back to this resource by purchasing nodes which are added to the cluster and that will be available to the community when not used by the owner. Also, “guaranteed” computer time that is purchased goes to supporting cluster infrastructure and purchasing additional “community” computer nodes. The idea is to create an efficient and sustainable computer resource for UNR. It is anticipated this UNR community resource will be housed on premise, though housing at a suitable off-premise central data center may be a viable option. The condominium will be managed by Central IT.

3.4.1.3 Off Premise

The local and condominium resources should be sufficient for meeting the needs of the majority of UNR’s high performance computing needs. However, for multiple reasons use of external resources are needed. These include:

- Sharing data and analysis with collaborators
- Transferring data and results to regional or national depositories for access by others
- Archiving research data and results
- Access to resources that provide higher performance computing and visualization capabilities

Central IT will provision high speed network connections to these external resources and staff will work with individual faculty to provide secure, reliable and as seamless as possible access to these resources.

3.5 Business Plan

3.5.1 Shared Cost

Shared cost is based on cooperative funding from both distributed and central institutional sources. The concept of a shared cost philosophy is different from, and in contrast to, the more usual cost recovery approach. The shared cost model encourages faculty to be actively involved in the design/bid process, as opposed to waiting until the machine is built and then deciding if they want to participate (cost recovery). By following the shared cost principle, UNR Central IT can offer competitively priced resources to compete with the commodity cost of resources that drive faculty to develop their own cyberinfrastructure as a substitute for central cyberinfrastructure while giving these same researchers a very active voice in the design of the resources.
3.5.2 Three Tiers of Access
There will be three tiers of access to the shared Community Condominium HPC Cluster based on need and ability to support the shared services. Access to on premise HPC resources will depend on the specific procedures put in place by the respective owners of those resources. Access to off premise HPC services will be based on ability to pay for those services or through agreements with those external entities (e.g. XSEDE). The three tiers of access for the Community Condominium will be:

- Contributor/Owner
- Pay Per Use
- No Charge Use

3.5.2.1 Condo Contributor/Owner
Owning a node on the UNR HPC Cluster entitles said owner to guaranteed, immediate access to the owned resource(s). In practice this means that if another user were utilizing “community” cycles on the resources that user’s job would be preempted immediately and the owner’s job would take its place. Owners can run on their owned resource and compete in the “community” portion of the cluster for resources. Owners also allow their resource to be used in the “kill” partition of the cluster when they are not utilizing it. Owners also get extended wall-time for their resources.

Other benefits of being a condo owner include:

- Node owners can purchase portions of the file storage system to park their data results for the life of their node. Alternately they could contribute hardware assets to the file storage system.
- Node owners can get enhanced software installation assistance and help running on their resources from the HPC team.
- Node owners are primary stakeholders and therefore have more say in how the cluster is managed in reference to wall-time runs and other scheduler functions.
- Node owners can gain accounting management for their resources to manage within their group as they see fit.

3.5.2.2 Condo Pay Per Use
Condo pay per use is guaranteed computer time that is purchased by the node. This tier is for users who may not want to participate as condo owners. This revenue goes to supporting cluster infrastructure and purchasing additional “community” computer nodes and associated resources. The idea is to create an efficient and sustainable computer resource for UNR.

3.5.2.3 Condo Community No Charge Use
The HPC resources will be sized to have capacity for reasonable use for which there is no charge. This would be available to all UNR campus faculty. Both graduate and undergraduate students working through faculty should also have access to this capacity. The specific rules to prioritize how this no charge access is granted are to be establish by the published policies and procedures to be recommended by the HPC Advisory Committee and approved by the condo owners. Central IT will manage the access according to those policies and procedures.

3.6 Governance
Governance primarily will focus on the Community Condominium resources with appropriate reference to local and off premise resources. As a community resource, the governance will also be structured as an open and shared community process. Central IT will manage the community assets according to the agreed upon policies and procedures.

3.6.1 Policies & Procedures
There will be a standing HPC Oversight Committee. The committee will recommend policies for the Community Condominium resources and review and advise on procedures established for operations based on the policies. The committee will act as the board of review when questions or conflicts arise with existing policies and procedures and recommend appropriate clarification or resolution. The committee will regularly review HPC operations across UNR, take an active role in procurement of new equipment, and provide a communication conduit both to the managers of the Community Condominium HPC cluster and to their respective campus departments and colleges.

Procedures will be developed and maintained by the Central IT Managers responsible for operation of the Community Condominium HPC cluster. These procedures will be regularly reviewed by the HPC Oversight Committee.

3.6.2 Oversight Committee
The HPC Oversight Committee will be a standing committee. The initial membership will be comprised of the members of the HPC subcommittee of the University Technology Council. That group will migrate to a separate, standing HPC Oversight Committee. This committee may be a subcommittee of a larger research or research computing or cyberinfrastructure committee yet to be determined. The HPC Oversight Committee will report jointly to the Vice President for Research and Innovation (VPRI) and the Vice Provost for Information Technology (VPIT). The precise number of members is yet to be determined. Every department, college or school that participates as a condo owner will have a seat. The remainder of the members will be sufficient to represent a cross section the colleges, schools and divisions of the university that are not active condo owners. Standing seats on the committee will include at least one member from the University Technology Council, undergraduate and graduate student members (one each, to be designated respectively by the ASUN and the GSA), a member from the office of the VPRI and a member from the office of the VPIT. Members will serve a defined term, possibly one-year, with staggered membership so one third of the members change each year. Members may serve two consecutive terms. The members from the offices of the VPRI and VPIT will be appointed by their respective offices and not rotate.

Other procedures and rules for the HPC Oversight Committee will be developed and implemented by the inaugural committee comprised of the existing UTC HPC subcommittee.

3.7 SYSTEM

The specifications of the Community Condominium HPC cluster, expanded from the current HPC cluster (UNR Grid), are to be determined by a working group composed of members from the HPC Oversight Committee and Central IT staff. Draft specifications developed by this group will be shared with the campus for comment and revision. This working group will then serve as the RFP committee for the
acquisition of hardware and software. Future system modifications will be vetted with the HPC Oversight Committee.

The four areas that will comprise the system are listed below. Details will be added as specifications are developed. The network will be complimentary to the core cluster and storage and sufficient to provide appropriate connectivity across the UNR domain and to external networks and resources.

3.7.1 Computer Cluster
- Nodes
- Cores
- Memory

3.7.2 Storage
- Home
- Scratch

3.7.3 Software
- Operating System
- Compilers
- Applications

3.7.4 Network
- Data Center
- Campus Local Area Network
- Wide Area Network

3.7.5 Colocation
Central IT can provide limited colocation space for campus HPC hardware in Central IT data centers. Adequate rack space, cooling, power (including UPS/generator backup), and controlled access will be provided. The data center environment is monitored by the Central IT staff which has access to real-time monitoring software dashboards and mobile alerts. Location and cost will vary depending on specific user needs (total rack space, special networking needs, and power requirements). IT staff works with the BCN Risk Management Office to address fire/safety issues to help ensure asset protection.

3.7.6 Staff
For this endeavor to be successful there will need to be sufficient staff with expertise to provide
- Maintenance and Operation of hardware, software, security, and network
- Consulting
- Training

Staff with depth and breadth to handle these responsibilities for high performance computing are difficult to recruit and retain. The staff for the UNR HPC environment will be a combination of Central IT staff in coordination with experienced individuals distributed across the campus in various departments. This will be one of the greater challenges to make this a success.
3.7.7 Operations
Central IT will provide infrastructure including networking, racks, floor space, cooling, and power. IT System Administrators will take care of critical and security patches, security incident management, operating system upgrades, and hardware repair so faculty and graduate students can focus on research activities. The Central IT HPC staff will work with vendors to obtain the best price for computing resources by pooling funds from different disciplines to leverage greater group purchasing power. Specifications for hardware and software will be developed in consultation with the HPC Advisory Committee with opportunity for all the UNR research community to provide feedback prior to a major purchase.

4 Plan of Action

1. Distribute the draft plan to appropriate campus committees, councils, governance bodies and advisory groups for review and comment. February, 2016
2. Revise as appropriate.
3. Make the revised draft available for review and comment by the entire campus.
4. Revise as appropriate.
5. Final draft is approved by the VPRI and CIO. April, 2016
6. Policies and procedures are drafted, reviewed and implemented. July-August, 2016
7. A working group of the advisory committee, facilitated by IT develops specifications for expanding the current HPC infrastructure. July, 2016
8. Draft specifications are available for review by the campus and revised as appropriate.
9. Revised specifications are put into an RFP with the above working group as the RFP committee.
10. Staff resources are identified or recruited. July-October, 2016
11. RFP responses are evaluated and awarded. November 2016
12. New hardware and software is installed and online. March-April, 2017

Comments or questions:

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