

HPC and Precision Medicine - A New Framework for Alzheimer's and Parkinson's

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The University of Nevada, Las Vegas and the Cleveland Clinic Lou Ruvo Center for Brain Health have been awarded an \$11 million federal grant from the National Institutes of Health and National Institute of General Medical Sciences to advance the understanding of Alzheimer's and Parkinson's diseases. In this session, we will present how UNLV's National Supercomputing Institute plays a critical role in this research by fusing brain imaging, neuropsychological and behavioral studies along with the diagnostic exome sequencing models to increase our knowledge of dementia-related and age-associated degenerative disorders.

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Agenda

- **About the NSI @ Switch**
- **UNLV Supercomputing Boosted Through New Collaboration with Altair**
- **Computing Challenges**
 - Spotlight on Alzheimer's and Parkinson's Research
 - Other Research Areas that Benefit from HPC
- **Data Flow and Analytics in support of Neurodegenerative Diseases**
 - Fusing brain imaging, neuropsychological and behavioral studies along with the diagnostic exome sequencing models
- **Questions**

About the NSI

Full-service supercomputing facility

Mission for excellence in education and research in supercomputing and its applications

Provides supercomputing training and services to academic and research institutions, government and private industry

Supports energy, the environment, medical informatics and health care

Serves researchers at the University of Nevada Las Vegas and other statewide, nationwide and global research



NSI @ Switch

- 2014 - UNLV moved its NSCEE facilities to Switch facility in Las Vegas
- Hosted on Cherry Creek system – large Intel system for scientific and economic R&D
- > 26,000 compute cores
- Intel Xeon E5-2697v2 12C 2.700GHz, Intel Truscale, Intel Xeon Phi 7120P
- Dedicated Research Network (DMZ) with 200Gb/s potential





switch

TSC

1000

1000

1000

1000

1000

1000

1000

NSI Computing Challenges

Numerous and complex workloads

- Hundreds of projects worldwide
- Highly compute-intensive research

Massive data needs

- Users must access massive data remotely to do their work

Time-sensitive projects

- Many NSI projects have critical governmental and environmental significance, so timely and reliable performance is a key requirement



Powerful and reliable infrastructure is mandatory!

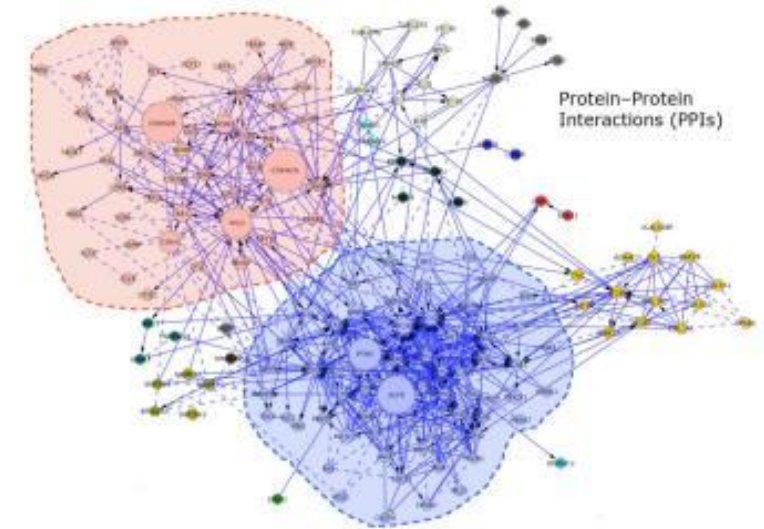
Spotlight: Alzheimer's Research

The need for innovation

- Alzheimer's Disease continue to cause tremendous family, social, and economic burdens to modern society
- Despite substantial progress, existing treatment approaches are limited – so new therapeutic approaches are desperately needed

The NSI project

- NSI works with researchers to compare genomes of Alzheimer's patient with normal patients
- **Challenge:** Researchers wanted to enhance the statistical power of previous analyses by including more than 10,000 additional patients (and thus genomic data sets) in the study – **meaning a massive leap in computational requirements**



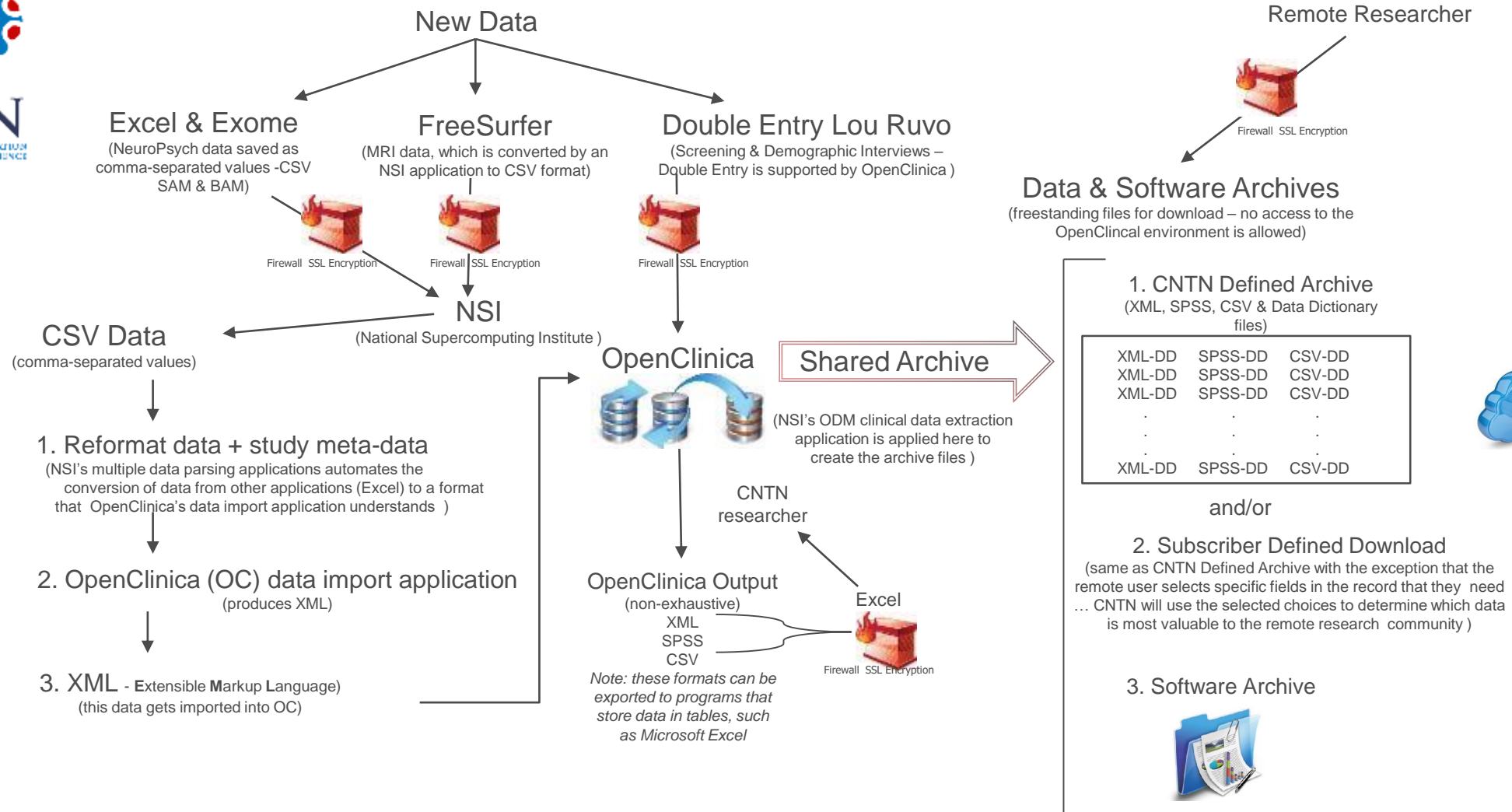
Specific Projects:

- **The Relationship between Neuropsychological Testing and MRI, PET and Blood Biomarkers in Neurodegenerative Disease - Sarah J. Banks, Ph.D**
 - Establish the relationship between neuropsychological tests results to findings on resting state fMRI in the AD continuum (mild cognitive impairment [MCI], mild to moderate AD) in comparison with cognitively normal controls (CNC)
- **Freezing of Gait (FOG) in Parkinson's Disease (PD) - Brent Bluett, DO**
 - Evaluate brain network functional and structural connectivity using multimodal neuroimaging in PD-FOG, in comparison to PD and healthy participants
- **The Role of GABA in Microglial Activation and Neurodegeneration in Alzheimer's Disease - Jefferson W. Kinney, Ph.D.**
 - Examination of GABA and immune alterations in a mouse model of AD.



Data Management and Statistics Core

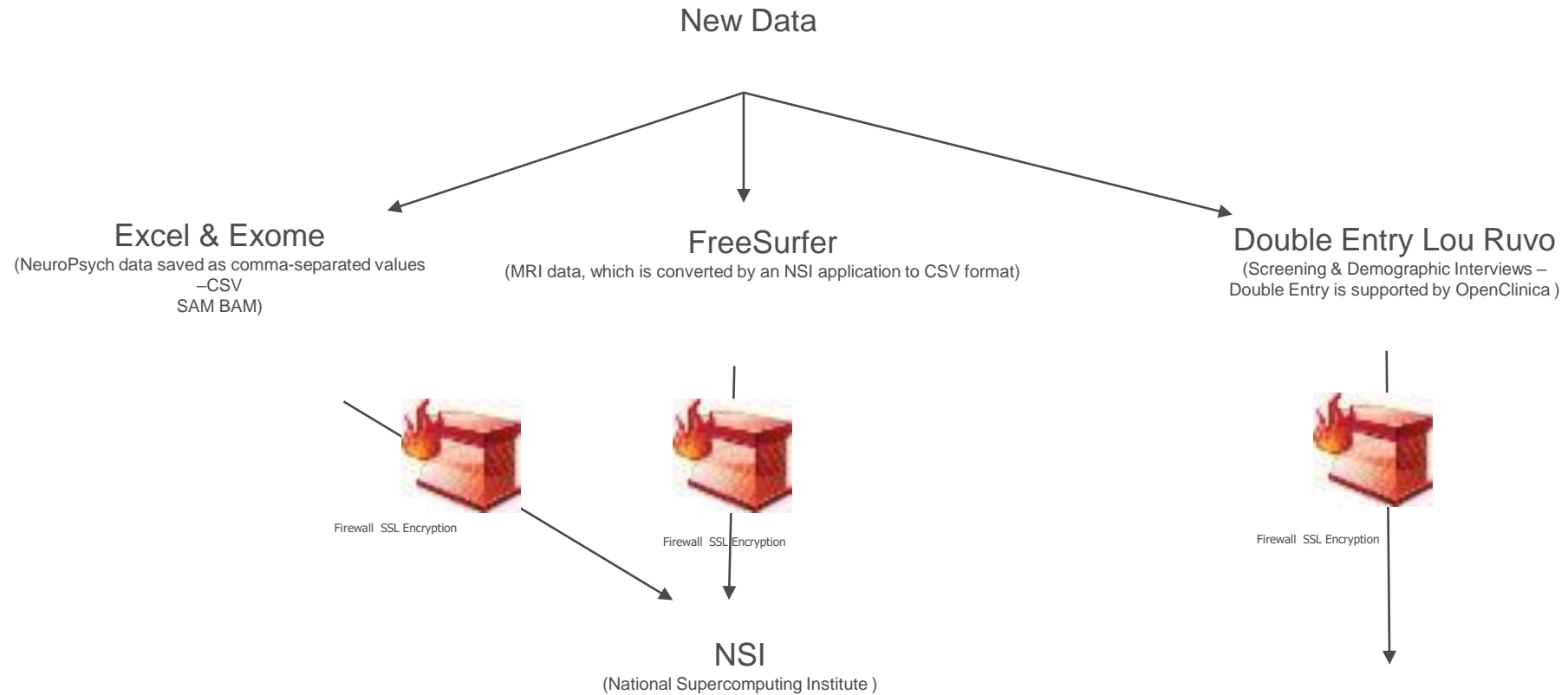
Data Flow Summary



- **FreeSurfer Software Suite:** An open source software suite for processing and analyzing (human) brain MRI images.
- **Statistical Package for the Social Sciences (SPSS):** SPSS is a software package used for logical batched and non-batched statistical analysis.
- **Operational Data Model (ODM)-XML:** a vendor-neutral, platform-independent format for exchanging and archiving clinical and translational research data, along with their associated metadata, administrative data, reference data, and audit information.
- **ODM clinical data extraction application:** NSI's software that produces an extract of clinical data from an ODM file produced by OpenClinica and then writes MRI thickness data for left and right hemispheres to a new file.
- **NSI application:** Software created by the National Supercomputing Institute (NSI) in support of CNTN.
- **Secure Sockets Layer (SSL):** is a protocol for encrypting data transferred between two computers.

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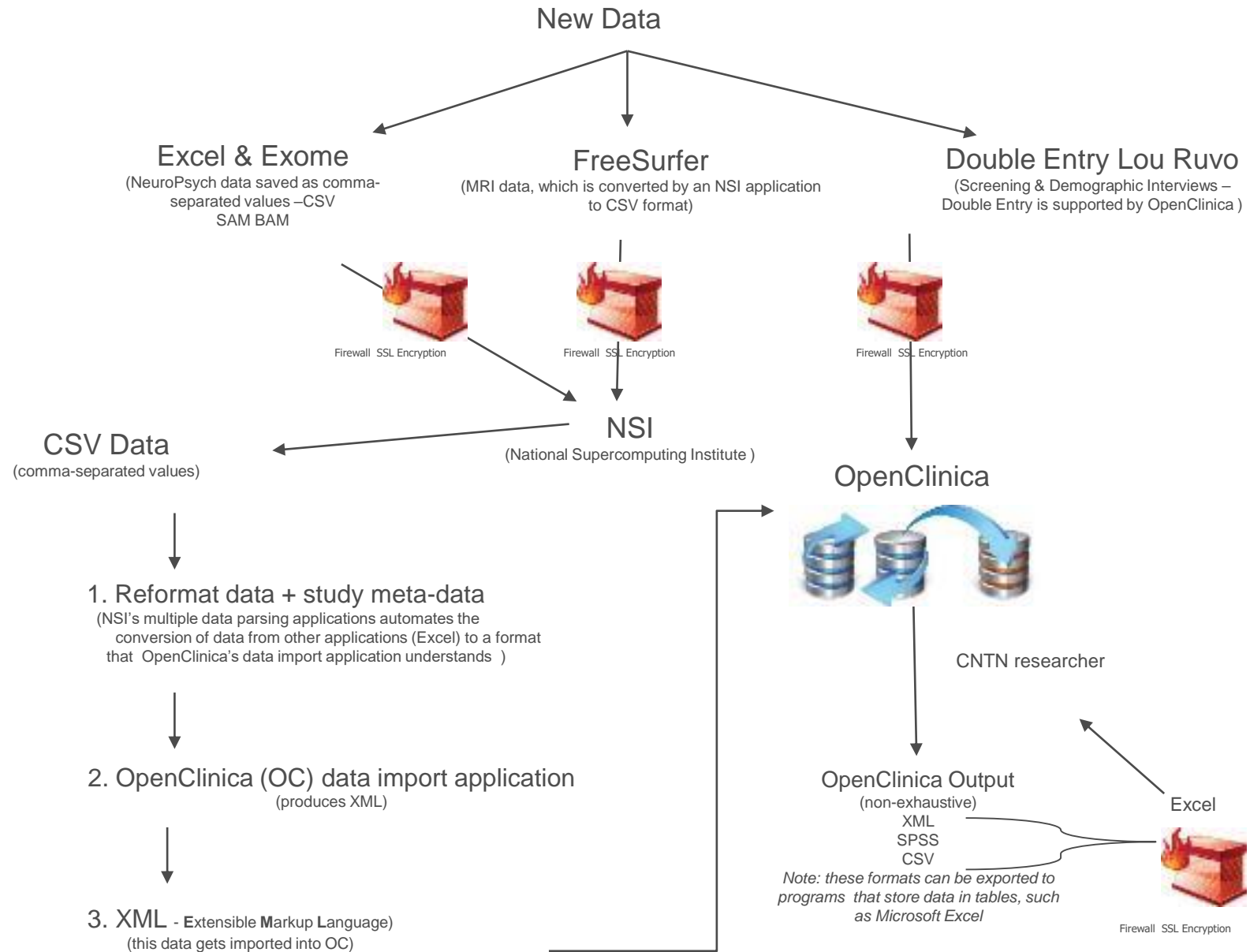


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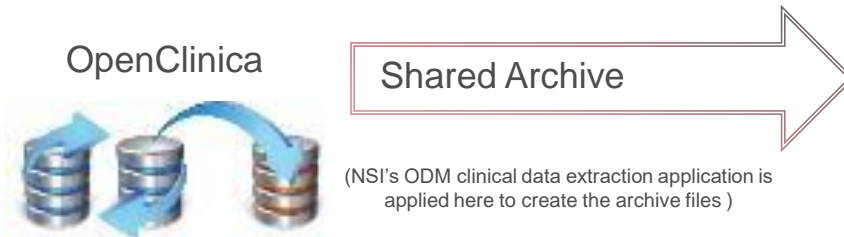


Data Management and Statistics Core

Data Flow Summary

Data & Software Archives

(freestanding files for download – no access to the OpenClinical environment is allowed)



1. CNTN Defined Archive (XML, SPSS, CSV & Data Dictionary files)

XML-DD	SPSS-DD	CSV-DD
XML-DD	SPSS-DD	CSV-DD
XML-DD	SPSS-DD	CSV-DD
.	.	.
.	.	.
XML-DD	SPSS-DD	CSV-DD



and/or

2. Subscriber Defined Download

(same as CNTN Defined Archive with the exception that the remote user selects specific fields in the record that they need ... CNTN will use the selected choices to determine which data is most valuable to the remote research community)

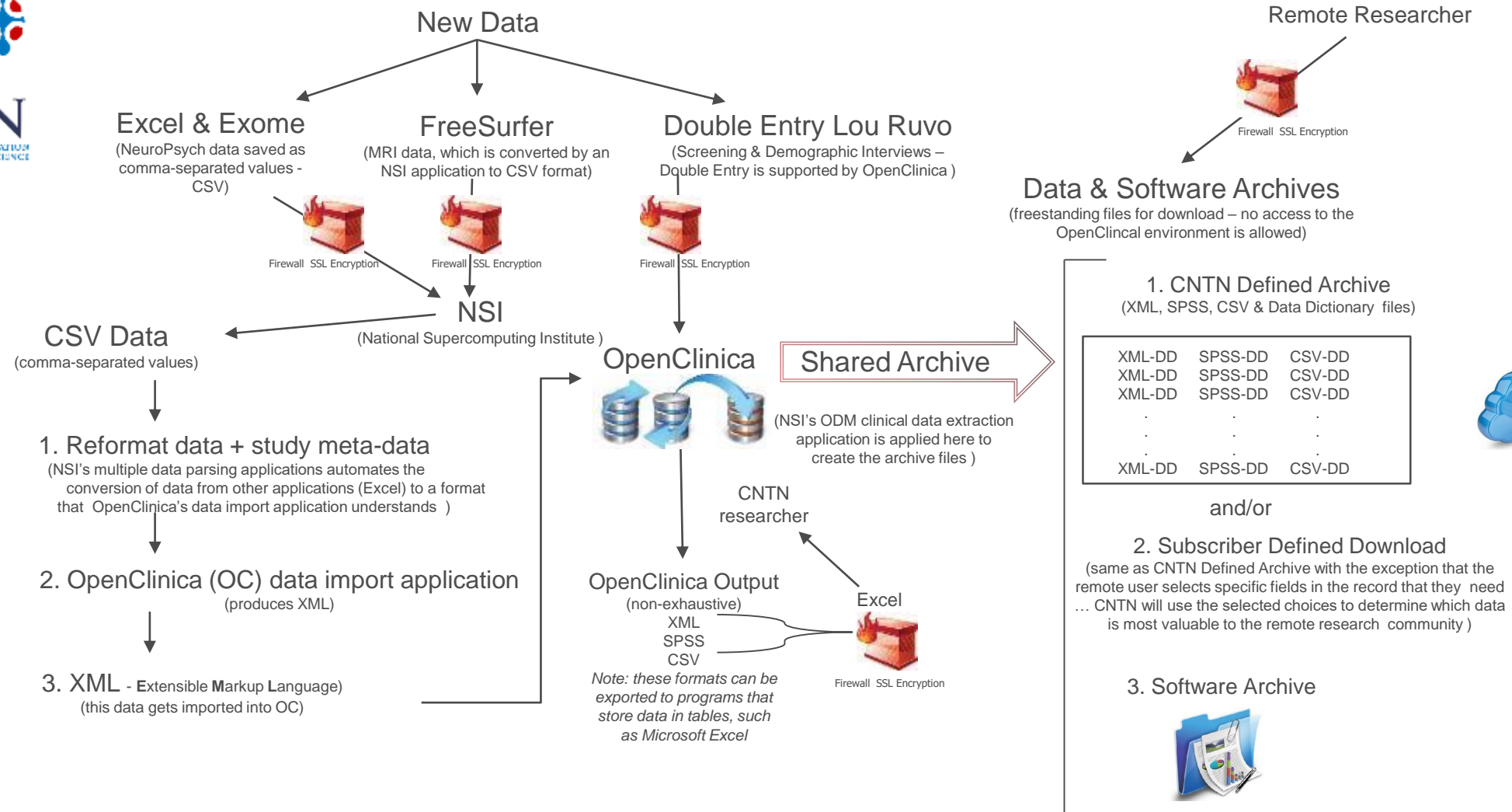
3. Software Archive





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Alzheimer's Project Results

- **Reduced overall runtimes for processing workload**
 - **Decreased processing time by more than 50%** using PBS Professional in conjunction with Rocks and an improved system with shared memory compute node
 - **3 hours instead of the 8+ hours** to process a genome
- **Fast, easy implementation**
- **Powerful, flexible customization capabilities** -- can be easily extended by adding site-specific processing plugins/hooks
- **Improved system manageability and extensibility:**
 - Lightweight solution
 - Very easy to manage
 - Not dependent on any specific operating system

Other NSI Research that Benefits from HPC...



Quantum Dynamics of Chemical Reactions

- HPC dramatically improves ability to understand how atoms and molecules interact and the chemical reactions that occur in different environments
- Researchers use complex theoretical calculations to explore how molecules behave at absolute zero temperatures and other conditions



Fracking

- Hydraulic fracturing often takes place >1 mile below groundwater supplies
- Mechanical engineers use sophisticated numerical models to more accurately predict prime locations for extraction and assess possible contamination associated with the process



Magnetically Dominated Jets in Gamma-Ray Burst

- Gamma-ray bursts are the most luminous, and violent, explosions in the universe -- they signify the deaths, collisions or swallowing up of stars
- Astrophysicists' computational research advances our understanding of the physical mechanisms behind GRBs and other high-energy astrophysical phenomena

Acknowledgements – non-exhaustive list more than 50 projects

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- Professor School of Life Science
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Fracking:

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Magnetically Dominated Jets in Gamma-Ray Burst:

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Thank you for your attention!

Questions?

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