Data Acquisition System for Dynamic Transmission Electron Microscopy

Research Team: Kerstin Kleese-van Dam, Mathew Thomas, Malachi Schram, Carina Lansing
Key Collaborators: James Evans, Nigel Browning, Patricia Abellan Baeza, Matthew Olszta, Danny Edwards, Layla Mehdi, Lucas R Parent

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965
ST1, Project 3.4; October 2013-September 2014

Purpose

- Improve current transmission electron microscopy (TEM) data acquisition process to support improved analysis capabilities and higher data volumes expected from the dynamic TEM (DTEM) under development at PNNL
- Key challenges include investigating existing software solutions; identifying hardware bottlenecks, such as PC storage, driver threadedness, data transfer protocols between microscope and computers, and network parameters (TCP Windows, MTU).

Expected Outcomes

- Acquisition system supporting higher data rates (initially 100-1000 images/sec)
- Ability to capture enhanced metadata
- System linked to PIC (PNNL Institutional Computing) and Analysis in Motion (AIM)/REXAN-based analysis pipelines to provide data streams for evaluating AIM framework efficacy and performance
- Hardware/software recommendations for further high-throughput data collection.

Research Accomplishments

Why we need it

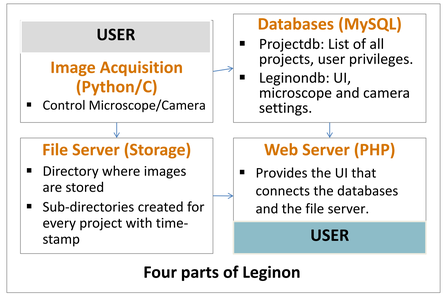
- Fast-growing imaging method
  - 600 instruments worldwide
  - Increasing by ~50/year
- Target acquisition
  - Full frame (4K x 4K or 4 Kx 3K)
    - 0.1-1 ms timescale
    - 1000-10000 fps
  - Sub-frame tiling
    - 48-64 sub frames (512 x 512 pixels)

Time	Instrument	Data Rates	Burst	Volume
Today	Conventional	100-1000 images/day	Single	
1-2 years	Environmental	1000 images/sec	10 min	11-13 TB/day
2-3 years	Dynamic	1,000,000 images/sec	10 sec	20 TB / burst

Expected DTEM Acquisition Rates

Software investigated

- SerialEM (U of Colorado, Boulder)
- Leginon (The Scripps Research Institute)



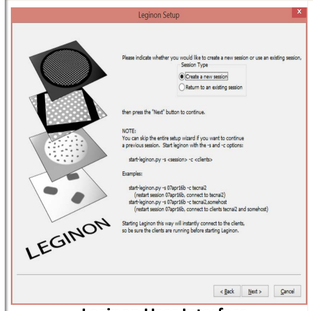
Four parts of Leginon

Comparison	SerialEM	Leginon
Platform	Windows	Windows: Microscope Linux: Everything else
Distributed computing	No	Yes
Programming language	C++	Python
Database	No	Yes
GPU processing	No	Yes (some modules)

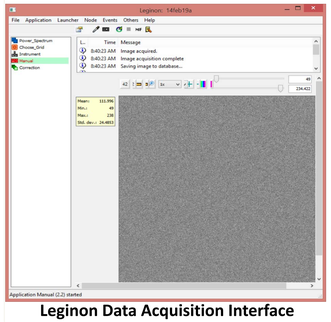
SerialEM vs. Leginon

Microscope/Camera

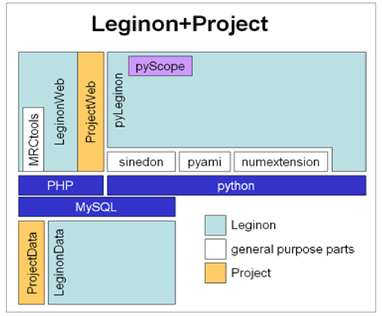
- Primary microscope: JEOL 2200Fs
- Possible Cameras: F224HD/DE-12



Leginon User Interface

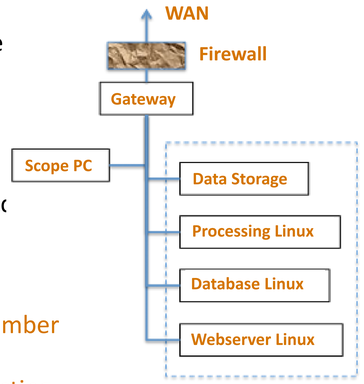


Leginon Data Acquisition Interface



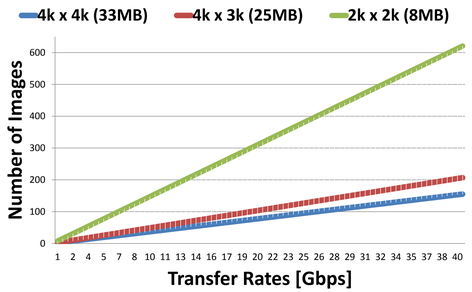
Leginon implementation setup

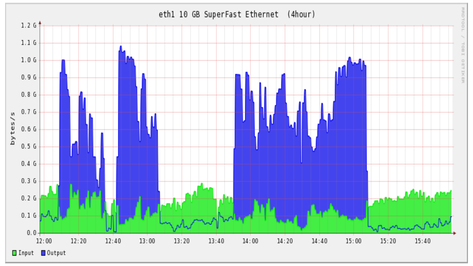
- 1 Windows box provides interface with the microscope
  - Simulation of microscope data acquisition used for testing
  - Provides interface to various existing microscopes
- 1 Linux box for all other functions.
- Currently generates continuous acquisition of simulated images producing raw data.



Profiling and requirement efforts

- Identified required transfer rates to achieve specific number of images.
- Saving selective data during acquisition and re-constructing later can significantly increase the transfer rates.





Hardware Performance Testing

Next Steps

- Provide dedicated data storage via PIC
- Investigate/modify the transfer protocol in Leginon as needed
- Interact with vendors to better understand current hardware
- Provide suggestions to address existing data acquisition bottlenecks
- Study more data to better understand correlation between adjacent images.