HIGH PERFORMANCE IMAGE RECONSTRUCTION IN SPECT
WITH DATA ANALYTICS TOOLS

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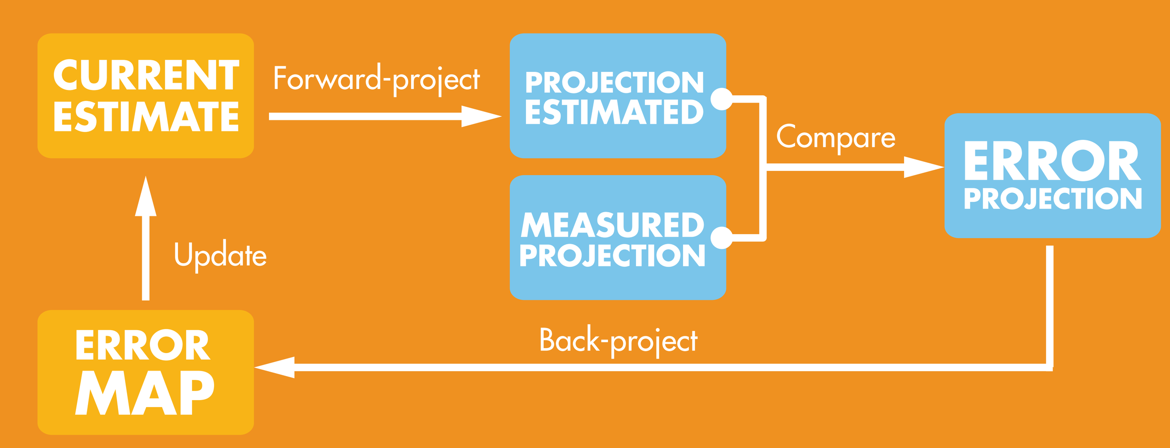
ITERATIVE SPECT IMAGE RECONSTRUCTION

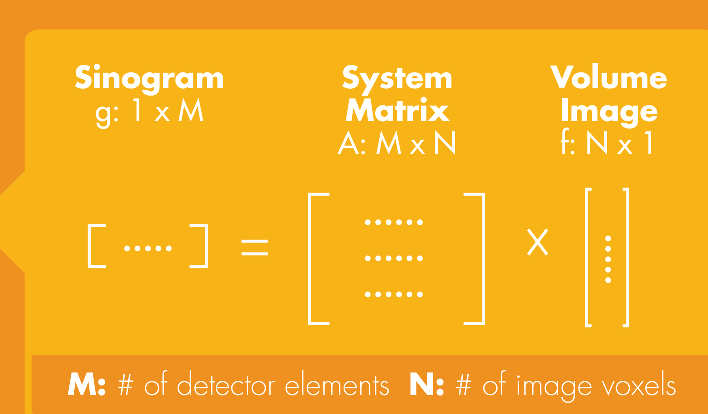
MLEM Maximum Likelihood Expectation Maximization

$$f_j^{n+1} = \frac{f_j^n}{\sum_i a_{ij}} \sum_i \frac{a_{ij}}{\sum_k a_{ik} f_k^n} g_i$$



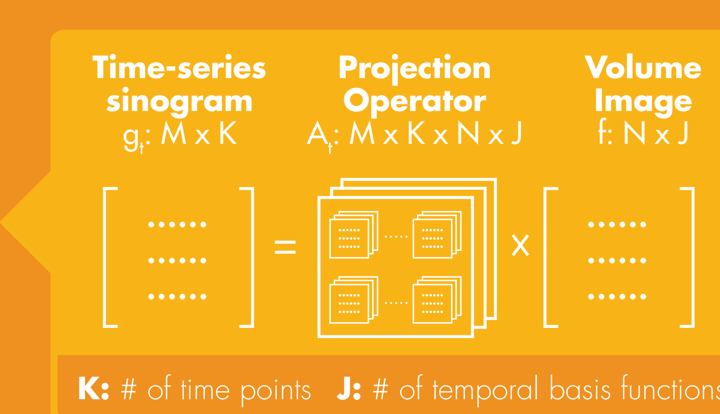
3D MLEM

7 second/iteration



BASIS FUNCTION 4D MLEM

8.8 minute/iteration



CAN WE FIND A BETTER SOLUTION?

- ☑ Scale nicely with data size
- ☑ Clinically suitable image processing time
- ☑ A generalized solution for other image reconstruction such as CT and PET

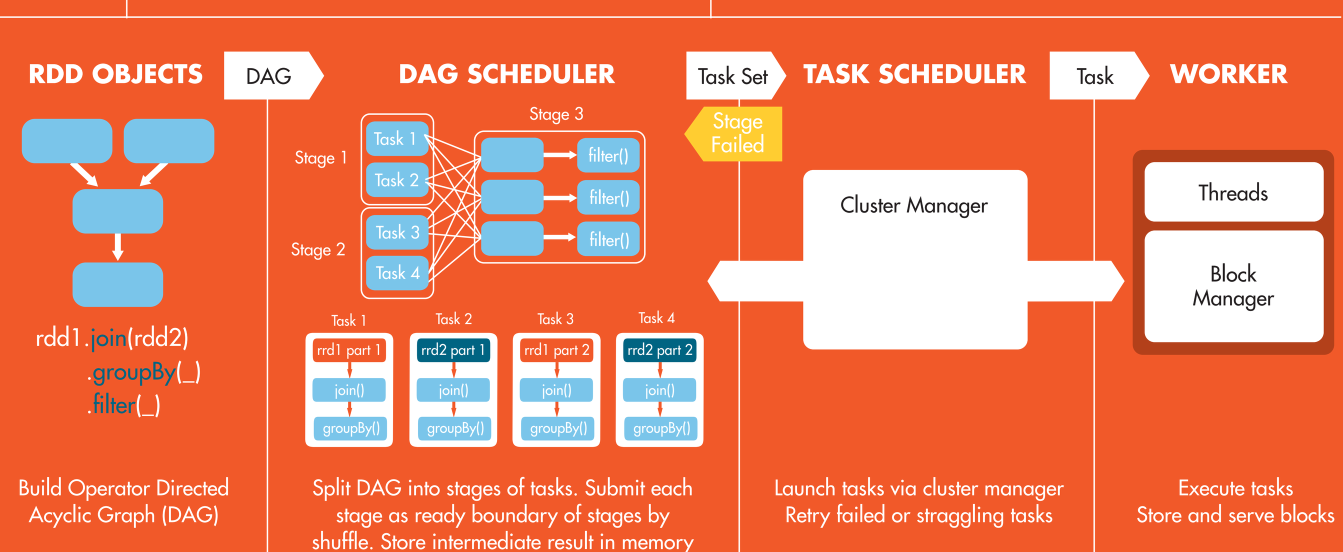
APACHE SPARK

WORKS
- Matei Zaharia, 2009
- UC Berkeley AMPLab
- Open-source distributed computing framework

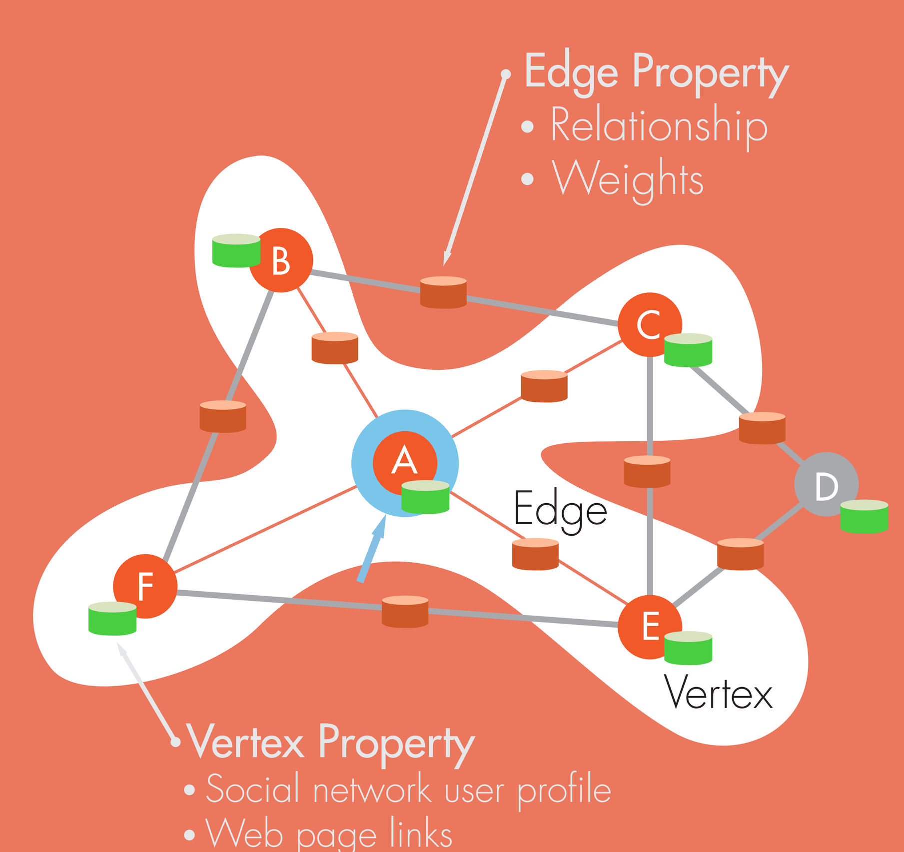
GOALS
- Generality
- Low latency for performance
- Fault tolerant
- Simplicity in code design

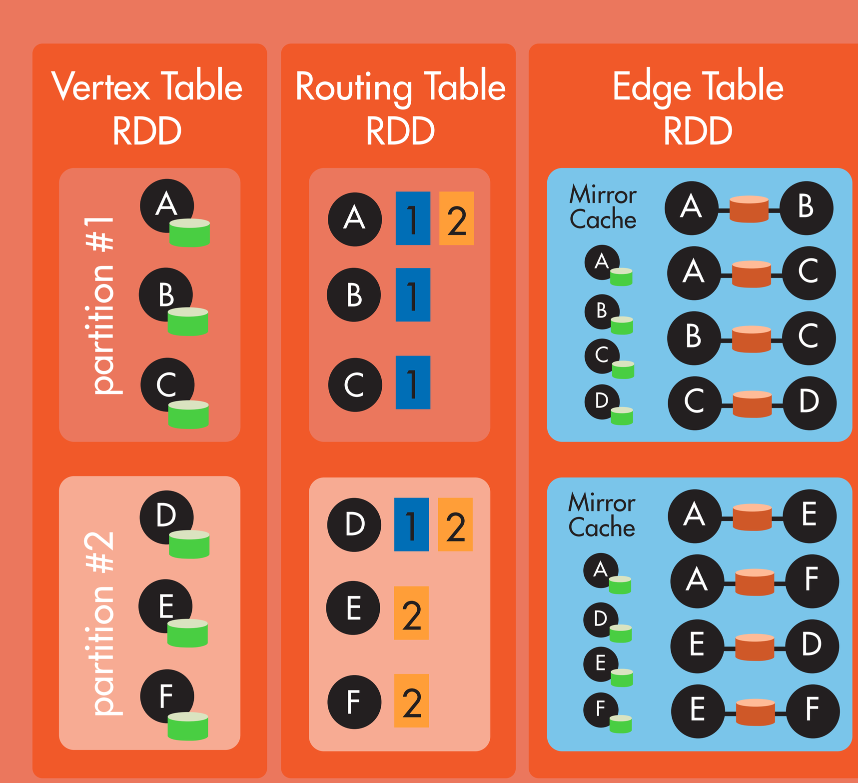
DATA STRUCTURE
- Collection of objects across a cluster Stored in RAM or on Disk
- Built through parallel transformation
- Automatically rebuild on data failure

Execution Model



GRAPHX





Parallel by vertices
Operation only on neighboring vertices

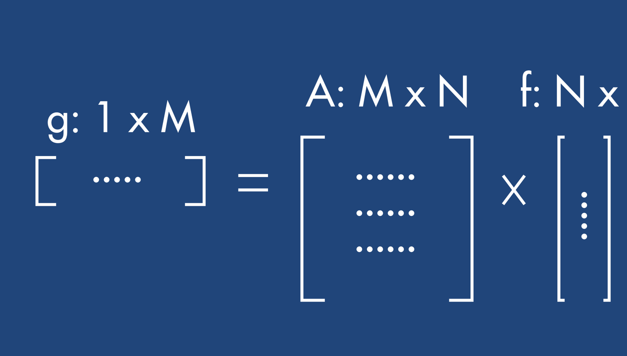
SPARK GRAPHX 3D MLEM

IMAGE RECONSTRUCTION
- Parallel-hole collimator SPECT imaging system
- Noiseless MCAT phantom sinogram (128 x 128 x 360, ~53% sparse matrix)
- Sparse, pre-computed system matrix (~3.6-million vertices, ~398-million edges)
- 128^3 reconstructed image volume
- 5 -10 iterations

SPARK EXECUTION
- ~ 50 lines of Scala code
- Relion 2800GT server, 32 Dual 2.7GHz Intel Xeon CPUs, 256GB RAM

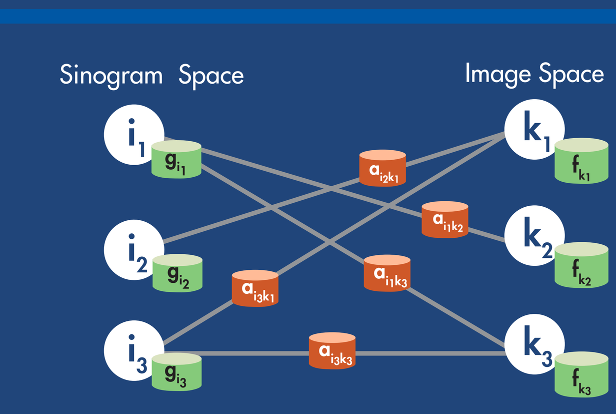
SYSTEM MATRIX MULTIPLICATION

Back-Projection $g_i = \sum_k a_{ik} f_k$

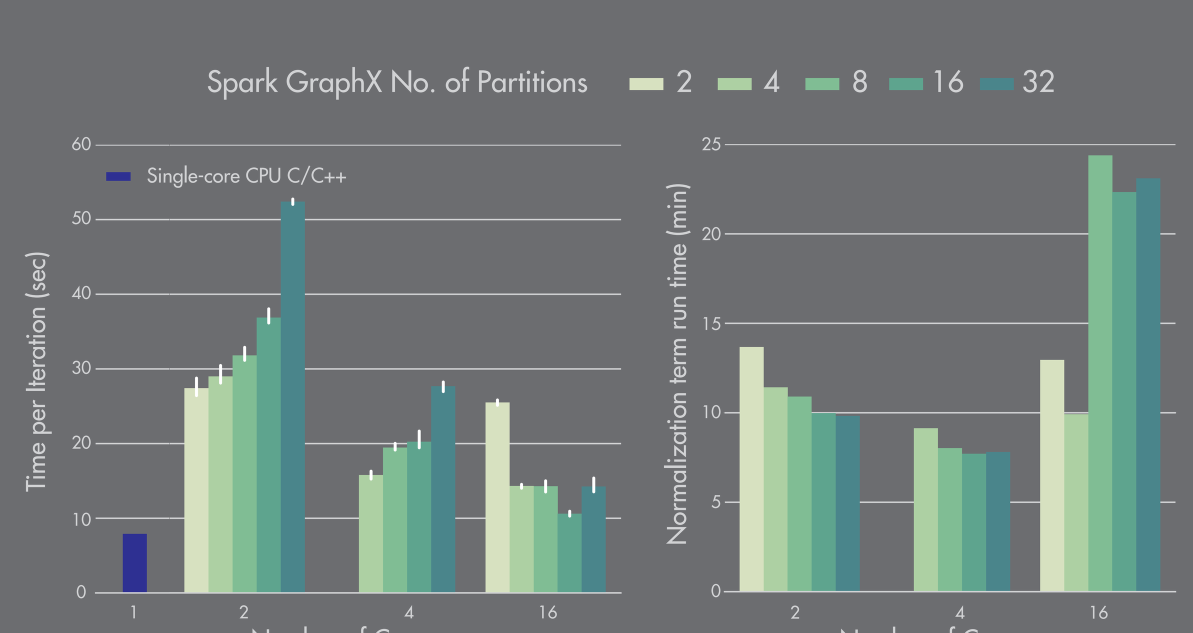


BI-PARTITE GRAPH

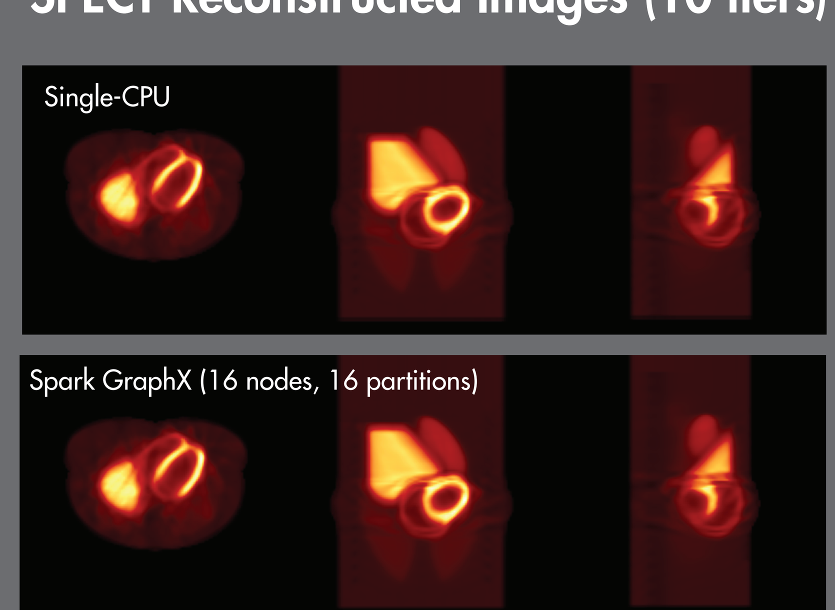
$$g_i = \sum_{f_k \in \{\text{neighbors of } g_i\}} a_{ik} f_k$$



FINDINGS



SPECT Reconstructed Images (10 iters)



CONCLUSIONS
- Validated Spark GraphX 3D MLEM SPECT reconstruction algorithm
- Comparable to C/C++ iteration time with GraphX MLEM using 16 cores & 16 partitions
- Data exchange between processor memories could cause longer computing time on multicores
- Higher-dimensional data executed on a supercomputing system may benefit more from Spark
- Future performance evaluation of SPARK MLEM on NERSC supercomputing system

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