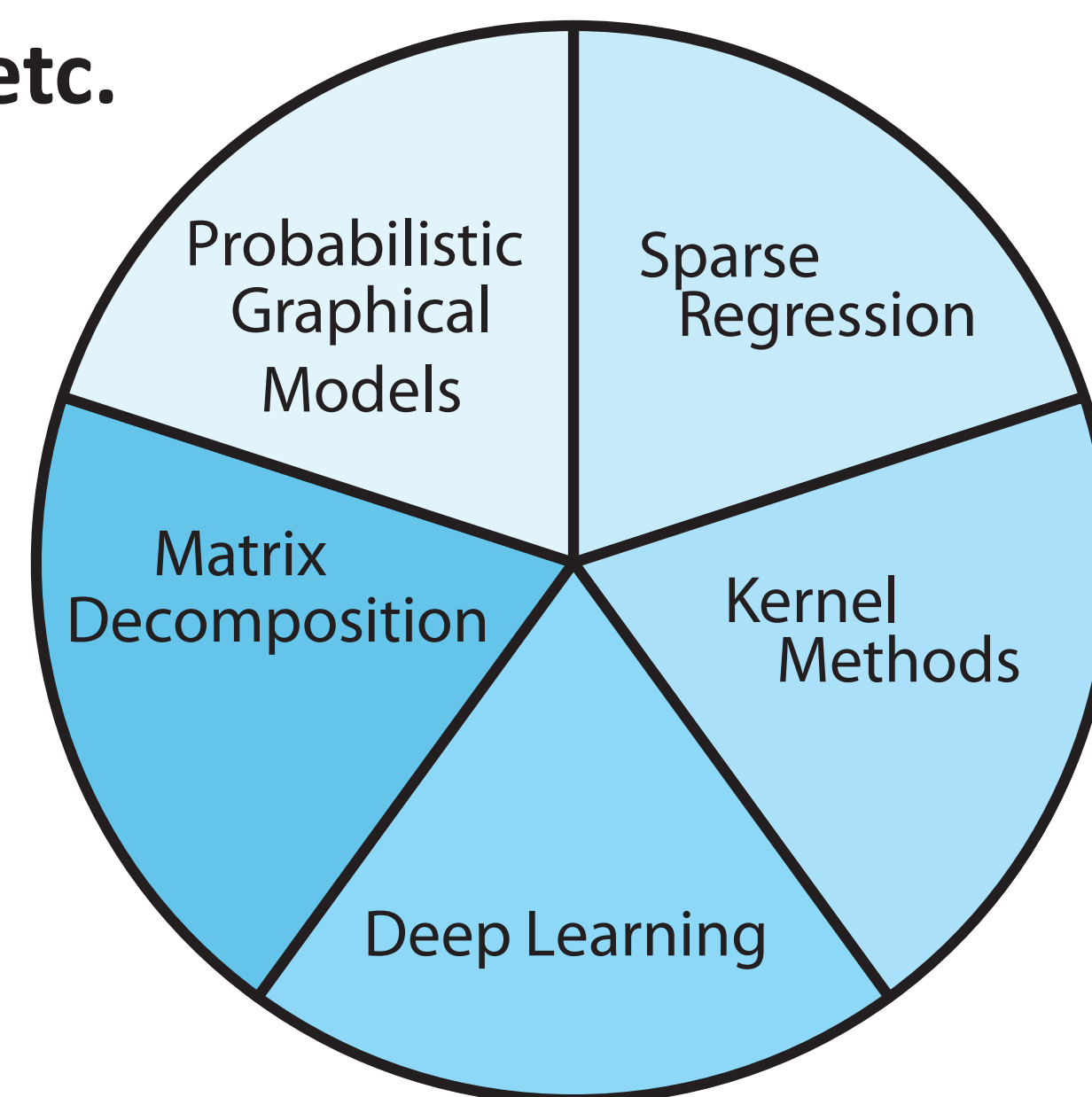


# BIG MACHINE LEARNING: NEEDS AND DIRECTIONS

Qirong Ho, Jim Cipar, Wei Dai, Jinliang Wei, Henggang Cui, and the rest of the Big Learning team (CMU)

## BIG PICTURE

- Many ML algorithms, but grouped into families
  - Five major families (ML Pie)
  - Each family uses math and techniques
- ML researchers keep implementing from scratch
  - Effort duplicated on MPI, distributed state, etc.
  - Little code reuse between research groups
- Need system support for Big ML that:
  - Handles computation and data partitioning
  - Addresses unique aspects of ML families
  - Facilitates future systems-ML research

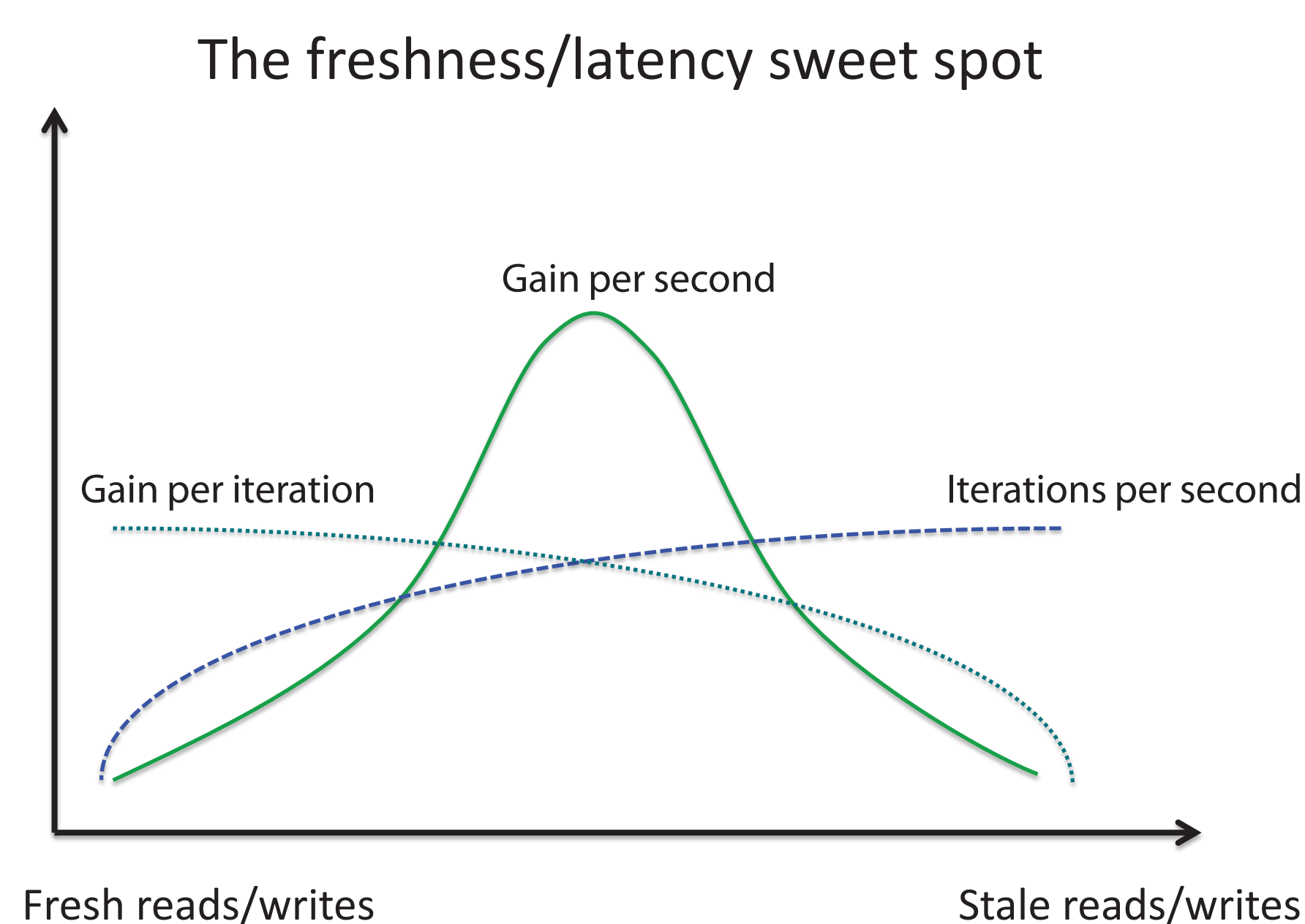


## WHAT'S AN ML ALGORITHM?

- Most "ML algorithms" are combo of two things:
  - Mathematical/statistical model
  - Algorithmic technique to solve the model
- This ML pie is model-centric
  - Family members share mathematical properties
  - Techniques may be used in more than one family

## STALENESS

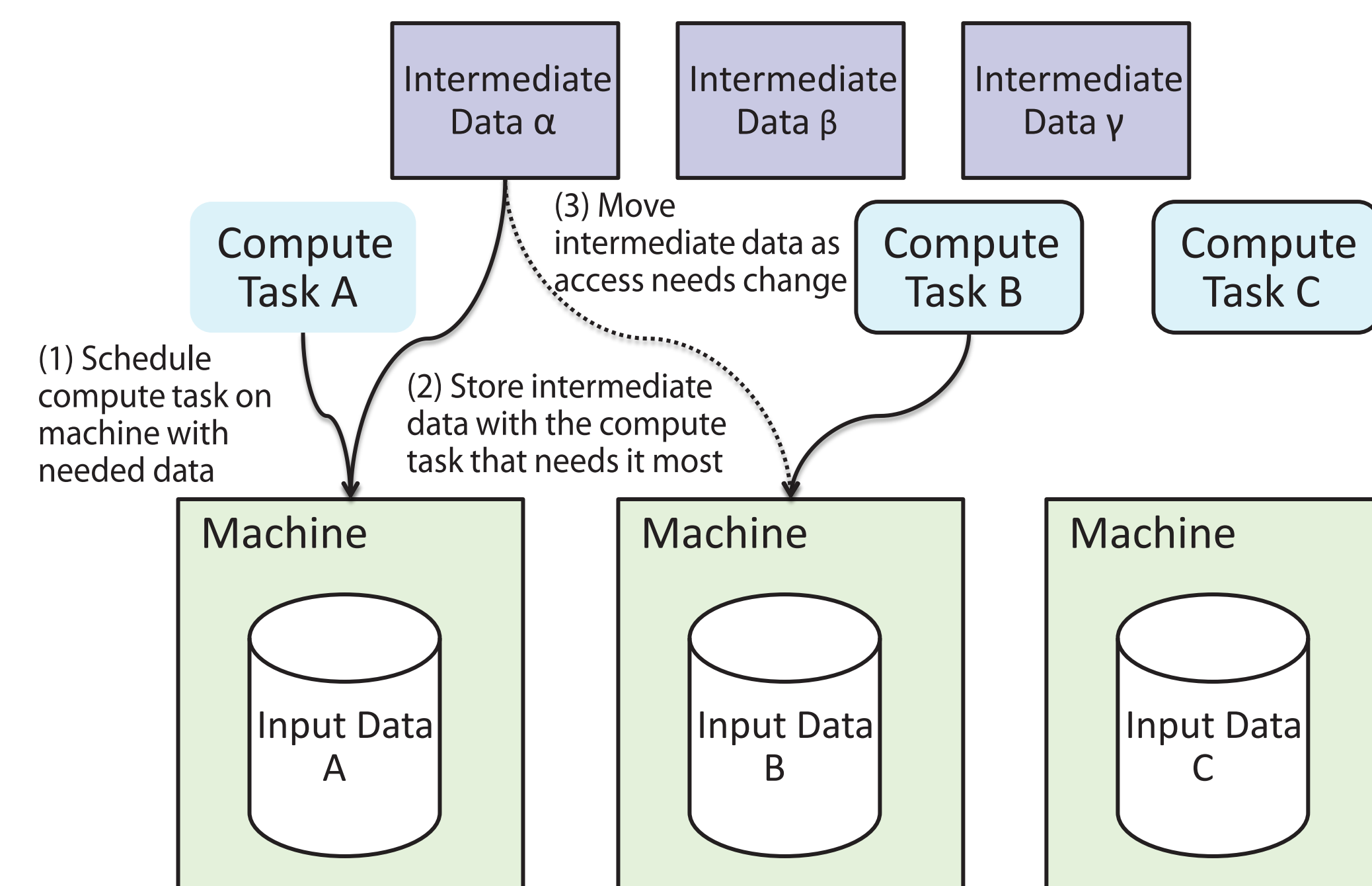
- ML algorithms iterate until convergence
  - Minor errors in intermediate data induce more iterations, but don't prevent convergence
- Each iteration reads/writes shared intermediate data
  - Locking quickly becomes a bottleneck
  - Limited network bandwidth a secondary bottleneck
- Big idea: let threads work on stale data
  - More iterations, but often much faster
- See LazyTables poster for more info!



## LOCALITY

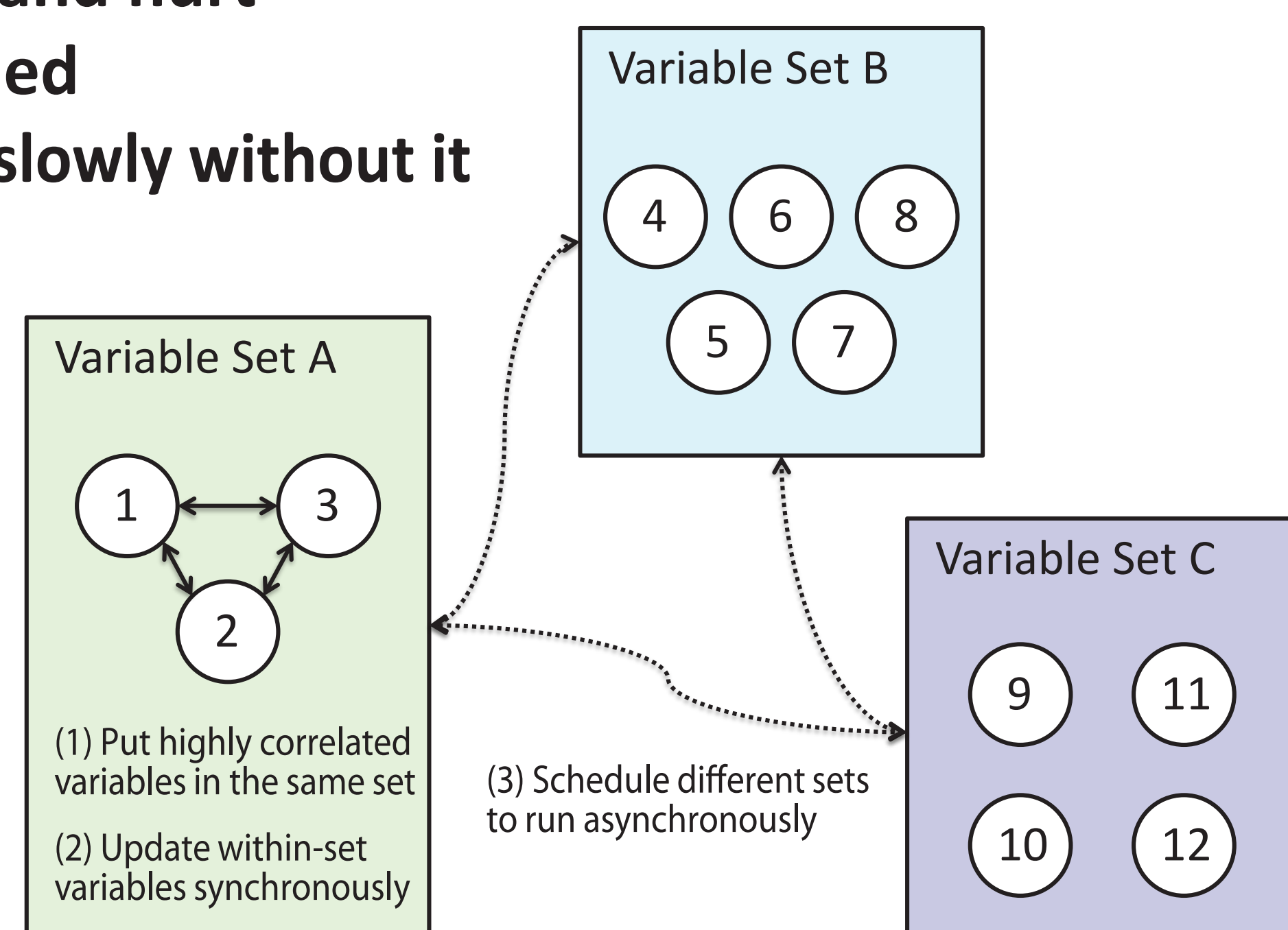
- Intermediate data is often large and distributed
  - Computation should be near intermediate data being used
- Intermediate data usage patterns change over time
  - May shift focus within intermediate data
  - Adaptive placement required to maximize performance
- Staleness can help with locality
  - LazyTables caches stale copies near each thread

Locality: Input Data, Intermediate Data, and Computation



## ADAPTIVE SYNCHRONIZATION

- Synchronization among threads can help and hurt
  - Slows iteration rate and often not needed
  - But, highly correlated variables converge slowly without it
- Big idea: dynamic variable sets
  - Within a set, update are synchronized
  - Between sets, they are not
  - Adaptively formed by measuring correlation



## ONGOING EXPLORATIONS

- Refining the ML pie
  - Useful for identifying systems opportunities
- Evaluating existing platforms
  - E.g., GraphLab, Spark, Piccolo
  - Each has strengths and weaknesses
  - Substantial slices of pie served by none
- Evaluating new systems support ideas
  - With real ML algorithm implementations

