# Intelligent HPC Cloud

## Illustrated by Harp and Harp-DAAL at Indiana University

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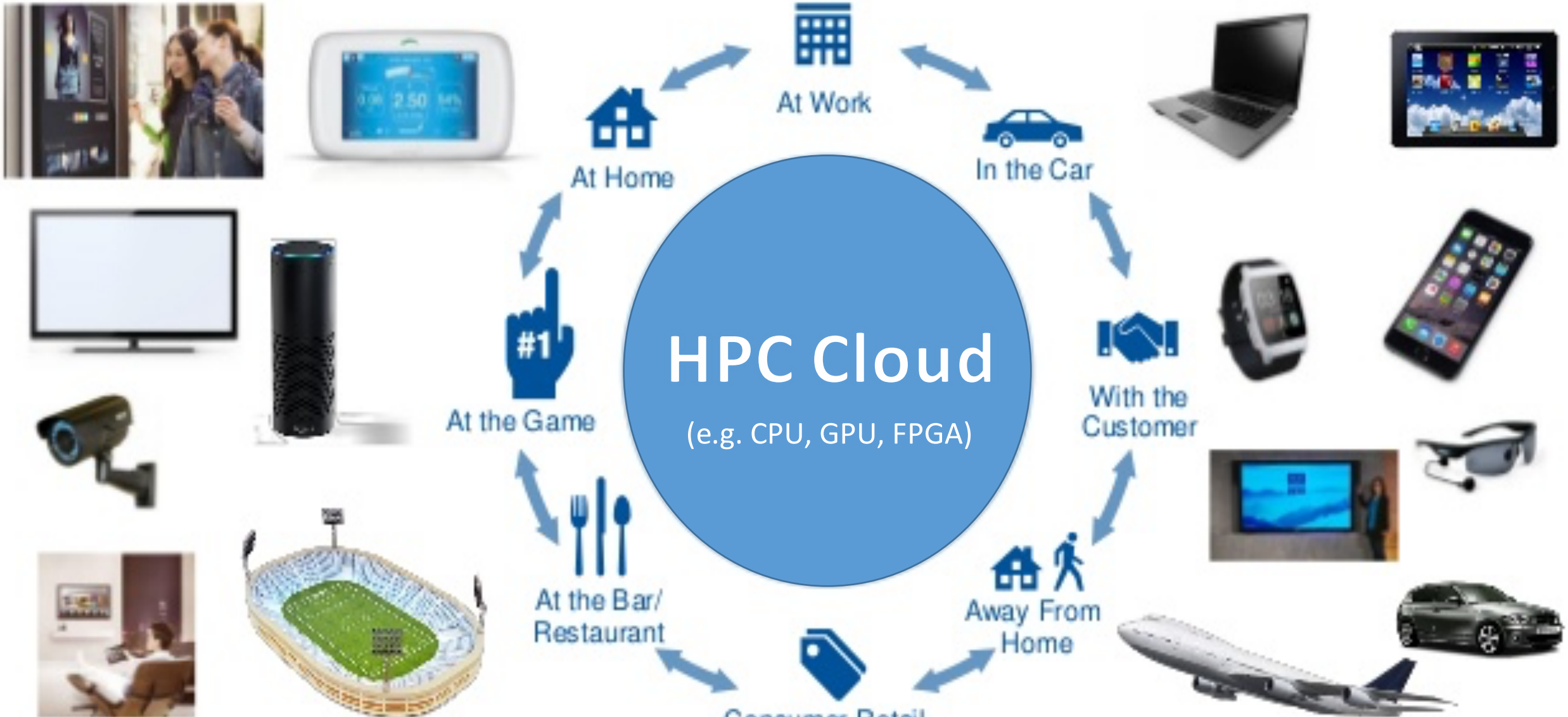
# Intelligent HPC Cloud

1. General Purpose Machine Intelligence requires both Cloud and HPC Technologies
2. HPC-Apache Big Data Stack supports AI and IoT
3. Illustration of Harp (Hadoop plug in) and Intel's High Performance Data Analytics

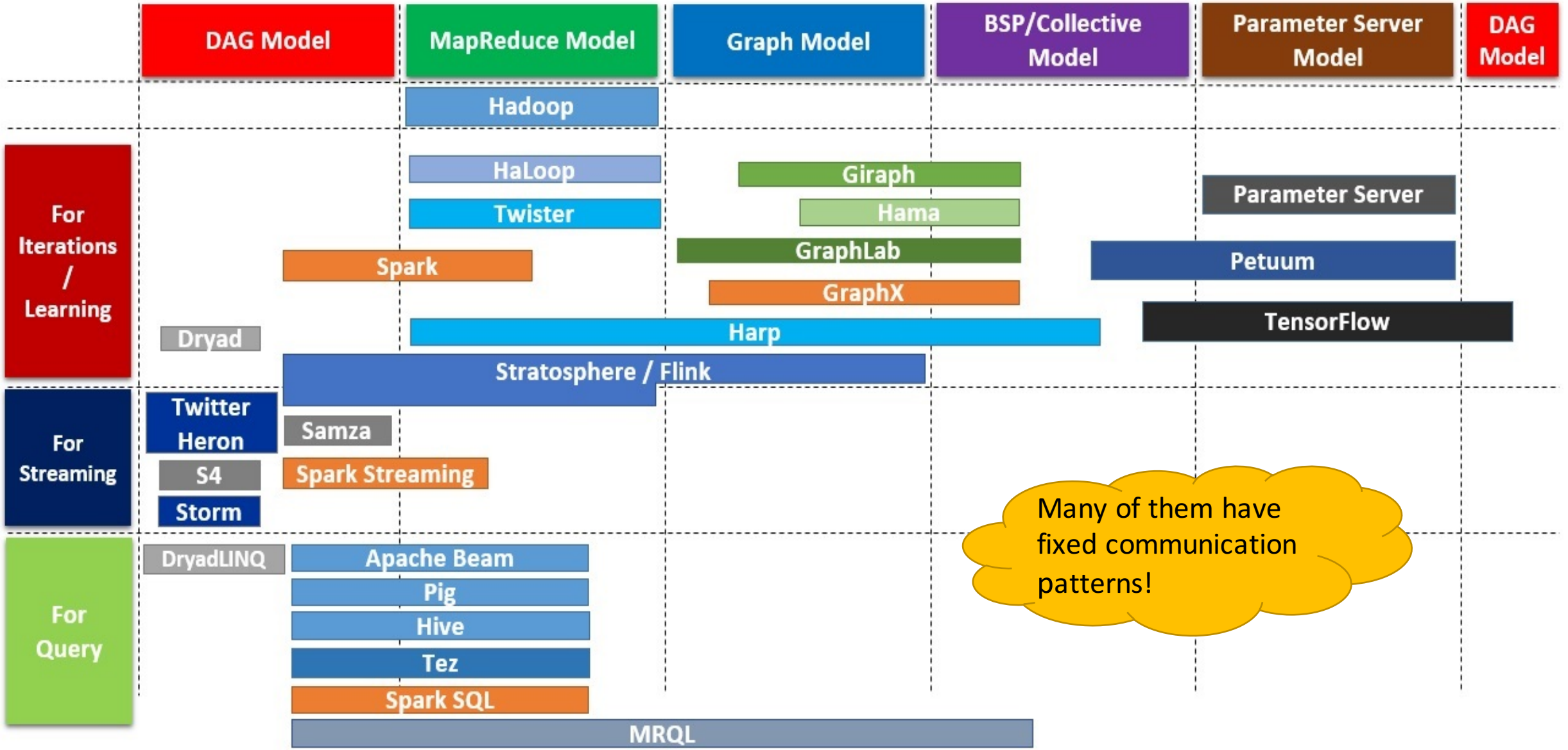
# 50 Billion Devices by 2020

World Popular will be 7.6 billion by 2020



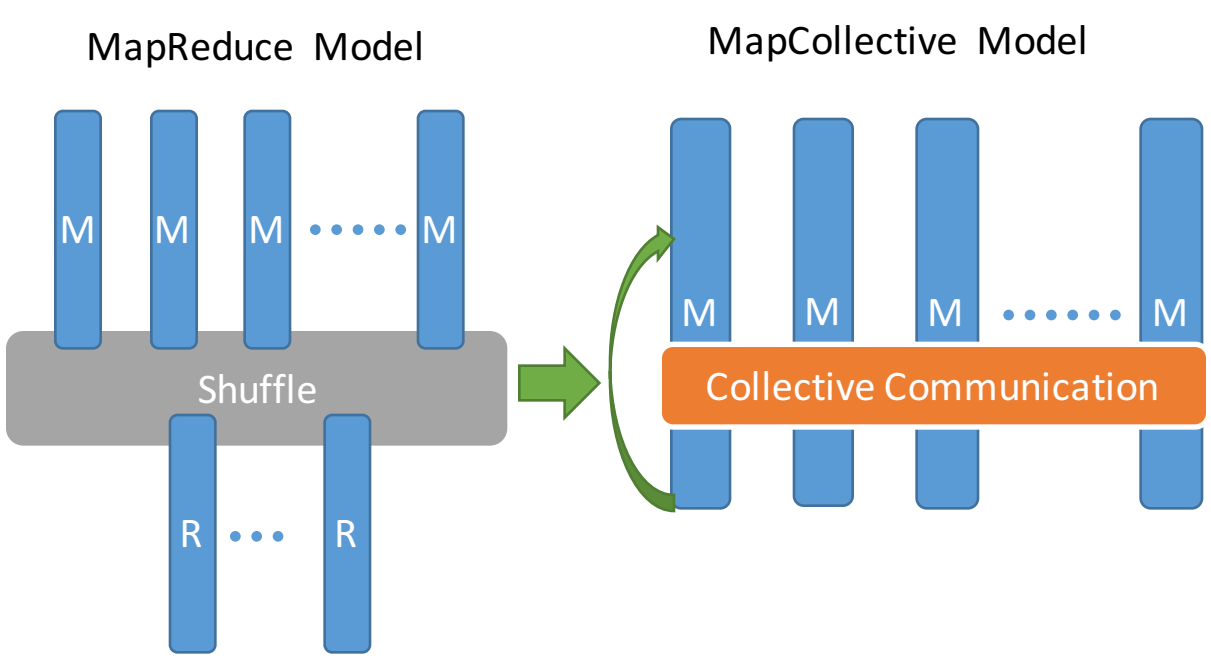
# High Performance – Apache Big Data Stack

**HPC-ABDS** as Cloud-HPC interoperable software with performance of HPC (High Performance Computing) and the rich functionality of the commodity Apache Big Data Stack was a bold idea developed.

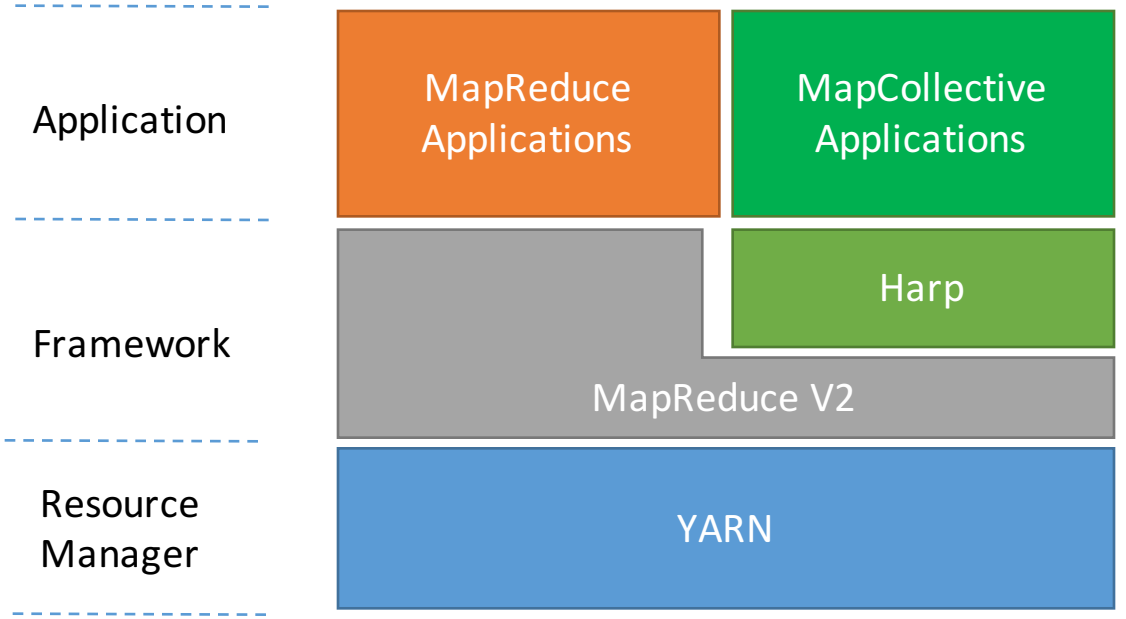


# The Concept of Harp Plug-in for Hadoop

## Parallelism Model




## Architecture

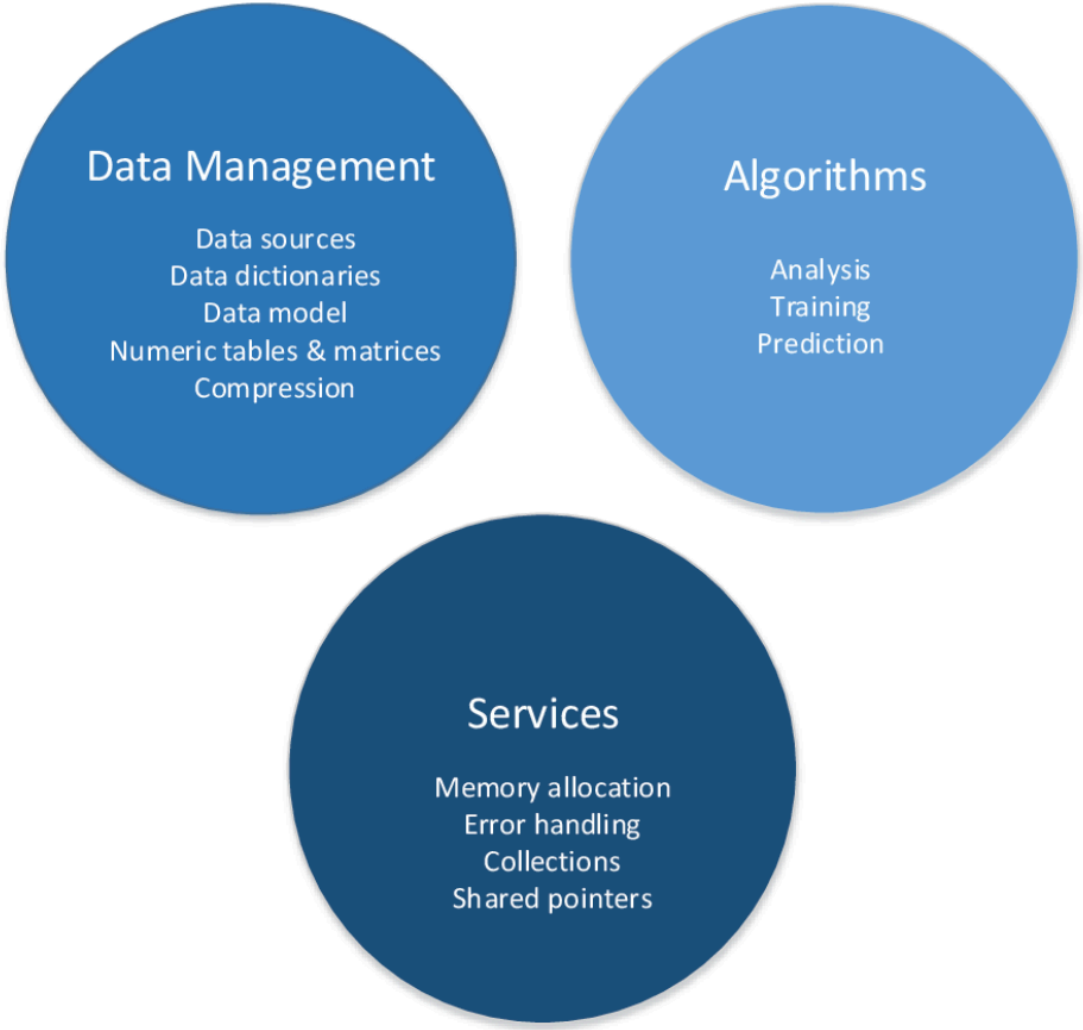



Harp is an open-source project developed at Indiana University [6], it has:

- MPI-like **collective communication** operations that are highly optimized for big data problems.
- Harp has efficient and innovative **computation models** for different machine learning problems.

[6] Harp project. Available at https://dsc-spidal.github.io/harp

# DAAL: Intel® Data Analytics Acceleration Library

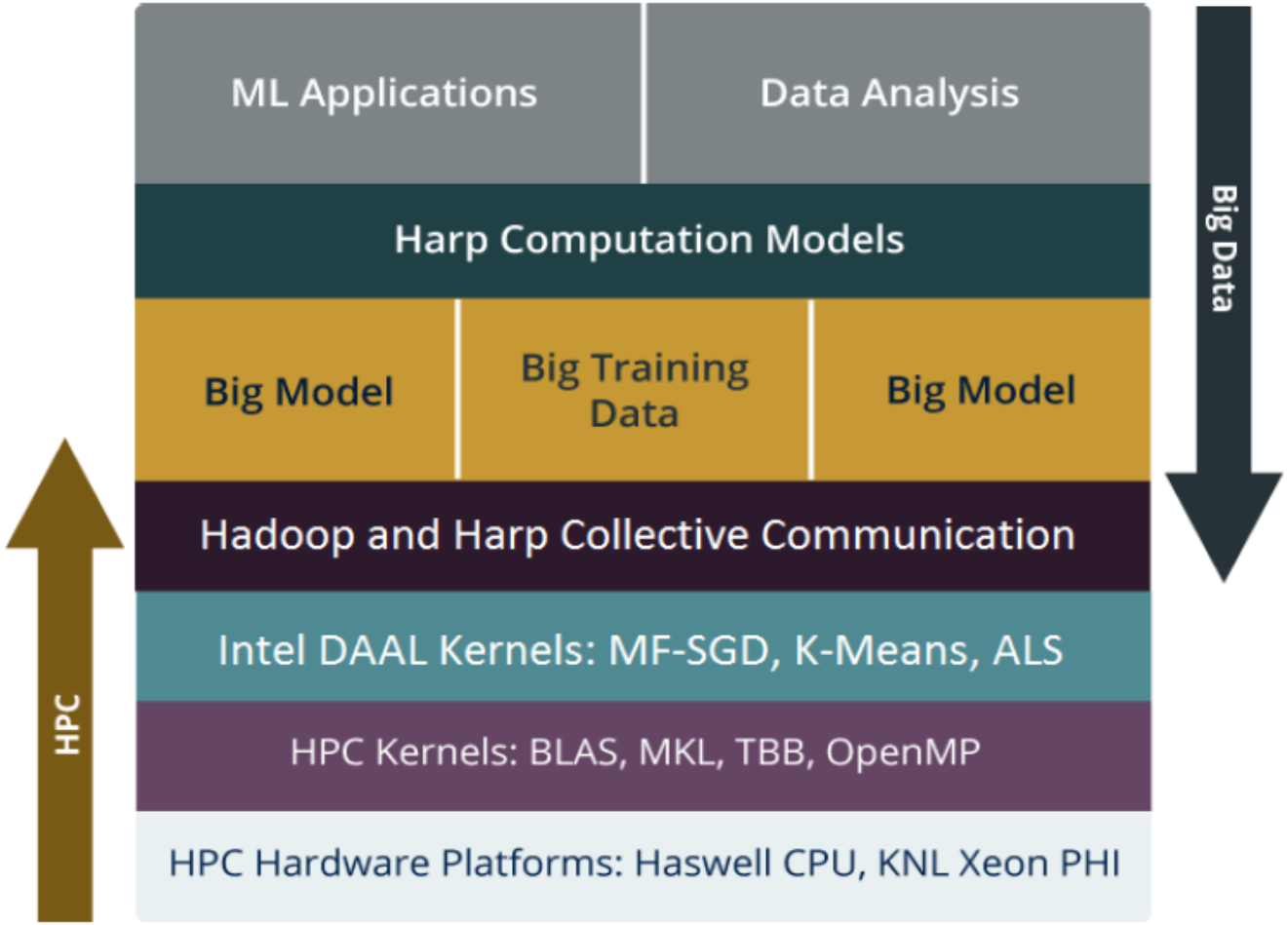



DAAL is an open-source project that provides:

- Algorithms Kernels to Users
  - Batch Mode (Single Node)
  - **Distributed Mode (multi nodes)**
  - Streaming Mode (single node)
- Data Management & APIs to Developers
  - Data structure, e.g., Table, Map, etc.
  - HPC Kernels and Tools: MKL, TBB, etc.
  - Hardware Support: Compiler

# Harp-DAAL enable faster Machine Learning Algorithms

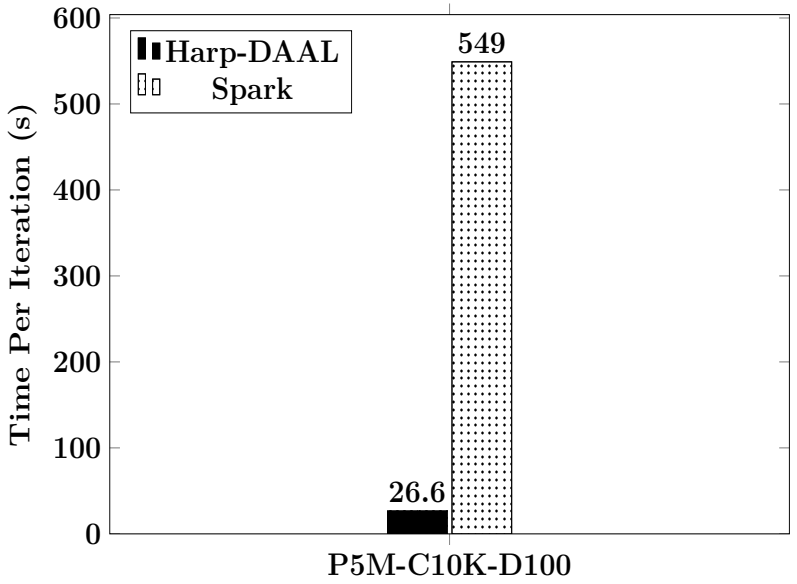
## with Hadoop Clusters on Multi-core and Many-core architectures




- Bridge the gap between HPC hardware and Big data/Machine learning Software
- Support Iterative Computation, Collective Communication, Intel DAAL and native kernels
- Portable to new many-core architectures like Xeon Phi and run on Haswell and KNL clusters

# Performance of Harp-DAAL on KNL Single Node

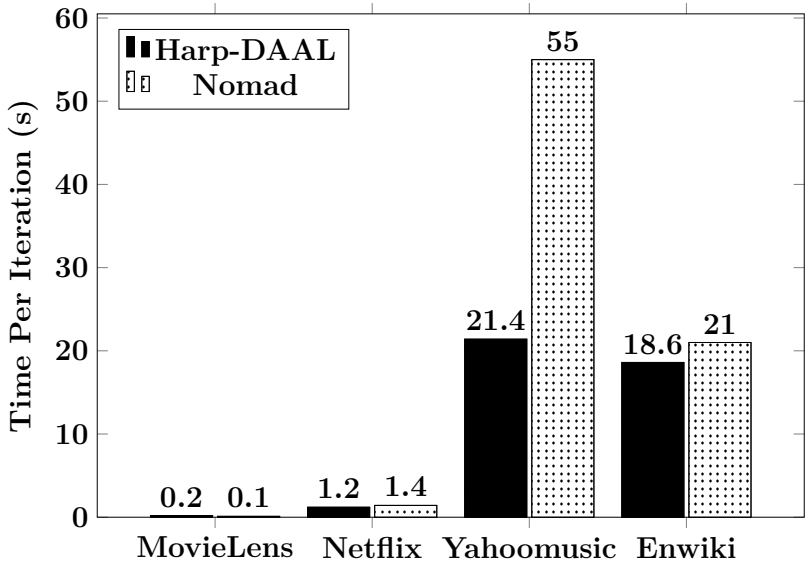
## *Harp-DAAL vs. Spark vs. NOMAD*




Harp-DAAL-Kmeans vs. Spark-Kmeans:

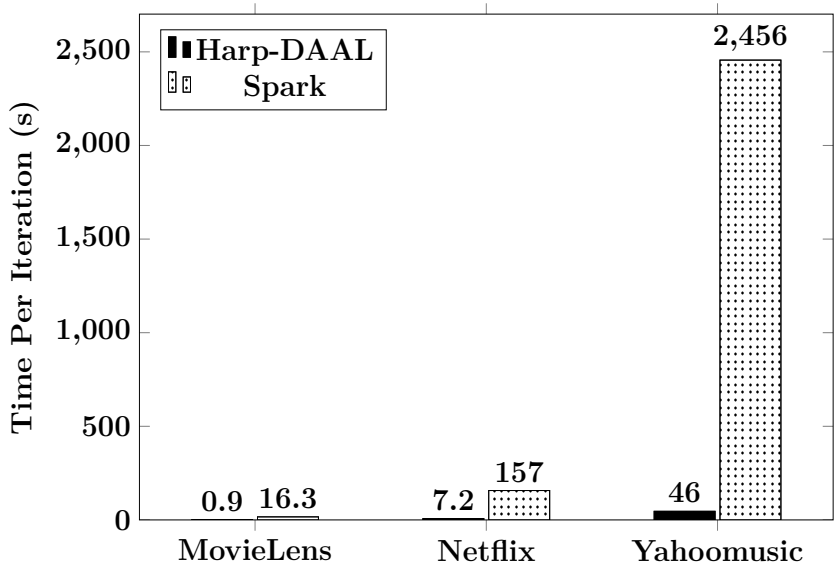
***~ 20x speedup***

1) Harp-DAAL-Kmeans invokes MKL matrix operation kernels at low level
2) Matrix data stored in contiguous memory space, leading to regular access pattern and data locality




Harp-DAAL-SGD vs. NOMAD-SGD

1) Small dataset (MovieLens, Netflix): comparable perf
2) Large dataset (Yahoomusic, Enwiki): ***1.1x to 2.5x***, depending on data distribution of matrices

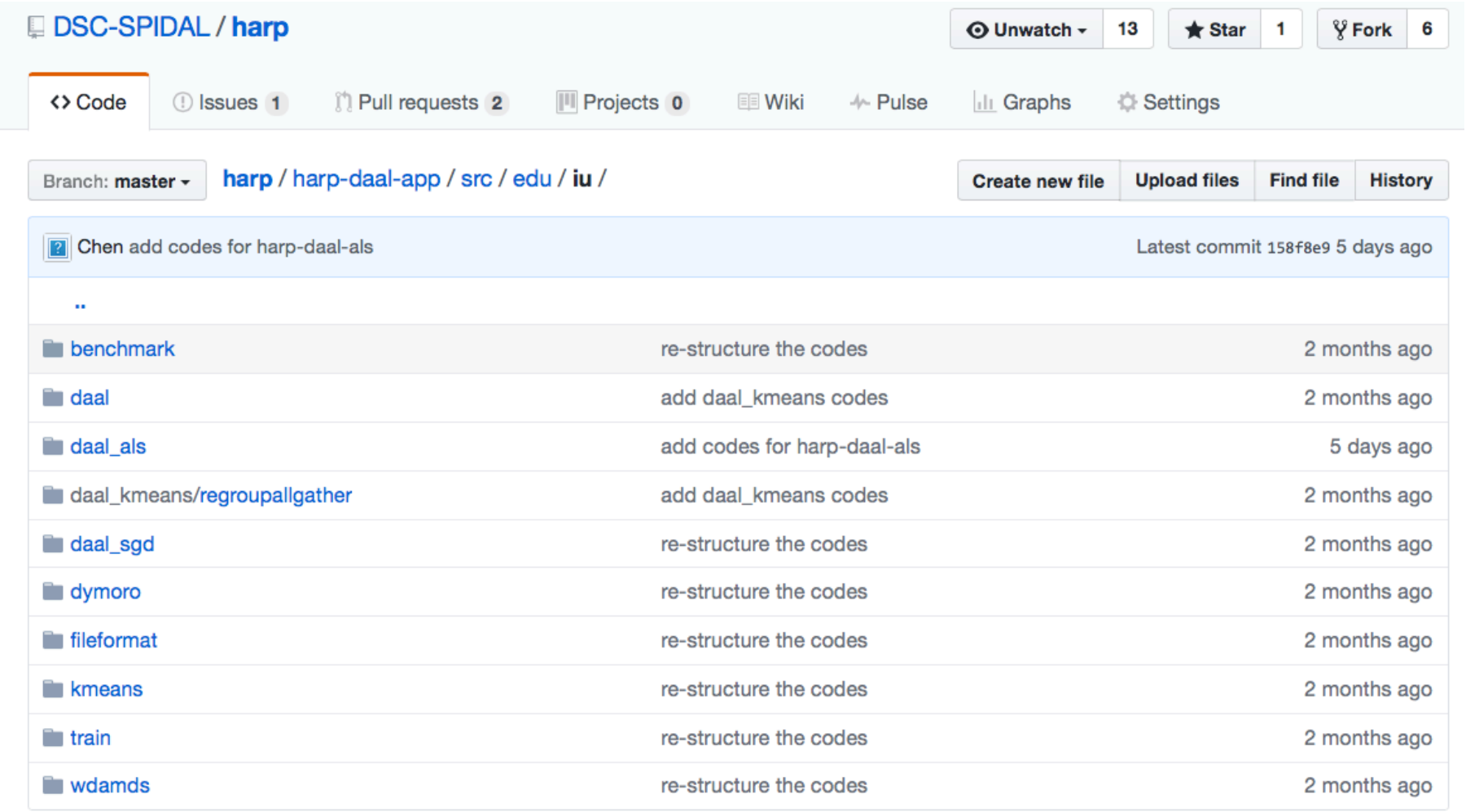



Harp-DAAL-ALS vs. Spark-ALS

***20x to 50x speedup***

1) Harp-DAAL-ALS invokes MKL at low level
2) Regular memory access, data locality in matrix operations

# Hadoop/Harp-DAAL: Prototype and Production Code




Source codes became available on Github at Harp-DAAL project in February, 2017.

- Harp-DAAL follows the same standard of DAAL's original codes
- Six Applications
  - Harp-DAAL Kmeans
  - Harp-DAAL MF-SGD
  - Harp-DAAL MF-ALS
  - Harp-DAAL SVD
  - Harp-DAAL PCA
  - Harp-DAAL Neural Networks

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# Scalable Algorithms implemented using Harp

| Algorithm | Category | Applications | Features | Computation Model | Collective Communication |
|---|---|---|---|---|---|
| **K-means** | Clustering | Most scientific domain | Vectors | AllReduce | allreduce, regroup+allgather, broadcast+reduce, push+pull |
| | | | | Rotation | rotate |
| **Multi-class Logistic Regression** | Classification | Most scientific domain | Vectors, words | Rotation | regroup, rotate, allgather |
| **Random Forests** | Classification | Most scientific domain | Vectors | AllReduce | allreduce |
| **Support Vector Machine** | Classification, Regression | Most scientific domain | Vectors | AllReduce | allgather |
| **Neural Networks** | Classification | Image processing, voice recognition | Vectors | AllReduce | allreduce |
| **Latent Dirichlet Allocation** | Structure learning (Latent topic model) | Text mining, Bioinformatics, Image Processing | Sparse vectors; Bag of words | Rotation | rotate, allreduce |
| **Matrix Factorization** | Structure learning (Matrix completion) | Recommender system | Irregular sparse Matrix; Dense model vectors | Rotation | rotate |
| **Multi-Dimensional Scaling** | Dimension reduction | Visualization and nonlinear identification of principal components | Vectors | AllReduce | allgarther, allreduce |
| **Subgraph Mining** | Graph | Social network analysis, data mining, fraud detection, chemical informatics, bioinformatics | Graph, subgraph | Rotation | rotate |
| **Force-Directed Graph Drawing** | Graph | Social media community detection and visualization | Graph | AllReduce | allgarther, allreduce |