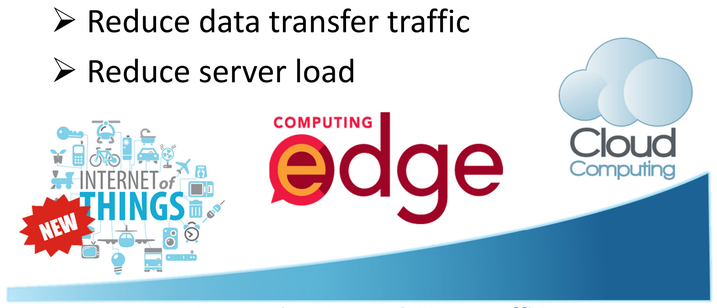
The Chorus in the Chaos: When Big Data Platforms Meet Small IoT Devices

Son Nam Nguyen[1], Teng Wang[1], Ranjan Dahal[1], Bin Zhao[2], and Bo Sheng[1]
[1]Department of Computer Science, University of Massachusetts Boston
[2]School of Computer Science and Technology, Nanjing Normal University

Problems & Motivation

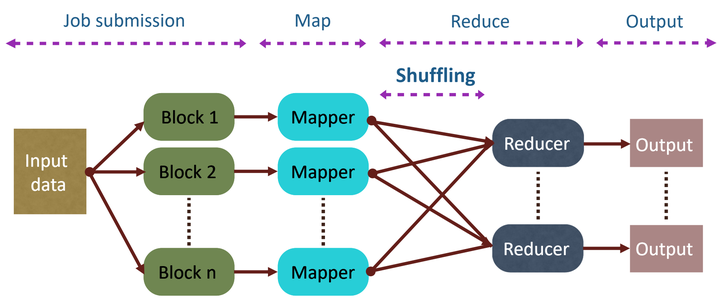
Motivation: Big Data processing on IoT

- IoT devices participate in the computation rather than being merely the data source
  - Evolved hardware capability
  - Reduce data transfer traffic
  - Reduce server load



Computing Power & Data Traffic

- Emerging big data platforms such as **Hadoop and Spark** split and process data in a distributed manner, suitable for a cluster of IoT devices.



MapReduce Process

Problems

- IoT devices rely on Wi-Fi connections
  - Low and unreliable network bandwidth
  - Shuffling data takes a long time
  - Serious **self-interferences**
    - Big data tasks tend to finish in waves and shuffle their data around the same time.
  - Packet scheduling without knowledge of the big data jobs

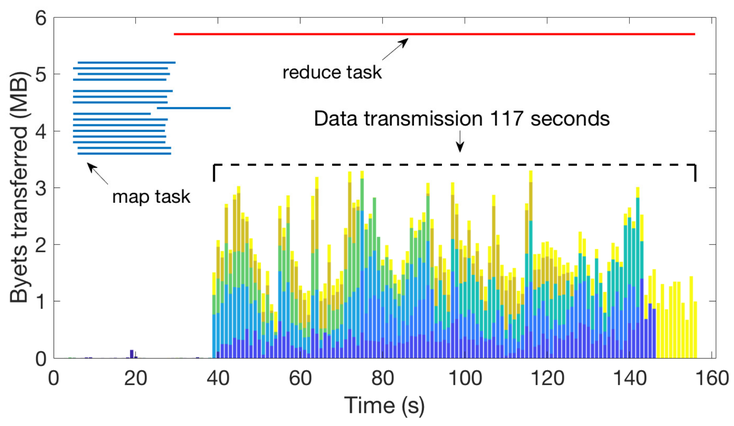
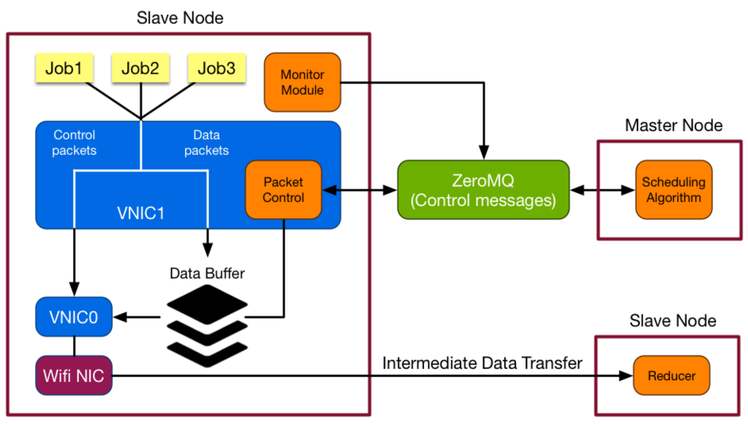


Figure 1: An example of self-interferences when sorting 256M data on a cluster of 9 Raspberry Pis.

Solution (A Token Based Packet Scheduler)

- Centralized control to avoid self-interferences
- Only the node granted with the token can transmit packets in a time window
- Assign the token and adjust the window size
  - Run-time job execution info (app layer)
  - Link qualities (data link layer)

Main Components



System Architecture

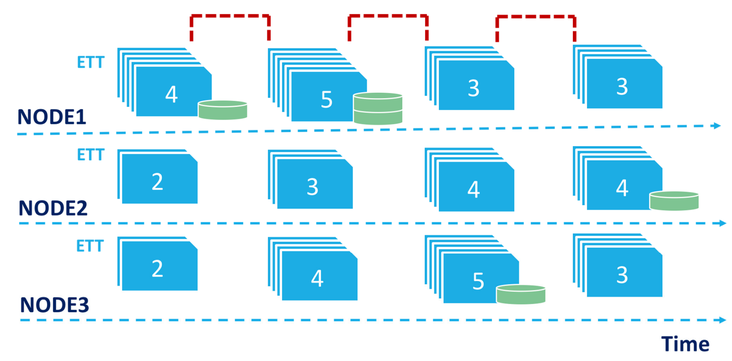
Monitor Module (slave nodes)

- Report the status of the big data jobs
  - Job progress
  - Size of intermediate data generated
- Measure the link quality
  - Historic statistics
  - Estimation based on signal strengths

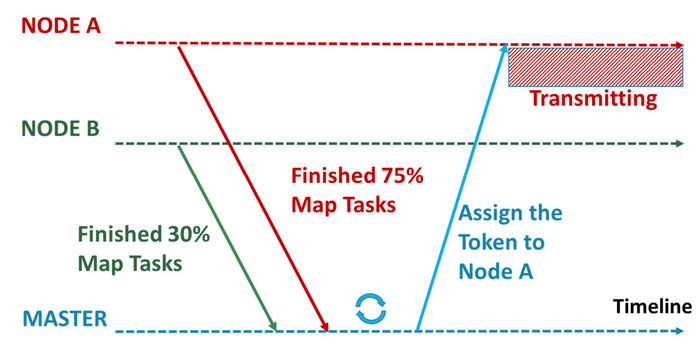
Packet Scheduling Algorithm (master node)

- Derive the Estimated Transfer Time (ETT) for each node
- The token is granted to the node (i) with the largest ETT. Its window size (W_i) is determined based on the predication of the data generation.

$$W_i = \text{argmax } t \{ ETT_i(t) > ETT_j(t), \text{ for any } j \neq i \}$$



- Among multiple jobs, the job that is close to the end of map phase is given a higher priority.



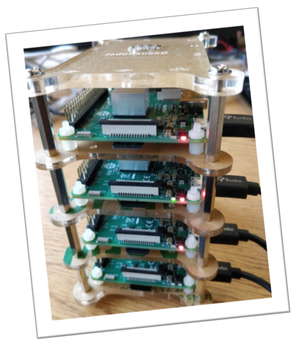
Packet Control Module (slave nodes)

- Enforce the packet schedule by capturing all outgoing shuffling packets into a buffer.
- The buffered packets are sent only during the scheduled time window.
- Handle lost control messages and transmission overtime

Evaluation

Implementation

- We implement our solution on Raspberry Pi 3 with Hadoop Yarn 2.7.2



Experiments

- Testbed: a cluster of 9 Raspberry Pis (1 master and 8 slave nodes). All nodes are connected in a WiFi ad-hoc network.
- Workload: Hadoop benchmark jobs
  - Sort: fixed and large intermediate data size
  - WordCount: various and small intermediate data size

Results

- Figure 2 shows the WiFi traffic of our solution when executing the same job as in Fig.1.

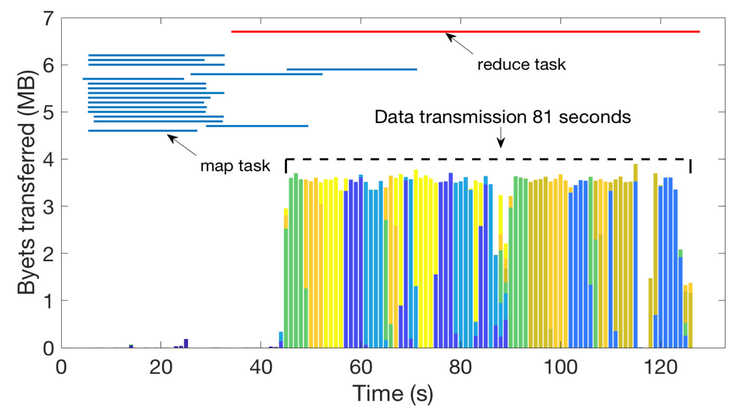


Figure 2: Self-interferences are dramatically reduced yielding a higher throughput and shorter shuffling time.

- Figure 3 compares the shuffling time of our solution and native Hadoop when executing Sort and WordCount jobs. The improvements on the shuffling time range from 12.7% to 30.7%.

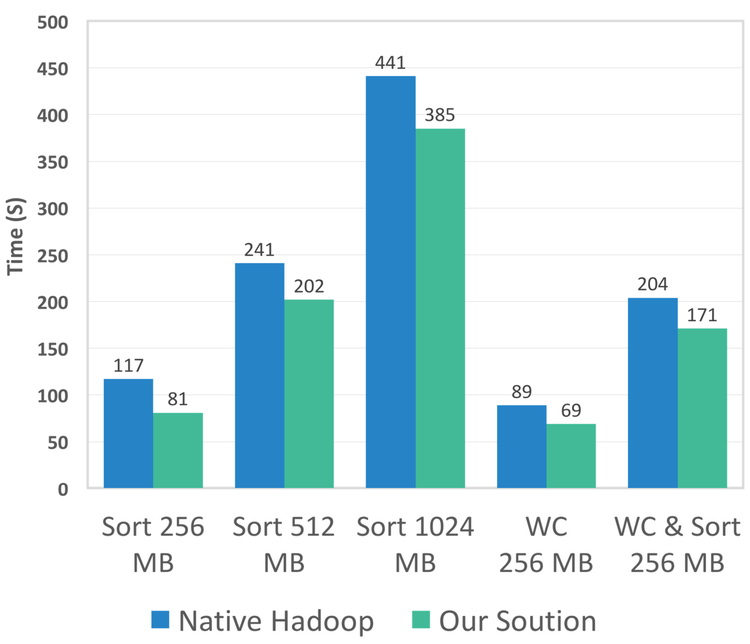


Figure 3. Comparison of shuffling time

Contact

Son Nam Nguyen
University of Massachusetts Boston
Email: Sonnam.nguyen001@umb.edu

Source Code

https://github.com/bboycoi/RPi-Hadoop