Social Network Analysis on Twitter with Chapel

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CHIUW
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Talk Outline

- Introduce the label propagation benchmark
- Describe a Chapel version
- Show one part of the benchmark and improvements to it
- Compare with the Spark version (*)

Processing Tweets: Background

Twitter: an online social networking service that enables users to send and read short 140-character messages called "tweets" -- Wikipedia

- tweets support mentioning other users via @*username*

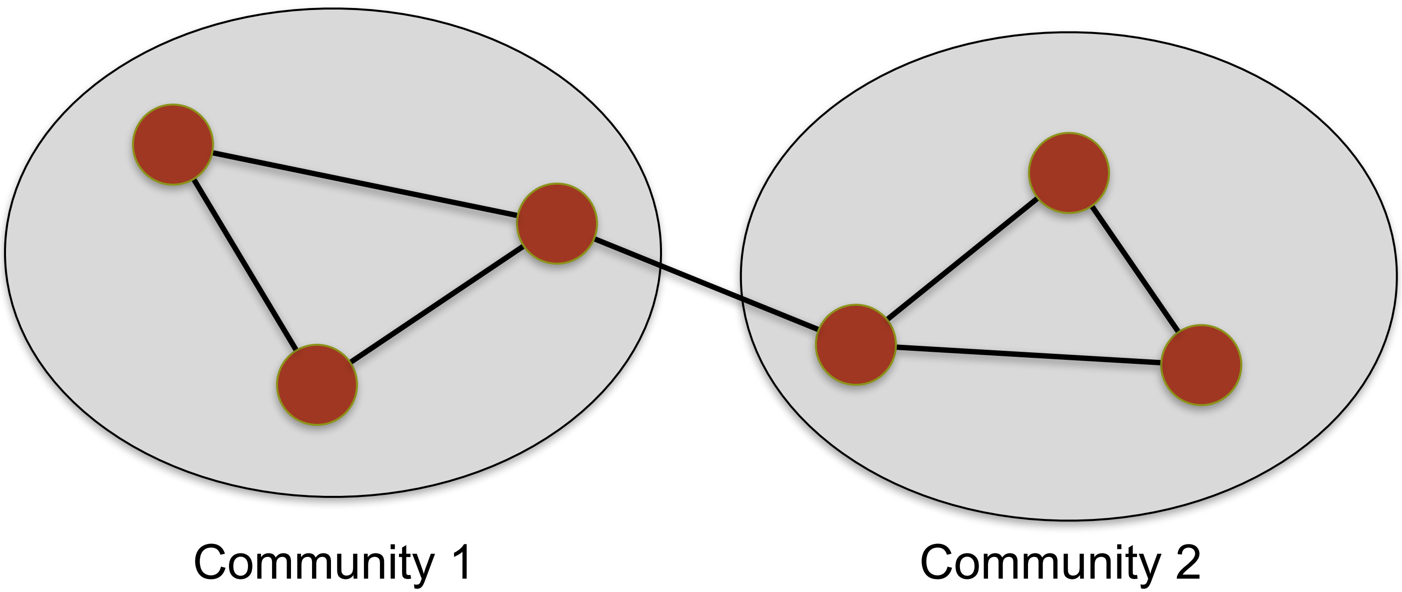
Benchmark: Label Propagation for Community Detection

- A form of data analytics - a hot topic in big data
- Identifies communities of users
- Useful for advertising or bot detection

- see CUG'15 paper: *Implementing a social-network analytics pipeline using Spark on Urika XA*

Processing Tweets: Computation Steps

- **Computation consists of these steps:**
  - Read in gzip files storing JSON-encoded tweets
  - Find pairs of Twitter users that @mention each other
  - Construct a graph from such users
  - Run a label propagation algorithm on that graph
  - Output the community structure resulting from label propagation



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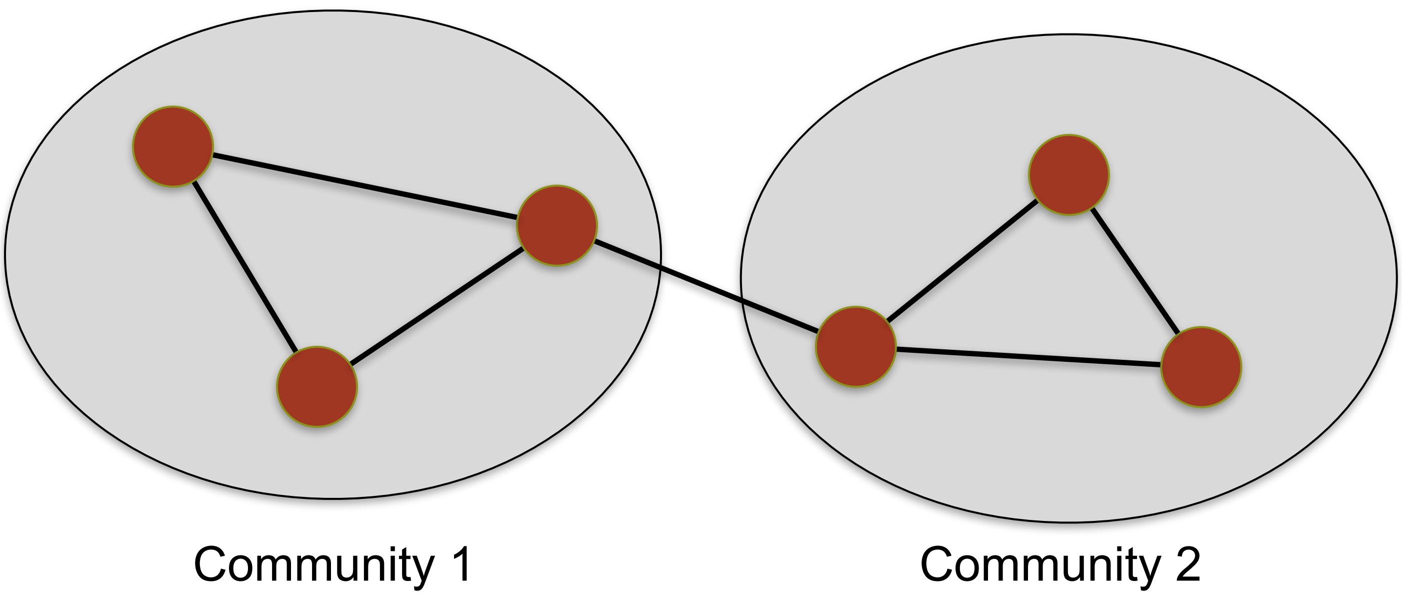

Processing Tweets: First Part

- Files are processed in a forall loop
  - Reads file using `gunzip` via the new Spawn module
  - Uses new functionality for parsing JSON
    - concept: use types and I/O that ignore irrelevant fields
- Constructs distributed associative domain to find mutual mentions

First Part Kernel

```
var Pairs: domain( (int, int) ) dmapped new UserMapAssoc(...);

forall logfile in distributedFiles() {
  while logfile.readf("%~jt", tweet) {
    var id = tweet.user.id;
    for mentions in tweet.entities.user_mentions {
      var other_id = mentions.id;
      if max_id < other_id then max_id = other_id;
      // Add (id, other_id) to Pairs,
      // but leave out self-mentions
      if id != other_id {
        Pairs += (id, other_id);
      }
    }
  }
}
```

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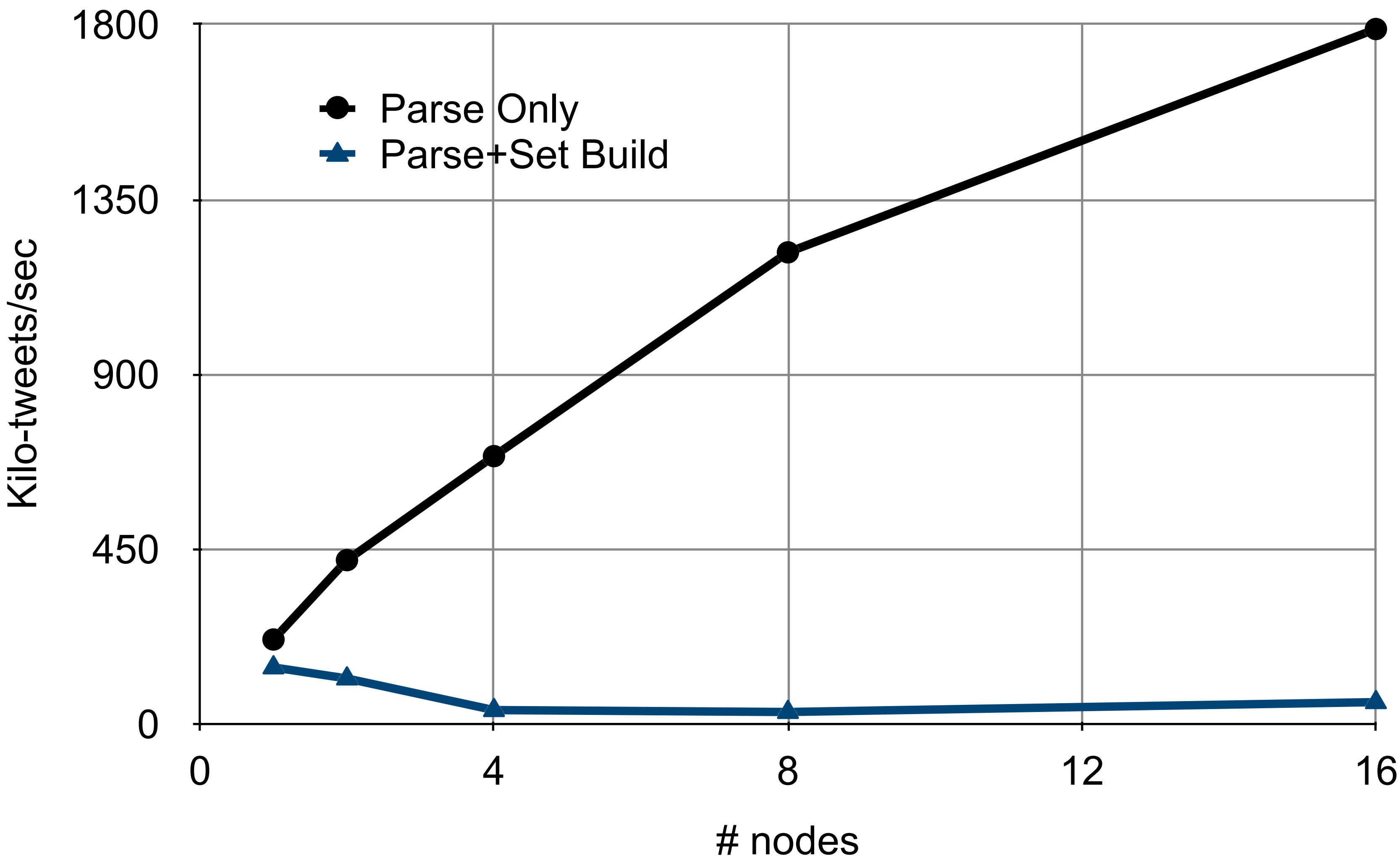
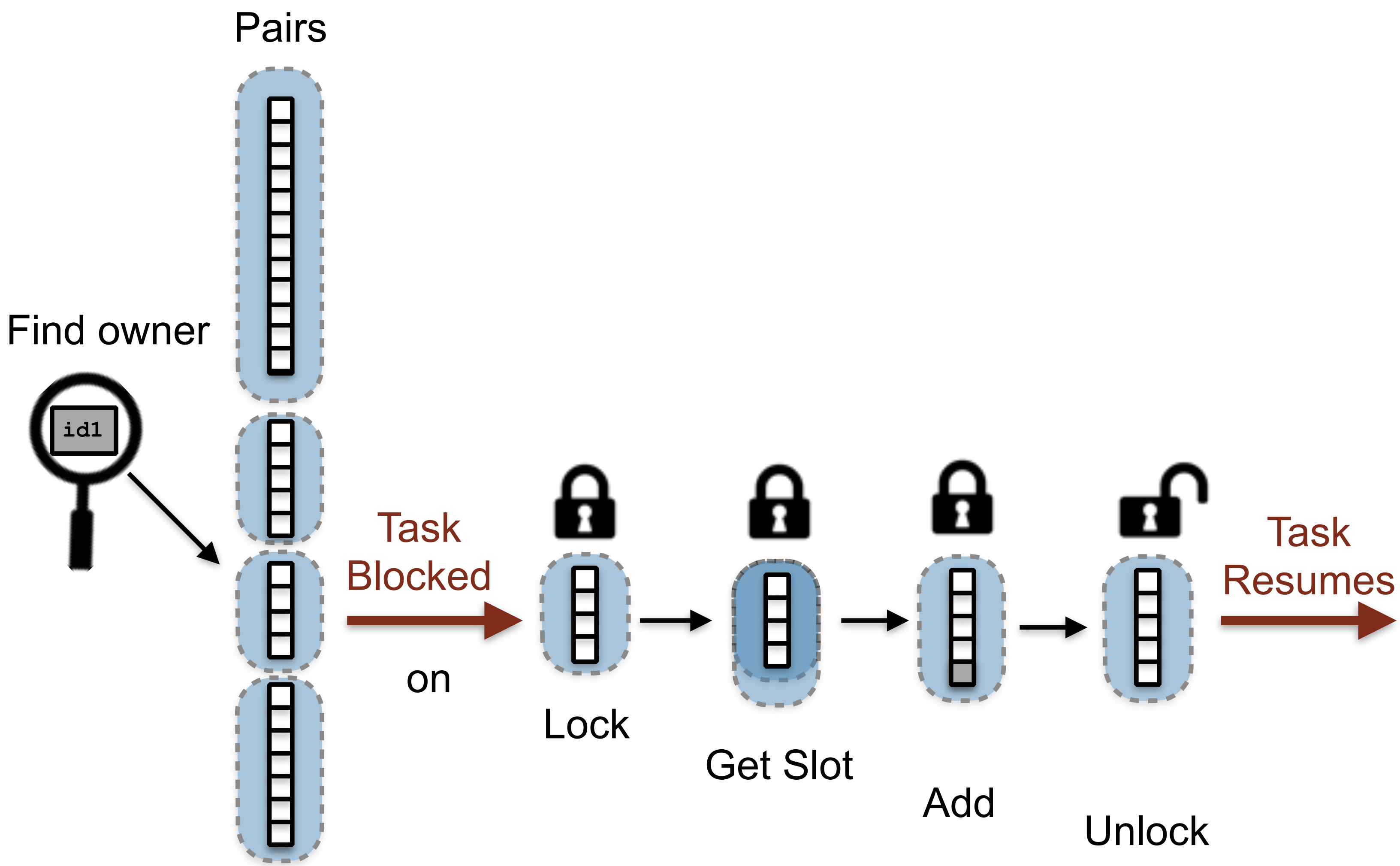
First Part Scalability



384 files, gasnet, fifo, gnu, XC30 24 cores/locale, fe29555c

Steps in Set Addition

```
Pairs += (id1, other1);
```



Steps in Set Addition

```
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```
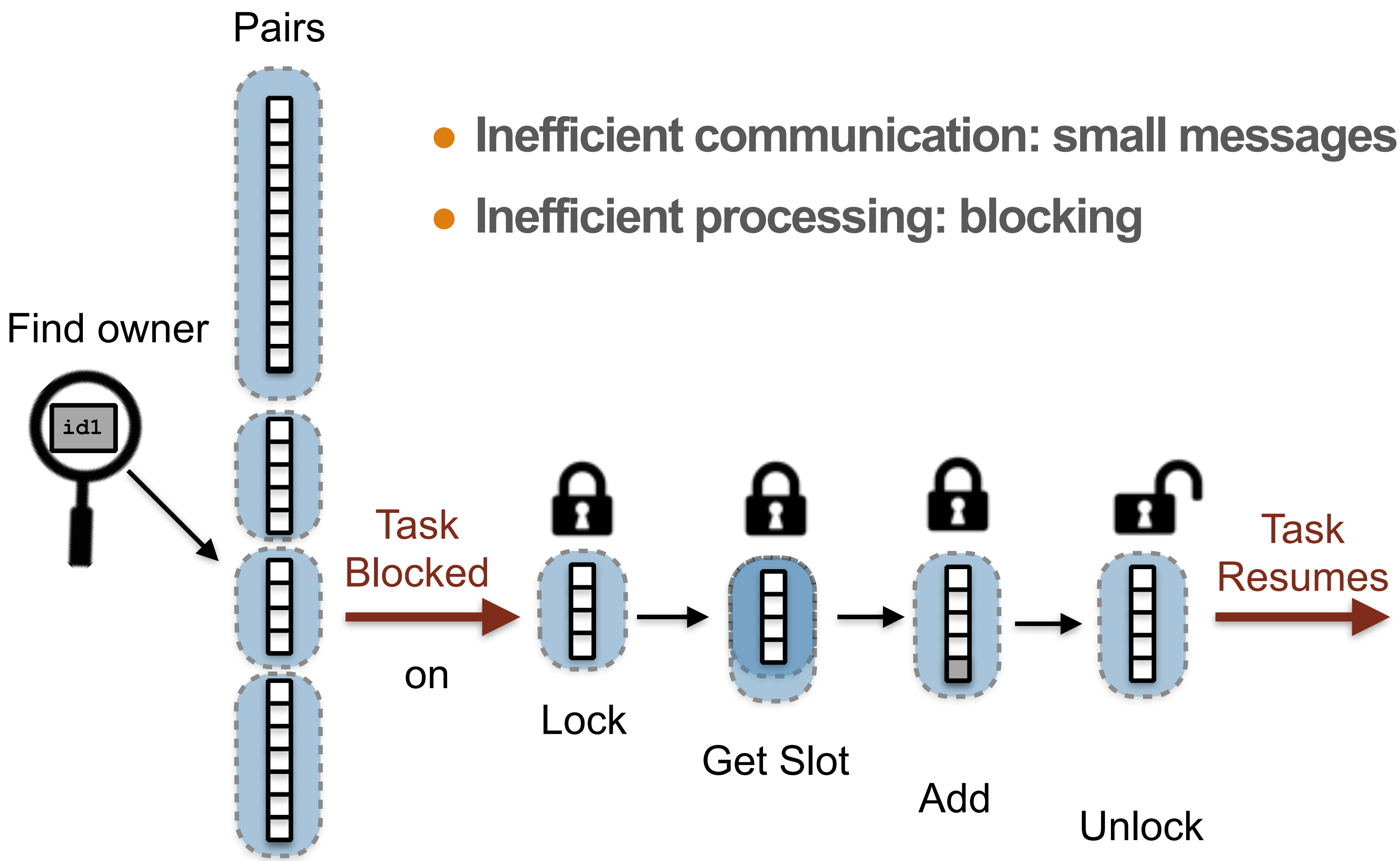
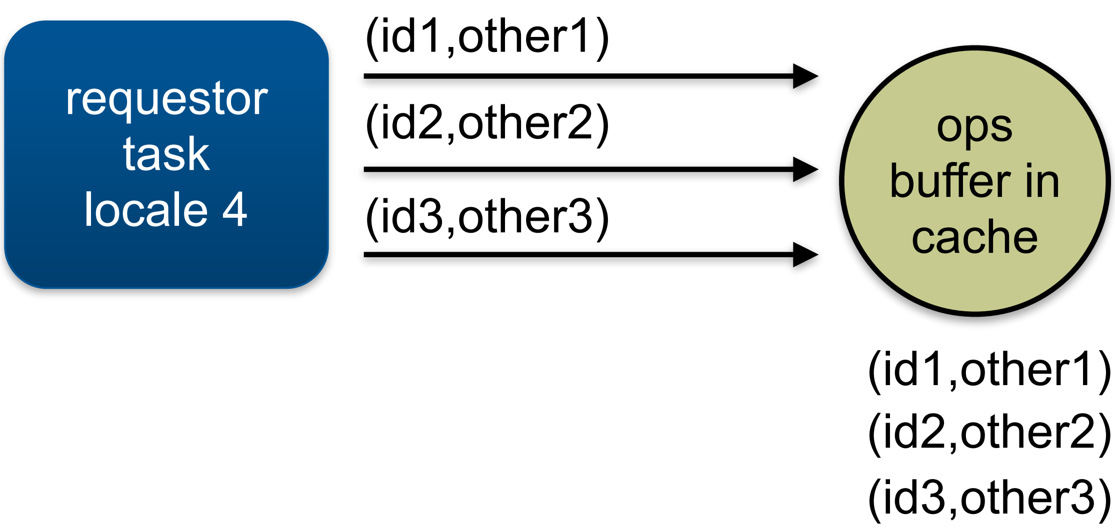

- Inefficient communication: small messages
- Inefficient processing: blocking



Operations Buffer Makes this Code Faster

```
Pairs += (id1, other1);
Pairs += (id2, other2);
Pairs += (id3, other3);
...
```



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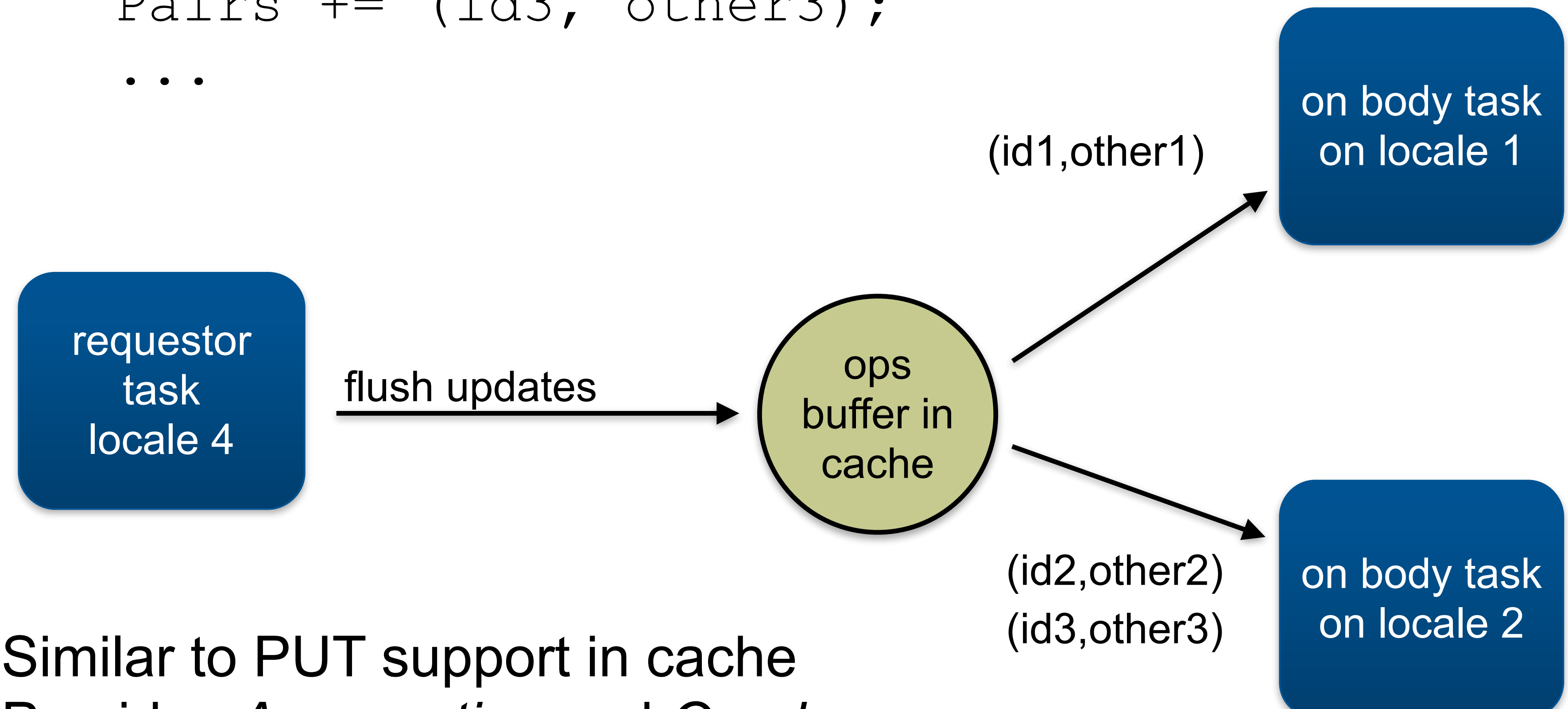
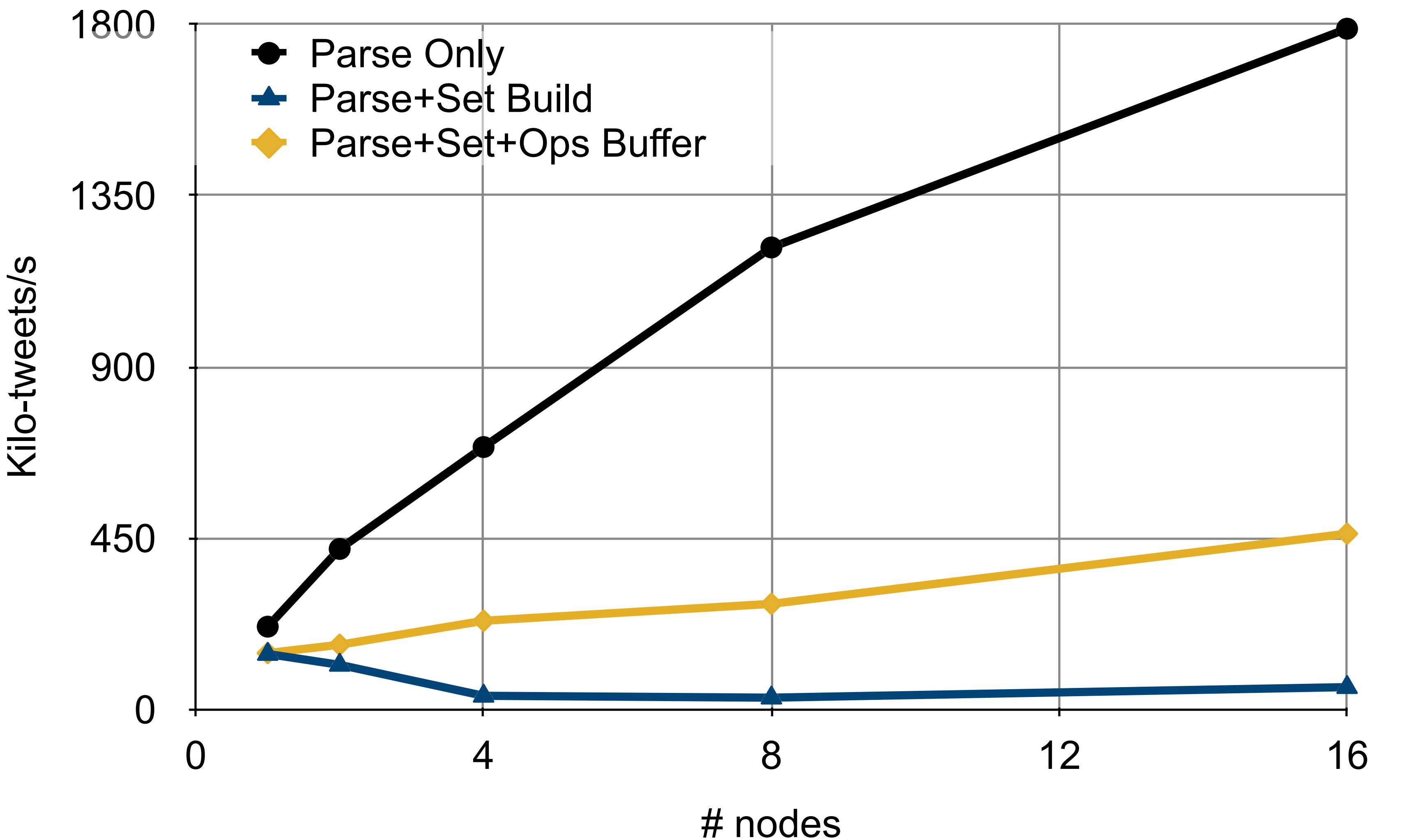


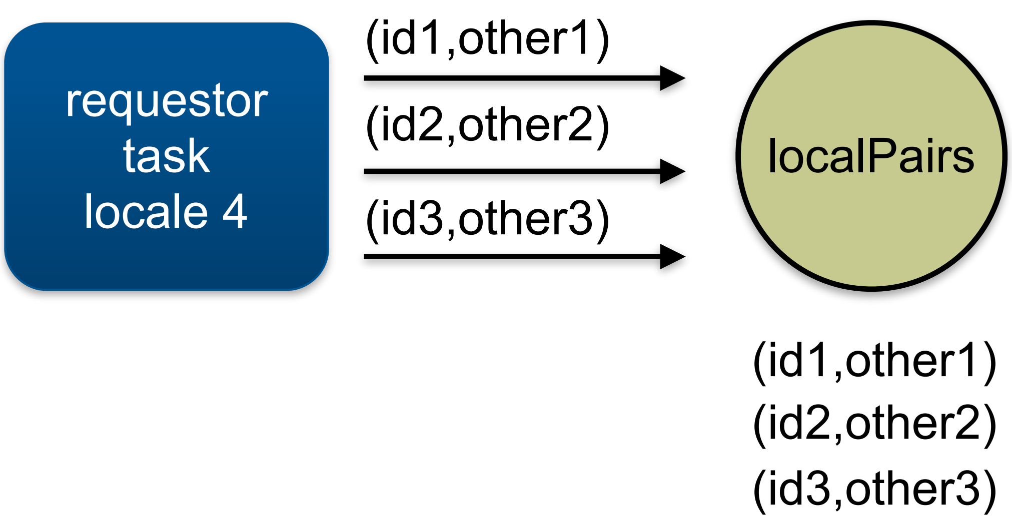
Similar to PUT support in cache
Provides *Aggregation* and *Overlap*

First Part Scalability with Operations Buffer



Bulk Addition is a Manual Alternative

```
localPairs.push_back((id1, other1));
localPairs.push_back((id2, other2));
localPairs.push_back((id3, other3));
...
sort(localPairs, byDestination());
Pairs += localPairs;
```



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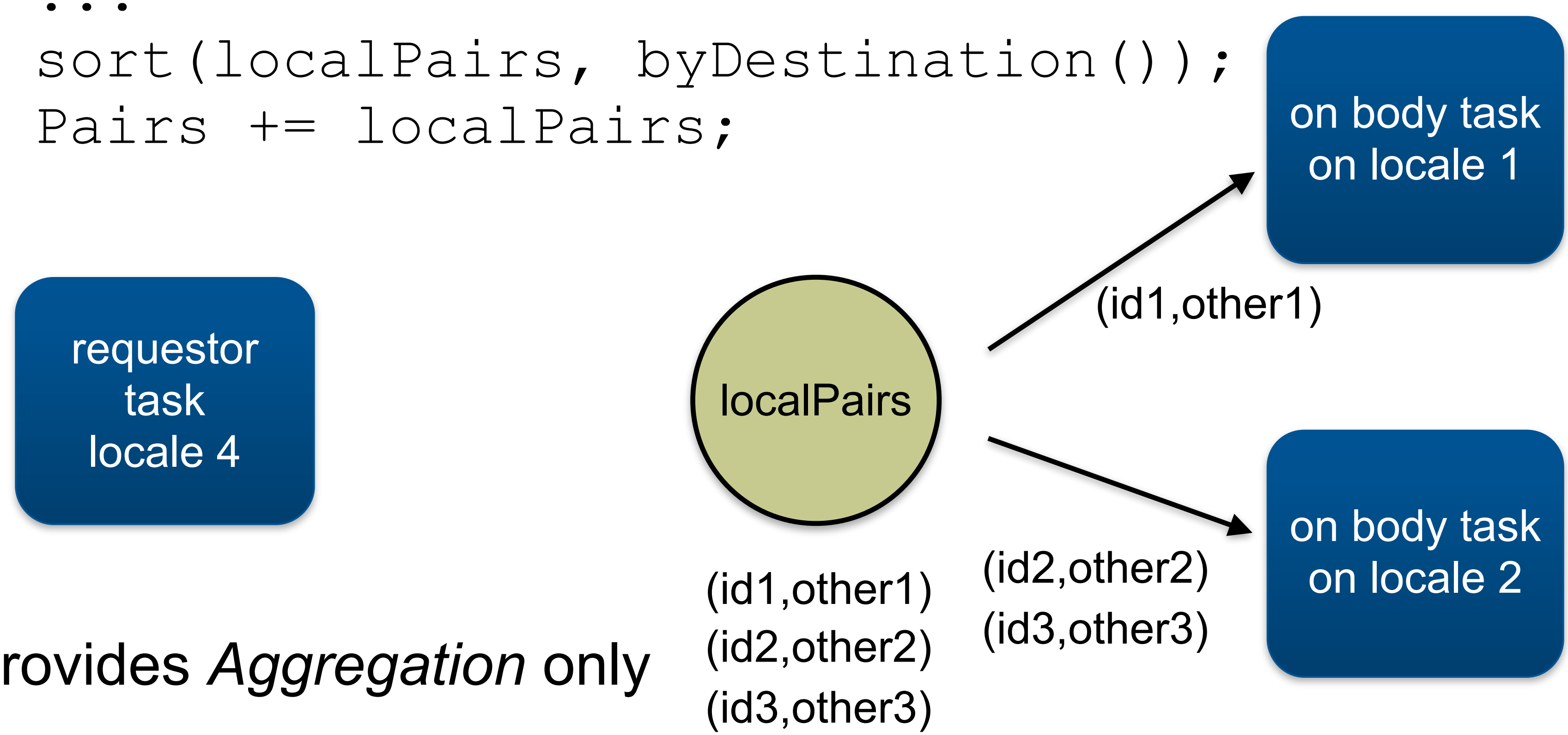
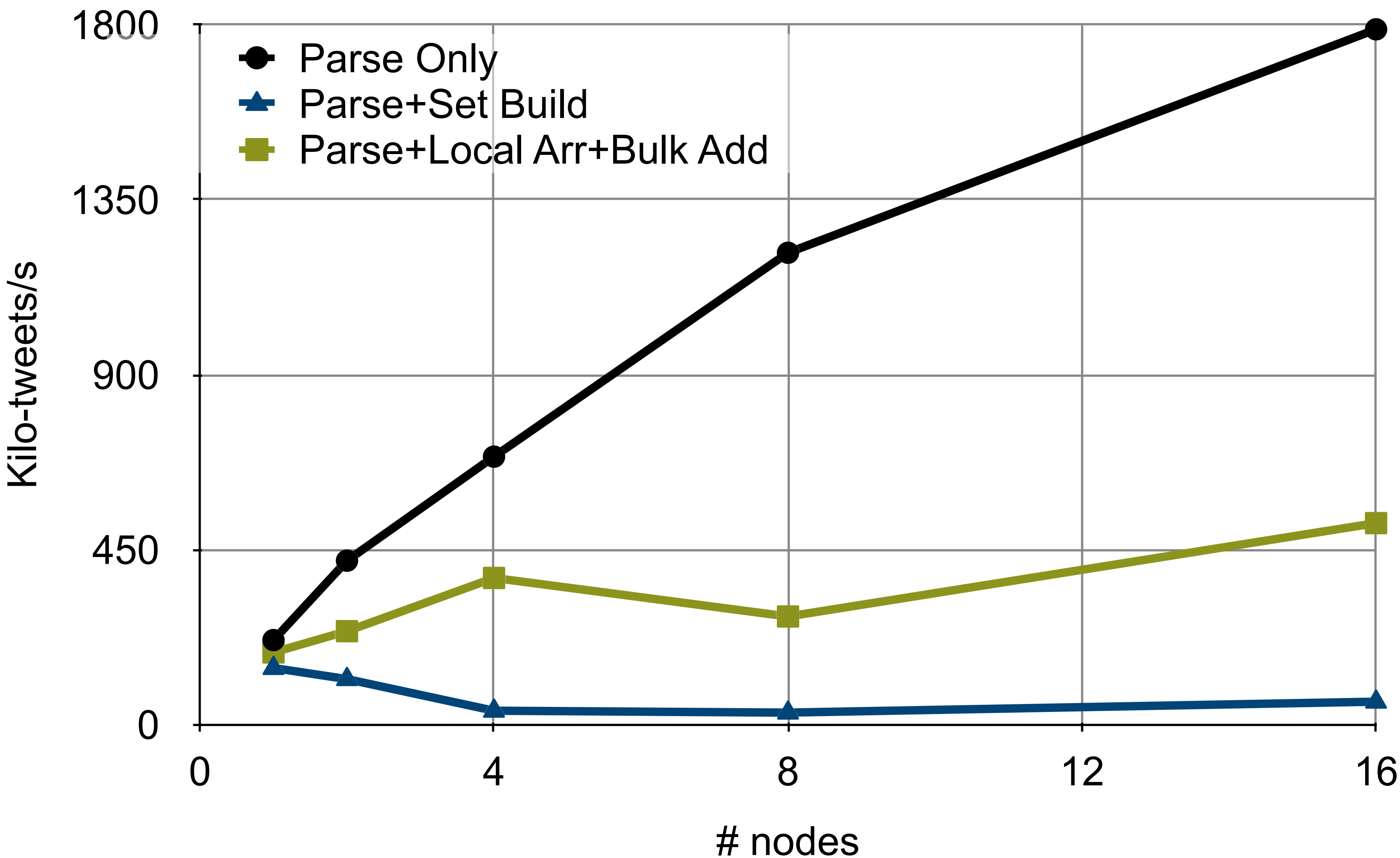
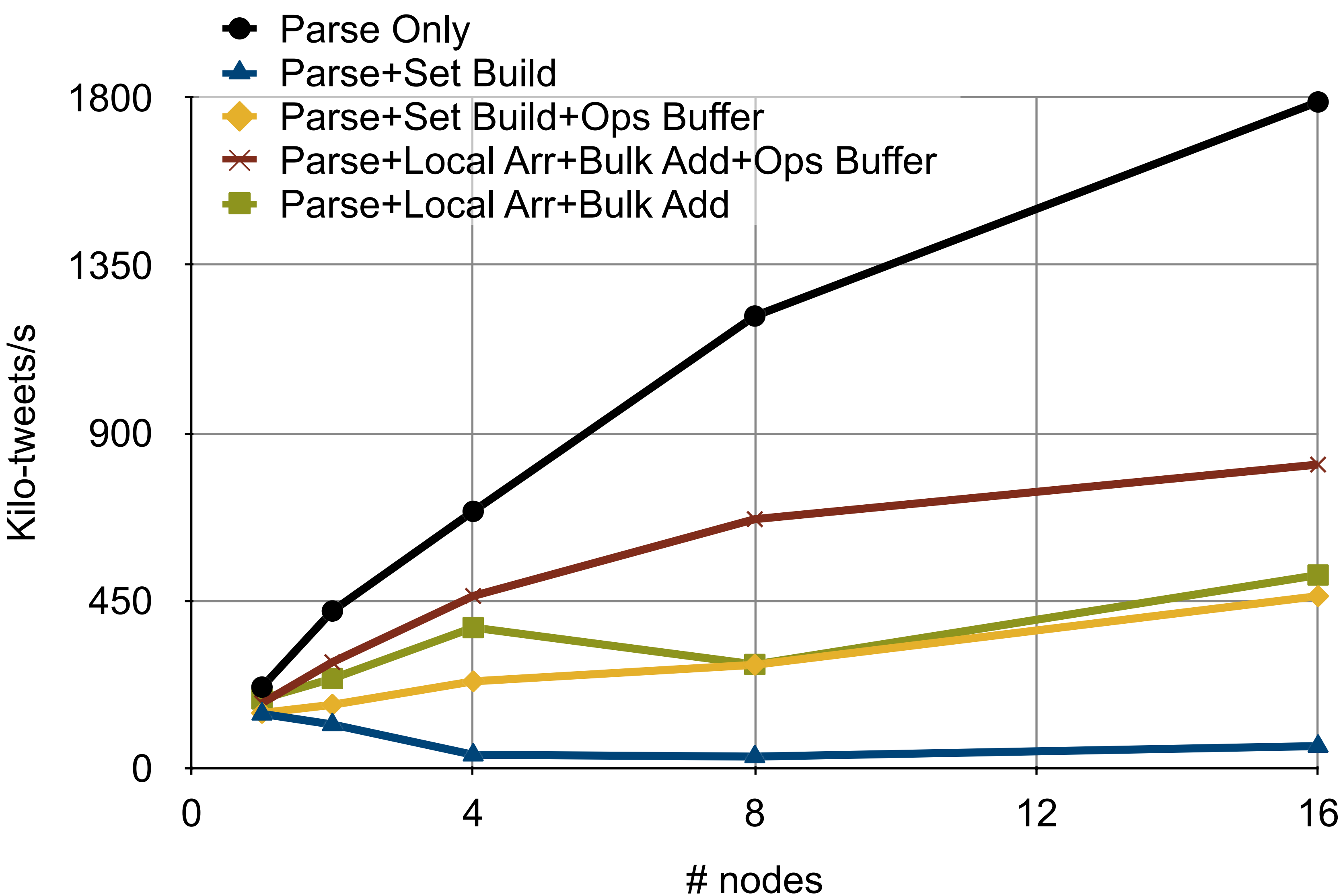


Provides *Aggregation* only

First Part Scalability + Manual Aggregation



First Part Scalability: Combining Approaches



Processing Tweets: Productivity Comparison

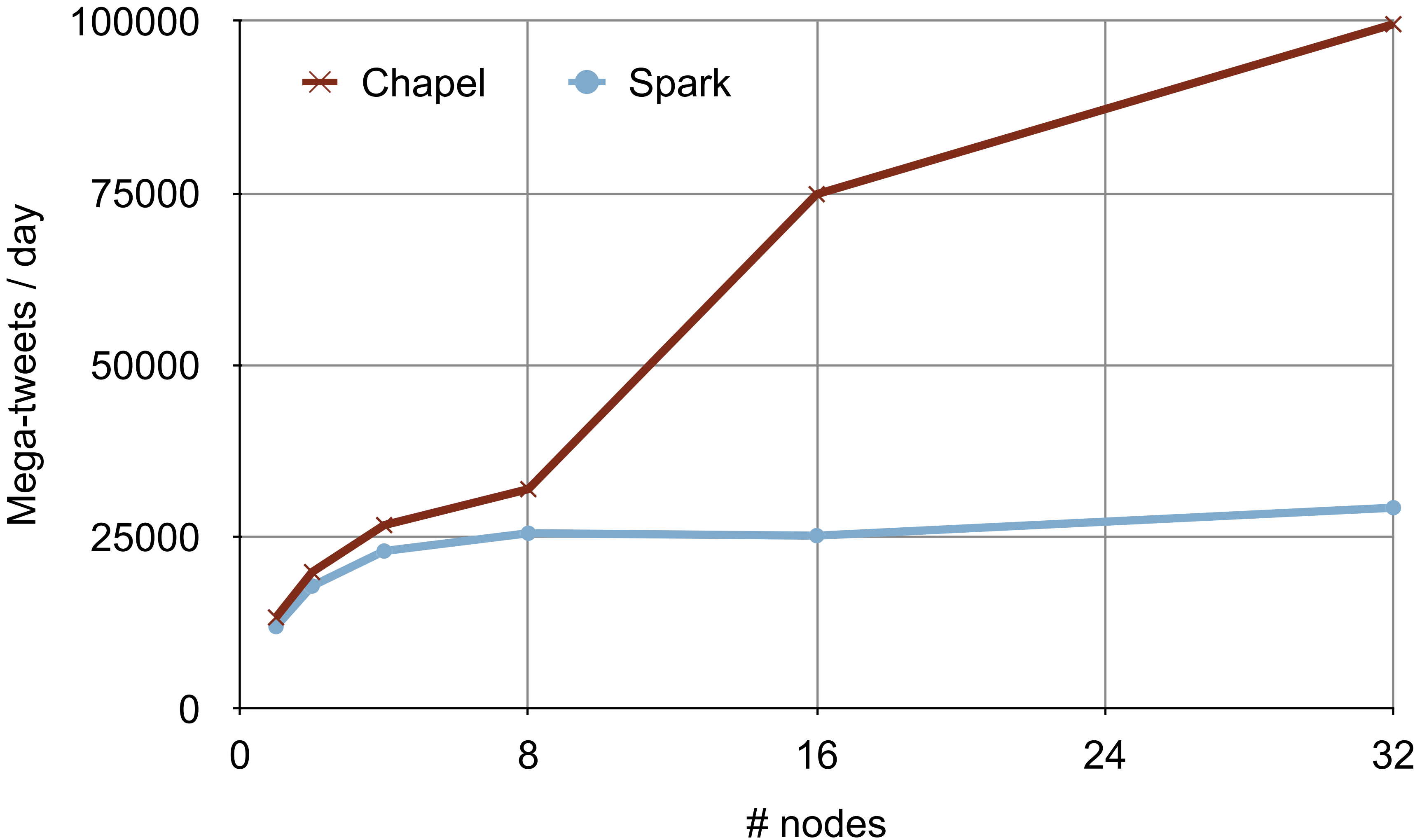
Spark

- RDDs are immutable
- Algorithm written in terms of mapping a fn on data

Chapel

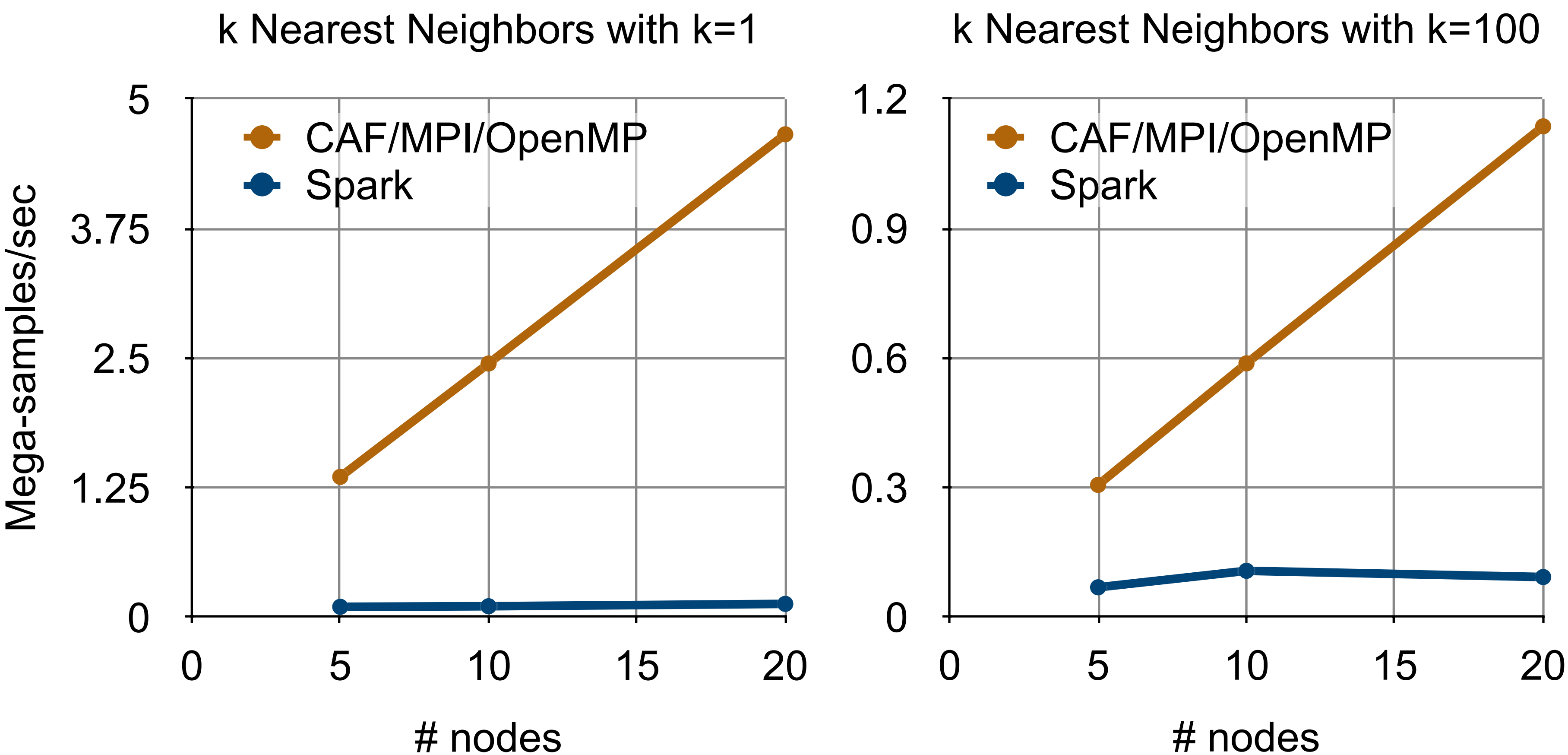
- Chapel arrays are mutable
- Algorithm written in terms of parallel loops

First Part: Chapel vs Spark*



* Lots of caveats. Chapel and Spark implementations are not necessarily optimal. Computing mutual mentions only. 420 files, XC30 36-cores/locale, Chapel version used gasnet, fifo, gnu, fe29555c. Spark 1.5.2

Previous Research on Spark Scalability: k Nearest Neighbors



Data from experiments reported in Reyes-Ortiz, Oneto, Anguita. Big Data Analytics in the Cloud: Spark on Hadoop vs MPI/OpenMP on Beowulf

Concluding

- We improved scalability for distributed domain +=
- Chapel performance compared favorably with Spark
- We think Chapel has a compelling future in data analytics

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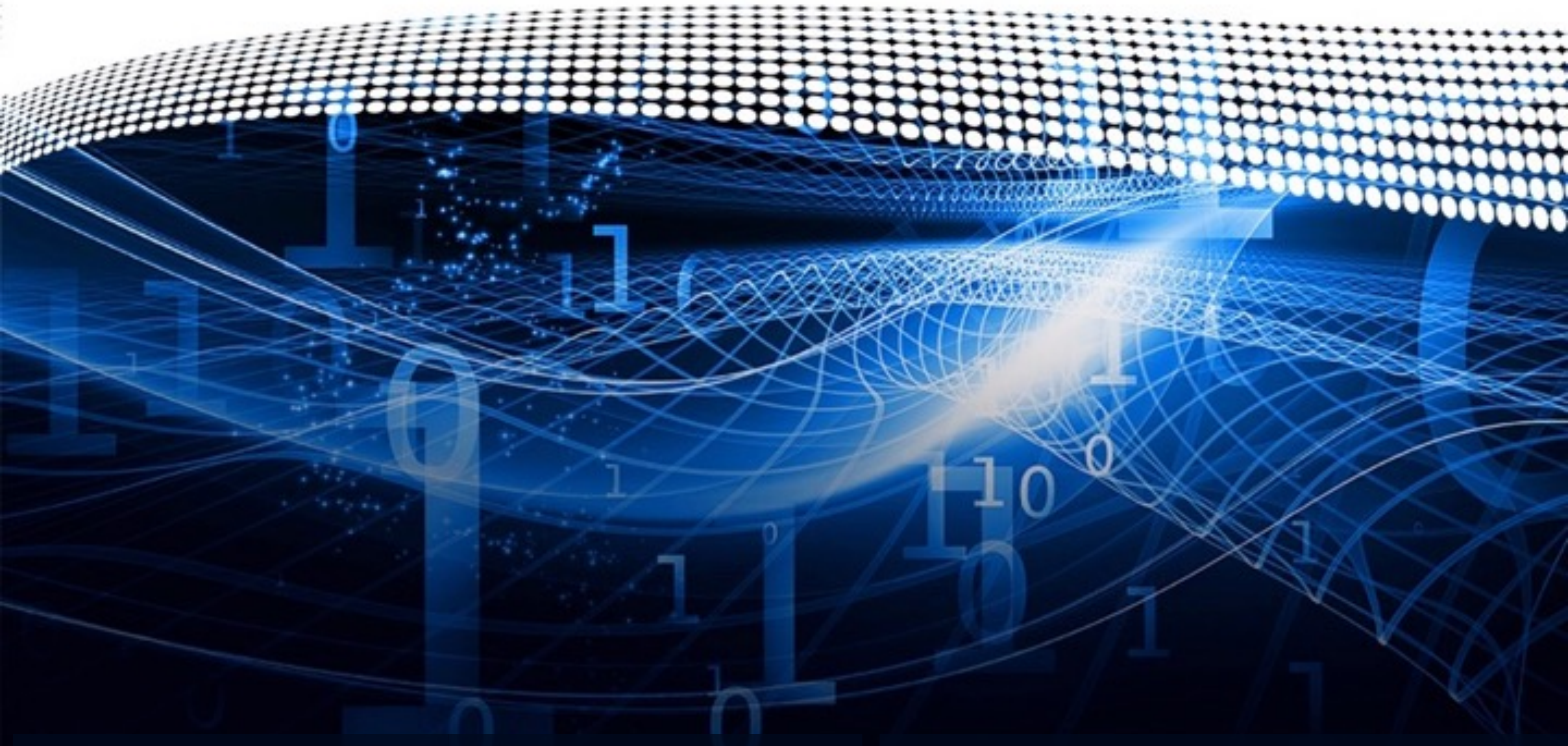

http://chapel.cray.com chapel_info@cray.com http://github.com/chapel-lang/chapel/

Backup Slides

Processing Tweets: Motivation

Motivating Question: Is Chapel useful for Data Analytics?

- What would it look like?
- What features are we missing?

Processing Tweets: Label Propagation

Label Propagation Algorithm

(described in *Near linear time algorithm to detect community structures in large-scale networks*)

1. Initialize the labels at all nodes in the network.
2. Set $i = 1$.
3. Arrange the nodes in the network in a random order and set it to X.
4. For each x in X, set node x's label to the one that occurs most frequently among neighbors, with ties broken uniformly randomly.
5. If every node has a label that the maximum number of neighbors have, stop the algorithm. Otherwise, set $i = i + 1$ and go to step 3.

Processing Tweets: Implementation Overview

- **First version < 400 lines of Chapel code**
  - plus a Graph module (< 300 lines, to become a standard module)
- **current version is partly multi-locale**
- **graph representation similar to other Chapel graph codes**
  - e.g., SSCA#2
- **I/O is different**

Processing Tweets: Algorithm in Chapel

Algorithm closely matches the psuedocode:

```
var i = 0;
var go: atomic bool;
go.write(true);
while go.read(…) && i < maxiter {
  go.write(false);
  // for each x in the randomized order
  forall vid in reordered_vertices {
    // set the label to the most frequent among neigbors
    mylabel = labels[vid].read(memory_order_relaxed);
    maxlabel = mostCommonLabelInNeighbors(vid);
    if countNeighborsWith(vid, mylabel) <
       countNeighborsWith(vid, maxlabel) then
       go.write(true); // stop the algorithm if …
    labels[vid].write(maxlabel, memory_order_relaxed);
  }
  i += 1;
}
```

Sidebar on I/O for Twitter Processing in Chapel

Example Tweet in JSON format

- **Tweets have 34 top-level fields**
  - including nested structures containing much more data

{ "coordinates": null, "created_at": "Fri Oct 16 16:00:00 +0000 2015", "favorited": false, "truncated": false, "id_str": "28031452151", "entities": { "urls": [{ "expanded_url": null, "url": "http://chapel.cray.com", "indices": [69, 100] }], "hashtags": [ ], "user_mentions": [{ "name": "Cray Inc.", "id_str": "23424245", "id": 23424245, "indices": [25, 30], "screen_name": "cray" }] }, "in_reply_to_user_id_str": null, "text": "Let's mention the user @cray – here is an embedded url .... http://chapel.cray.com", "contributors": null, "id": 28039652140, "retweet_count": null, "in_reply_to_status_id_str": null, "geo": null, "retweeted": false, "in_reply_to_user_id": null, "user": { "profile_sidebar_border_color": "C0DEED", "name": "Cray Inc.", "profile_sidebar_fill_color": "DDEEF6", "profile_background_tile": false, "profile_image_url": "http://a3.twimg.com/profile_images/2342452/icon_normal.png", "location": "Seattle, WA", "created_at": "Fri Oct 10 23:10:00 +0000 2008", "id_str": "23502385", "follow_request_sent": false, "profile_link_color": "0084B4", "favourites_count": 1, "url": "http://cray.com", "contributors_enabled": false, "utc_offset": -25200, "id": 23548250, "profile_use_background_image": true, "listed_count": 23, "protected": false, "lang": "en", "profile_text_color": "333333", "followers_count": 1000, "time_zone": "Mountain Time (US & Canada)", "verified": false, "geo_enabled": true, "profile_background_color": "C0DEED", "notifications": false, "description": "Cray Inc", "friends_count": 71, "profile_background_image_url": "http://s.twimg.com/a/2349257201/images/themes/theme1/bg.png", "statuses_count": 302, "screen_name": "gnip", "following": false, "show_all_inline_media": false }, "in_reply_to_screen_name": null, "source": "web", "place": null, "in_reply_to_status_id": null }

Reading JSON Tweets

```
// define Chapel records whose fields reflect only
// the portions of the JSON data we care about

record TweetUser {
  var id: int;
}
record TweetEntities {
  var user_mentions: list(TweetUser);
}
record User {
  var id: int;
}
record Tweet {
  var id: int,
      user: User,
      entities: TweetEntities;
}
```

```
proc process_json(…) {
  var tweet: Tweet;

  while true {
    // "%~jt" format string:
    //     j: JSON format
    //     t: any record
    //     ~: skip other fields
    got = logfile.readf("%~jt",
                         tweet,
                         error=err);
    if got && !err then
      handle_tweet(tweet);
    if err == EFORMAT then ...;
    if err == EEOF then break;
}
```

Set Addition is Blocking

```
Pairs += (id1, other1);
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```
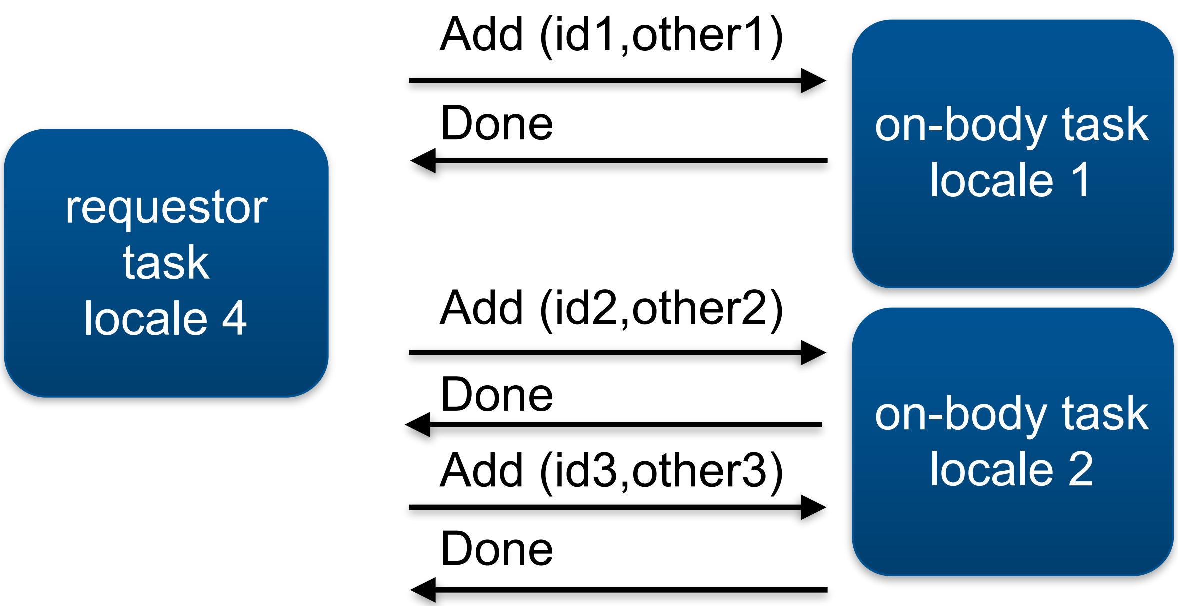
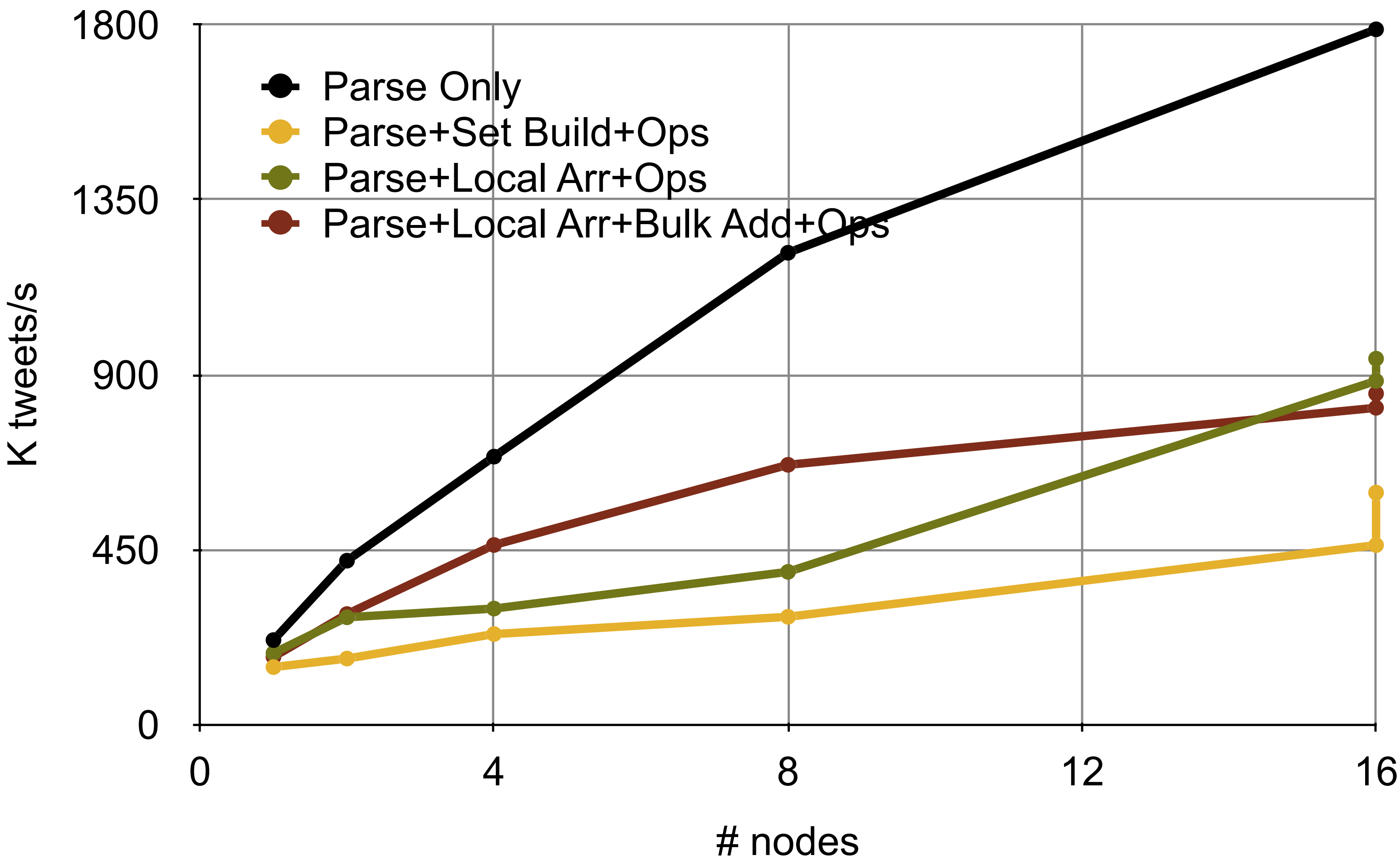



First Part Scalability + Operations + Manual



Processing Tweets: Productivity Comparison

Spark

- **RDDs are immutable**
  - create new RDD every iteration through algorithm
- **Algorithm written in terms of mapping a fn on data**
  - difficult to visit vertices in random order
  - movement of information is described as messages contributing to a new RDD
  - breaking ties randomly might require a custom operator

Chapel

- **Chapel arrays are mutable**
  - Algorithm can update labels in-place
- **Algorithm written in terms of parallel loops**
  - straightforward to visit vertices in random order
  - movement of information occurs through variable reads and writes
  - breaking ties randomly is an easy change

These differences reflect Spark's declarative nature vs. Chapel's imperative design.