Social Network Analysis on Twitter with Chapel

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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*
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
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
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);
            }
        }
    }
}
First Part Kernel

```javascript
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);
            }
        }
    }
}
```
First Part Scalability

- **Kilo-tweets/sec**
  - Parse Only
  - Parse+Set Build

- **# nodes**
  - 0
  - 4
  - 8
  - 12
  - 16

384 files, gasnet, fifo, gnu, XC30 24 cores/locale, fe29555c
Steps in Set Addition

Pairs += (id1, other1);

Find owner

Task Blocked

Lock

Get Slot

Add

Unlock

Task Resumes
Steps in Set Addition

Pairs += (id1, other1);

- Inefficient communication: small messages
- Inefficient processing: blocking
Operations Buffer Makes this Code Faster

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

requestor

task

locale 4

(id1,other1)
(id2,other2)
(id3,other3)

ops buffer in cache

(id1,other1)
(id2,other2)
(id3,other3)
Operations Buffer Makes this Code Faster

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

Similar to PUT support in cache
Provides Aggregation and Overlap
First Part Scalability with Operations Buffer

- Parse Only
- Parse+Set Build
- Parse+Set+Ops Buffer
Bulk Addition is a Manual Alternative

```cpp
localPairs.push_back((id1, other1));
localPairs.push_back((id2, other2));
localPairs.push_back((id3, other3));
...
sort(localPairs, byDestination());
Pairs += localPairs;
```
Bulk Addition is a Manual Alternative

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

Provides *Aggregation* only
First Part Scalability + Manual Aggregation

- Parse Only
- Parse+Set Build
- Parse+Local Arr+Bulk Add

Kilo-tweets/s vs. # nodes
First Part Scalability: Combining Approaches

Kilo-tweets/s

- Parse Only
- Parse+Set Build
- Parse+Set Build+Ops Buffer
- Parse+Local Arr+Bulk Add+Ops Buffer
- Parse+Local Arr+Bulk Add

# nodes

0 4 8 12 16
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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Backup Slides
Motivating Question: Is Chapel useful for Data Analytics?

- What would it look like?
- What features are we missing?
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
Algorithm closely matches the psuedocode:

```chapel
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 neighbors
        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

```json
{
  "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",
    "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_status_id": null,
      "source": "web",
      "place": 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);
Pairs += (id2, other2);
Pairs += (id3, other3);
...

requestor

on-body task locale 1

on-body task locale 2

Add (id1,other1)
Done

Add (id2,other2)
Done

Add (id3,other3)
Done
First Part Scalability + Operations + Manual

- parse only
- parse+set build+ops
- parse+local arr+ops
- parse+local arr+bulk add+ops

K tweets/s vs. # nodes

Graph showing scalability and operations for different tasks with manual intervention.
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.