Grab-Bag Topics / Demo

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Outline

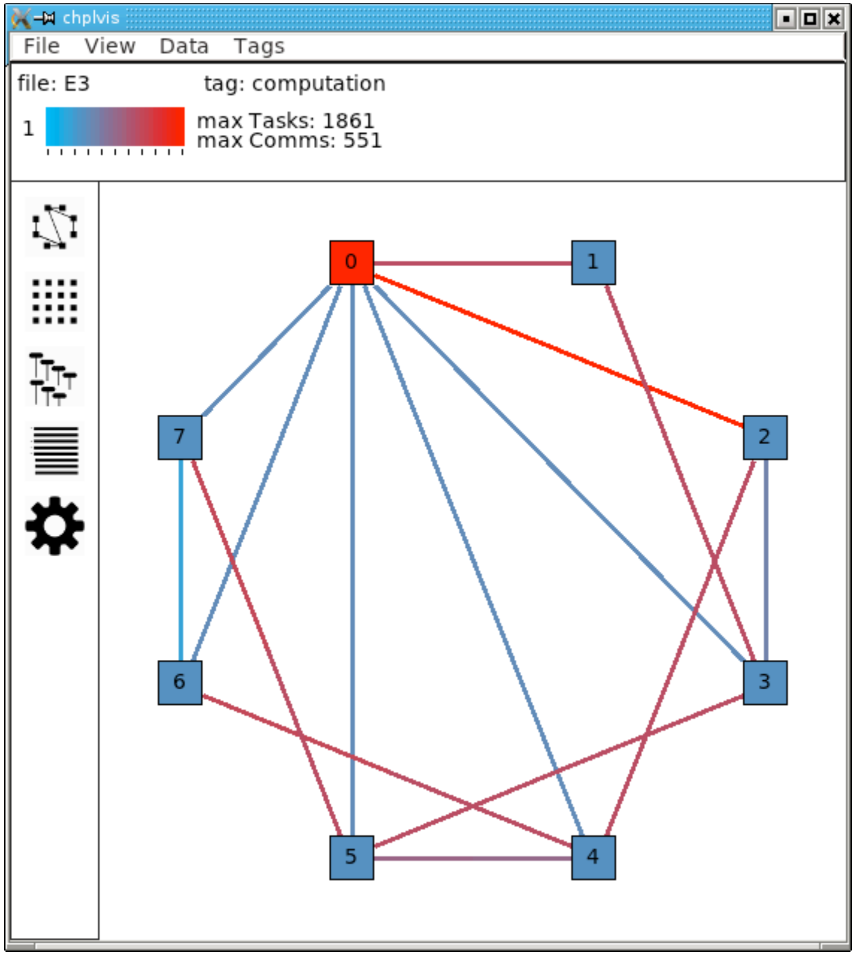
- **Demonstrate chplvis**
- **Study an example: Detecting Duplicate Files**
- **You will learn about:**
  - viewing communication pattern and volume with chplvis
  - optimizing for communication
  - spawning subprocesses with the Spawn module
  - working with the FileSystem and IO modules
  - sorting data with the Sort module
  - calling C functions
- **And use knowledge from earlier:**
  - tuples
  - block distribution
  - zippered iteration
  - forall loops
  - …

chplvis

chplvis

- Seehttp://chapel.cray.com/docs/latest/tools/chplvis/chplvis.html

- Example 3 is Jacobi-like



file: E3

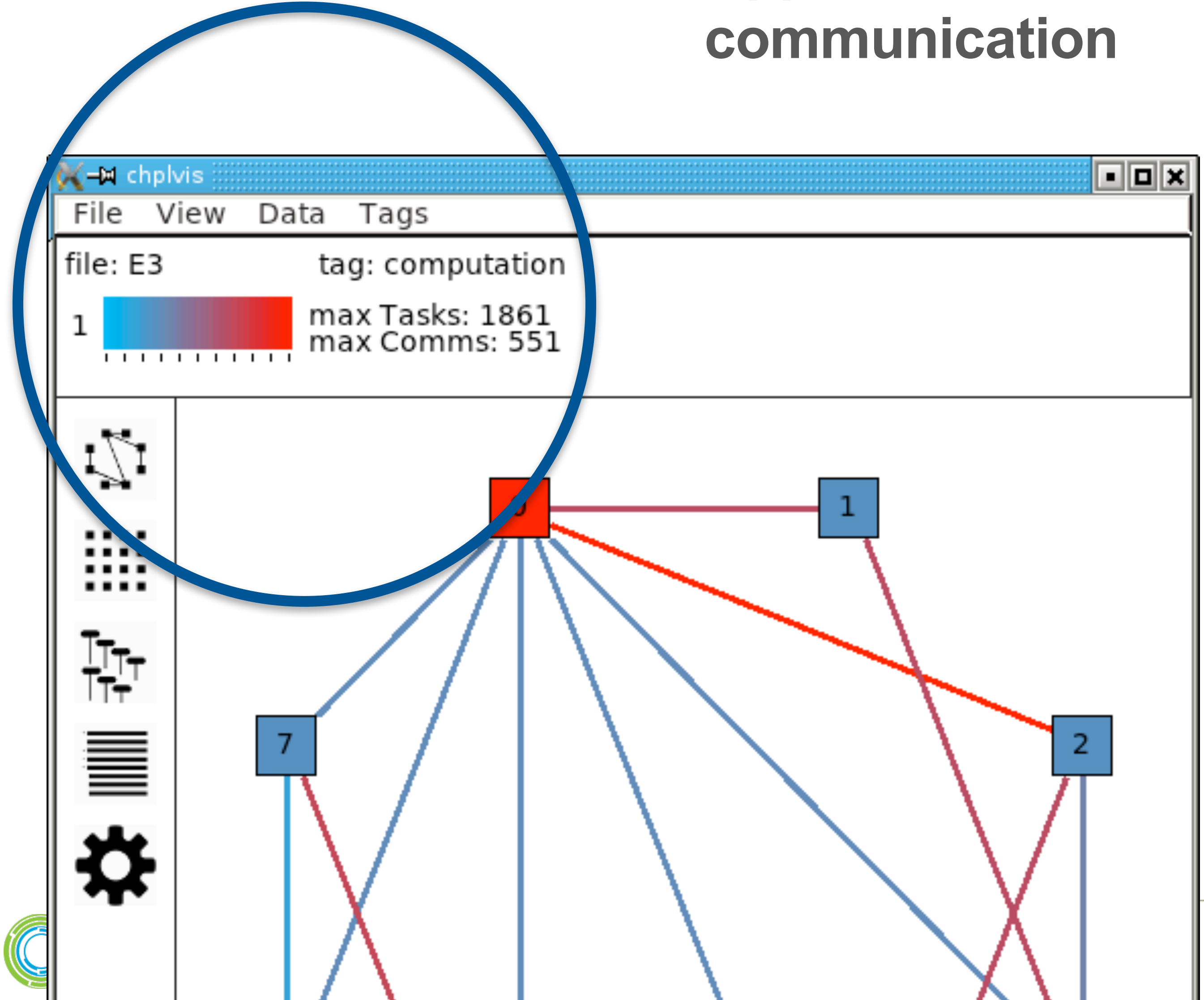
tag: computation

1

max Tasks: 1861
max Comms: 551

chplvis

- Upper Left shows scale of communication



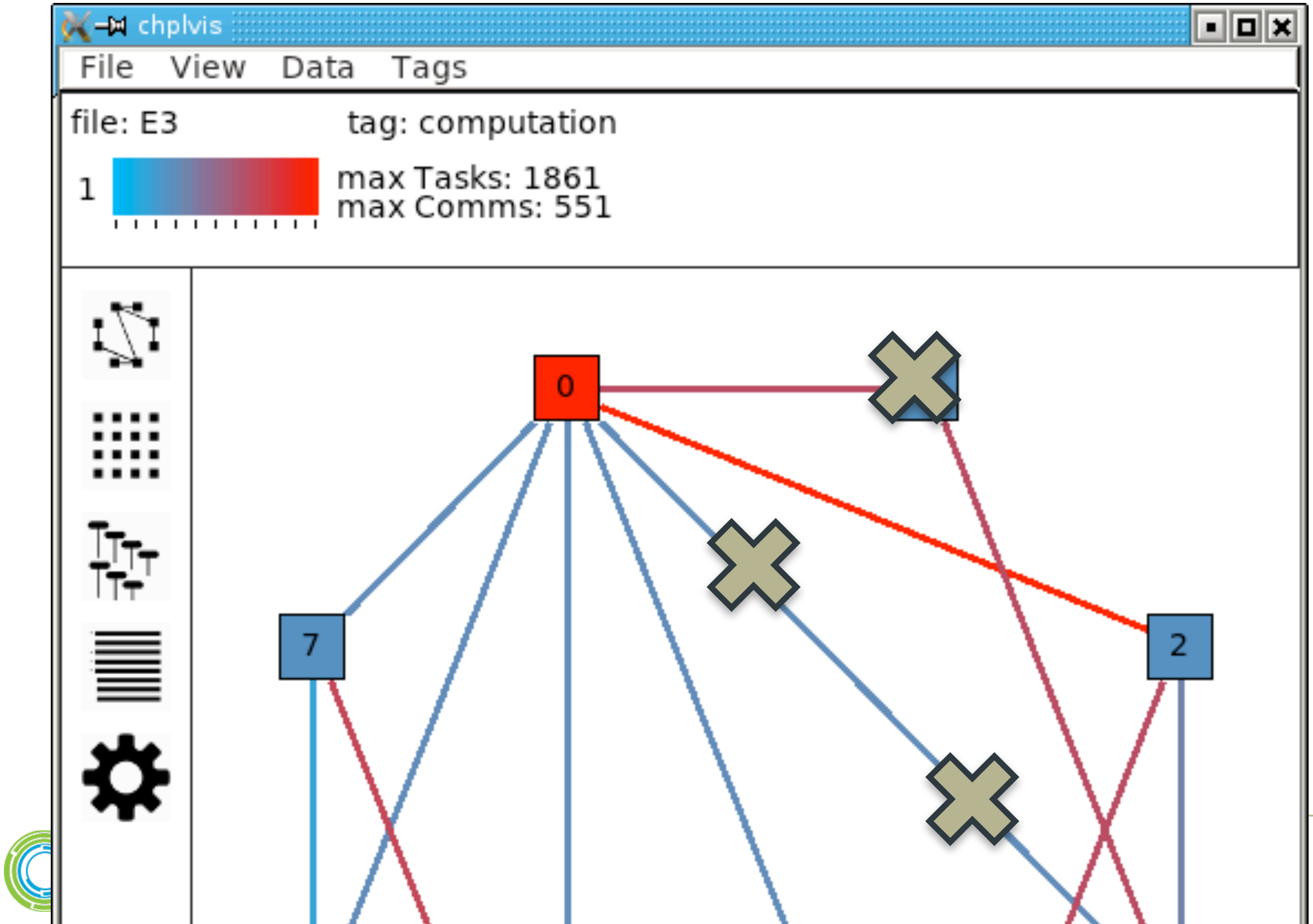
file: E3

tag: computation

max Tasks: 1861
max Comms: 551

chplvis

- **Try clicking on:**
  - both halves of each line
  - the boxes indicating Locales



file: E3 tag: computation

max Tasks: 1861
max Comms: 551

Detecting Duplicate Files

Detecting Duplicate Files

- **Goal: Write a program that produces a list of files that have the same contents**
  - take in files and directories as arguments
  - use SHA1 hash in order to find likely duplicates

Reading Arguments and Enumerating Files

```
proc main(args:[] string)
{
  // This program looks for duplicate files.
  // Arguments are files or directories to include in search.

  // Gather the paths we want to hash to find duplicates.
  // Start out with a 0-length array
  // We'll append to it with push_back
  // This is only possible for arrays that do not share a domain.
  var paths:[1..0] string;

  for arg in args[1..] {
    if isFile(arg) then
      paths.push_back(arg);
    else if isDir(arg) then
      // use FileSystem.findfiles to easily enumerate files.
      // A parallel version is available.
      for path in findfiles(arg, recursive=true) do
        paths.push_back(path);
  }
```

Arrays for the Computation

```
// Create a distributed array of paths so that we can
// distribute the work of hashing files to
// different Locales
var n:int = paths.size;
var BlockN = {1..n} dmapped Block({1..n});
var distributedPaths:[BlockN] string;
distributedPaths = paths;

// Create an array of hashes paths.
// This array is not distributed in this version.
// The array will store (hash, path).
// After computing this array, we'll sort it in order to
// find duplicates.
var hashAndFile:[1..paths.size] (string, string);
```

Computing SHA1 with Spawn

```
// Using the Spawn module, compute the SHA1 sums with an
// external program
forall (id,path) in zip(distributedPaths.domain,
distributedPaths) {
  // The spawn call creates a subprocess. By specifying
  // stdout=PIPE, we are requesting that the output of
  // the subprocess be sent to a pipe that we can read from.
  var sub = spawn(["sha1sum", path], stdout=PIPE);
  // Read the hash value from the output of sha1sum.
  // Note that sha1sum output looks like this:
  // d556d22d3e7b3ae55108442b36b5833523c923b7  file-name
  var hashString:string;
  sub.stdout.read(hashString);
  // Store the hash and the path into the array.
  // Since the array is not distributed, this sends data
  // to Locale 0.
  hashAndFile[id] = (hashString, path);
  sub.wait();
}
```

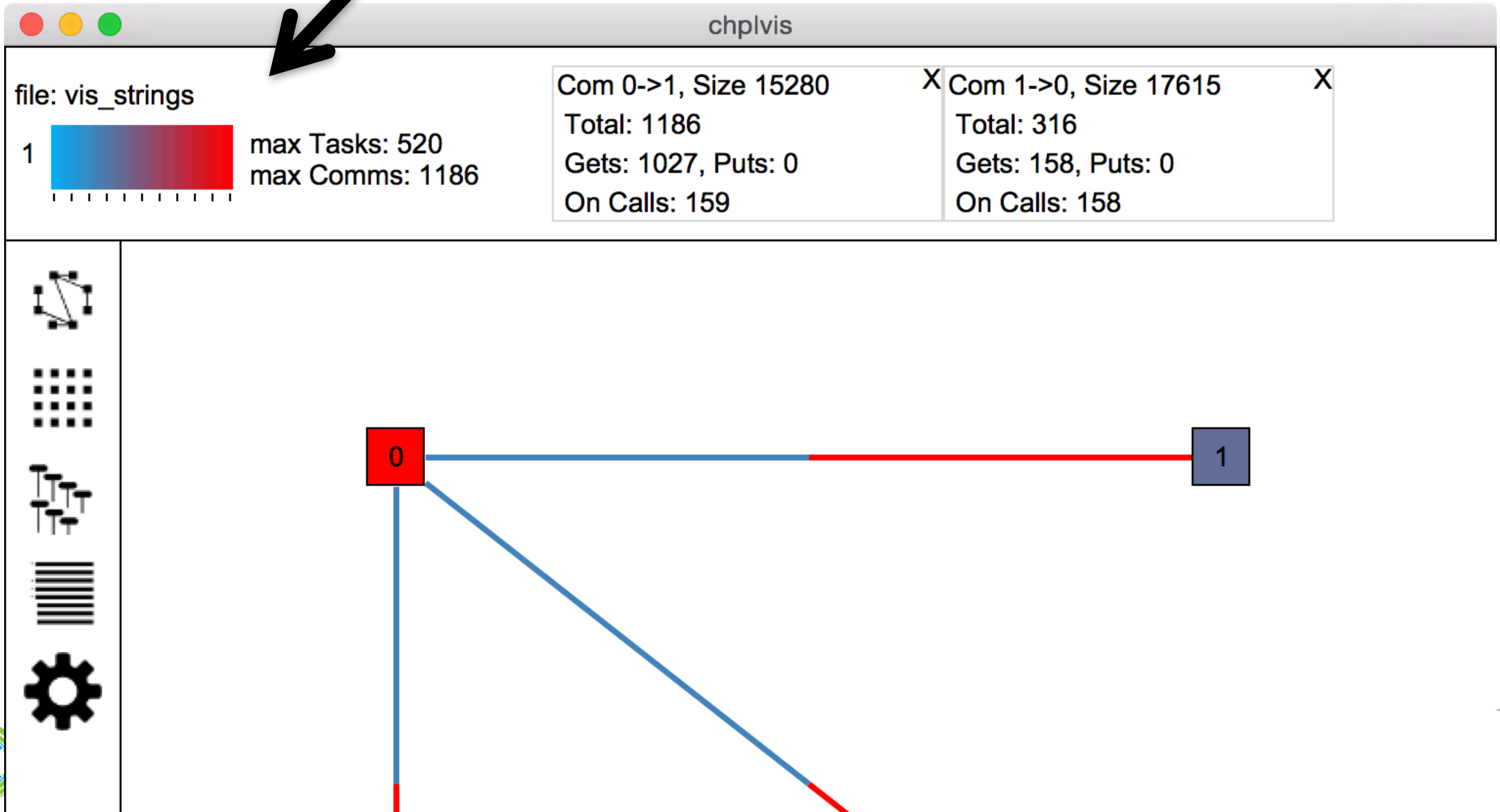
Sorting to Group Duplicates

```
// Sort the hashAndFile array on Locale 0
// Since we stored the hash value first in the tuple elements,
// this call groups values with the same hash.
// Use the Sort Module.
sort(hashAndFile);
```

Let's look at chplvis output!

chplvis output: string version

- Significant communication (for only 316 files)



chplvis

file: vis_strings

1

max Tasks: 520
max Comms: 1186

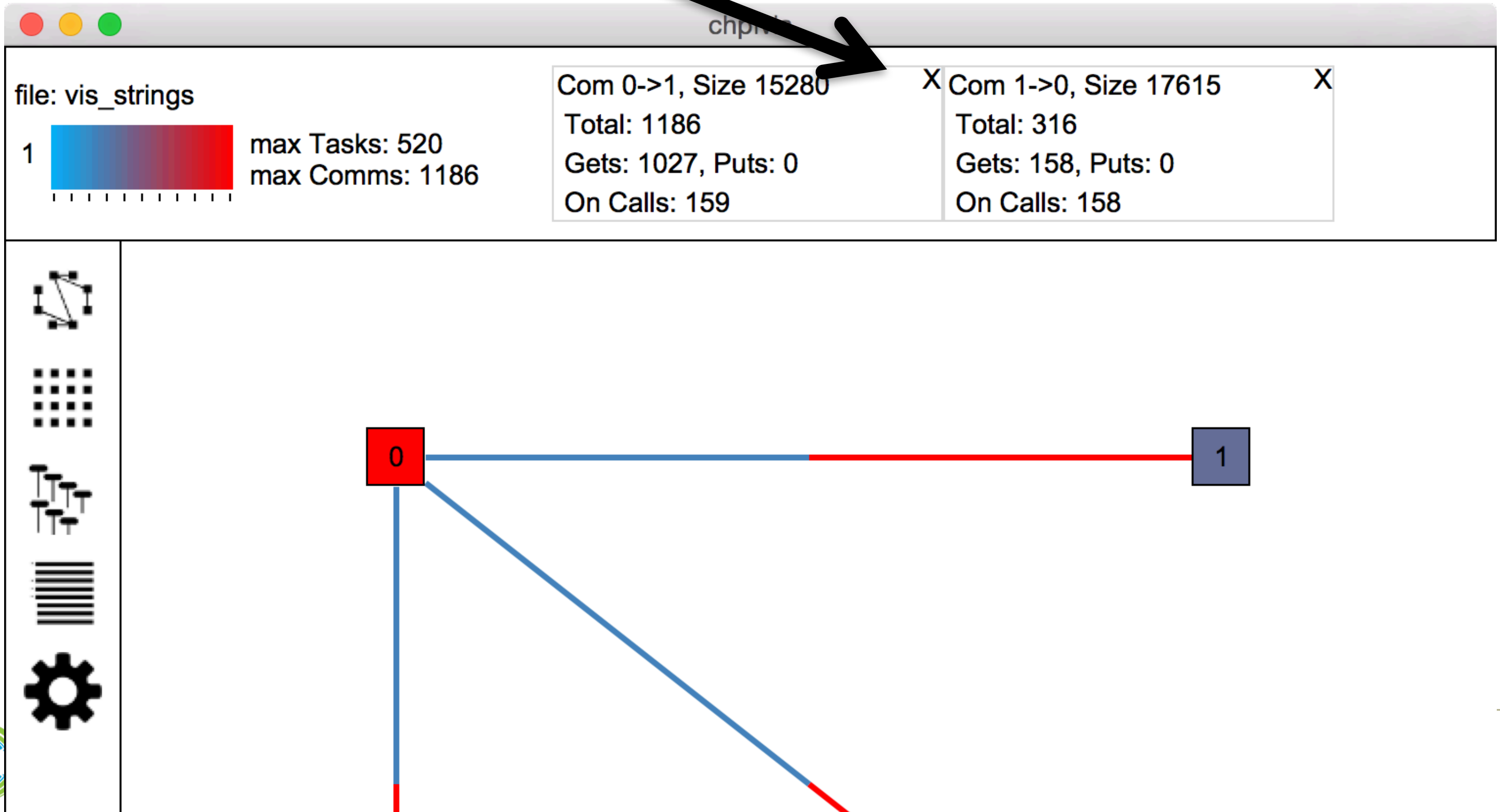
Com 0->1, Size 15280 X
Total: 1186
Gets: 1027, Puts: 0
On Calls: 159

Com 1->0, Size 17615 X
Total: 316
Gets: 158, Puts: 0
On Calls: 158

chplvis output: string version

- Lots of 'on' statements
- communicating strings is expensive!

```
// Store the hash and the path into the array.
// Since the array is not distributed, this sends
// to Locale 0.
hashAndFile[id] = (hashString, path);
```



file: vis_strings

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Reducing overhead with integers

Using Integers

- We don't actually need to communicate strings
- Instead of a path string, could store integer index into paths array
- Instead of a hash string, could store a tuple of integers
  - SHA1 hash is 20 bytes -- fits in 3 Chapel ints

Creating a type for hashes

```
// a SHA-1 hash is 160 bits, so it fits in 3 64-bit ints.
type Hash = (int,int,int);
```

Using integers in the hashAndFile array

```
// Create an array of hashes and file ids
// a file id is just the index into the paths array.
var hashAndFileId:[1..paths.size] (Hash, int);
```

Working with integers in the loop

```
var hash = stringToHash(hashString);
// This version is just communicating 4 integer values
// back to Locale 0.
hashAndFileId[id] = (hash, id);
```

Converting hex to ints

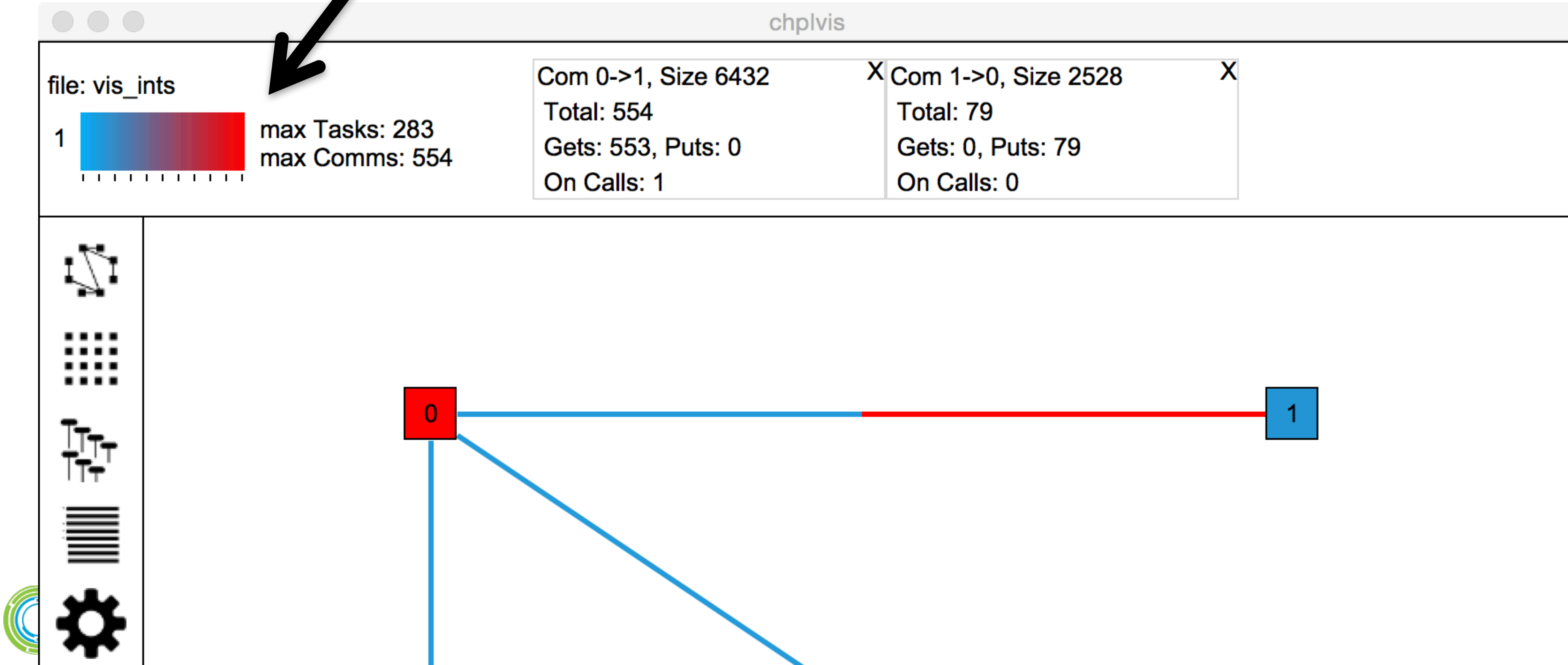
```
proc stringToHash(s:string): Hash {
  // The below is a workaround since Chapel doesn't yet have
  // an equivalent of sscanf in C and readf for integers
  // can't take in a maximum field width

  // Open up an in-memory "file"
  var f = openmem();
  var w = f.writer();
  // Write int-sized substrings separated by spaces
  w.write(s[1..16], " ");
  w.write(s[17..32], " ");
  w.write(s[17..32]);
  w.close();
  var r = f.reader();
  var hash:Hash;
  // Use Formatted I/O to read hex values into integers
  r.readf("%xu%xu%xu", hash(1), hash(2), hash(3));
  r.close();
  return hash;
}
```

Let's look at chplvis output!

chplvis output: integer version

- Reduced communication (for only 316 files)



chplvis

file: vis_ints

1

max Tasks: 283
max Comms: 554

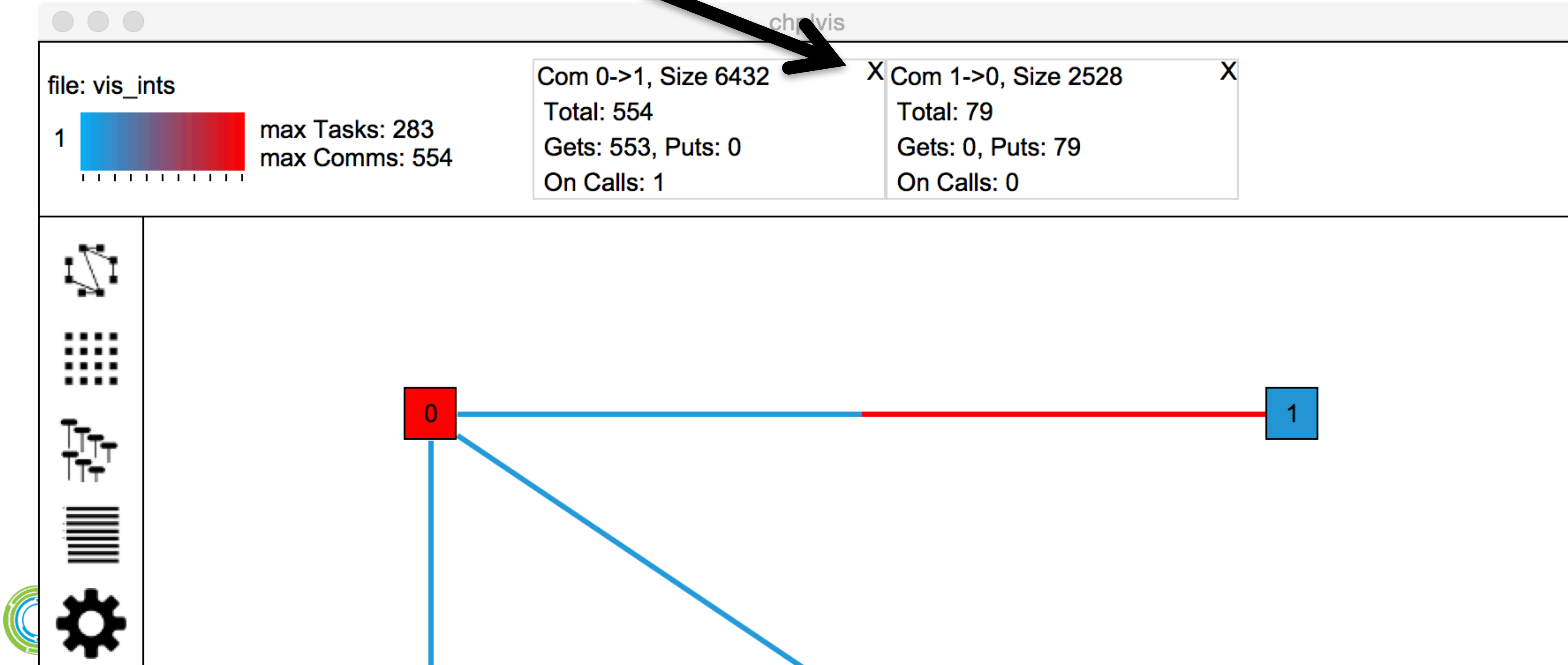
Com 0->1, Size 6432 X
Total: 554
Gets: 553, Puts: 0
On Calls: 1

Com 1->0, Size 2528 X
Total: 79
Gets: 0, Puts: 79
On Calls: 0

chplvis output: integer version

- Only 1 on statement
- Now communication to Locale 0 uses PUT

```
// This version is just communicating 4 integers
// back to Locale 0.
hashAndFileId[id] = (hash, id);
```



chplvis

file: vis_ints

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Gets: 0, Puts: 79
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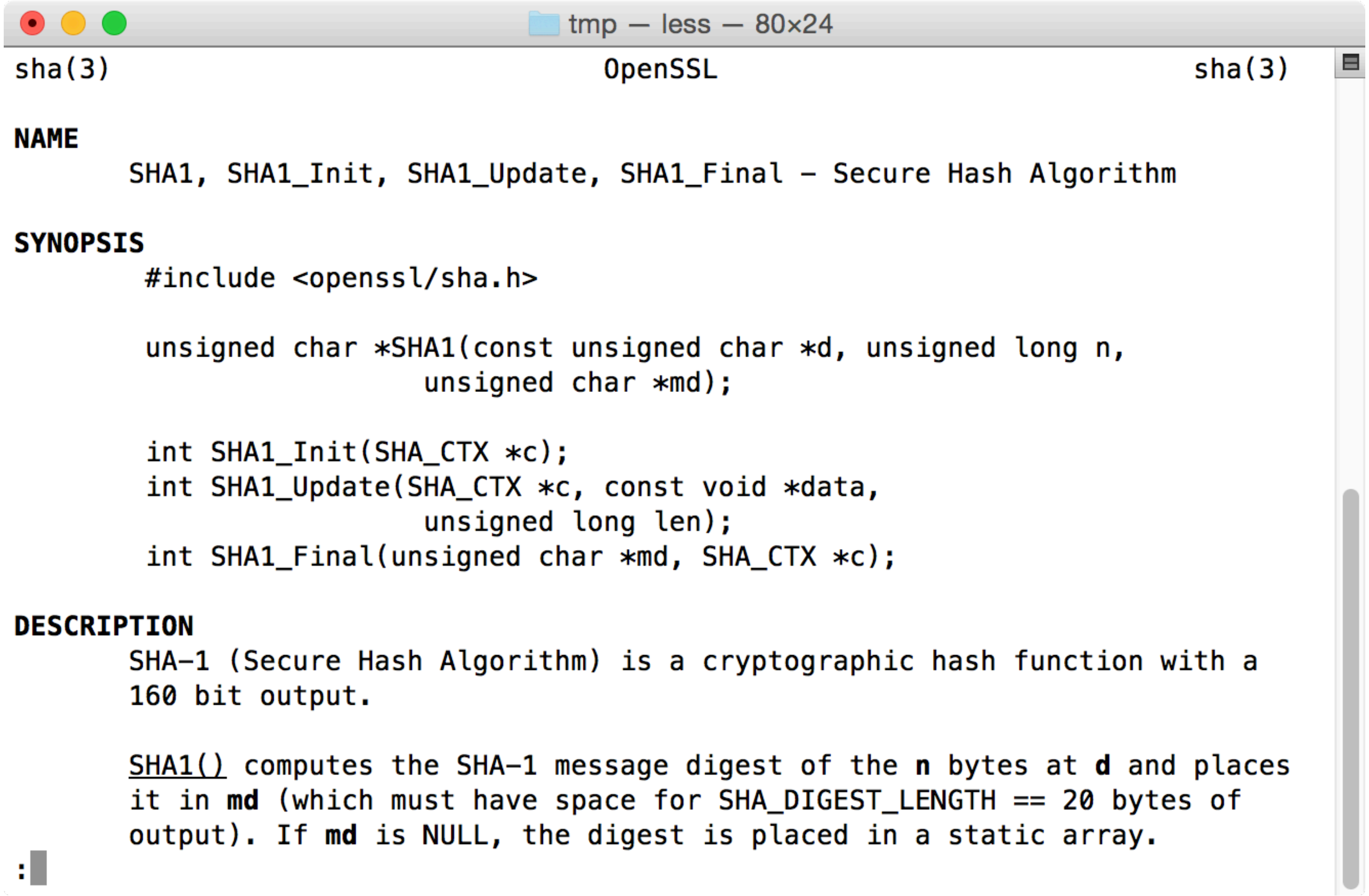
Using a C library to SHA

SHA1 available in OpenSSL library



```
sha(3)                              OpenSSL                              sha(3)

NAME
       SHA1, SHA1_Init, SHA1_Update, SHA1_Final - Secure Hash Algorithm

SYNOPSIS
        #include <openssl/sha.h>

        unsigned char *SHA1(const unsigned char *d, unsigned long n,
                         unsigned char *md);

        int SHA1_Init(SHA_CTX *c);
        int SHA1_Update(SHA_CTX *c, const void *data,
                         unsigned long len);
        int SHA1_Final(unsigned char *md, SHA_CTX *c);

DESCRIPTION
       SHA-1 (Secure Hash Algorithm) is a cryptographic hash function with a
       160 bit output.

       SHA1() computes the SHA-1 message digest of the n bytes at d and places
       it in md (which must have space for SHA_DIGEST_LENGTH == 20 bytes of
       output). If md is NULL, the digest is placed in a static array.
:
```

Including SHA1

```
// This require statement allows this module to add
// some required libraries to the link line
require "-lcrypto", "-lssl";

// The extern block allows Chapel source code to include
// C declarations. The declarations are automatically
// added to the enclosing Chapel scope. Functions,
// variables, and types are supported - including
// inline functions. Macros have limited support.
// See C Interoperability
extern {
  #include <openssl/sha.h>
}
```

Calling SHA1

```
// The extern block above included everything in
// openssl/sha.h, including the SHA1 function. But,
// in order to call it, we need to create C types
// from some Chapel data.
//   string.c_str() returns a C string referring to
//                  the string's data
//   c_ptrTo(something) returns a C pointer referring
//                      to something
SHA1(data.c_str(), data.length:uint, c_ptrTo(mdArray));
```

Alternative way of including SHA1

```
// This require statement indicates that the generated code
// should #include "openssl/sha.h" and be compiled with
// -lcrypto -lssl
require "openssl/sha.h", "-lcrypto", "-lssl";
// This 'extern proc' declaration tells the Chapel
// compiler that a C function SHA1 is available and
// describes the arguments in the Chapel type system.
extern proc SHA1(d:c_string, n:size_t, md:c_ptr(uint(8)));
```

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