PHISH Documentation

http://www.sandia.gov/~sjplimp/phish.html

Table of Contents

Table of Contents

PHISH Documentation

Version info:

The PHISH "version" is the date when it was released, such as 1 Sept 2012. PHISH is updated continuously. Whenever we fix a bug or add a feature, we release it immediately, and post a notice on this page of the WWW site. Each dated copy of PHISH contains all the features and bug-fixes up to and including that version date. The version date is printed to the screen every time you run the bait.py tool on a PHISH input script. It is also in the PHISH directory name created when you unpack a tarball.

- If you browse the HTML or PDF doc pages on the PHISH WWW site, they always describe the most current version of PHISH.
- If you browse the HTML or PDF doc pages included in your tarball, they describe the version you have.

PHISH stands for Parallel Harness for Informatic Stream Hashing.

The PHISH package has two parts. The first is a simple, portable library that user-written programs can call to send and receive datums to and from other programs, running on the same or different machines. The second is a setup tool that allows specification of a data-driven algorithm as a collection of independent processes with communication patterns between them. Input data to the algorithm can arrive continuously in a streaming fashion or be read from files.

PHISH was developed at Sandia National Laboratories, a US Department of Energy facility, with funding from the DOE. It is an open-source code, distributed freely under the terms of the Berkeley Software Distribution (BSD) License.

The authors of PHISH are Steve Plimpton and Tim Shead who can be contacted at sjplimp at sandia.gov or tshead at sandia.gov. The PHISH WWW Site at http::/phish.sandia.gov has more information about the code and its uses.

The PHISH documentation is organized into the following sections. If you find errors or omissions in this manual or have suggestions for useful information to add, please send an email to the developers so we can improve the PHISH documentation.

PDF file of the entire manual, generated by htmldoc

1. Introduction

This section explains what the PHISH software package is and why we created it. It outlines the steps to creating your own PHISH program, and gives a simple of using PHISH to perform a parallel calculation. These are the topics discussed:

1.1 Motivation

Informatics is data-driven computing and is becoming more prevalent, even on large-scale parallel machines, traditionally used to run scientific simulations. It can involve processing large archives of stored data or data that arrives on-the-fly in real time. THe latter is often referred to as "streaming" data. Common attributes of streaming data are that it arrives continuously in a never-ending stream, its fast incoming rate requires it be processed as it arrives which may limit the computational effort per datum that can be expended, and its high volume means it cannot be stored permanently so that individual datums are examined and discarded.

A powerful paradigm for processing streaming data is to use a collection of programs, running as independent processes, connected together in a specified communication topology. Each process receives datums continuously, either from the stream itself, read from a file, or sent to it from other processes. It performs calculations on each datum and may choose to store "state" internally about the stream it has seen thus far. It can send the datum on to one or more other processes, either as-is or in an altered form.

In this model, a data-processing algorithm can be expressed by choosing a set of processes (programs) and connecting them together in an appropriate fashion. If written flexibly. individual programs can be re-used in different algorithms.

PHISH is a small software package we created to make the task of designing and developing such algorithms easier, and allowing the resulting program to be run in parallel, either on distributed memory platforms that support MPI message passing, or on a collection of computers that support socket connections between them.

PHISH stands for Parallel Harness for Informatic Stream Hashing.

Parallelism can be achieved by using multiple copies of processes, each working on a part of the stream. It is a framework or harness for connecting processes in a variety of simple, yet powerful, ways that enable parallel data processing. While it is desinged with streaming data in mind, it can also be used to process archived data from files or in a general sense to perform a computation in stages, using internally generated data of any type or size. Hashing refers to sending datums to specific target processes based on the result of a hash operation, which is one means of achieving parallelism.

It is important to note that PHISH does not replace or even automate the task of writing code for the individual programs needed to process data, or of designing an appropriate parallel algorithm to perform a desired computation. It is simply a library that processes can call to exchange datums with other processes, and a set of setup tools that convert an input script into a runnable program and allow it to be easily launched in parallel.

Our goal in developing PHISH was to make it easier to process data, particularly streaming data, in parallel, even on distributed-memory or geographically-distributed platforms. And to provide a framework to quickly experiment with parallel informatics algorithms, either for streaming or archived data. Our own interest is in graph algorithms but various kinds of statistical, data mining, machine learning, and anomaly detection algorithms can be formulated for streaming data, in the context of the model described above.

1.2 PHISH lingo

The name PHISH was also chosen because it evokes the idea of one or more fish swimming in a stream (of data). This unavoidably gives rise to the following PHISH lingo, which we use without apology throughout the rest of the documentation:

- minnow = a (typically small) stand-alone program, run as an individual process
- school = a set of duplicate minnows, working (swimming) in a
- coordinated fashion
- net(work) = a PHISH program, typically consisting of multiple minnow
- schools, connected together to perform a calculation, as in the diagram below
- bait = Bait.py = a script for hooking schools of minnows together into a net
- wrapper = a Python wrapper for the PHISH library, included in the
- PHISH distribution

1.3 PHISH Pheatures:link(intro_3),h4

The model described above is not unique to PHISH. Many programs provide a framework for moving chunks of data between computational tasks interconnected by "pipes" in a data-flow kind of paradigm. Visualization programs often use this model to process data and provide a GUI framework for building a processing pipeline by connecting the outputs of each computational node to the inputs of others. The open source Titan package, built on top of VTK, is one example, which provides a rich suite of computation methods, both for visualization and data processing. The commercial DataMiner tool from IBM uses a similar dataflow model, and is designed for processing streaming data at high rates.

These programs include a suite of processing modules and are typically designed to run as a single process or in parallel on a shared memory machine. The computational nodes in the processing pipeline are functions called as needed by a master process, or launched as threads running in parallel. This means data can be sent from one computational task to another in a low-overhead fashion by passing a pointer or via shared memory buffers. (Is the preceding true, does Titan have nodes that can do MPI-style paralellism?).

By contrast, PHISH minnows (nodes in the processing pipeline), are independent processes and the PHISH library moves data between them via "messages" which requires copying the aata, either using the message-passing MPI library or sockets. This allows PHISH programs to be run on a broader range of hardware, and PHISH minnows to be developed as independent stand-alone programs, but also incurs a higher overhead for moving data from process to process.

The following list highlights additional PHISH pheatures:

- The PHISH package is open-source software, distributed under the Berkeley Software Development (BSD) license. This effectively means that anyone can use the software for any purpose, including commercial redistribution.

- The PHISH library is a small piece of code (couple 1000 lines), with a compact API (couple dozen functions). It is written in C++, with a C-style interface, so that it can be easily called from programs written in a variety of languages (C, C++, Fortran, Python, etc). The library is highly portable and can be compiled on any platform with a C++ compiler.
- The PHISH library comes in two flavors with the same API: one based on message passing via the MPI library, one based on sockets. The latter uses the open-source ZMQ library. This means you need one or both of these packages (MPI, ZMQ) installed on your machine to build a program (minnow) that uses the PHISH library.
- A Python wrapper for the PHISH library is provided, so that programs (minnows) that call the PHISH library can be written in Python.
- The PHISH library encodes data exchanged between processes (minnows) with strict data typing rules, so that data can be passed between programs written in different languages (e.g. C++ vs Fortran vs Python) and running on different machines (4-byte vs 8-byte integers). Eventually, we may also allow for data exchange between machines with different floating point representations or endian ordering of data types.
- PHISH programs (nets) which involve coordinated computation and data exchange between many processes (minnows) can be specified in PHISH input scripts, which are text files with a simple command syntax.
- PHISH input scripts use a connect command which allows data to be exchanged in various patterns between collections of independent processes (minnows). This enables parallelism in data processing to be easily expressed and exploited.
- PHISH input scripts can be converted into launch scripts via a provided Bait.py program. This produces a file suitable for running either with MPI or sockets.
- PHISH programs (nets) running on top of MPI are launched via the standard mpirun or mpiexec command. Note that a PHISH net is different than the usual MPI program run on P processors where P copies of the same executable are launched. A PHISH net typically consists of several different schools of minnows; each minnow is an independent executable.
- PHISH programs (nets) running on top of sockets are launched via a provided Python script, called Launch.py, which mimics the operation of mpirun. It invokes the set of independent processes (minnows) on various machines via ssh commands, sets up the socket connections between them, and synchrnoizes their launch so that no data is dropped as the processes (minnows) begin exchanging data.
- PHISH programs (nets) can be run on a single processor, so long as the OS supports multiple processes. They can be run on a multicore box. They can be run on any distributed-memory or shared-memory platform that supports MPI or sockets. Or they can be run on a geographically dispersed set of machines that support socket connections.
- A PHISH program (net) can look for incoming data on a socket port. It can likewise export data to a socket port. This means that two or more PHISH programs (nets) can be launched independently and exchange data. This is a mechanism for adding/deleting processes (minnows) to/from a calculation on the fly.
- A handful of programs (minnows) that call the PHISH library are provided in the distribution, as are some example PHISH input scripts that encode PHISH programs (nets). Makefiles are also provided to assist in creating and building your own new programs (minnows).
- Programs (minnows) are provided that wrap stand-alone executables that read from stdin and/or write to stdout. This allows those executables to be used in a PHISH program (net) and exchange data with other programs (minnows).

1.4 Steps to creating and running a PHISH net (program)

The PHISH package contains a library and several related tools for defining and running PHISH nets. These are the steps and associated tools typically used to perform a calculation, assuming you have designed an algorithm that can be encoded as a series of computational tasks, interconnected by moving chunks of data between them.

1. build the PHISH library
2. write and build one or more minnows that call the PHISH library
3. write an input script defining a PHISH net, as schools of minnows and the communication patterns connecting them
4. uss the bait.py tool to process the input script
5. use mpirun or Launch.py to run the output file created by Bait.py,
6. and perform the calculation

Step (1): An overview of the PHISH library and instructions for how to build it is given in "this section".

Step (2): A minnow is a stand-alone application which makes calls to the PHISH library. An overview of minnows, their code structure, and how to build them, is given in "this section". The API to the PHISH library is given in "this section", with links to a doc page for each function in the library.

Step (3): The syntax and commands used in PHISH input scripts are described in "this section", with links to individual commands that explain their operation and options.

Step (4): The bait.py tool, its command-line options, and instructions on how to run it, are described in "this section".

Step (5): Bait.py produces a file as output. If the "-mode mpich" or "-mode openmpi" switch was used, the file can be run using the standard mpirun command to run a parallel job. In all the examples that follow, "outfile" is the name of the file produced by bait.py.

For MPICH, you would do this as follows:

```
mpiexec -configfile outfile
```

For OpenMPI, you would do this as follows:

```
mpirun -configfile outfile
```

If the "-mode socket" switch was used with bait.py, then the file can be run using the Launch.py tool, as follows:

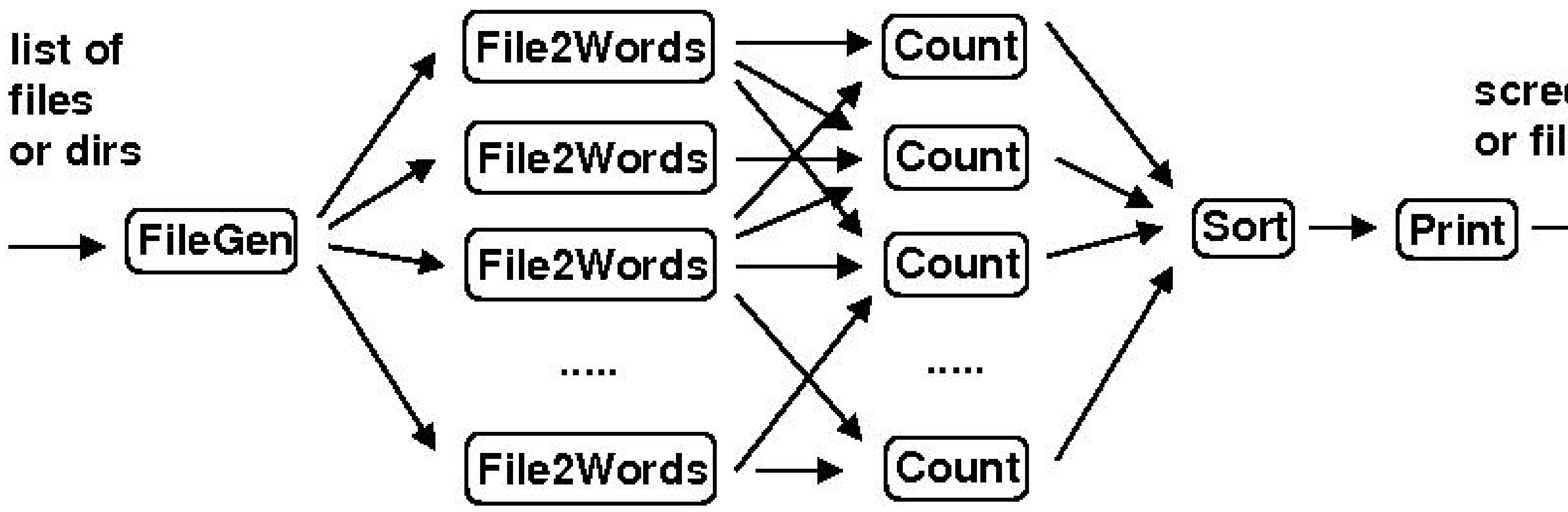
```
launch.py ... outfile
```

TIM: Launch.py support the following command-line arguments ...

TIM: Does launch.py need its own doc page?

1.5 Simple example

The steps outlined in the preceding section are somewhat abstract. Here is a concrete example of using a PHISH program to count the number of times different words appear in a corpus of text files. This is effectively a MapReduce operation, where individual minnow processes perform the map() and reduce() functions. This is a diagram of how 5 different kinds of minnows can beconnected together to perform the computation:



Code for all 5 of these minnows is in the example directory of the PHISH distribution, both in C++ and Python. The *FileGen* minnow takes a list of files and/or directories as user input, searches them recursively, and generates a series of filenames. The filenames are sent one-at-a-time to one of several *File2Words* minnows. Each receives a filename as input, opens and reads the content, and parses it into words. Each word is hashed and sent to a specific *Count* minnow. The key point is that each *Count* minnow will receive all occurrences of a subset of possible words. It stores an internal hash table and counts the occurrences of each word it receives.

When the *FileGen* minnow sends the last filename if finds, it sends a "done" message to each of the *File2Words* minnows. When they receive a "done" message, they send a "done" message to each *Count* minnow. When a *Count* minnow receives a "done" message from all the *File2Words* minnows, it sends its entire list of unique words and associated counts to the *Sort* minnow, followed by a "done" message. When the *Sort* minnow has received "done" message from all the upstream *Count* minnows, it knows it has received a list of all the unique words in the corpus of documents, and the count for each one. It sorts the list by count and sends the top *N* to the *Print* minnow, one by one, followed by a "done" message. *N* is a user-defined parameter. The *Print* minnow echoes each datum it receives to the screen or a file, until if receives a "done" message. At this point all minnows in the school have been shut down.

More details about this example are discussed in subsequent sections of the manual.

In this section of the Bait.py Tool doc page, the PHISH input script that encodes the minnows and communication connections of the above diagram is discussed, and its processing by the bait.py tool.

In this section of the PHISH Minnows doc page, the code for the *Count* minnow is discussed in detail, to illustrate what calls it makes to the PHISH library to send and receive datums.

In this section of the PHISH Library doc page, the format of datums exchanged between minnows is discussed.

Note that like a MapReduce, the PHISH program runs in parallel, since there can be N *File2Words* minnows and M *Count* minnows where N >=1, M >=1, and N = M is not required. This is similar to the option in Hadoop to vary the numbers of mappers and reducers.

However, there are also some differences between how this PHISH program works as compared to a traditional MapReduce, e.g. as typically performed via Hadoop or the MapReduce-MPI library.

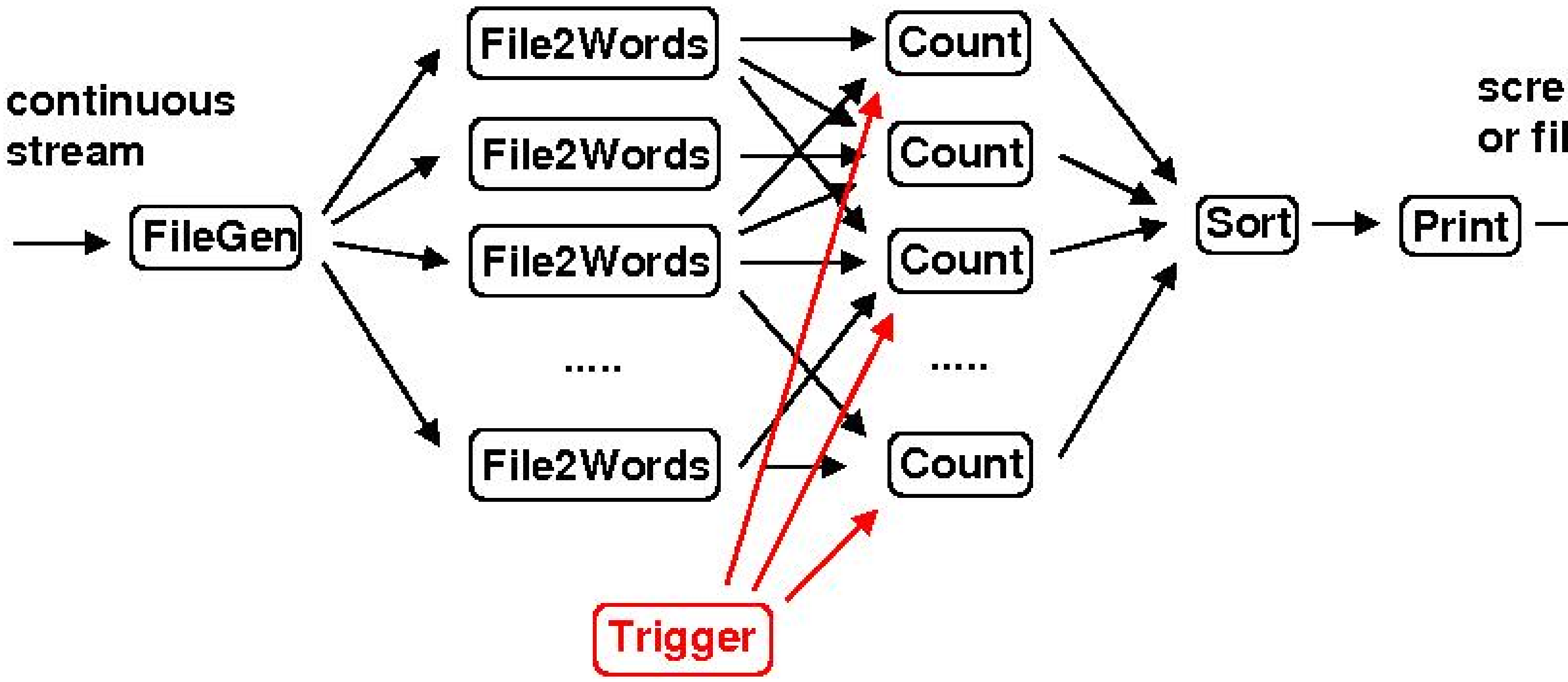
In a traditional MapReduce, the "map" stage (performed by the *File2Words* minnows) creates a huge list of all the words, including duplicates, found in the corpus of documents, which is stored internally (in memory or on disk) until the "mapper" process is finished with all the files it processes. Each mapper then sends chunks of the list to each "reduce" process (performed by the *Count* minnows). This is the "shuffle" phase of a Hadoop MapReduce. The reducer performs a merge sort of all the words in the chunks it receives (one from each mapper). It can then calculate the count for each unique word.

In contrast, the PHISH program operates in a more continuous fashion, streaming the data (words in this case) through the minnows, without ever storing the full data set. Only a small list of unique words is stored (by the *Count* minnows), each with a running counter. In this example, PHISH exchanges data between minnows via many tiny messages (one word per message), whereas a traditional MapReduce would aggregate the data into a few large messages.

This is a simplistic explanation; a fuller description is more complex. Hadoop, for example, can operate in streaming mode for some forms of MapReduce operations, which include this wordcount example. (MapReduce operations where the "reducer" needs all data associated with a key at one time, are not typically amenable to a streaming mode of operation.) The PHISH minnows used in this school could be modified so as to aggregate data into larger and fewer messages.

However the fundamental attributes of the PHISH program are important to understand. Data moves continuously, in small chunks, through a school of minnows. Each minnow may store "state" information about the data it has previously seen, but typically not all the data itself. "State" is typically limited to information that can be stored in-memory, not on disk. This is because for streaming data, too much data arrives too quickly, for a minnow to perform much computation before discarding it or sending it on to another minnow.

Here is a diagram of a variant of the wordcount operation that illustrates how PHISH can be used to process continuous, streaming data. The PHISH program in this case might run for days or weeks, without using the "done" messages described above.



In this case the *FileGen* minnow is continuously seeing new files appear in directories it monitors. The words in those files are processed as they appear. A *Trigger* minnow has been added which accepts user queries, e.g. via a keyboard or a socket connection. When the user makes a request (hits a key), a message is sent to each of the *Count* minnows on a different input port than it receives words from the *File2Words* minnows; see this section of the PHISH Minnows doc page for a discussion of ports. The message triggers the *Count* minnows to send their current unique word/count list to the *Sort* minnow which is sorted and printed via the *Print* minnow.

The PHISH job now runs continuously and a user can query the current top N words as often as desired. The *FileGen*, *Count*, and *Sort* minnows would have to be modified, but only in small ways, to work in this mode. Additional logic could be added (e.g. another user request) to re-initialize counts or accumulate counts in a time-windowed fashion.

1.6 Acknowledgments and citations

PHISH development has been funded by the US Department of Energy (DOE), through its LDRD program at Sandia National Laboratories.

The following paper describe the basic ideas in PHISH. If you use PHISH in your published work, please cite this paper and include a pointer to the PHISH WWW Site (http://phish.sandia.gov):

S. J. Plimpton and T. Shead, PHISH in action, J Parallel and Distributed Compuing, submitted (2012).

PHISH was developed by the following folks at Sandia National Labs:

- Steve Plimpton, sjplimp at sandia.gov
- Tim Shead, tshead at sandia.gov

2. Bait.py Tool

Bait.py is a Python program which converts a PHISH input script into a configuration file that can be launched via MPI or a shell script, so as to run a school of minnows in parallel on many processors, i.e. to run as a PHISH program and perform a calculation. A minnow is simply PHISH-speak for an independent process, created by running one instance of a stand-alone program.

You can edit the input script or pass it different parameters via command-line arguments to bait.py to change the calculation. Rerunning bait.py will create a new launch script.

The remainder of this page discusses how bait.py is used and how a PHISH input script is formatted. The PHISH input script commands recognized by bait.py have their own doc pages.

2.1 Input script commands

- variable
- set
- minnow
- connect
- layout

2.2 Running bait.py

The bait.py Python script is in the bait directory of the PHISH distribution.

Like any Python script you can run it in one of two ways:

```
bait.py -switch value(s) ... <in.script
python bait.py -switch values ...  <in.script
```

For the first case, you need to insure that the first line of bait.py gives the correct path to the Python installed on your machine, e.g.

```
#!/usr/local/bin/python
```

and that the bait.py file is executable, e.g.

```
chmod +x bait.py
```

Normally you will want to invoke bait.py from the directory where your PHISH input script is, so you may need to prepend bait.py with a path or make an alias for running it.

The switch/value command-line arguments recognized by bait.py are discussed in the next section.

2.3 Command-line arguments

These are the command-line arguments recognized by bait.py. Each is specified as "-switch value(s)". Each switch has an abbreviated form; several of them have default settings.

-var or -v	-var name str1 str2 ...
-out or -o	-out filename
-path or -p	-path dir1:dir2:dir3:...
-mode or -m	-mode outstyle

The *-var* switch defines a variable that can be used within the script. It can be used multiple times to define different variables. A variable command can also be used in the input script itself. The variable name is any alphanumeric string. A list of strings is assigned to it, e.g. a series of filenames. For example,

```
bait.py -v files *.cpp <in.phish
```

creates the variable named "files" containing a list of all CPP files in the current directory.

The *-out* switch specifies a filename that bait.py will create when it writes out the MPI or socket script that can be used to launch the PHISH program. The default value is "outfile".

The *-path* switch specifies a colon-separated list of directories, which are added to an internal list stored by bait.py. Initially the list contains only the current working directory. When bait.py processes each minnow, as specified by the minnow command, it looks for the minnow's executable file in the list of directories, so that it can write it to the launch script with a full, correct path name. This switch can be used multiple times, adding more directories each time.

The *-mode* switch specifies the format of the launch file that bait.py writes out. The valid *outstyle* values are *mpich* or *openmpi* or *socket*. *Mpich* is the default.

2.4 Input script syntax and parsing

A PHISH input script is a text file that contains commands, typically one per line.

Blank lines are ignored. Any text following a "#" character is treated as a comment and removed, including the "#" character. If the last printable character in the line is "&", then it is treated as a continuation character, the next line is appended, and the same procedure for stripping a "#" comment and checking for a trailing "&" is repeated.

The resulting command line is then searched for variable references. A variable with a single-character name, such as "n", can be referenced as $n. A variable with a multi-character name (or single-character name), such as "foo", is referenced as ${foo}. Each variable found in the command line is replaced with the variable's contents, which is a list of strings, separated by whitespace. Thus a variable "files" defined either by a bait.py command-line argument or the variable command as

```
-v files f1.txt f2.txt f3.txt
variable files f1.txt f2.txt f3.txt
```

would be substituted for in this command:

```
minnow 1 filegen ${files}
```

so that the command becomes:

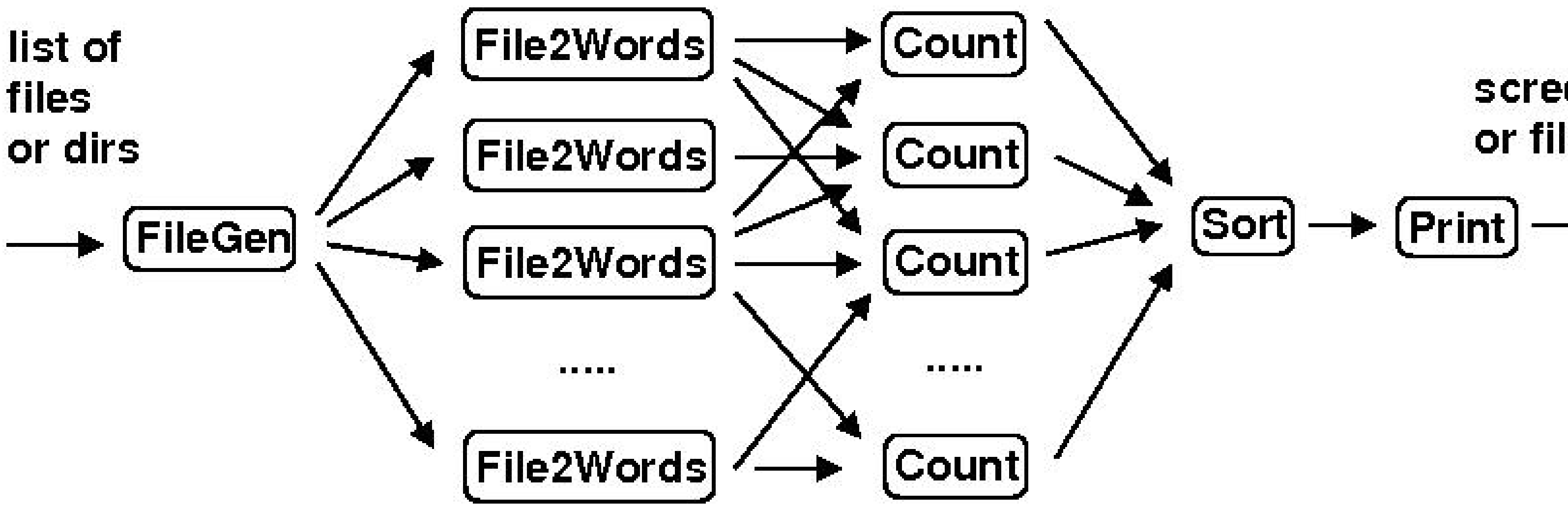
```
minnow 1 filegen f1.txt f2.txt f3.txt
```

After variable substitution, a single command is a series of "words" separated by whitespace. The first word is the command name; the reamining words are arguments. The command names recognized by bait.py are listed above. Each command has its own syntax; see its doc page for details.

With one exception, commands in a PHISH input script can be listed in any order. The script is converted by bait.py into a launch script for running a PHISH program, after the entire script is read. The exception is that a variable cannot be substituted for before it is defined.

2.5 Simple example

This section of the Introduction doc page, discussed this diagram of a PHISH calculation for counting the number of times words appear in a corpus of files, performed as a streaming MapReduce operation.



This is the PHISH input script example/in.wc that represents the diagram:

```
# word count from files
# provide list of files or dirs as -v files command-line arg

minnow 1 filegen $files
minnow 2 file2words
minnow 3 count
minnow 4 sort 10
minnow 5 print

connect 1 roundrobin 2
connect 2 hashed 3
connect 3 single 4
connect 4 single 5

layout 1 1
layout 2 5
layout 3 3
layout 4 1
layout 5 1
```

The minnow commands list the 5 different minnows used. Note the use of the ${files} variable to pass a list of filenames or directories to the *FileGen* minnow.

The connect commands specify the communication pattern used bewteen different sets of minnows. The key pattern for this example is the *hashed* style, which allows the *File2Words* minnow to pass a "key" (a word) to the PHISH library. The library hashes the word to determine which *Count* minnow to send the datum to.

The layout commands specify how many instances of each minnow to launch. Any number of *File2Words* and *Count* minnows could be specified.

When this script is run thru bait.py in the example directory, as

```
../bait/bait.py -v files in.* -p ../minnow <in.wc
```

then bait.py produces the following lines in outfile

-n 1 ../minnow/filegen -minnow filegen 1 1 0 -out 1 0 0 roundrobin 5 1 0 -args in.bottle in.cc in.cc.jon in.filelist in.pp in.rmat in.slow in.wc in.wrapsink in.wrapsource in.wrapsourcefile in.wrapss -n 5 ../minnow/file2words -minnow file2words 2 5 1 -in 1 0 0 roundrobin 5 1 0 -out 5 1 0 hashed 3 6 0 -n 3 ../minnow/count -minnow count 3 3 6 -in 5 1 0 hashed 3 6 0 -out 3 6 0 single 1 9 0 -n 1 ../minnow/sort -minnow sort 4 1 9 -in 3 6 0 single 1 9 0 -out 1 9 0 single 1 10 0 -args 10

```
-n 1 ../minnow/print -minnow print 5 1 10 -in 1 9 0 single 1 10 0
```

which is the format of a "configfile" for the MPICH flavor of MPI. There is one line per minnow, as defined by the input script. The "-n N" specifies how many copies of the minnow will be invoked. The next argument is the name of the minnow executable. Several switches like "-minnow", "-in", "-out" follow which are created by bait.py to encode the communication patterns between the minnows as represented by the diagram above and the connect commands of the input script. The final "-args" switch is followed by minnow-specfic arguments that appeared in the input script.

As discussed in this section of the Introduction doc page, this outfile can be launched via the MPICH mpiexec command as:

```
mpiexec -configfile outfile
```

This will launch 11 independent processes as an MPI job. Each process will call the PHISH library to exchange datums with other processes in the pattern indicated in the diagram. The datum exchanges will be performed via MPI\Send() and MPI_Recv() calls since the MPI version of the PHISH library is being invoked.

3. PHISH Minnows

In PHISH lingo, a "minnow" is a stand-alone program which makes calls to the PHISH library. Often they are small programs which perform a single task, e.g. they parse a string into keywords and store statistics on those keywords. But they can also be large programs which perform sophisticated computations and make only a few calls to the PHISH library. In which case they should probably be called sharks or whales ...

An individual minnow is part of a school of one or more duplicate minnows. One or more schools make a PHISH net(work) which works together to perform a calculation. Minnows communicate with each other to exchange data via calls to the PHISH library.

This doc page covers these topics:

3.1 List of minnows

This is a list of minnows in the minnow directory of the PHISH distribution. Each has its own doc page. Some are written in C++, some in Python, some in both:

- count
- file2fields
- file2words
- filegen
- ping
- pong
- print
- readgraph
- rmat
- slowdown
- sort

These are special minnows which can wrap stand-alone non-PHISH executables which read from stdin and write to stdout, so that they can be used as minnows in a PHISH net and communicate with other minnows:

- wrapsink
- wrapsource
- wrapss

These are simple codes which can be compiled into stand-alone non-PHISH executables. They are examples of code that can be wrapped by the "wrap" minnows:

- echo
- reverse

3.2 Code structure of a minnow

The best way to make sense of how a minnow makes calls to the PHISH library, is to examine a few simple ones from the minnow directory. Here we list the count.py minnow which is written in Python. There is a also a count.cpp minnow, written in C++, which does the same thing. The purpose of this minnow is to ...

```
1   #!/usr/local/bin/python
2
3   import sys,os,glob,copy
4   import phish
5
6   def count(nvalues):
7     if nvalues != 1: phish.error("Count processes one-value datums")
8     type,str,tmp = phish.unpack()
9     if type != phish.STRING:
10      phish.error("File2words processes string values")
11    if hash.has_key(str): hashstr = hashstr + 1
12    else: hashstr = 1
13
14  def sort():
15    pairs = hash.items()
16    for key,value in pairs:
17      phish.pack_int(value)
18      phish.pack_string(key)
19      phish.send(0)
20
21  args = phish.init(sys.argv)
22  phish.input(0,count,sort,1)
23  phish.output(0)
24  phish.check()
25
26  if len(args) != 0: phish.error("Count syntax: count")
27
28  hash =
29
30  phish.loop()
31  phish.exit()
```

Note that on line 4, the Python minnow imports the phish module, which is provided with the PHISH distribution. Instructions on how to build this module, which wraps the PHISH library, and add it to your Python are given in "this section" of the documentation.

The main program begins on line 21. The call to phish.init() is typically the first line of a PHISH minnow. When the minnow is launched, as described in "this section" extra PHISH library command-line arguments are used to describe how the minnow will communicate with other minnows. These are stripped off by the phish.init() function, and the remaining minnow-specific arguments are returned as "args". The phish.input() and phish.output() calls setup the input and output ports used by the minnow.

Is this first place ports are discussed? Or in next section? One call for each input and each output port used by the minnow. Callback specified for input port, which is a minnow function that will be called when a datum is received on that input port. Count in this case. A callback function to call when the input port is closed can also be specified. Sort in this case

After errr checking, initialize hash to empty, and then call phish.loop(). This will look for incoming datums, invoking the callback count function when each is received. It will not return until all input ports are closed, which will invoke the sort function. The minnow finally calls phish.exit() which deallocates memory allocated by the library, and closes any output ports of the minnow, which sends done messages to downstream minnows.

Discuss count function.

Discuss sort function.

This structure is typical of many minnows. A beginnning section with calls to phish.init() and input/output ports, and phish.check().

Then a call to loop vs probe vs recv to receive datums.

The callbacks unpack datums, process them, store state, send messsages via phish.pack() and phish.send().

After loop, etc exits, the minnow shuts down via a call to phish.close() or phish.exit(), since it will receive no more datums.

3.3 Communication via ports

NOTE: dropping data versus perfrect answer (pipeline throttles itself)

rules about ports

Deinfe ports as in connect command

many connections to one port and vice versa is possible

port is only think queryable about a message, other than content. Doesn't make sense to query what connection it came on or which proc in connection. This is b/c the input script is separate from the minnow. Minnow actions shouldn't depend on that info. If it does, then encode it in message.

how general vs specific to write minnow when processing datums note that PHISH input script can send unexpected data to minnow

---

3.4 Shutting down a minnow

regular datum vs done message

For a PHISH program whose minnows operate in a pipelined one-directional fashion (e.g. one or more minnows read input, send datums to a 2nd set of minnows, on to a 3rd set, etc), it is typically sufficient to trigger an orderly shutdown of the entire program

one-way schools, triggered by head done messages, per port level close ports explicitly or implicitly calls to exit, close, etc special care for ring or chain connections or when school has loops Ctrl-C option output at end

doc how to shutdown a ring, which is tricky if one calls phish exit first, then can't receive its close messgae do it like in ccdummy, where one calls phish close first, then wait in loop for last message to return to it

shutdown in ZMQ is buggy

3.5 Building a minnow

makefile

debug a school in stages, since no connection to an output ports is required, or could just hook output to a print minnow

use of slowdown minnow to throttle

4. PHISH Library

This is the API to the PHISH library that minnows (stand-alone applications) call. The API for the MPI and socket verions of the PHISH library are identical.

A general discussion of how and when minnows call PHISH library functions is given in the Minnows section of the manual.

PHISH minnows communicate with other minnows by sending and receiving datums. Before looking at individual library calls, it may be helpful to understand how data is stored internally in a datum by the PHISH library. This topic is discussed below, in the section entitled Format of a datum.

NOTE: Say something about using int32 or uint32 or just int in minnow.

NOTE: put this next text in a sub-section 4.2 or 4.3?

The PHISH library has a C-style API, so it is easy to write minnows in any language, e.g. C, C++, Fortran, Python. The doc pages for individual library functions document the C, C++, and Python interface_Python.html to the library. Note that a C++ program can use either the C or C++ interface.

To use the C interface, a C or C++ program includes the file src/phish.h and makes calls to functions as follows:

```
#include "phish.h"
phish_error("My error");
```

The C++ interface in src/phish.hpp encloses the PHISH API in the namespace "phish", so functions can be invoked as

```
#include "phish.hpp"
using namespace phish
error("My error");
```

or as

```
#include "phish.hpp"
phish::error("My error");
```

To use the Python interface, the Python PHISH wrapper needs to be installed in your machine's Python. See this section of the manual for details.

4.1 List of library functions

The PHISH library is not large; there are only a handful of calls. They can be grouped into the following categories. Follow the links to see a doc page for each library call.

1. Library calls for initialization

phish_init()
phish_input()
phish_output()
phish_callback()
phish_check()

2. Library calls for shutdown
   phish_exit()
   phish_close()
3. Library calls for receiving datums
   phish_loop()
   phish_probe()
   phish_recv()
   phish_unpack()
   phish_datum()
4. Library calls for sending datums
   phish_send()
   phish_send_key()
   phish_send_direct()
   phish_pack_datum()
   phish_pack_raw()
   phish_pack_byte()
   phish_pack_int()
   phish_pack_uint64()
   phish_pack_double()
   phish_pack_string()
   phish_pack_int_array()
   phish_pack_uint64_array()
   phish_pack_double_array()
5. Library calls for queueing datums
   phish_queue()
   phish_dequeue()
   phish_nqueue()
6. Miscellaneous library calls
   phish_query()
   phish_reset_receiver()
   phish_error()
   phish_warn()
   phish_abort()
   phish_timer()

4.2 Format of a datum

A datum is a chunk of bytes sent from one PHISH minnow to another. This section describes the format of the chunk, which is the same whether the datum is sent via MPI or via sockets.

NOTE: discuss and use int32_t in what is below

- # of fields in datum (int)
- type of 1st field (int)
- size of 1st field (optional int)
- data for 1st field (bytes)

- type of 2nd field (int)
- size of 2nd field (optional int)
- data for 2nd field (bytes)
- ...
- type of Nth field (int)
- size of Nth field (optional int)
- data for Nth field (bytes)

The "type" values are one of these settings, as defined in src/phish.h:

- PHISH_RAW = 0
- PHISH_CHAR = 1
- PHISH_INT8 = 2
- PHISH_INT16 = 3
- PHISH_INT32 = 4
- PHISH_INT64 = 5
- PHISH_UINT8 = 6
- PHISH_UINT16 = 7
- PHISH_UINT32 = 8
- PHISH_UINT64 = 9
- PHISH_FLOAT = 10
- PHISH_DOUBLE = 11
- PHISH_STRING = 12
- PHISH_INT8_ARRAY = 13
- PHISH_INT16_ARRAY = 14
- PHISH_INT32_ARRAY = 15
- PHISH_INT64_ARRAY = 16
- PHISH_UINT8_ARRAY = 17
- PHISH_UINT16_ARRAY = 18
- PHISH_UINT32_ARRAY = 19
- PHISH_UINT64_ARRAY = 20
- PHISH_FLOAT_ARRAY = 21
- PHISH_DOUBLE_ARRAY = 22
- PHISH_PICKLE = 23

NOTE: add info on all new data types

NOTE: discuss why are picky about int32, etc so can be portable across machines

PHISH_RAW is a string of raw bytes, which can be of any length, and which the minnow can format in any manner. PHISH_BYTE, PHISH_INT, PHISH_UINT64, and PHISH_DOUBLE are a single byte, int, uint64, and double value. PHISH_INT is a signed int, typically 32-bits in length. PHISH_UINT64 is an unsigned 64-bit int. PHISH_STRING is a standard C-style NULL-terminated C-string. The NULL is included in the field. The ARRAYS are contiguous sequences of int, uint64 or double values.

The "size" values are only included for PHISH_RAW (# of bytes), PHISH_STRING (# of bytes including NULL), and the ARRAY types (# of values).

The field data is packed into the datum in a contiguous manner. This means that no attention is paid to alignment of integer or floating point values.

The maximum allowed size of an entire datum (in bytes) is set by MAXBUF in src/phish.cpp, which defaults to 1

Mbyte.

NOTE: this is now a user-settable parameter

When a datum is sent via the MPI version of the PHISH library, MPI flags the message with an MPI "tag". This tag encodes the receiving minnow's input port and also a "done" flag. Specifically, if the datum is not a done message, the tag is the receiver's input port (0 to Nport-1). For a done message a value of MAXPORT (defined at the top of src/phish.cpp) is added to the tag.

NOTE: MAXPORT is hardwired, could re-compile - this is so all minnows use same setting.

See the phish_input doc page for a discussion of ports. See the shutdown section of the Minnows doc page for a discussion of "done" messages.

TIM: How is this encoding of port and done implemented for sockets?

5. Examples

This is the list of PHISH input scripts provided in the examples directory of the distribution.

** in.pp = ping-pong test between 2 processes

2 procs, each connect to each other via one2one send message of M bytes back-and-forth N times

** in.test = test bait.py syntax processing

arbitrary commands to test that bait.py can process it correctly

** in.wc = word count from files

open files from list convert to words count word occurrence sort to keep top N print the results

can use many procs for file reading and accumulating counts like MapReduce

** in.wrapsink = reverse each filename in a list of filenames

uses wrapssink pass filenames to simple standalone reverse program can launch multiple instances of reverse

** in.wrapss = reverse each filename in a list of filenames

uses wrapss wrap simple standalone reverse program can launch multiple instances of reverse

6. Python Interface to PHISH

How to wrap the PHISH lib with Python.

This allows minnows to be written in Python and make calls to the PHISH library.

Include setup of Python info from MR-MPI.

7. Errors

special error cases:

overflow of stacked-up messages ZMQ shutdown

how to debug a PHISH school via an input script, stage by stage

This is the list of error messages bait.py and the PHISH library can generate.

layout command

Syntax:

connect sendID:outport style recvID:inport

- sendID = ID of minnows which will send datums
- outport = output port datums are written to by sending minnows (default = 0)
- style = kind of connection between sending minnows and receiving
- minnows = *single* or *paired* or *hashed* or *roundrobin* or *direct* or *bcast* or *chain* or *ring* or *publish* or *subscribe*
- recvID = ID of minnows which will receive datums
- inport = input port datums are read from by receiving minnows (default = 0)

Examples:

```
connect ...
```

Description:

Connect is a command that can be used in a PHISH input script which is recognized by the bait.py setup program. It determines how the output from one minnow is routed to the input of another minnow when the PHISH program is run. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

The topology of connections defined by a series of connect commands defines how a school of minnows is harnessed together to perform a desired computational task. It also defins how parallelism is exploited by the collection of minnows.

A connection is made between two sets of minnows, one set sends datums, the other set receives them. Each set may contain one or more processes, where a process is a single minnow. The layout command specifies how many minnows run within each set. Since a datum is typically sent from a single minnow to a single receiving minnow, the style of the connection determines which minnow in the sending set communicates with which minnow in the receiving set.

Each minnow can send datums through specific output ports. If a minnow defines N output ports, then they are numbered 0 to N-1. Likewise a minnow can receive data through specific input ports. If a minnow defines M input ports, then they are numbered 0 to M-1. Ports enable a minnow to have multiple input and output connections, and for a PHISH input script to connect a single set of minnows to multiple other sets of minnows with different communication patterns. For example, a stream of data might be processed by a minnow, reading from its input port 0, and writing to its output port 0. But the minnow might also look for incoming datums on its input port 1, that signify some kind of external message from a "control" minnow triggered by the user, e.g. asking the minnow to print out its current statistics. See the Minnows doc page for more information about how minnows can define and use ports.

The specified *sendID* and *outport* are the minnows which will send datums through their output port *outport*. If *outport* is not specified with a colon following the *sendID*, then a default output port of 0 is assumed.

The specified *recvID* and *inport* are the minnows which will receive the sent datums through their input port *inport*. If *inport* is not specified with a colon following the *recvID*, then a default input port of 0 is assumed.

Both *sendID* and *recvID* must be the IDs of minnows previously defined by a minnow command.

Note that there can be multiple connect commands which connect the same *sendID* and same (or different) *outport* to different *recvID:inport* minnows. Likewise, there can be multiple connect commands which connect the same *recvID* and same (or different) *inport* to different *sendID:outport* minnows. There can even be multiple connect commands which connect the same *sendID* and same (or different) *outport* to the same *recvID:inport* minnows.

Also note that for all of the styles (except as noted below), the *sendID* and *recvID* can be the same, meaning a set of minnows will send datums to themselves.

These are the different connection styles supported by the connect command.

The *single* style connects *N* sending minnows to one receiving minnow. *N* = 1 is allowed. All the sending minnows send their datums to a single receiving minnow.

The *paired* style connects *N* sending minnows to *N* receiving minnows. *N* = 1 is allowed. Each of the *N* sending minnows sends it datums to a specific partner receiving minnow.

The *hashed* style connects *N* sending minnows to *M* receiving minnows. *N* does not have to equal *M*, and either or both of *N*, *M* = 1 is allowed. When any of the *N* minnows sends a datum, it must also define a value for the PHISH library to hash on, which will determine which of the *M* receiving minnows it is sent to. See the doc page for the phish_send_hashed() library function for more explanation of how this is done.

The *roundrobin* style connects *N* sending minnows to *M* receiving minnows. *N* does not have to equal *M*, and either or both of *N*, *M* = 1 is allowed. Each of the *N* senders cycles through the list of *M* receivers each time it sends a datum, in a roundrobin fashion. a different. If the receivers are numbered 0 to M-1, a sender will send its first datum to 0, its 2nd to 1, its Mth to M-1, its M+1 datum to 0, etc.

The *direct* style connects *N* sending minnows to *M* receiving minnows. *N* does not have to equal *M*, and either or both of *N*, *M* = 1 is allowed. When any of the *N* minnows sends a datum, it must also choosed a specific one of the *M* receiving minnows to sent to. See the doc page for the phish_send_direct() library function for more explanation of how this is done.

The *bcast* style connects *N* sending minnows to *M* receiving minnows. *N* does not have to equal *M*, and either or both of *N*, *M* = 1 is allowed. When any of the *N* minnows sends a datum, it sends a copy of it once to each of the *M* receiving minnows.

The *chain* style configures *N* minnows as a 1-dimensional chain so that each minnow sends datums to the next minnow in the chain, and likewise each minnow receives datums from the previous minnow in the chain. The first minnow in the chain cannot receive, and the last minnow in the chain cannot send. *N* > 1 is required. The *sendID* must also be the same as the *recvID*, since the same set of minnows is sending and receiving.

The *ring* style is the same as the *chain* style, except that the *N* minnows are configured as a 1-dimensional loop. Each minnow sends datums to the next minnow in the loop, and likewise each minnow receives datums from the previous minnow in the loop. This includes the first and last minnows. *N* > 1 is required. The *sendID* must also be the same as the *recvID*, since the same set of minnows is sending and receiving.

The *publish* and *subscribe* styles are different in that they do not connect two sets of minnows to each other. Instead they connect one set of minnows to an external socket, either for writing or reading datums. The external socket will typically be driven by some external program which is either reading from the socket or writing to it, but the running PHISH program requires no knowledge of that program. It could be another PHISH program or some completely different program.

The *publish* style connects *N* sending minnows to a socket. *N* = 1 is allowed. The *recvID:inport* argument is replaced with a TCP port #, which is an integer, e.g. 25. When each minnow sends a datum it will "publish" the bytes of the datum to that TCP port, on the machine the minnow is running on. In socket lingo, "publishing" means that the sender has no communication with any processes which may be reading from the socket. The sender simply writes the bytes and continues without blocking. If no process is reading from the socket, the datum is lost.

The *subscribe* style connects *M* receiving minnows to a socket. *M* = 1 is allowed. The *sendID:outport* argument is replaced with a hostname and TCP port #, separated by a colon, e.g. www.foo.com:25. Each minnow receives datums by "subscribing" to the TCP port on the specified host. In socket lingo, "subscribing" means that the receiver has no communication with any process which is writing to the socket. The receiver simply checks if a datum is available and reads it. If a new datum arrives before the receiver is ready to read it, the datum is lost.

Note that multple processes can publish to the same physical socket, and likewise multiple processes can subscribe to the same physical socket. In the latter case, each receiving process reads the same published datum.

NOTE: how does the PHISH library check the socket and return if there is no datum?

NOTE: how does the read from the socket delimit the PHISH datum, so the minnow knows how much to read?

Restrictions:

The *publish* and *subscribe* styles are only supported by the socket version of the PHISH library, not the MPI version.

Related commands:

minnow, layout

Default: none

layout command

Syntax:

```
layout minnow-ID Np keyword value ...
```

- minnow-ID = ID of minnow
- Np = # of duplicate processes to launch for this minnow
- zero or more keyword/value pairs can be appended

```
  possible keywords = host or invoke
    host value = machine
      machine = name of host to run the minnow on
                what if want some minnows on one host, some on another?
    invoke value = launcher
      launcher = run minnow via this program
```

Examples:

```
layout 3 10
layout countapp 1
layout countapp 1 host foo.locallan.gov
layout myApp 5 invoke python
```

Description:

Layout is a command that can be used in a PHISH input script which is recognized by the bait.py setup program. It determines how a minnow application will be launched when the PHISH program is run. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

The *minnow-ID* is the ID of the minnow, as previously defined by a minnow command.

Np is the number of instances of this minnow that will be launched when the PHISH program is run.

The *host* keyword sets a value used by the socket version of the PHISH library, and thus can only be used when the *-mode socket* command-line argument is used with bait.py. The *machine* value is the name of the machine (e.g. foo.locallan.gov) to launch all the minnow processes on.

The *invoke* keyword can be used if the minnow application should be run by another program. For example if the minnow is a Python script, the *launcher* could be set to "python" or to "/usr/local/bin/python2.4". In this case, if the minnow *exefile* was specified as foo.py, then the launch script output by bait.py would include a line such as

```
python foo.py ...
```

instead of simply

```
foo.py ...
```

Restrictions: none

Related commands:

minnow

Default:

If a layout command is not specified, then Np is assumed to be 1, so that one process is launched when the PHISH program is run.

minnow command

Syntax:

```
minnow ID exefile arg1 arg2 ...
```

- ID = ID of minnow
- exefile = executable file name
- arg1,arg2 ... = arguments to pass to executable

Examples:

```
minnow 1 count
minnow 5 filegen ${files}
minnow myapp app 3 f1.txt 4.0
```

Description:

Minnow is a command that can be used in a PHISH input script which is recognized by the bait.py setup program. It defines a minnow application and assigns it an ID which can be used elsewhere in the input script. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

The *ID* of the minnow can only contain alphanumeric characters and underscores.

The *exefile* is the name of the executable which will be launched when the PHISH program is run. It should reside in one of the directories specified by the *-path* command-line argument for bait.py.

The *arg1*, *arg2*, etc keywords are arguments that will be passed to the *exefile* program when it is launched.

Restrictions: none

Related commands:

layout

set command

Syntax:

set keyword value

- keyword = *memory* or *safe* or *port*

```
memory value = N
    N = max size of datum in Kbytes
  safe value = none
```

Examples:

set memory 1024 set safe

Description:

Set is a command that can be used in a PHISH input script which is recognized by the bait.py setup program. It resets default values that are used by the bait.py program as it reads and processes commands from the PHISH input script.

The *memory* keyword sets the maximum length of datums that are exchanged by minnows when a PHISH program runs. Send and receive buffers for datums are allocated by the PHISH library. Only 2 such buffers are allocated, so this setting essentially determines the memory footprint of the PHISH library.

The *N* setting is in Kbytes, so that *N* = 1024 is 1 Mbyte, and *N* = 1048576 is 1 Gbyte. The default is *N* = 1, since typical PHISH minnows send and receive small datums.

The *safe* keyword is only relevant the MPI version of the PHISH library. It forces the library to use MPI_Ssend() calls which are a safer version than the normal MPI_Send() function. Safe in this context refers to messages being dropped if the receiving process is backed up. This can happen if a minnow in a PHISH school of minnows is significantly slower to process datums than all the others, and a large number of datums are being continually sent to it. With the safe mode of MPI calls, the slow minnow should effectively throttle the incoming messages so an overflow does not occur. This requires extra handshaking between the MPI processes and slows down the rate at which small messages are exchanged, so this safe mode is "off" by default. Many PHISH programs do not seem to need it, as MPI is robust enough to insure no messages are dropped.

Note that the *safe* keyword takes no value. If it is not specified, the default is for the PHISH library to use normal MPI_Send() calls.

Restrictions: none

Related commands:

See the discussion of command-line arguments for the bait.py tool.

Default:

The default settings are memory = 1 (1 Kbyte), safe is not set.

variable command

Syntax:

```
variable ID str1 str2 ...
```

Examples:

```
variable files f1.txt f2.txt f3.txt
variable N 100
```

Description:

Variable is a command that can be used in a PHISH input script which is recognized by the bait.py setup program. It creates a variable with name *ID* which contains a list of one or more strings. The variable can be used elsewhere in the input script. The substitution rules for variables is described by the bait.py doc page.

The *ID* of the variable can only contain alphanumeric characters and underscores. The strings can contain any printable character.

Restrictions: none

Related commands:

See the *-var* command-line argument for bait.py.

Default: none

count minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

count instances of keyed datums

syntax: no args

creates an internal hash, so it can count instances of keys hash key = string, hash value = count keeps track of largest key it receives

for each datum: treat buf of nbytes as a string and hash it increment hash value for that string

when done: iterate over hash table send all hash entries downstream as count/string

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

echo application

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Echo is a stand-alone program. Unlike other PHISH minnows in the minnows directory of the PHISH distribution, it is not a program that needs to be linked with the PHISH library. It is provided for illustration purposed, because it can be wrapped with the wrapss minnow so that can it be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

echo lines from stdin to stdout

Restrictions: none

Related commands:

reverse

file2fields minnow

read file and emit words

syntax: no args

for each datum: treat message as filename open it, parse into words separated by whitespace send each word downstream, using word as key emit filenames

syntax: filengen file1 file2 ...

filenames can also be directories directories are opened recursively and their files added to list send each file name one by one downsteram

phish_callback() function

C syntax:

```
void phish_callback(void (*alldonefunc)(), void (*abortfunc)())
```

C examples:

#include "phish.h" phish_callback(mydone,NULL); phish_callback(NULL,myabort); phish_callback(mydone,myabort);

C++ syntax:

```
void callback(void (*alldonefunc)(), void (*abortfunc)())
```

C++ examples:

#include "phish.hpp" PHISH::callback(mydone,NULL); PHISH::callback(NULL,myabort); PHISH::callback(mydone,myabort);

Python syntax:

```
def callback(alldonefunc,abortfunc)
```

Python examples:

```
import phish
phish.callback(mydone,None)
phish.callback(None,myabort)
phish.callback(mydone,myabort)
```

Description:

This is a PHISH library function which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

This function allows you to define 2 callback functions which the PHISH library will use to call back to the minnow under specific conditions. If one or both is not set, which is the default, then the PHISH library does not make a callback.

The alldonefunc() function is used to specify a callback function invoked by the PHISH library when all the minnow's input ports have been closed. The callback function should have the following form:

```
void alldonefunc() {
}
```

or

```
def alldonefunc()
```

in Python,

where "alldonefunc" is replaced by a function name of your choice. A minnow might use the function to print out some final statistics before the PHISH library exits. See the phish_close function and shutdown section of the Minnows doc page, for more discussion of how a school of minnows closes ports and shuts down.

The abortfunc() function is used to specify a callback function that invoked by the PHISH library when phish_error is called, either by the minnow, or internally by the PHISH library.

The callback function should have the following form:

```
void abortfunc(int flag) {
}
```

or

```
def abortfunc(flag)
```

in Python,

where "abortfunc" is replaced by a function name of your choice.

As explained on the phish_error doc page, the phish_error() function prints a message and then causes the minnow itself and the entire school of PHISH minnows to exit. If this callback is defined, the PHISH library will call the function before exiting. This can be useful if the minnow wishes to close files or otherwise clean-up. The function should not make additional calls to the PHISH library, as it may be in an invalid state, depending on the error condition.

TIM: what is the flag?

Restrictions:

This function can be called anytime. It is the only PHISH library function that can be called before phish_init has been called, which can be useful if you wish to do some clean-up via abortfunc() even if phish_init() encounters an error.

Related commands:

phish_error, phish_abort

phish_check() function

C syntax:

```
void phish_check()
```

C examples:

```
phish_check();
```

Python syntax:

```
def check()
```

Python examples:

```
import phish
phish.check()
```

Description:

This is a PHISH library function which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

This function is typically the final function called by a minnow during its setup phase, after the minnow has defined its input and output ports via the phish_input and phish_output functions. It must be called before any datums are received or sent to other minnows.

The function checks that the input and output ports defined by the minnow are consistent with their usage in the PHISH input script, as processed by the bait.py tool.

Specifically, it does the following:

- checks that required input ports are used by the script
- checks that no ports used by the script are undefined by the minnow
- opens all ports used by the script so that data exchanges can begin

---

Restrictions: none

Related commands:

phish_input, phish_output

phish_error() function

phish_warn() function

phish_abort() function

C syntax:

```
#include "phish.h"
void phish_error(char *str)

void phish_warn(char *str)

void phish_abort()
```

C examples:

phish_error("Bad datum received"); phish_warn("May overflow internal buffer"); phish_abort();

C++ syntax:

```
void error(char *str)

void warn(char *str)

void abort()
```

C++ examples:

#include "phish.hpp" PHISH::error("Bad datum received"); PHISH::warn("May overflow internal buffer"); PHISH::abort();

Python syntax:

```
def error(str)

def warn(str)

def abort()
```

Python examples:

```
import phish
phish.error("Bad datum received")
phish.warn("May overflow internal buffer")
phish.abort()
```

Description:

There are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions print error or warning messages. The phish_error() and phish_abort() functions also cause a PHISH program and all of its minnows to exit.

These functions can be called by a minnow, but are also called internally by the PHISH library when error conditions are encountered.

Also note that unlike calling phish_exit, these functions do not close a minnows input or output ports. The latter trigger "done" messages to be sent to downstream minnows. This means that no other minnows are explicitly told about the failed minnow. However, see the discussion below about the phish_abort() function and its effect on other minnows.

The phish_error() function prints the specified character string to the screen, invokes the user-specified abort callback function if it is defined via phish_callback, then calls phish_abort().

The error message is printed in this format for the MPI version of the MPI library (replated MPI by SOCKET for the socket version):

```
PHISH MPI ERROR: Minnow exename ID idminnow # idglobal: message
```

where exename is the name of executable minnow file (not the full path, just the filename), idminnow is the ID of the minnow as specified in the PHISH input script, idglobal is the global-ID of the minnow, and message is the error message. Each minnow has a global ID from 0 to Nglobal-1, where Nglobal is the total number of minnows in the school of minnows specified by the PHISH input script. This supplementary information is helpful in debugging which minnow generated the error message.

The phish_warn() function prints the specified character string to the screen, in the same format as phish_error(), execpt ERROR is replaced by WARNING. The abort callback is not invoked and neither is phish_abort(). Control is simply returned to the calling minnow which can continue on.

The phish_abort() function prints no message.

For the MPI version of the PHISH library, phish_abort() invokes MPI_Abort(), which should force all minnows in the PHISH school to exit, and the "mpirun" or "mpiexec" command that launced the school to exit.

TIM: how does this work for socket version? Does it cause all minnows to exit?

Restrictions: none

Related commands:

phish_exit

phish_init() function

C syntax:

```
void phish_init(int *narg, char ***args)
```

C examples:

phish_init(&argc,&argv);

Python syntax:

```
def init(args)
```

Python examples:

import phish args = phish.init(sys.argv) first_minnow_arg = args**0**

Description:

This is a PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

A PHISH program typically includes one or more sets of minnows, as specified in a PHISH input script. Each minnow in each set is an individual process. In a local sense, each minnow has a local-ID from 0 to Nlocal-1 within its set, where *Nlocal* is the number of minnows in the set. Globally, each minnow has a global-ID from 0 to Nglobal-1, where *Nglobal* is the total number of minnows. The global-IDs are ordered by set, so that minnows within each set have consecutive IDs. These IDs enable the PHISH library to orchestrate communication of datums between minnows in different sets. E.g. when running the MPI version of the PHISH library, the global-ID corresponsds to the rank ID of an MPI process, used in MPI_Send() and MPI_Recv() function calls.

See the phish_query function for how a minnow can find out these values from the PHISH library.

The phish_init() function must be the first call to the PHISH library made by a minnow. Since it alters the command-line arguments passed to the minnow, it is typically the first executable line of a minnow program.

It's purpose is to initialize the library using special command-line arguments passed to the minnow when it was launched, typically by the MPI or socket launch script that the bait.py tool creates from a PHISH input script.

The two arguments to phish_init() are pointers to the number of command-line arguments, and a pointer to the arguments themselves as an array of strings. These are passed as pointers, because the PHISH library reads and removes the PHISH-specific arguments. It then returns the reamining minnow-specific arguments, which the minnow can read and process.

Note that in the Python version of phish.init(), the full argument list is passed as an argument, and the truncated argument list is returned.

There are the switches and arguments the PHISH library looks for and processes. These are generated automatically by the bait.py tool when it processes a PHISH input script, so normally you don't need to think about this level of detail, but it may be helpful for understanding how PHISH works.

- -minnow exefile ID Nlocal Nprev
- -memory N
- -safe
- -in sprocs sfirst sport style rprocs rfirst rport
- -out sprocs sfirst sport style rprocs rfirst rport
- -args arg1 arg2 ... = args for the minnoq itself

The *-minnow* switch appears once, as the first argument. *Exefile* is the name of executable file for this minnow, e.g. count or count.py. The ID is the minnow ID in the PHISH input script. The *Nlocal* argument was explained above. *Nprev* is the total number of minnows in sets of minnows previous to this one. It is used to infer the *local-ID* value discussed above.

The *-memory* and *-safe* and switches change default settings within the PHISH library.

The *-memory* value *N* sets the maximum size of the buffers used to send and receive datums.

The *-safe* switch forces the MPI version of the PHISH library to use MPI_SSend() calls instead of the standard MPI_Send(). These are "safer" in the sense they insure messages are not dropped due to a minnow not keeping up with its incoming messages. See the set command of the bait.py tool for more information on the settings of these switches.

The *-in* switch appears once for every connection the minnow has with other minnows, where it is a receiver of datums. See the connect command in PHISH input scripts processed by the bait.py tool, for more information.

Sprocs, *sfirst*, and *sport* refer to the set of minnows sending to this minnow. They are respectively, the number of minnows in the set, the global ID of the first minnow in the set, and the output port used by those minnows. *Rprocs*, *rfirst*, and *rport* refer to the set of minnows receivng the datums, i.e. the set of minnows this minnow belongs to. They are respectively, the number of minnows in the set, the global ID of the first minnow in the set, and the input port used by those minnows. *Style* is the connection style, as specified by the connect command in the PHISH input script processed by the bait.py tool. E.g. *style* is a word like "single" or "hashed". If it is "subscribe", then extra info about the external host and its TCP port is appended to the *style*, e.g. "subscribe/www.foo.com:25".

The *-out* switch appears once for every connection the minnow has with other minnows, where it is a sender of datums. See the connect command in PHISH input scripts processed by the bait.py tool, for more information.

Sprocs, *sfirst*, and *sport* refer to the set of minnows sending datums, i.e. the set of minnows this minnow belongs to. They are respectively, the number of minnows in the set, the global ID of the first minnow in the set, and the output port used by those minnows. *Rprocs*, *rfirst*, and *rport* refer to the set of minnows receivng the datums. They are respectively, the number of minnows in the set, the global ID of the first minnow in the set, and the input port used by those minnows. *Style* is the connection style, as specified by the connect command in the PHISH input script processed by the bait.py tool. E.g. *style* is a word like "single" or "hashed". If it is "publish", then extra info about the TCP port is appended to the *style*, e.g. "publish/25".

The *-args* switch appears last and lists all the remaining minnow-specific arguments. The PHISH library ignores these, but strips of all command-line arguments up to and including the *-args* switch before returning the args to the minnow caller.

The phish_init() function also flags each specified input port and output port with a CLOSED status, instead of UNUSED. See the connect command for the bait.py tool for more info about communication ports. See the phish_input and phish_output functions for more info about port status.

Restrictions: none

Related commands:

phish_query

phish_reset_receiver() function

C syntax:

```
void phish_reset_receiver(int iport, int receiver)
```

C examples:

```
phish_reset_receiver(0,3);
```

Python syntax:

```
def reset_receiver(iport,receiver)
```

Python examples:

```
import phish
phish.reset_receiver(0,3)
```

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These are miscellaneous functions, which are not used by typical minnows, but serve special purposes.

---

change the process I send messages to on output port iport can be used to effectively permute the ordering of processes in a ring receiver = 0 to M-1, where M = # of receivers in the connection only supported by "ring" connection

---

Restrictions: none

Related commands: none

phish_pack_datum

phish_pack_raw

phish_pack_byte

phish_pack_int

phish_pack_uint64

phish_pack_double

phish_pack_string

phish_pack_int_array

phish_pack_uint64_array

phish_pack_double_array

C syntax:

void phish_pack_datum(char *buf, int n) void phish_pack_raw(char *buf, int n) void phish_pack_byte(char cvalue) void phish_pack_int(int ivalue) void phish_pack_uint64(uint64_t uvalue) void phish_pack_double(double dvalue) void phish_pack_string(char *str) void phish_pack_int_array(int *ivec, int n) void phish_pack_uint64_array(uint64_t *uvec, int n) void phish_pack_double_array(int *dvec, int n)

C examples:

Python syntax:

def pack_datum(buf,n) def pack_raw(buf,n) def pack_byte(cvalue) def pack_int(ivalue) def pack_uint64(uvalue) def pack_double(dvalue) def pack_string(str) def pack_int_array(ivec,n) def pack_uint64_array(uvec,n) def pack_double_array(dvec,n)

Python examples:

NOTE: need to provide examples NOTE: need to doc how Python is different below

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions are used to pack data into a datum before sending it to another minnow.

As discussed in this section of the PHISH Library doc page, datums sent and recived by the PHISH library contain one or more fields. A field is a fundamental data type, such as an "int" or vector of "doubles" or a NULL-terminated character string. These pack functions (except for pack_datum()) add a single field to a datum by packing data into a contiguous byte string, using integer flags to indicate what type and length of data comes next. Unpack functions allow the minnow to extract data from the datum, one field at a time.

Once data has been packed, the minnow may re-use the memory that stores the data; the pack functions copy the data into a send buffer.

The pack_datum() function

A minnow can build the structure of a datum itself, using the information this section of the PHISH Library doc page. But the more common usage is to use this function to pack a datum just received and unpacked via the phish_datum function, so that it can be sent as-is to another minnow.

NOTE: This call be followed by additional pack calls, but not vice versa.

The remaining pack functions correspond one-to-one with the kinds of fundamental data that can be packed into a PHISH datum:

- phish_pack_raw() = pack a string of raw bytes of length *n*
- phish_pack_byte() = pack a single character
- phish_pack_int() = pack a single int
- phish_pack_uint64() = pack a single unsigned 64-bit int
- phish_pack_double() = pack a single double
- phish_pack_string() = pack a C-style NULL-terminated string of bytes
- phish_pack_int_array() = pack *n* int values from *ivec*
- phish_pack_uint64_array() = pack *n* uint64 values from *uvec*
- phish_pack_double_array() = pack *n* double values from *dvec*

Phish_pack_raw() can be used with whatever string of raw bytes the minnow puts into the *buf* argument, e.g. a C data structure containing a collection of various C primitive data types. The "int" data type refers to a signed int, typically 32-bits in length. The "uint64" data type refers to an unsigned 64-bit int. Phish_pack_string() will pack a standard C-style NULL-terminated string of bytes. The array pack functions exepct the *ivec* or *uvec* or *dvec* pointer to point to a contiguous vector of "int" or "uint64" or "double" values.

Restrictions: none

Related commands:

phish_send, phish_unpack

phish_input() function

phish_output() function

C syntax:

```
void phish_input(int iport, void (*datumfunc)(int), void (*donefunc)(), reqflag)
```

```
void phish_output(int iport)
```

C examples:

phish_input(0,count,NULL,1); phish_input(1,count,mydone,0); phish_output(0);

Python syntax:

```
def input(iport,datumfunc,donefunc,reqflag)
```

```
def output(iport)
```

Python examples:

import phish phish.input(0,count,None,1) phish.input(1,count,mydone,0) phish.output(0)

Description:

There are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

The phish_input() and phish_output() functions define input and output ports for the minnow. An input port is where datums are sent by other minnows, so they can be read by this minnow. An output port is where the minnow sends datums to route them to the input ports of other minnows. These inter-minnow connections are setup by the connect command in a PHISH input script, as discussed on the bait.py doc page.

A minnnow can define and use multiple input and output ports, to send and receive datums of different kinds to different sets of minnows. Both input and output ports are numbered from 0 to Pmax-1, where Pmax = the maximum allowed ports, which is a hard-coded value in src/phish.cpp. It is currently set to 16; most minnows use 1 or 2. Note that a single port can be used to send or receive datums to many other minnows (processors), depending on the connection style. See the connect command for details.

The minnow should make one call to phish_input() for each input port it uses, whether or not a particular PHISH input script actually connects to the port. Specify *reqflag* = 1 if a PHISH input script must specify a connection to the input port in order to use the minnow; specify *reqflag* = 0 if it is optional. The phish_check function will check for compatibility between the PHISH input script and the minnow ports.

Two callback function pointers are passed as arguments to phish_input(). Either or both can be specied as *NULL*, or *None* in the Python version, if the minnow does not require a callback. Note that multiple input ports can use the same callback functions.

The first callback is *datumfunc*, and is called by the PHISH library each time a datum is received on that input port.

The *datumfunc* function should have the following form:

```
void datumfunc(int nfields) {
}
```

or

```
def datumfunc(nfields)
```

in Python,

where "datumfunc" is replaced by a function name of your choice. The function is passed "nfields" = the # of fields in the received datum. See the phish_unpack and phish_datum doc pages for info on how the received datum can be further processed.

The second callback is *donefunc*, and is a called by the PHISH library when the input port is closed.

The *donefunc* function should have the following form:

```
void donefunc() {
}
```

or

```
def donefunc()
```

in Python,

where "donefunc" is replaced by a function name of your choice. A minnow might use the function to print out some statistics about data received thru that input port, or its closure might trigger further data to be sent downstream to other minnows. See the phish_close function and shutdown section of the Minnows doc page, for more discussion of how a school of minnows closes ports and shuts down.

The minnow should make one call to phish_output() for each output port it uses, whether or not a particular PHISH input script actually connects to the port. Usage of an output port by an input script is always optional. This makes it easy to develop and debug a sequence of pipelined operations, one minnow at a time, without requiring a minnow's output to be used by an input script.

Restrictions:

These functions cannot be called after phish_check has been called.

Related commands:

phish_check, phish_close

phish_query() function

C syntax:

```
int phish_query(char *keyword, int flag1, int flag2)
```

- keyword = "idlocal" or "nlocal" or "idglobal" or "nglobal" or "inport/status" or "inport/nconnect" or "inport/nminnows" or "outport/status" or "outport/nconnect" or "output/nminnows" or "outport/direct"

```
  idlocal ignores flag1,flag2
  nlocal ignores flag1,flag2
  idglobal ignores flag1,flag2
  nglobal ignores flag1,flag2
  inport/status uses flag1 = input port # (0 to Maxport-1), ignores flag2
  inport/nconnect uses flag1 = input port # (0 to Maxport-1), ignores flag2
  inport/nminnow uses flag1 = input port # (0 to Maxport-1),
                      flag2 = connection # on that port (0 to Nconnect-1)
  outport/status uses flag1 = output port # (0 to Maxport-1), ignores flag2
  outport/nconnect uses flag1 = output port # (0 to Maxport-1), ignores flag2
  outport/nminnow uses flag1 = output port # (0 to Maxport-1),
                       flag2 = connection # on that port (0 to Nconnect-1)
  outport/direct uses flag1 = output port # (0 to Maxport-1), ignores flag2
```

C examples:

```
int nlocal = phish_query("nlocal",0,0);
int nrecv = phish_query("outport/direct",2,0);
```

Python syntax:

```
def query(str,flag1,flag2)
```

Python examples:

import phish nlocal = phish.query("nlocal",0,0) nrecv = phish.query("outport/direct",2,0)

Description:

This is a PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

This function is used by a minnow to query information about the set of minnows it belongs to and the global school of minnows running the PHISH program. It can also query information about the input and output ports the minnow is connected to for communicating with other minnows, and the number of minnows it sends datums to or receives datums from.

The "idlocal", "nlocal", "idglobal", and "nglobal" keywords return info about the minnow and its relation to other minnows running the PHISH program. These keywords ignore the flag1 and flag2 values; they can simply be set to 0.

A PHISH program typically includes one or more sets of minnows, as specified in a PHISH input script. Each minnow in each set is an individual process. In a local sense, each minnow has a local-ID from 0 to Nlocal-1 within its set, where *Nlocal* is the number of minnows in the set. Globally, each minnow has a global-ID from 0 to

Nglobal-1, where *Nglobal* is the total number of minnows. The global-IDs are ordered by set, so that minnows within each set have consecutive IDs. These IDs enable the PHISH library to orchestrate communication of datums between minnows in different sets. E.g. when running the MPI version of the PHISH library, the global-ID corresponsds to the rank ID of an MPI process, used in MPI_Send() and MPI_Recv() function calls.

The "inport/status", "inport/nconnect", and "inport/nminnows" keywords return info about the input ports that connect to the minnow by which it receives datums from other minnows. Likewise, the "outport/status", "outport/nconnect", "output/nminnows", and "output/direct" keywords return info about the output ports the minnow connects to by which it sends datums to other minnows.

All of these keywords require the use of *flag1* to specify the input or output port, which is a number from 0 to Maxport-1. Some of them, as noted below, require the use of *flag2* to specify the connection #, which is a number from 0 to Nconnect-1.

See this section of the PHISH Minnows doc page for more information about input and output ports.

See the connect command which is processed by the bait.py tool in a PHISH input script, to establish connections between sets of minnows.

The "status" keyword returns the status of the port, which is one of the following values:

- unused = 0
- open = 1
- closed = 2

The "nconnect" keyword returns the number of sets of minnows that are connected to a port.

The "nminnows" keyword returns the number of minnows connected to a port thru a specific connection, as specified by flag2.

The "outport/direct" keyword returns the number of minnows connected to an output port thru a connection of style *direct*. The first such connection found is used to return this value, so if another *direct* connection is desired, the "outport/nminnows" keyword should be used.

See the phish_send_direct function for a discussion of how datums are sent via *direct* style connections, and why this particular phish_query() keyword can be useful.

Restrictions: none

Related commands:

phish_init, phish_send_direct

phish_queue() function

phish_dequeue() function

phish_nqueue() function

C syntax:

```
int phish_queue()
```

```
int phish_dequeue(int n)
```

```
int phish_nqueue()
```

C examples:

```
nq = phish_queue();
nvalues = phish_dequeue(0);
nq = phish_nqueue();
```

Python syntax:

```
def queue()
```

```
def dequeue(n)
```

```
def nqueue()
```

Python examples:

```
import phish
nq = phish.queue()
nvalues = phish.dequeue(0)
nq = phish.nqueue()
```

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions are used to store and retrieve datums in an internal queue maintained by the PHISH library. This can be useful if a minnow receives a datum but wishes to process it later.

The phish_queue() function stores the most recently received datum in the internal queue. It returns the number of datums in the queue, which includes the one just stored.

The phish_queue() function does not conflict with phish_unpack or phish_datum functions. They can be called before or after a phish_queue() call.

The phish_dequeue() function retrieves a stored datum from the internal queue and copies it into the receive buffer, as if it had just been received. The datum is deleted from the queue, though it can be requeued via a subsequent call to phish_queue.

After a call to phish_dequeue, the datum can be unpacked or its attributes queried via the phish_unpack or phish_datum functions, as if it just been received.

The input parameter "n" for phish_dequeue is the index of the datum to retrieve. N can be any value from 0 to Nqueue-1 inclusive, where Nqueue is the number of datums in the queue. Thus you can easily retrieve the oldest or newest datum in the queue.

The phish_nqueue() function returns the number of datums currently held in the internal queue.

Restrictions: none

Related commands:

phish_recv, phish_datum

phish_loop() function

phish_probe() function

phish_recv() function

C syntax:

```
void phish_loop()
```

```
void phish_probe(void (*probefunc)())
```

```
int phish_recv()
```

C examples:

```
phish_loop();
phish_probe(count);
n = phish_recv();
```

Python syntax:

```
def loop()
```

```
def probe(probefunc)
```

```
def recv()
```

Python examples:

```
import phish
phish.loop()
phish.probe(count)
n = phish.recv()
```

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions are used to receive datums sent by other minnows.

All received datums arrive on input ports the minnow defines and which the PHISH input script uses to route datums from one set of minnows to another set.

The functions documented on this page receive the next datum, whichever input port it arrives on. It is up to the minnow to take the appropriate port-specific action if necessary. This can be done by defining a port-specific callback function via the phish_input function. Or by querying what port the datum was received on via the phish_datum function.

The phish_loop() function turns control over to the PHISH library. It will wait for the next datum to arrive on any input port. When it does one of three things happen:

(1) For a regular datum, phish_loop() will make a callback to the minnow, to the *datum* callback function assigned to the input port the datum was received on. See the phish_input function for how this callback function is assigned. When the callback function returns, control is returned to phish_loop().

(2) For a datum that signals the closure of an input port, phish_loop() will make a callback to the minnow, to the *done* callback function assigned to the input port the datum was received on. See the phish_input function for how this callback function is assigned. When the callback function returns, control is returned to phish_loop().

(3) For a datum that closes the last open input port, step (2) is performed, and then an additional callback to the minnow is made, to the *alldone* callback function (optionally) assigned by the phish_done function. When the callback function returns, control is returned to phish_loop().

After option (3) has occurred, phish_loop() returns, giving control back to the minnow. Typically, the minnow will then clean up and call phish_exit, since all its input ports are closed and no more datums can be received.

The phish_probe() function is identical to phish_loop(), except that instead of waiting for the next datum to arrive, phish_probe() checks if a datum has arrived. If not, then it immediately calls the specified *probefunc* callback function. This allows the minnow to do useful work while waiting for the next datum to arrive.

The *probefunc* function should have the following form:

```
void probefunc() {
}
```

or

```
def provefunc()
```

in Python,

where "datumfunc" is replaced by a function name of your choice. When the *probefunc* callback function returns, control is returned to phish_probe().

Note that just like phish_loop(), phish_probe() will not return control to the minnow, until option (3) above has occured, i.e. all input ports have been closed.

The phish_recv() function allows the minnow to request datums explicitly, rather than be handing control to phish_loop() or phish_probe() and being called back to by those functions.

The phish_recv() function checks if a datum has arrived and returns regardless. It returns a value of 0 if no datum is available. It returns a value N > 0 if a datum has arrived, with N = the number of fields in the datum. See the phish_unpack and phish_datum doc pages for info on how the received datum can be further processed.

If a datum is received that signals the closure of an input port, then phish_recv() will perform the same options (2) and (3) listed above, making callbacks to the *done* callback function and *alldone* callback function as appopriate, and then return with a value of -1.

Restrictions:

These functions can only be called after phish_check has been called.

Related commands:

phish_input, phish_done

phish_send() function

phish_send_key() function

phish_send_direct() function

C syntax:

```
void phish_send(int iport)
```

```
void phish_send_key(int iport, char *key, int nbytes)
```

```
void phish_send_direct(int iport, int receiver)
```

C examples:

```
phish_send(0);
phish_send_key(1,id,strlen(id));
phish_send_direct(0,3);
```

Python syntax:

```
def send(iport)
```

```
def send_key(iport,key)
```

```
def send_direct(iport,receiver)
```

Python examples:

```
import phish
phish.send(0)
phish.send_key(1,id)
phish.send_direct(0,3)
```

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions are used to send datums to other minnows. Before a datum can be sent, it must be packed into a buffer. See the doc page for the phish_pack functions to see how this is done.

All datums are sent via output ports the minnow defines and which the PHISH input script uses to route datums from one set of minnows to another set. Thus these send functions all take an *iport* argument to specify which output port to send thru.

The specific minnow(s) that the datum will be sent to is determined by the connection style(s) defined for the output port. See the PHISH input script connect command, as discussed on the bait.py tool doc page, for details. Some connection styles require additional information from the minnow to route the datum to the desired minnow. This is the reason for the phish_send_key() and phish_send_direct() variants of phish_send().

The phish_send() function sends a datum to the specified *iport* output port.

This generic form of a send can be used for all connection styles except the *hashed* and *direct* styles. See the PHISH input script connect command for details. Note that multiple sets of receiving minnows, each with their own connection style, can be connected to the same output port.

If phish_send() is used with a *hashed* or *direct* connection style, an error will result.

The phish_send_key() function sends a datum to the specified *iport* output port and allows specification of a byte string or *key* of length *nbytes*, which will be *hashed* by the PHISH library and converted into an index for choosing a specific receiving processor to send the datum to.

This form of sending must be used for a *hashed* connection style. See the PHISH input script connect command for details. If one or more of the connection styles connected to the output port is not a *hashed* style, then the *key* and *nbytes* arguments are ignored, and the generic phish_send() form is used to send the datum.

NOTE: does Python syntax not include len? or can other non-string keys be *hashed*?

The phish_send_direct() function sends a datum to the specified *iport* output port and allows a specific receiving minnow to be selected via the *receiver* argument. The *receiver* is an integer offset into the set of receiving minnows connected to this output port. If there are *M* minnows in the receiving set, then 0 <= *receiver* < M is required. The phish_query function can be used to query information about the receiving set of minnows. For example this phish_query() call would return M, assuming the receiving processors are connected to output port 0.

```
int m = phish_query("outport/direct",0,0);
```

This form of sending must be used for a *direct* connection style. See the PHISH input script connect command for details. If one or more of the connection styles connected to the output port is not a *direct* style, then the *reciever* argument is ignored, and the generic phish_send() form is used to send the datum.

Restrictions: none

Related commands:

phish_pack

phish_exit() function

phish_close() function

C syntax:

```
void phish_exit()

void phish_close(int iport)
```

C examples:

```
phish_exit();
phish_close(0);
```

Python syntax:

```
def exit()

def close(iport)
```

Python examples:

```
import phish
phish.exit();
phish.close(0);
```

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions serve to shutdown a running minnow, either entirely or a portion of its output capabilities. They trigger the closing of a minnow's output port(s) which notifies downstream minnows, so they also can clean-up and exit.

See this section of the Minnows doc page for a discussion of shutdown options for PHISH programs.

The phish_exit() function is the most commonly used mechanism for performing an orderly shutdown of a PHISH program. Once called, no further calls to the PHISH library can be made by a minnow, so it is often the final line of a minnow program.

When phish_exit() is called it performs the following operations:

- print stats about the # of datums received and sent by the minnow
- warn if any input port is not closed
- close all output ports
- free internal memory allocated by the PHISH library
- shutdown communication protocols to other minnows

The stats message is printed with the same supplementary information as the phish_error function, to identify the minnow that printed it.

Closing a minnow's output port involves sending a "done" message to each minnow (in each set of minnows) connected as a receiver to that port, so that they know to expect no more datums from this minnow.

When all the minnows in a set have invoked phish_exit() to close an output port, each downstream minnow that receives output from this port will have received a series of "done" messages on its corresponding input port. Each minnow keeps a count of the total # of minnows that send to that port, so it will know when the requisite number of done messages have been received to close the input port.

In the MPI version of the library, the final step is performed by invoking MPI_Finalize(), which means no further MPI calls can be made.

NOTE: how is this done for the sockets version?

Note that this function is often called directly by the most upstream minnow(s) in a PHISH school, when they are done with their task (e.g. reading data from a file).

Other downstream minnows often call phish_exit() after the phish_loop or phish_probe function returns control to the minnow, since that only occurs when all the minnow's input ports have been closed. In this manner, the shutdown procedure cascades from minnow to minnow.

The phish_close() function is less often used than the phish_exit() function. It can be useful when some minnow in the middle of a data processing pipeline needs to trigger an orderly shutdown of the PHISH program.

Phish_close() closes the specified *iport* output port of a minnow. This procedure involves sending a "done" message to each minnow (in each set of minnows) connected as a receiver to that port, so that they know to expect no more datums from this minnow.

When all the minnows in a set have invoked phish_close() on an output port, each downstream minnow that receives output from this port will have received a series of "done" messages on its corresponding input port. Each minnow keeps a count of the total # of minnows that send to that port, so it will know when the requisite number of done messages have been received to close the input port. As input ports are closed, this typically triggers the minnow to invoke phish_exit() or phish_close(). In this manner, the shutdown procedure cascades from minnow to minnow.

This function does nothing if the specified output port is already closed.

Restrictions: none

Related commands:

phish_loop, phish_probe

phish_timer() function

C syntax:

```
double phish_timer()
```

C examples:

```
double t1 = phish_timer();
...
double t2 = phish_timer();
printf("Elapsed time = %g\n",t2-t1);
```

Python syntax:

```
def timer()
```

Python examples:

```
import phish
t1 = phish.timer();
...
t2 = phish.timer();
print "Elapsed time =",t2-t1
```

Description:

This is a PHISH library function which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

This function provides a portable means to time operations within a minnow. For the MPI version of the PHISH library, the function is a wrapper on MPI_Wtime().

NOTE: how does this work for socket version?

The function returns the current time in CPU seconds. To calculated an elapsed time, you need to bracket a section of code with 2 calls to phish_timer() and calcualte the difference between the 2 returned times, as in the example above.

Restrictions: none

Related commands: none

phish_unpack() function

phish_datum() function

C syntax:

```
int phish_unpack(char **buf, int *len)
```

```
int phish_datum(char **buf, int *len)
```

C examples:

```
char *buf;
int len;
int type = phish_unpack(&buf,&len);
int iport = phish_datum(&buf,&len);
```

Python syntax:

```
def unpack()
```

```
def datum()
```

Python examples:

```
import phish
type,value,len = phish.unpack()
iport,buf,len = phish.datum()
```

NOTE: need to doc how Python is different below

Description:

These are PHISH library functions which can be called from a minnow application. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library.

These functions are used to unpack a datum after it has been received from another minnow.

As discussed in this section of the PHISH Library doc page, datums sent and recived by the PHISH library contain one or more fields. A field is a fundamental data type, such as an "int" or vector of "doubles" or a NULL-terminated character string. These fields are packed into a contiguous byte string when then are sent, using integer flags to indicate what type and length of data comes next. These unpack functions allow the minnow to extract data from the datum, one field at a time.

Note that these functions return pointers to the internal buffer holding the datum within the PHISH library. The buffer will be overwritten when the minnow returns control to the PHISH library and the next datum is received. Typically this occurs when a callback function in the minnow returns. This means that if you want the data to persist within the minnow, you must make a copy. It is OK to unpack several fields from the same datum before making copies of the fields. It is also OK to pack one or more fields for sending and wait to send it until after another datum is received. This is because calls to "phish_pack" functions copy data into a send buffer.

The phish_unpack() function returns the next field in the latest received datum. The function itself returns an integer flag set to one of these values (defined in src/phish.h):

- PHISH_RAW = 0
- PHISH_BYTE = 1
- PHISH_INT = 2
- PHISH_UINT64 = 3
- PHISH_DOUBLE = 4
- PHISH_STRING = 5
- PHISH_INT_ARRAY = 6
- PHISH_UINT64_ARRAY = 7
- PHISH_DOUBLE_ARRAY = 8

PHISH_RAW is a string of raw bytes which can store whatever the sending minnow put into its send buffer, e.g. a C data structure containing a collection of various C primitive data types. PHISH_INT is a signed int, typically 32-bits in length. PHISH_UINT64 is an unsigned 64-bit int. PHISH_STRING is a standard C-style NULL-terminated string. The ARRAY types mean the field is a sequence of "int" or "uint64" or "double" values, packed one after the other.

The function also returns *buf* and *len*. *Buf* is a char pointer to where the field starts. You will need to cast this to the appropriate data type if necessary to access the data. *Len* is the length of the field, with the following meanings:

- PHISH_RAW: len = # of bytes
- PHISH_BYTE: len = 1
- PHISH_INT: len = 1
- PHISH_UINT64: len = 1
- PHISH_DOUBLE: len = 1
- PHISH_STRING: len = # of bytes, including the trailing NULL
- PHISH_INT_ARRAY: len = # of int values
- PHISH_UINT64_ARRAY: len = # of uint64 values
- PHISH_DOUBLE_ARRAY: len = # of double values

The phish_datum() function returns information about the entire datum. The function itself returns the input port it was received on. See the phish_port functions for a discussion of ports.

The function also returns *buf* and *len*. In this case, unlike the phish_unpack() function, *buf* is a char pointer to where the entire datum starts, which includes other info besides the data itself, e.g. the number of fields and the data type flags. Likewise, *len* is the length in bytes of the entire datum, including its data and flags.

A minnow can parse the entire datum following this function call, to extract whatever info it needs; see this section of the PHISH Library doc page for a description of the structure of a datum. But the more common usage is to follow a phish_datum() call with a call to the phish_pack_datum function to pack the entire datum as-is for sending to another minnow.

The phish_datum() function does not conflict with the phish_unpack() function. Phish_datum() can be called before or after or in between a series of phish_unpack() calls.

Restrictions: none

Related commands:

phish_recv, phish_pack

ping minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

reflect messages to a receiver

fill M-byte buffer with NULLs send it and go into loop

for each datum: when recv from partner increment count and send back to partner when count hits M, send done message

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

pong minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

reflect messages to a sender

syntax: no args

datum method: when recv from partner, send message back to partner

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

print minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

print datums to screen or file

syntax: print -f filename -f is optional, if not specified, prints to stdout

for each datum: print string

when done: close file

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

reverse application

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Echo is a stand-alone program. Unlike other PHISH minnows in the minnows directory of the PHISH distribution, it is not a program that needs to be linked with the PHISH library. It is provided for illustration purposed, because it can be wrapped with the wrapss minnow so that can it be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

reverse characters in lines from stdin and write to stdout

Restrictions: none

Related commands:

echo

rmat minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

rmat gen minnow

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

slowdown minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

read datum and emit it with slowdown delay

syntax: slowdown delta delta = time to delay (in seconds)

read each datum and insure delay seconds have passed before writing it downstream

for each datum: query time since last datum was processed and invoke usleep() if needed send entire datum downstream

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

sort minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

sort datums, emit highest count ones

syntax: sort N N = keep top N of sorted list

for each datum: assume message is int/string store in/string as STL pair in a vector list

when done: sort the list based on integer count send the top N list items downstream as count/string

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

pong

wrapsink minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

wrap a child process which consumes datums by reading from stdin

syntax: wrapsink "program" "program" can be any string with flags, redirection, etc enclose in quotes to prevent shell from processing it

write datums to child, one by one, as lines of input write done via popen pipe

for each datum: write datum to pipe with appended newline

when done: close the pipe

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

wrapsource, wrapss

wrapsource minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

wrap a child process which creates datums by writing to stdout

syntax: wrapsource -f "program" -f is optional

if -f is specified, receive filenames in stream and invoke child process on each filename generate "program" via sprintf() using filename as arg so "program" presumably has %s in it if -f is not specified, invoke child process just once using "program"

"program" can be any string with flags, redirection, etc enclose in quotes to prevent shell from processing it

read lines of output from child one by one as datums via a pipe send them downstream

for each datum: launch the child process on the filename read all its output until child exits send each line of output downstream vis phish_send w/out newline

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

wrapsink, wrapss

wrapss minnow

Syntax:

```
ping N M
```

- N = # of datums to ping/pong with partner minnow
- M = # of bytes in each datum

Examples:

```
ping 1000 0
ping 100 100000
```

Description:

Ping is a PHISH minnow that can be used as one of a school of minnows in a PHISH program. In PHISH lingo, a "minnow" is a stand-alone application which makes calls to the PHISH library to exchange data with other PHISH minnows.

wrap a child process which both consumes and creates datums via stdin/stdout so child is a sink and a source

syntax: wrapss "program" "program" can be any string with flags, redirection, etc enclose in quotes to prevent shell from processing it

open 2 pipes to child via pipe() fork() into parent and child processes parent calls phish_probe() to query incoming messages and child output child hooks its stdin/stdout to 2 pipes via dup2() child invokes the "program" via execv()

datum method: write datum to pipe with appended newline

probe method: poll pipe for output from child if output is there, read it and break into lines phish_send() each line downstream as string w/out newline

close method: close write pipe to child so it will know parent is done wait for all output from child read pipe send DONE message to notify receivers

Restrictions:

Note: set command may be required to boost buffer size

Related commands:

wrapsink, wrapsource