Private Dropbox
Final Report
COSC480

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1 Abstract

I have written a program in Python which reads user settings from a file, and synchronises the appropriate files to the appropriate machines when they have been modified. It does this using an efficient two way file synchronising tool called Unison. I will discuss in this dissertation what I have done and how I have tested my program.

Contents

2 Introduction

2.1 Project goals

The aim of this project was to develop a file synchronisation tool. Similar to Dropbox (and others) its main function should be to keep data synchronised between multiple devices. What makes it different however is it should:

- Support decentralised operation. It will not necessarily need to communicate with 'the cloud'. The program should not require a centralised server. However it should be possible to configure the system to behave like a centralised system if the user wants to. The system should be flexible in this regard.
- Allow file synchronisation between multiple clients not just point-to-point between two clients. Synchronisation between two clients however is the basis for multiple client synchronisation. Clients may be running different operating systems. Clients may be connected to different networks, with different costs of access, including being disconnected from the Internet at times.
- The user should be able to choose what to replicate and how often to do it within different sets of files. Choosing what to replicate could be done based on file name, file types, file size *etc.* They system should allow for fine-grained user control for the majority of the program's functionality.
- Show statistics about which files are being replicated, efficiency (time taken for the files to become fully up to date), cost (bandwidth, disk space used). These statistics could also possibly lead to a heuristic for when to synchronise a given file. For example if a file is updated and a node has many neighbours to potentially send the file too. Perhaps choosing the neighbour whose links has the lowest cost would be a good choice to send the data to first.
- Operate automatically, without the user having to initiate a file synchronisation themselves. The system's autonomous operation should be influenced by the users choices on how often to sync and what files should be synced, this relates to the fine-grained controls mentioned above.

2.2 Background

There are already many services available that can synchronize your files between different devices. Dropbox, Google Drive, Microsoft SkyDrive, Apple iCloud are all examples of cloud based solutions for distributing your files across your devices. The problems with these services is privacy and availability. Storing your data with a third party gives them access to your documents. If you are a commercial organisation with sensitive information this might be concerning. You could of course choose to encrypt your files. Encrypting your files adds two slow extra steps, encrypting them before you upload

and decrypting files before you can use them, this is less than ideal. You also cannot guarantee that you will always be able to access your data, if the company that hosts your data goes bankrupt or decides to shutdown their service you could lose all of your data with little or no warning.

For example Megaupload, a file hosting service, has recently been shut down by the United States Department of Justice for alleged copyright infringement. According to its founder, 100 million users lost access to 12 billion unique files[1].

There are other possible approaches to replicating files across multiple computers. For example you could use version control systems like Subversion, Mercurial, and CVS. One problem with these is that they are centralised (they rely on a central server), should that server fail the replication will break. Not only that, they create a bottleneck at the server which can slow replication down. Cloud based solutions are often centralised. Another problem is that even if they are decentralised like git, they will not automatically push updates to other working sets. This could be accomplished with some cron scripts or a post-commit hook to get git to propagate data onwards. Git might have made a promising base to build my application on top of, the only real problem was the version control overhead that comes with it. Old revisions would take up space on the hard disk and require more data to be transmitted across network links. I decided that as a file synchronisation program, revision history was out off scope and that my program would deal with just keeping files in sync. Using git would be an interesting extension to my program and could easily be integrated into my current system.

2.3 Example use case

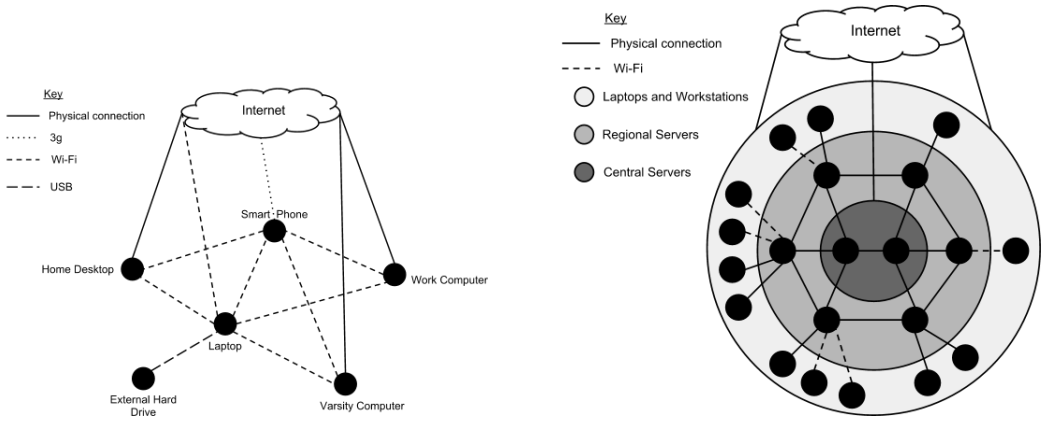
Here is an example use case demonstrating why I find my program useful.

I like to keep all of the data on my laptop backed up to an external hard drive. The data on my computer that I wish to back up falls into three main categories: documents, music, and movies. Documents are mostly scripts and programs that I am writing for University or work projects. Documents also include reports for assessment. These documents change very frequently and are very important to me. Often these are small files (but not always). My music collection changes relatively infrequently, files are around $\approx$5MB and I like to have a relatively current backup of this collection. My movie collection contains fairly large files but I do not need it to be backed up very often as it does not change very much and I do not care if I loose some of these movies. Files that I work on at University would be very useful to have on my laptop at home. Files that I work on at work mostly stay at work but occasionally I might want to bring something home to work on. The other device I always have with me and may be on one of any given (Wi-Fi or 3G) network at a certain time is my smart phone. I would like to have photos taken on this backed up to either (or both) my laptop and external hard drive.

[1] http://computerworld.co.nz/news.nsf/news/kim-dotcom-wants-his-money-back

Some of the files that I move around are of a sensitive or personal nature and I would prefer not to store them with a third party vendor. I also have different synchronisation requirements for different types of data. For example my collection of large video files does not change that often and will chew up valuable network bandwidth whenever it has to transfer a new file. I like this to be replicated only occasionally as I do not use it that much. On the other hand my document collection which I use for work and coursework changes very often, is very important, and is fairly small. I would like this to be as up to date as possible.

Existing file synchronisation tools do not do enough for me. I do not have enough control over my data. I want to know which machines my files are going to and when. I want to feel confident that I will always be able to access my data even if the service closes down or my internet connection fails. My program is aimed at addressing these issues.



(a) Personal Network (b) Corporate Network

Figure 1: Example use cases

I have already described the personal network shown in figure 1a. Figure 1b shows a graph of a corporate network, this is another example use case. It will have many of the same basic needs as the personal graph. The coloured rings represent the need for different policies for different machines in a network. Something which Dropbox will not provide but my system does.

3 Supporting architecture and program development

3.1 Virtual Machines, Node networks

For testing my program I needed to have a network of computers that can be linked together in different arrangements easily. I decided to use virtual machines for this job since it means I do not need to have a large number of physical machines. I can create new machines very easily, and manipulate the links between them.

I have used Oracle's VirtualBox software. I chose VirtualBox because of its easy to use command line interface. My program should be able to run across any network of nodes. So I wanted to test as many different arrangements as possible. I decided that I needed to be able change network topologies easily without having to re-write my scripts. I built some bash scripts to run on top of a program called Graphviz.

"Graphviz is open source graph visualization software".[2] I used Graphviz to generate graphs of all the topologies I worked with. This made it easy to keep track of what a topology looked like which was useful for debugging. It was also useful to display results alongside an image of what the topology looks like. Building my program on top of Graphviz meant that I could couple the production of the topology graph and the configuration of the virtual machines together. I never wanted one without the other so this was very useful.

I use Graphviz configuration files to set up my virtual machines as well as generate graphs. This means I only have to write a configuration file once. Graphviz uses a simple notation which made it easy to have a bash script also read this file.

My bash script enables the appropriate network adaptors on each virtual machine. Then it sets these adaptors to use an internal network which it also creates. I chose to use an internal network as the link between any given machines because this way I could guarantee that no other programs were running over that interface using up network traffic.

I have decided to start testing my program with some simple topologies to see if I can gain any insight into how best to replicate data around a network with many nodes. The next step will be to use those principles and start running more complicated networks to see how the program performs.

3.2 Getting my IP, networking issues

route etc.

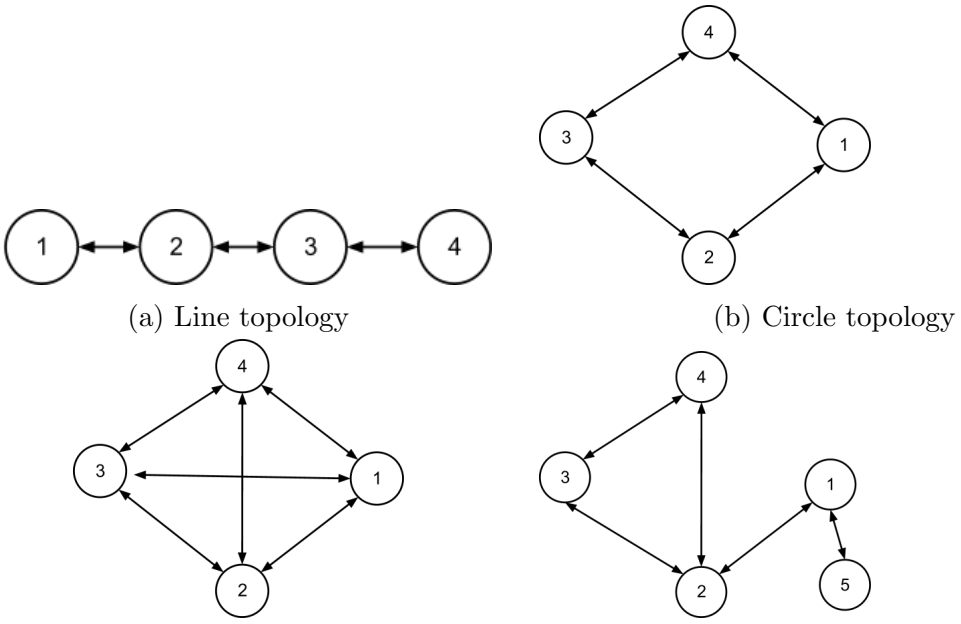
3.3 settings and stored data

stores files sync time, how up to date all graph data could be utilised

3.4 Python

I have chosen to use Python to implement my program. Python appealed to me because it supports many different platforms (Windows, Linux, Mac OS X). This is useful because it means I will (hopefully) encounter fewer compatibility problems when running my program across different operating systems in the future.

[2] www.graphviz.org



(a) Line topology (b) Circle topology

(c) Connected mesh topology (d) Other topology

Figure 2: Simple network topologies

3.5 User control

One of the main goals of my project is to allow the user to have a large amount of control over how the program behaves. I currently have the program reading from configuration files that allow the user to specify which directories they want to watch and where those directories should be synchronised to.

I chose to use directories as my granularity for replication as opposed to files because keeping track of a large list of files may become unwieldy, and because I replicate directories recursively, I can replicate large amounts of data without a cluttered configuration file.

Another reason I chose directories as my granularity was because it may be handy to have a directory full of symlinks pointing to other directories.

4 Monitoring Directories

The application needs to monitor directories for changes so that it knows when to perform a sync. The reason I have chosen to do this is because synchronising a directory that has not been changed is a waste of time and my application is designed to be as efficient as possible. I do not however want to be continually polling the watched directories to see if there have been any changes made. This would be a significant waste of CPU time. Instead I have looked into ways of being notified of a change in the file system below the watched directory.

- Inotify
  - Inotify is a linux kernel feature that has been included in the Linux kernel since version 2.6. It is used to watch directories for changes and notify listeners when a change occurs. Inotify is inode based and replaced dnotify, an older system which provided the same function. Dnotify however was inefficient, it opened up the file descriptors for each directory it was watching which meant the backing device could not be unmounted. It also had a poor user-space interface which uses SIGIO. Inotify only uses one file descriptor and returns events to the listener as they occur [1]. It works well and does what I need it to do. There is a Python module called pyinotify that provides a Python interface to inotify, which I have used and tested in my program. Another reason I chose inotify was because different kinds of changes triggered different inotify events. So I can differentiate between a file being deleted, created or modified *etc.*

- FSEvents
  - FSEvents is an API in MacOS X [2]. It is similar to inotify in that it provides a notification to other applications when a directory is changed however it does not inform you which file in the directory was changed. This does not matter for my application since Unison is smart enough not to copy unchanged files in a directory. There is a Python module for FSEvents, as well.

    I also looked at using the `kqueue` [3] system call that is supported by OS X and FreeBSD. It notifies the user when a kernel event occurs. I decided against using `kqueue` as the high level approach of FSEvents, suits the application's needs.

- ReadDirectoryChangesW
  - Windows, like the other operating systems I have looked up, provides a nice way of doing this too. There is a function called ReadDirectoryChangesW. There is a FileSystemWatcher Class in .NET version 4 and above. IronPython might prove to be a good choice for a Windows implementation. I have chosen only to implement my program on linux because portability wasn't in the main scope of the project. It would have been nice to look at it further but became too time consuming and not interesting from a research perspective.

5 Point-to-Point synchronisation

After some preliminary analysis of the available file synchronisation tools I have found a tool called Unison to be a promising starting base for this project. Unison is an open

source file synchronisation tool. It supports efficient (*i.e.,* it attempts to only send changes between file versions) file synchronisation between two directories (including sub-folders) between two machines (or the same machine).

I decided to run some tests using unison and the network I had set up to determine whether this would make a good base for my program or not.

I looked at three methods of file synchronisation across different networks. Naïve copying; using rsync, an application designed for efficiently copying files in one direction by looking at the differences in the files; and unison described above.

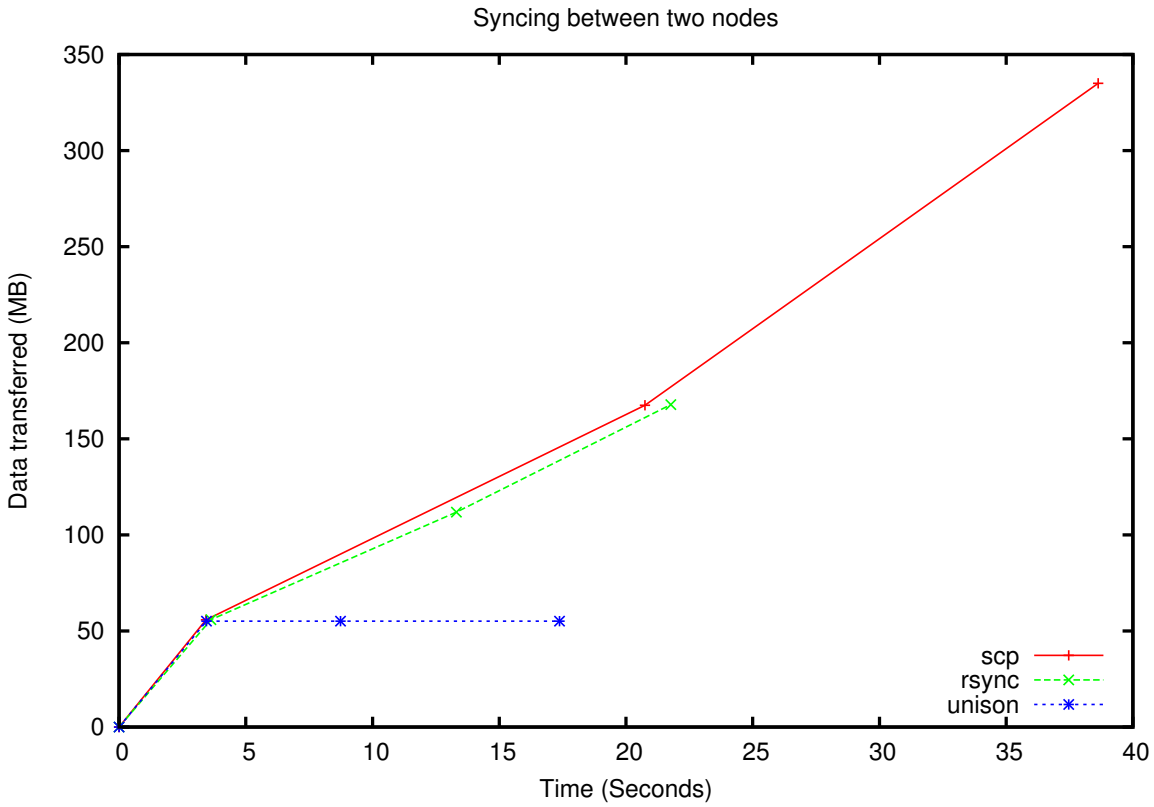


Figure 3: Comparison of SCP, Rsync, Unison, between two nodes

Rsync and unison performed significantly better than the naïve copy method (as expected). After the initial file transfer subsequent edits to the file meant much less data had to be transmitted over the network, which meant the node graph became up to date much more quickly.

The reason naïve copy sent over 300Mb of data to copy three 50Mb files was because my implementation is deliberately naïve, it will copy the entire directory each time it is changed. For rsync and unison this is not a problem because they work based on the differences between the files. However copy doesn't look at the files it just copies everything in the directory tree. Hence it will copy 50Mb after file one is created, 100Mb after the second file is added and finally 150Mb when all three files are present.

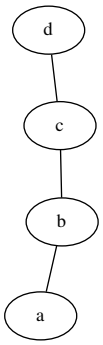
50Mb + 100Mb + 150Mb = 300Mb

Rsync copies the expected 150Mb for three 50Mb files. While Figure 3 illustrates another advantage of unison over rysnc. The graph shows three zero filled binary files being copied from one node to another one after the other. Unison recognised that even though the files were named differently they were the same file. Another advantage of unison is that it handles replication in two directions without clobbering the files on the other side.

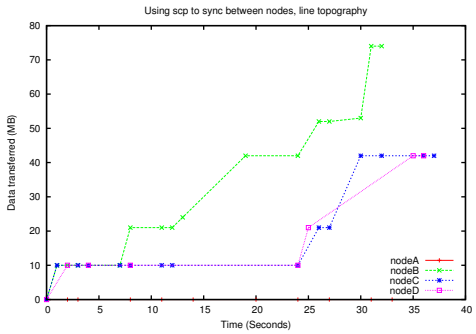
Each of the three methods I trialled had some overhead associated with them. This overhead was due to the ssh tunnel between the machines which all three methods used. Unison and rsync also require some overhead when checking the differences between the files in the directories. This is why the graph shows the three lines slightly above where you might expect them to be for the amount of data that was copied.

6 Full graph replication

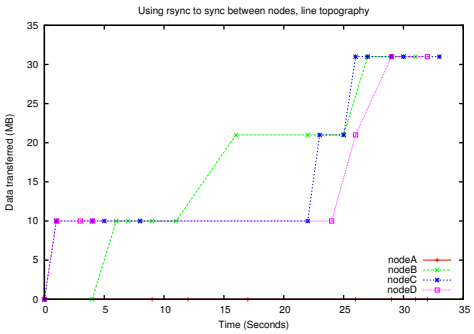
As you can see unison and rsync outperformed scp advantage of unison is two-way sync



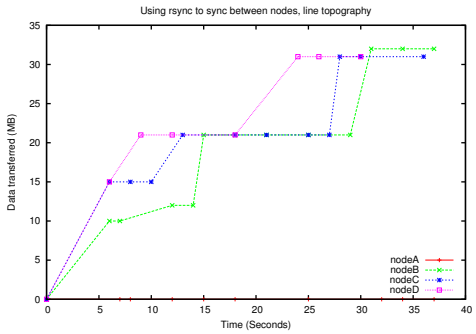
(a) Line - Generated Graph of Topology



(b) SCP



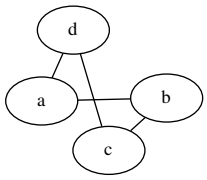
(c) Rsync



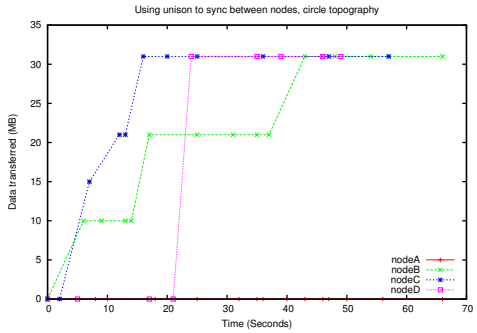
(d) Unison

Figure 4: Comparison of methods over line topology

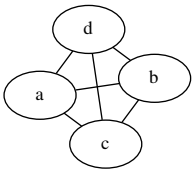
For next graphs I dropped scp as not only is it inferior it is also completely wrong the programs behaviour is undefined for changes coming from two directions.



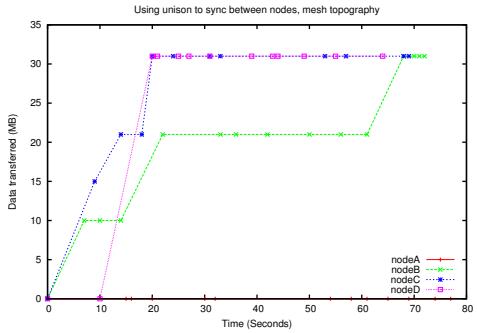
(a) Circle - generated graph of topology



(b) Unison running over circle topology



(c) Mesh - generated graph of topology



(d) Unison running over mesh topology

Figure 5: Comparison of different topologies

7 When to stop copying

After testing my program on some simple topologies one problem became clear. Each node would notice changes had occurred to a folder it was watching and would then try to copy these changes to other nodes that it was connected to. The problem was that if the changes came from one of its neighbour nodes this would cause an infinite loop of two nodes trying to copy changes to each other. This was particularly a problem when using scp to copy. When using Unison this was not as much of a problem because it could detect that no changes had occur between the nodes and would stop syncing after one check (which had minimal overhead).

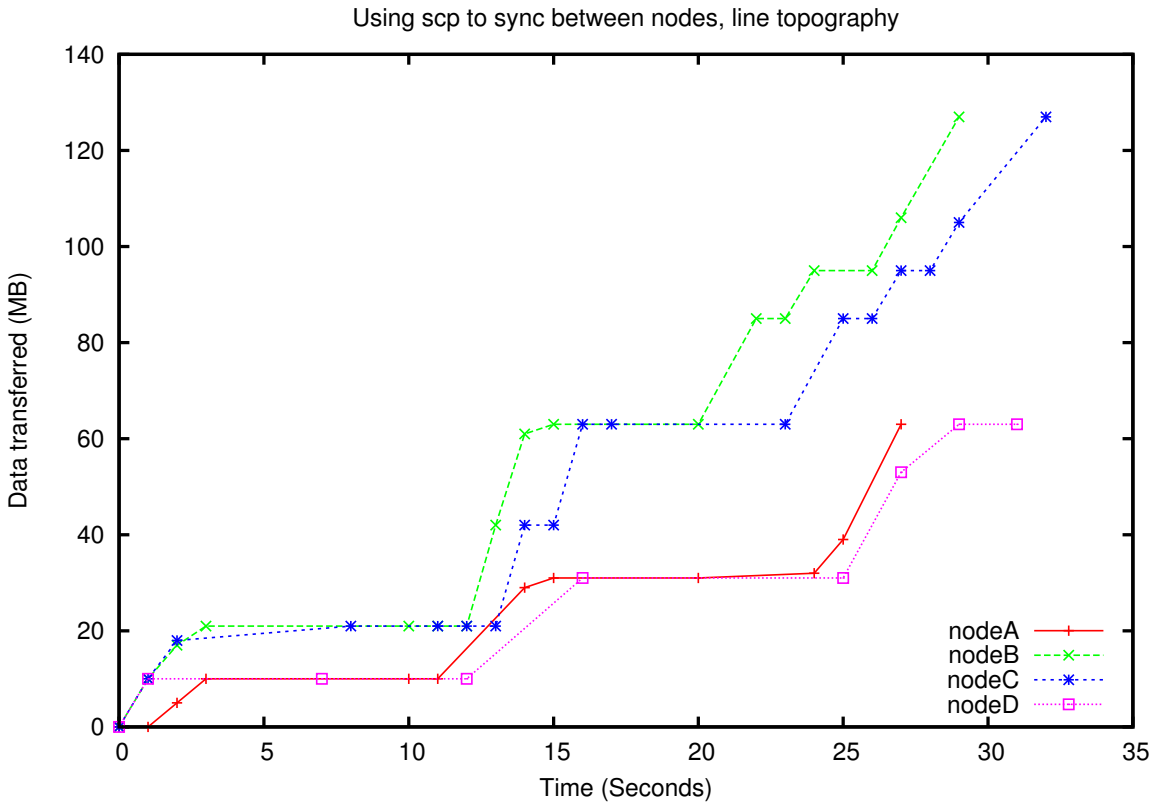


Figure 6: Line topology, using scp, nodes copying data back and forth

Figure 6 shows three 10Mb files being copied to a node in a line topology. The problem is that nodeB and nodeC continue to send data to each other even after every node has all of the files. NodeA receives a lot of data even though it was the source of the file changes.

The data points in figure 7 show that when using unison although no extra data was sent unison had to make checks to see whether there were any changes or not.

I used a configuration file to get around this problem. Each time a node synchronised with another node it would write out a configuration file telling the other node what

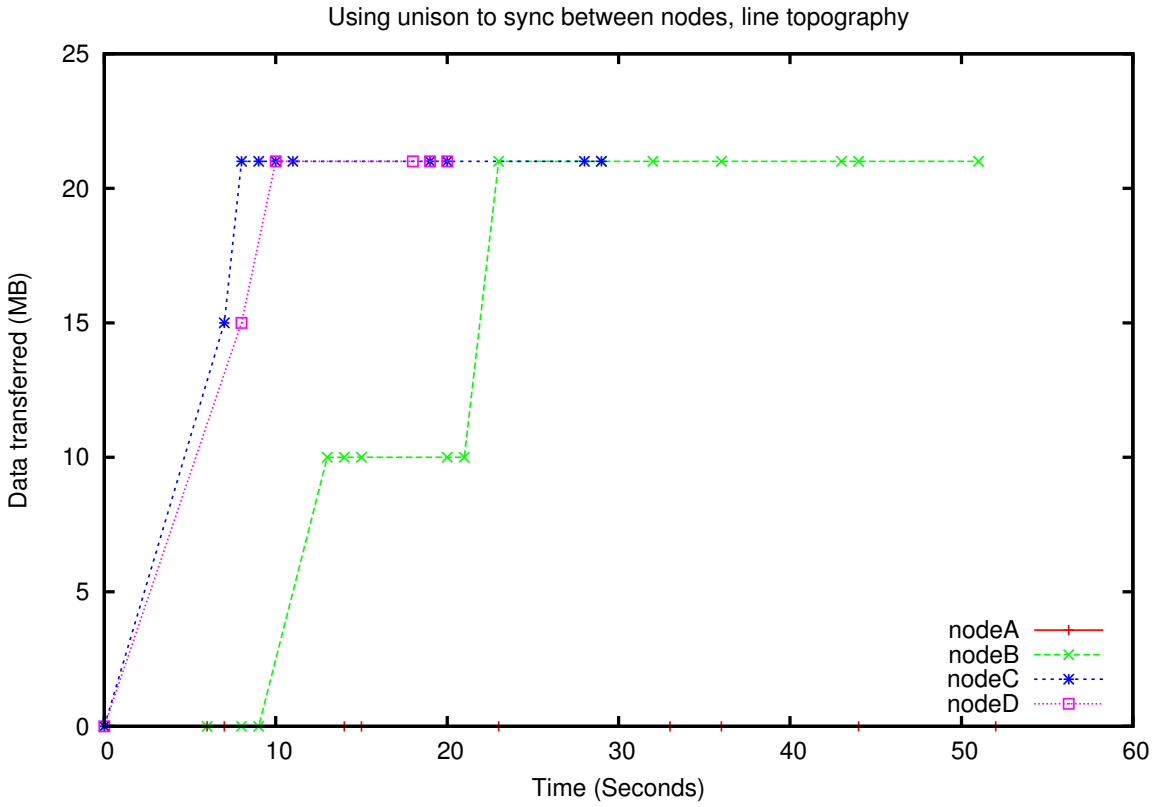


Figure 7: Line topology, using unison, unnecessary checking

files had been copied, who sent them and what the modification time of the files were. In this way a node could check if it was about to synchronise a file back to the node it received the file from or if it had local changes that were newer than a received file it could continue with its sync.

8 Dealing with Sub-nodes

I chose to classify directories as 'sub nodes' of a graph. The reason I choose directories is because they are easy to manage a configuration file of directories to keep in sync (from the users point of view). If we wanted to only synchronize certain files in a directory we could write a unison configuration file with exclusions/inclusions in it. The other reason directories are a good choice is because I can have different directories in different places on different file systems by using symbolic links. I wanted to see how the freshness of different sub-nodes varied between nodes when the program was running.

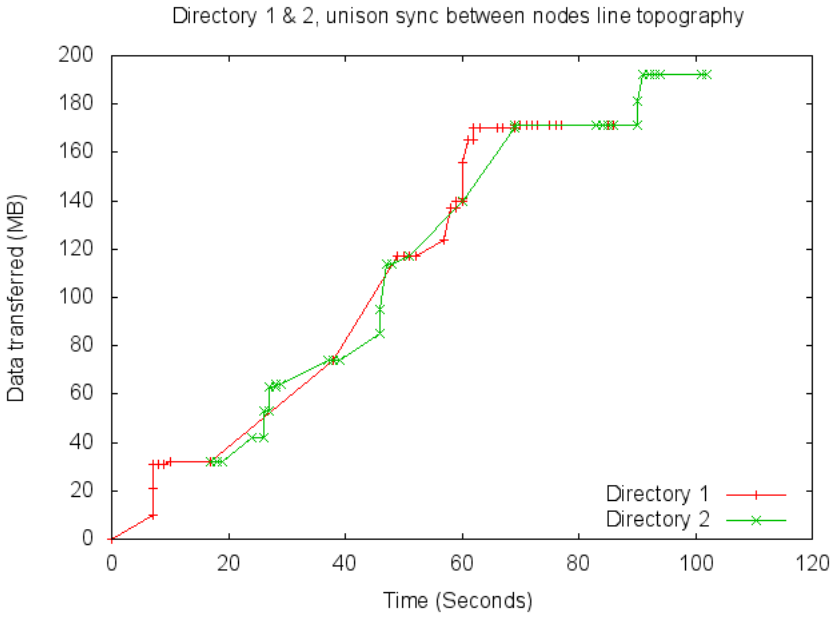
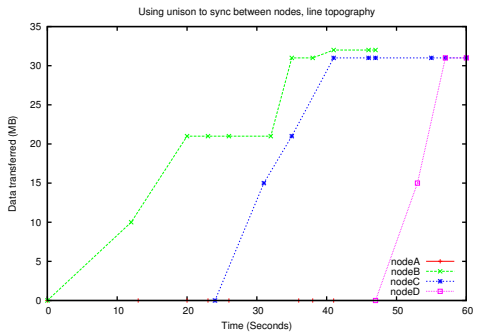


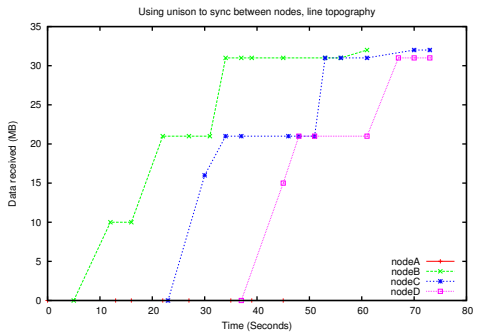
Figure 8: Line topology, using unison, two different directories being synced

9 How often to sync

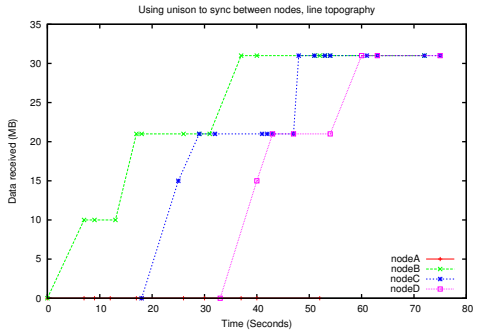
So how often should I sync once I noticed a change. If lots of small changes are occurring frequently it might be more efficient to perform a synchronisation after several changes have occurred. Given that there is overhead with each synchronisation, fewer copies means less data sent over the network.



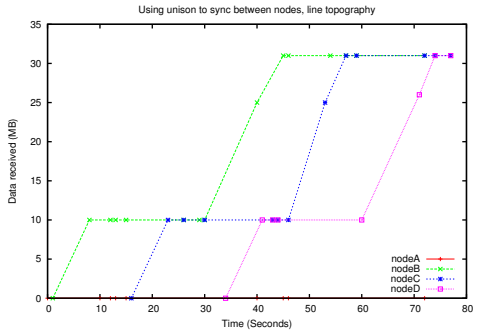
(a) 5 second sync



(b) 10 second sync



(c) 20 second sync



(d) 30 seconds sync

Figure 9: Comparison how frequently to sync

As you can see in figure when using unison it is best to just sync as often as possible. This is because unison only sends the difference between files and the network overhead associated with synchronising is negligible when dealing with large files.

SCP showed a noticeable difference however...?

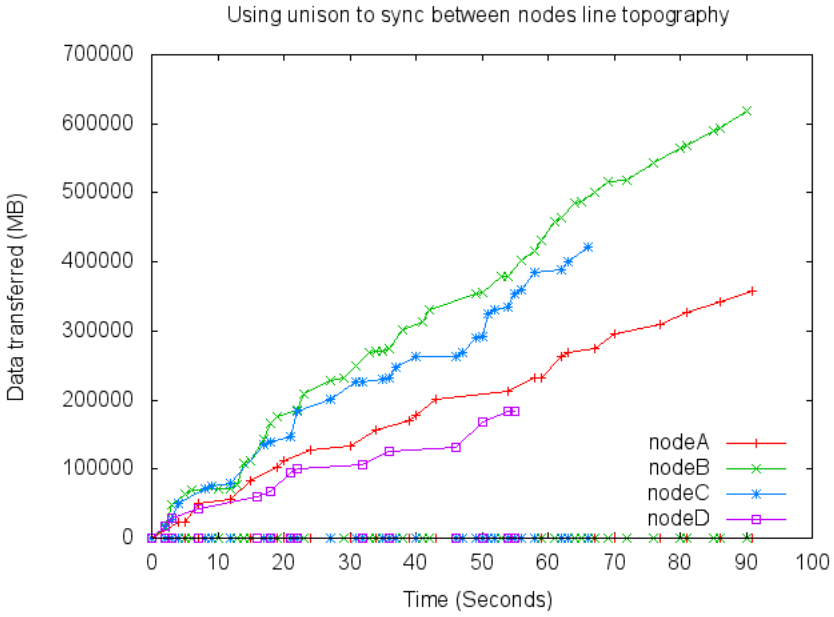


Figure 10: 2 seconds sleep text file

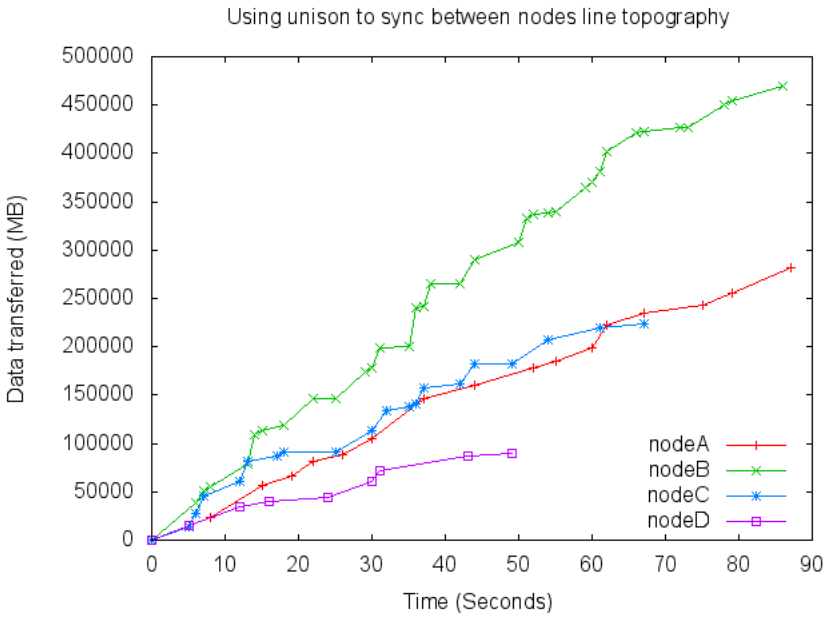


Figure 11: 5 seconds sleep text file

10 Unison and temporary files

I noticed that when Unison ran it created temporary files in the directory and once these files had been fully copied it renamed them to their intended name. The problem with this was that my program was picking up these temporary files as they were created and trying to copy them to the next node, only to find that these files no longer existed. To get around this problem I decided to implement a filter on the files to be copied. The program filters out files that contain ".tmp" in the filename. Unison is not the only program that uses temporary files. I decided that this should be a user set preference given that users may want to filter out different files.

My program simply reads from a file with each file pattern to exclude listed on a new line. It is easy to add to/remove from. As I said above I added .tmp to the file as a default. This could easily be extended to allow a user to omit certain files from the replication by adding all files in my programs ignore file to unisons ignore list. Or conversely by maintaining a white list of files to sync. This would allow for greater granularity when syncing nodes.

11 Wi-Fi vs 3G

Circle topology start at node A, node B is on Wi-Fi and node C is on 3G. Results and discussion to come.

12 Mobile Nodes

13 Feedback

14 Results

15 Conclusion

My program does better than naïve copying, works in a variety of situations allows for fine grained user control.

References

[1] www.kernel.org/pub/linux/kernel/people/rml/inotify/README, 22 September 2004.

[2] Apple Inc. `https://developer.apple.com/library/mac/#documentation/Darwin/Conceptual/FSEvents_ProgGuide/Introduction/Introduction.html`, 11 October 2011.

[3] Apple Inc. http://developer.apple.com/library/mac/#documentation/Darwin/Reference/ManPages/man2/kqueue.2.html

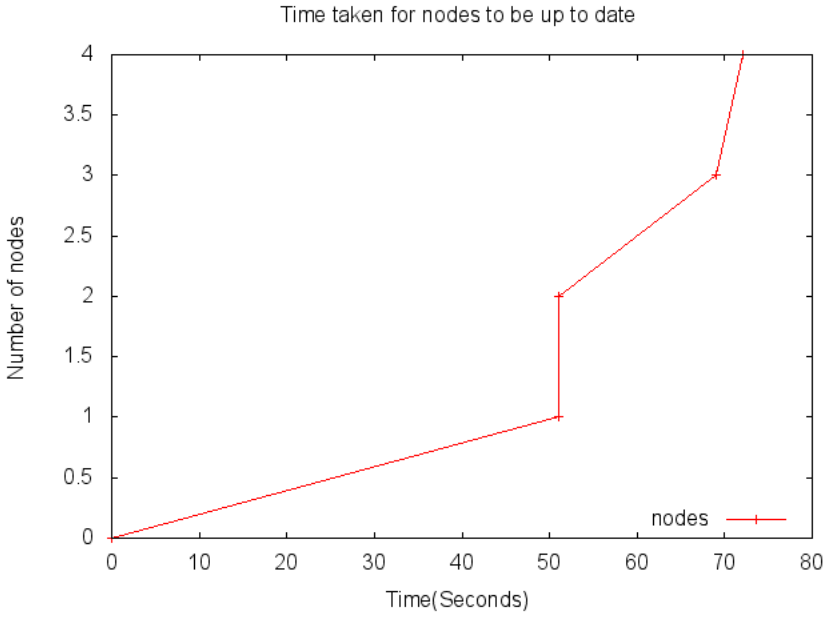


Figure 12: Unison, line, finishing times

A WatchAndSync.py

```
1  import pyinotify, os, subprocess, argparse, socket, time, glob
       , datetime
2  import readnet
3
4  wm = pyinotify.WatchManager()
5  watchedfolders = {}
6  homepath = "/home/cal/Documents/Private-Sync/"
7  #homepath = "/Users/calum/Documents/Private-Sync/"
8
9  parser = argparse.ArgumentParser()
10 parser.add_argument("-c","--scp",action="store_true",help="
       Copy using scp")
11 parser.add_argument("-r","--rsync",action="store_true",help="
       Copy using rsync")
12 args = parser.parse_args()
13
```

```
14 class Tools():
15     def updateFolderInfo(self, wfolds):
16         f = open('./folders.dat','w')
17         for fold in wfolds:
18             f.write(fold + " ")
19             for i in range(0,len(wfolds[fold])-1):
20                 f.write(wfolds[fold][i] + " ")
21             f.write(wfolds[fold][len(wfolds[fold])-1] + "\n")
22         f.close()
23 
24     def timeElapsed(self, dtstamp, diff):
25         if diff == "*":
26             print "Sync ASAP"
27             return
28         diff = int(diff)
29         FMT = '%Y-%m-%d %H:%M:%S.%f'
30         #FMT = '%Y-%m-%d %H:%M:%S'
31         tdelta = datetime.datetime.now() - datetime.datetime.
               strptime(dtstamp, FMT)
32         print  tdelta.total_seconds()
33         timeDiff = tdelta.total_seconds()
34         if (timeDiff >= diff):
35             print "Time period reached"
36         else:
37             print "Time not elapsed, sleeping for " + str(diff
                   - timeDiff + 1)
38             time.sleep(int(diff - timeDiff + 1))
39 
40 class MyEventHandler(pyinotify.ProcessEvent):
41     def flipIP(self,ip):
42         octets = ip.split(".")
43         if(octets[3] == "1"):
44             octets[3] = "2"
45         elif(octets[3] == "2"):
46             octets[3] = "1"
47         else:
48             octets[3] = "1"
49         return ".".join(octets)
50 
51     #Get the last modified time of a file
52     def getModTime(self,path):
53         try:
54             return time.ctime(os.path.getmtime(path))
```

```
55          except Exception, e:
56              return ""
57
58      #Deprecated - Check for IP not to copy too
59      def getStopInfo(self):
60          stopIP = ["",""]
61          try:
62              o = open("./stop",'r')
63              stopIP = o.read().split()
64              o.close()
65          except IOError, e:
66              pass
67          return stopIP
68
69      def inStopFile(self,ip,path):
70          stopIPs = {}
71          stop = False
72          modTime = self.getModTime(path)
73          while True:
74              tmpcount = 0
75              print "Files found: " + str(glob.glob("Stop-*"))
76              for files in glob.glob("Stop-*"):
77                  #print "File: " + str(files)
78                  if ".tmp" in files:
79                      tmpcount += 1
80                      time.sleep(5)
81                      break
82                  f = open(files,"r");
83                  for line in f:
84                      l = line.split()
85                      if self.exclusions(l[1]):
86                          print str(l[1]) + " was in ignore file
                               skipping"
87                      else:
88                          print "local " + str(path) + " modtime
                               : " + modTime
89                          print "Stop " + l[1] + " modtime: " +
                               str(l[2:])
90                          ts1 = time.strptime(modTime,"%a %b %d
                               %H:%M:%S %Y")
91                          ts2 = time.strptime(" ".join(l[2:]),"%
                               a %b %d %H:%M:%S %Y")
```

```
92                          print "local <= stop: " + str(ts1 <=
                                ts2)
93                          #if l[0] == ip and l[1] == path and
                                ts1 <= ts2:
94                          #If IP sending to has sent data more
                                recently don't send back
95                          if l[0] == ip and ts1 <= ts2:
96                              print "Stop = True, file: " + l[0]
97                              stop = True
98                          else:
99                              stopIPs[l[0]] = [l[1]," ".join(l
                                    [2:])]
100
101                 if stop:
102                     f.close()
103                     #f = open(files,"w")
104                     #for k in stopIPs.keys():
105                     #    f.write(k + " " + stopIPs[k][0] + " "
                            + stopIPs[k][1] + "\n")
106                     #f.close()
107                     #stopIPs.clear()
108                     return True
109
110                 f.close()
111                 #stopIPs.clear()
112             if tmpcount == 0:
113                 break
114
115         return False
116
117     #Set flag on other server telling it not to immediately
            try and copy data here
118     def setStopFileUniq(self,ip,myIP,path,folder):
119         nodename = self.getNodeName()
120         #print "ssh",ip,"echo " + myIP + " " + path + " " +
                self.getModTime(path) + " >> " + homepath + "Stop-"
                + nodename + ".tmp;"
121         #subprocess.call(["ssh",ip,"echo " + myIP + " " + path
                + " " + self.getModTime(path) + " >> " + homepath +
                "Stop-" + nodename + ".tmp;"])
122         subprocess.call(["ssh",ip,"rm " + homepath + "Stop-" +
                nodename + ".tmp;"])
123         for cpFile in glob.glob(folder + "/*"):
```

```
124             subprocess.call(["ssh",ip,"echo " + myIP + " " +
                    cpFile + " " + self.getModTime(cpFile) + " >> "
                    + homepath + "Stop-" + nodename + ".tmp;"])
125
126     #Sets the config files on the remote node
127     def beginCopy(self, ip):
128         nodename = self.getNodeName()
129         print "ssh",ip,"touch " + homepath + "Stop-" +
                nodename + ".tmp; mv " + homepath + "Stop-" +
                nodename + " " + homepath + "Stop-" + nodename + ".
                tmp;"
130         subprocess.call(["ssh",ip,"touch " + homepath + "Stop-
                " + nodename + ".tmp; mv " + homepath + "Stop-" +
                nodename + " " + homepath + "Stop-" + nodename + ".
                tmp;"])
131
132     #Moves the Stop files back into place
133     def endCopy(self, ip):
134         nodename = self.getNodeName()
135         print "ssh",ip,"mv " + homepath + "Stop-" + nodename +
                ".tmp " + homepath + "Stop-" + nodename
136         subprocess.call(["ssh",ip,"mv " + homepath + "Stop-" +
                nodename + ".tmp " + homepath + "Stop-" + nodename
                ])
137
138     #Get node name from whoami file
139     def getNodeName(self):
140         w = open(homepath + "whoami","r")
141         nodename = w.read()
142         nodename = nodename[0].upper()
143         w.close()
144         return nodename
145
146     #Deprecated stop file
147     def setStopFile(self,ip,myIP,path):
148         subprocess.call(["ssh",ip,"echo " + myIP + " " + path
                + " > " + homepath + "stop"])
149         print "ssh",ip,"echo " + myIP + " > " + homepath + "
                stop"
150
151     def rmTree(self,path):
152         subprocess.call(["ssh",ip,"rm -r '" + path + "'"])
153         print "ssh",ip,"rm -r '" + path + "'"
```

```
154
155     #Exclude files matching patterns in the ignore file
156     def exclusions(self, path):
157         try:
158             f = open("./ignore",'r')
159             for line in f:
160                 if line.rstrip() in path:
161                     #print "Ignoring: " + path
162                     return True
163             f.close()
164         except error, e:
165             print e
166         return False
167
168     def initFileSync(self,event):
169         if self.exclusions(event.pathname):
170             #print "Excluded returning"
171             return
172         pathparts = event.pathname.split("/")
173         foldName = "/".join(pathparts[0:len(pathparts)-1])
174         print "Removing watch on: " + foldName
175         wm.rm_watch(wm.get_wd(foldName), rec=True)
176         self.fileSync(event)
177         print "Putting watch back on: " + foldName
178         wm.add_watch(foldName.rstrip(),pyinotify.ALL_EVENTS,
                rec=True, auto_add=True)
179
180     #Sync files
181     def fileSync(self,event):
182         t = Tools()
183         if os.path.isdir(event.pathname):
184             print "Watching: ",event.pathname
185         for folder in watchedfolders.keys():
186             print "For each folder: " + str(folder) + " in
                    watchedfolder keys"
187             if folder in event.pathname:
188                 for i in range(0, len(watchedfolders[folder])
                        ,4):
189                     ip = watchedfolders[folder][i]
190                     path = watchedfolders[folder][i+1]
191                     waitTime = watchedfolders[folder][i+2]
192                     lastTime = watchedfolders[folder][i+3]
```

```
193                 print "Wait: " + str(waitTime) + " Last: "
                        + str(lastTime)
194                 print "Current ip and path: " + ip + " " +
                        path
195                 readnet.logIPtraffic(ip, event.pathname)
196                 myIP = readnet.getMyIP(ip)
197                 subprocess.call(["ssh",ip,"/usr/bin/python
                        " + homepath + "readnet.py -i " + myIP
                        + " -f " + event.pathname])
198                 print "ssh",ip,"'/usr/bin/python " +
                        homepath + "readnet.py -i " + myIP + " -
                        f " + event.pathname + "'"
199                 fparts = folder.split("/")
200                 fname = fparts[len(fparts)-1]
201                 #stopIP = self.getStopInfo()
202                 #print "STOP: " + stopIP[0] + " " + stopIP
                        [1]
203                 #if stopIP[0] == ip and stopIP[1] == event
                        .pathname:
204                 if self.inStopFile(ip,event.pathname):
205                     print "STOPPED to " + ip + " " + path
206                     #os.remove("./stop");
207                 else:
208                     print "CONTINUE"
209                     t.timeElapsed(lastTime, waitTime)
210                     watchedfolders[folder][i+3] = str(
                            datetime.datetime.now())
211                     t.updateFolderInfo(watchedfolders)
212                     self.beginCopy(ip)
213                     if args.scp:
214                         #print "SCP: For cpFile in " +
                                folder
215                         for cpFile in glob.glob(folder + "
                                /*"):
216                             #print "SCP GLOB:" + cpFile
217                             print "scp","-rp",cpFile,ip +
                                    ":" + cpFile + ".tmp"
218                             subprocess.call(["scp","-rp",
                                    cpFile,ip + ":" + cpFile + "
                                    .tmp"])
219                             #subprocess.call(["ssh",ip,"
                                    yes y | find /tmp/" + fname
                                    + " -type f -exec cp -p {} "
```

```
                                    + path + fname + "/ \; rm /
                                    tmp/" + fname])
220                                 print "ssh",ip,"mv " + cpFile
                                        + ".tmp " + cpFile
221                                 subprocess.call(["ssh",ip,"mv
                                        " + cpFile + ".tmp " +
                                        cpFile])
222                                 print "END SCP GLOB"
223                             elif args.rsync:
224                                 print "rsync","-rt",folder,ip + ":
                                        " + path
225                                 subprocess.call(["rsync","-rt",
                                        folder,ip + ":" + path])
226                             else:
227                                 time.sleep(5)
228                                 print "unison","-batch","-
                                        confirmbigdel=false","-times",
                                        folder,"ssh://" + ip + "/" +
                                        path + fname
229                                 subprocess.call(["unison","-batch"
                                        ,"-confirmbigdel=false","-times"
                                        ,folder,"ssh://" + ip + "/" +
                                        path + fname])
230                             print "Set stop files uniq: " + event.
                                    pathname
231                             self.setStopFileUniq(ip,myIP,event.
                                    pathname,folder)
232                             self.endCopy(ip)
233                         subprocess.call(["ssh",ip,"/usr/bin/python
                                " + homepath + "readnet.py -i " + myIP
                                + " -f " + event.pathname])
234                         readnet.logIPtraffic(ip, event.pathname)
235
236     #def process_IN_CREATE(self, event):
237     #    print "Create:", event.pathname
238     def process_IN_DELETE(self, event):
239         print "Delete: ",event.pathname
240         #self.initFileSync(event)
241     def process_IN_CREATE(self, event):
242         print "CREATE: ",event.pathname
243         self.initFileSync(event)
244     def process_IN_MOVED_FROM(self, event):
245         print "Move from: ",event.pathname
```

```
246         #     self.initFileSync(event)
247         def process_IN_MODIFY(self, event):
248             #print "Modify: ", event.pathname
249             self.initFileSync(event)
250         def process_IN_MOVED_TO(self, event):
251             print "Move to: ", event.pathname
252             self.initFileSync(event)
253 
254 
255 def main():
256     t = Tools()
257     f = open('./folderstowatch','r')
258 
259     for folder in f:
260         if(folder[0] == '#'):
261             pass
262         else:
263             info = folder.split()
264             wm.add_watch(info[0].rstrip(),pyinotify.ALL_EVENTS
                , rec=True, auto_add=True)
265             print "Watching: ", info[0].rstrip()
266             if info[0] not in watchedfolders.keys():
267                 watchedfolders[info[0].rstrip()] = []
268             watchedfolders[info[0].rstrip()].append(info[1])
269             watchedfolders[info[0].rstrip()].append(info[2])
270             watchedfolders[info[0].rstrip()].append(info[3])
271             watchedfolders[info[0].rstrip()].append(str(
                datetime.datetime.now()))
272     f.close()
273 
274     try:
275         f = open('./folders.dat','r')
276         for folder in f:
277             if(folder[0] == '#'):
278                 pass
279             else:
280                 info = folder.split()
281                 if info[0] in watchedfolders.keys():
282                     del watchedfolders[info[0].rstrip()]
283                     #wm.add_watch(info[0].rstrip(),pyinotify.
                        ALL_EVENTS, rec=True, auto_add=True)
284                     #print "Watching: ", info[0].rstrip()
285                     if info[0] not in watchedfolders.keys():
```

```
286                             watchedfolders[info[0].rstrip()] = []
287                         watchedfolders[info[0].rstrip()].append(
                                info[1])
288                         watchedfolders[info[0].rstrip()].append(
                                info[2])
289                         watchedfolders[info[0].rstrip()].append(
                                info[3])
290                         watchedfolders[info[0].rstrip()].append(
                                str(datetime.datetime.now()))
291                 else:
292                     print "Removing: " + info[0]
293         f.close()
294     except IOError, e:
295         print "Folders.dat does not exist, skipping"
296 
297     t.updateFolderInfo(watchedfolders)
298 
299     #print watchedfolders
300     eh = MyEventHandler()
301 
302     notifier = pyinotify.Notifier(wm, eh)
303     notifier.loop()
304 
305 if __name__ == '__main__':
306     main()
```

B ReadNet.py

```
1  import subprocess, datetime, socket, argparse
2  
3  homepath = "/home/cal/Documents/Private-Sync/"
4  #homepath = "/Users/calum/Documents/Private-Sync/"
5  
6  parser = argparse.ArgumentParser()
7  parser.add_argument('-i',action="store",dest='ip',help='IP 
       address to record for')
8  parser.add_argument('-f',action="store",dest='fold',help='
       Folder to record for')
9  
10 interfacenames = []
11 
12 w = open(homepath + "whoami","r")
13 nodename = w.read()
```

```
14 nodename = nodename[0]
15 w.close()
16
17 #Get my ip corresponding to the interface with ipaddr
18 def getMyIP(ipaddr):
19     route = subprocess.check_output("ip route get " + ipaddr,
       shell=True)
20     words = route.split()
21     interface = ""
22     for word in words:
23         if word.startswith("eth"):
24             interface = word
25             #print interface
26             break
27     ifconf = subprocess.check_output("ifconfig " + interface,
       shell=True)
28     words = ifconf.split()
29     now = False
30     for word in words:
31         if word == "inet":
32             now = True
33         elif now:
34             word = word.split(":")
35             #print word[1]
36             return word[1]
37
38 #Log interface coresponding to ipaddr
39 def logIPtraffic(ipaddr, folder):
40     route = subprocess.check_output("ip route get " + ipaddr,
       shell=True)
41     words = route.split()
42     interface = ""
43     for word in words:
44         if word.startswith("eth"):
45             interface = word
46             #print interface
47             break
48     writeIface(interface, folder)
49
50 def writeIface(iface, folder):
51     ifs = subprocess.check_output("ifconfig -s",shell=True)
52     ilines = ifs.split("\n")
53     for i in range(1,len(ilines)-1):
```

```
54          interfacenames.append(ilines[i].split()[0])
55      output = subprocess.check_output("ifconfig",shell=True)
56      splitput = output.split()
57      interface = False
58      interfacename = ""
59      nex = ""
60      count = 0
61      upload = 0
62      download = 0
63      for split in splitput:
64          if split in interfacenames:
65              interface = True
66              interfacename = split
67              #print interfacename
68          if(nex != ""):
69              sp = split.split(":")
70              if(sp[0] == "bytes"):
71                  if(nex == "RX"):
72                      download = int(sp[1])
73                  else:
74                      upload = int(sp[1])
75                  nex = ""
76                  count += 1
77                  if(count == 2):
78                      interface = False
79                      if interfacename == iface:
80                          f = open(homepath + "log/" \
81                          + "node" + nodename.upper() + "-" \
82                          + iface + ".log",'a')
83                          f.write("#D " + folder + "\n")
84                          f.write(str(datetime.datetime.now()) +
                                " " + interfacename + " download: "
                                + str(download) + " upload: " + str
                               (upload) + "\n")
85                          f.close()
86                      count = 0
87          elif(interface):
88              if(split == "RX" or split == "TX"):
89                  nex = split
90
91  #Log all interfaces
92  def main():
93      ifs = subprocess.check_output("ifconfig -s",shell=True)
```

```
94      ilines = ifs.split("\n")
95      for i in range(1,len(ilines)-1):
96          interfacenames.append(ilines[i].split()[0])
97      output = subprocess.check_output("ifconfig",shell=True)
98      splitput = output.split()
99      interface = False
100     interfacename = ""
101     nex = ""
102     count = 0
103     upload = 0
104     download = 0
105     for split in splitput:
106         if split in interfacenames:
107             interface = True
108             interfacename = split
109             #print interfacename
110         if(nex != ""):
111             sp = split.split(":")
112             if(sp[0] == "bytes"):
113                 if(nex == "RX"):
114                     download = int(sp[1])
115                 else:
116                     upload = int(sp[1])
117                 nex = ""
118                 count += 1
119                 if(count == 2):
120                     interface = False
121                     f = open(homepath + "log/" \
122                     + str(socket.gethostname()) + "-" \
123                     + interfacename + ".log",'a')
124                     f.write(str(datetime.datetime.now()) + "␣"
                            + interfacename + "␣download:␣" + str(
                            download) + "␣upload:␣" + str(upload) +
                            "\n")
125                     f.close()
126                     count = 0
127         elif(interface):
128             if(split == "RX" or split == "TX"):
129                 nex = split
130
131 if __name__ == "__main__":
132     args = parser.parse_args()
133     if args.ip != None:
```

```
134             logIPtraffic(args.ip, args.fold)
135             #getMyIP(args.ip)
136         else:
137             pass
138             main()
```

C onTheFly.sh

```
1  vm_name_arr=("Ubuntu-Pool" "Ubuntu-Silence" "Ubuntu-Wild" "
       Ubuntu-Spheros")
2  vm_addr_arr=("192.168.0.28" "192.168.0.27" "192.168.0.19" "
       192.168.0.14")
3  intnetarr=("lion" "tiger" "cat" "dog" "fish" "kiwi")
4  #These should all be in one big dictionary apart from inet
       names
5  letterarr=("a" "b" "c" "d" "e" "f" "g")
6  ifcountarr=(2 2 2 2 2 2 2 2 2)
7  ethcountarr=(1 1 1 1 1 1 1 1 1)
8  incount=1
9  bigncount=2
10 littlencount=1
11 folderpath="/home/cal/Documents/t03"
12 folderpath2="/home/cal/Documents/t02"
13 homepath="/home/cal/Documents/Private-Sync/"
14 waitTime=10
15
16 function clear_ifaces() {
17     i=0
18     while [ "$i" -lt "${#vm_name_arr[@]}" ]; do
19         VBoxManage modifyvm ${vm_name_arr[$i]} --nic2 none
20         echo "VBoxManage modifyvm ${vm_name_arr[$i]} --nic2
               none"
21         VBoxManage modifyvm ${vm_name_arr[$i]} --nic3 none
22         echo "VBoxManage modifyvm ${vm_name_arr[$i]} --nic3
               none"
23         VBoxManage modifyvm ${vm_name_arr[$i]} --nic4 none
24         echo "VBoxManage modifyvm ${vm_name_arr[$i]} --nic4
               none"
25         let "i++"
26     done
27 }
28
29 function clear_watched_folders() {
```

```
30      i=0
31      while [ "$i" -lt "${#vm_addr_arr[@]}" ]; do
32          ssh cal@${vm_addr_arr[$i]} "echo \"#Local folder path
               to watch, host to copy to, remote dir to copy to,
               min time between syncs\" > /home/cal/Documents/
               Private-Sync/folderstowatch; echo ${letterarr[$i]} >
                /home/cal/Documents/Private-Sync/whoami"
33          let "i++"
34      done
35  }
36
37  function git_pull() {
38      i=0
39      while [ "$i" -lt "${#vm_addr_arr[@]}" ]; do
40          echo "ssh cal@${vm_addr_arr[$i]} \"cd /home/cal/
               Documents/Private-Sync; git pull origin master\""
41          ssh cal@${vm_addr_arr[$i]} "cd /home/cal/Documents/
               Private-Sync; git pull origin master"
42          let "i++"
43      done
44  }
45
46  function search_letters() {
47      index=0
48      while [ "$index" -lt "${#letterarr[@]}" ]; do
49          if [ "${letterarr[$index]}" = "$1" ]; then
50              echo $index
51              return
52          fi
53          let "index++"
54      done
55      echo "None"
56  }
57
58  function vbmMOD {
59      echo "VBoxManage modifyvm $1 --nic$3 intnet"
60      VBoxManage modifyvm $1 --nic$3 intnet
61      echo "VBoxManage modifyvm $1 --intnet$3 $2"
62      VBoxManage modifyvm $1 --intnet$3 $2
63  }
64
65  function gatherLogs {
66      index=0
```

```
67      while [ "$index" -lt "${#vm_addr_arr[@]}" ]; do
68          echo "scp cal@${vm_addr_arr[$index]}:/home/cal/
               Documents/Private-Sync/log/* ../logs/"
69          scp cal@${vm_addr_arr[$index]}:/home/cal/Documents/
               Private-Sync/log/* ../logs/
70          let "index++"
71      done
72  }
73
74  function clean {
75      index=0
76      while [ "$index" -lt "${#vm_addr_arr[@]}" ]; do
77          echo "ssh cal@${vm_addr_arr[$index]} \"rm ${homepath}
               log/*; rm ${homepath}Stop-*; rm ${homepath}folders.
               dat\""
78          ssh cal@${vm_addr_arr[$index]} "rm ${homepath}log/*;
               rm ${homepath}Stop-*; rm ${homepath}folders.dat"
79          let "index++"
80      done
81  }
82
83  function cleanFold {
84      index=0
85      while [ "$index" -lt "${#vm_addr_arr[@]}" ]; do
86          echo "ssh cal@${vm_addr_arr[$index]} \"rm -rf ${
               folderpath}/*;\""
87          ssh cal@${vm_addr_arr[$index]} "rm -rf ${folderpath
               }/*;"
88          let "index++"
89      done
90  }
91
92  function sendKeys {
93      index=0
94      while [ "$index" -lt "${#vm_addr_arr[@]}" ]; do
95          #ssh cal@${vm_addr_arr[$index]} "rm /home/cal/.ssh/
               authorized_keys"
96          for file in /Users/calum/.ssh/*.pub; do
97              #echo "$file"
98              echo "cat $file | ssh cal@${vm_addr_arr[$index]} \
                   "cat >> /home/cal/.ssh/authorized_keys\""
99              cat $file | ssh cal@${vm_addr_arr[$index]} "cat >>
                   /home/cal/.ssh/authorized_keys"
```

```
100             done
101             let "index++"
102         done
103         #for file in /Users/calum/.ssh/*.pub; do
104         #    echo "$file"
105         #    cat $file | ssh cal@192.168.0.17 "cat >> /home/cal/.
                ssh/testfile"
106         #    echo "cat $file | ssh cal@192.168.0.17 \"cat >> /home
                /cal/.ssh/testfile\""
107         #done
108     }
109
110     function ifconf {
111         echo "ssh cal@$1 'sudo /sbin/ifconfig eth$2 192.168.$3.$4
                netmask 255.255.255.0 up; echo \"$folderpath 192.168.$3.
                $5 /home/cal/Documents/ $waitTime\" >> /home/cal/
                Documents/Private-Sync/folderstowatch'"
112         ssh cal@$1 "sudo /sbin/ifconfig eth$2 192.168.$3.$4
                netmask 255.255.255.0 up; echo \"$folderpath 192.168.$3.
                $5 /home/cal/Documents/ $waitTime\" >> /home/cal/
                Documents/Private-Sync/folderstowatch" < /dev/null
113     }
114
115     function ifconf2 {
116         echo "ssh cal@$1 \"sudo /sbin/ifconfig eth$2 192.168.$3.$4
                netmask 255.255.255.0 up; echo \"$folderpath 192.168.$3
                .$5 /home/cal/Documents/ *\" >> /home/cal/Documents/
                Private-Sync/folderstowatch; echo \"$folderpath2
                192.168.$3.$5 /home/cal/Documents/ *\" >> /home/cal/
                Documents/Private-Sync/folderstowatch\" < /dev/null"
117         ssh cal@$1 "sudo /sbin/ifconfig eth$2 192.168.$3.$4
                netmask 255.255.255.0 up; echo \"$folderpath 192.168.$3.
                $5 /home/cal/Documents/ *\" >> /home/cal/Documents/
                Private-Sync/folderstowatch; echo \"$folderpath2
                192.168.$3.$5 /home/cal/Documents/ *\" >> /home/cal/
                Documents/Private-Sync/folderstowatch" < /dev/null
118     }
119
120     if [ $2 == "vm" ]; then
121         clear_ifaces
122
123         while read line
124         do
```

```
125         first=$(echo "$line" | awk '{print $1}')
126         last=$(echo "$line" | awk '{print $(NF)}' | sed 's
                /[;]//g')
127         #echo "$first and $last"
128         index=$(search_letters $first)
129         if [ "$index" = "None" ]; then
130             #echo "None"
131             :
132         else
133             vbmMOD ${vm_name_arr[$index]} ${intnetarr[$incount
                    ]} ${ifcountarr[$index]}
134             #echo "in: $index"
135             (( ifcountarr[$index]++ ))
136             index=$(search_letters $last)
137             vbmMOD ${vm_name_arr[$index]} ${intnetarr[$incount
                    ]} ${ifcountarr[$index]}
138             #echo "in: $index"
139             (( ifcountarr[$index]++ ))
140             incount=$incount+1
141         fi
142     done <graphs/$1
143 elif [ $2 == "if" ]; then
144     clear_watched_folders
145
146     while read line
147     do
148         first=$(echo "$line" | awk '{print $1}')
149         last=$(echo "$line" | awk '{print $(NF)}' | sed 's
                /[;]//g')
150         echo "$first and $last"
151         index=$(search_letters $first)
152         if [ "$index" = "None" ]; then
153             #echo "None"
154             :
155         else
156             ifconf ${vm_addr_arr[$index]} ${ethcountarr[$index
                    ]} $bigncount $littlencount $(( $littlencount+1
                    ))
157             #echo "in: $index"
158             (( ethcountarr[$index]++ ))
159             (( littlencount++ ))
160             index=$(search_letters $last)
```

```
161             ifconf ${vm_addr_arr[$index]} ${ethcountarr[$index
                    ]} $bigncount $littlencount $(( $littlencount-1
                    ))
162             #echo "in: $index"
163             (( ethcountarr[$index]++ ))
164             incount=$incount+1
165             (( bigncount++ ))
166             (( littlencount-- ))
167         fi
168     done <graphs/$1
169 elif [ $2 == "if2" ]; then
170     clear_watched_folders
171
172     while read line
173     do
174         first=$(echo "$line" | awk '{print $1}')
175         last=$(echo "$line" | awk '{print $(NF)}' | sed 's
                /[;]//g')
176         echo "$first and $last"
177         index=$(search_letters $first)
178         if [ "$index" = "None" ]; then
179             #echo "None"
180             :
181         else
182             ifconf2 ${vm_addr_arr[$index]} ${ethcountarr[
                    $index]} $bigncount $littlencount $((
                    $littlencount+1 ))
183             #echo "in: $index"
184             (( ethcountarr[$index]++ ))
185             (( littlencount++ ))
186             index=$(search_letters $last)
187             ifconf2 ${vm_addr_arr[$index]} ${ethcountarr[
                    $index]} $bigncount $littlencount $((
                    $littlencount-1 ))
188             #echo "in: $index"
189             (( ethcountarr[$index]++ ))
190             incount=$incount+1
191             (( bigncount++ ))
192             (( littlencount-- ))
193         fi
194     done <graphs/$1
195 elif [ $2 == "key" ]; then
196     sendKeys
```

```
197 elif [ $2 == "gather" ]; then
198     gatherLogs
199 elif [ $2 == "clean" ]; then
200     clean
201 elif [ $2 == "pull" ]; then
202     git_pull
203 elif [ $2 == "clean-fold" ]; then
204     cleanFold
205 elif [ $2 == "help" ]; then
206     echo "vm__________-_setup_vm_networking"
207     echo "if__________-_setup_network_addresses_etc_for_each_
        vm"
208     echo "if2_________-_setup_network_addresses_etc_for_each_
        vm_for_two_folders"
209     echo "gather______-_gather_the_logs_in"
210     echo "clean_______-_clean_out_the_logs/config_files"
211     echo "clean-fold__-_clean_out_the_files_folder"
212     echo "pull________-_pull_the_latest_code_from_the_
        repository_to_each_vm"
213     echo "help________-_display_this_help_message"
214 else
215     echo "Oops_try_again"
216 fi
217
218 neato -Tpng graphs/$1 > graphs/$1-graph.png
```