Beowulf Clusters

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What is beowulf?

- Mythical Old-English hero who defeats Grendel, the green dragon
- Movie starring a CG-animated Angelina Jolie
- Cluster architecture

Beowulf cluster history

- 1993 - Becker & Sterling started Beowulf project
- 1994 – Becker & Sterling constructed a 16 node cluster
- 1996 – DOE and NASA demonstrate beowulf cluster that surpasses 1GFlop/s
- 1997 – Caltech demonstrates beowulf cluster that surpasses 10GFlop/s
- Present – beowulf clusters are used at many universities, industries, and government sites

What is a beowulf cluster?

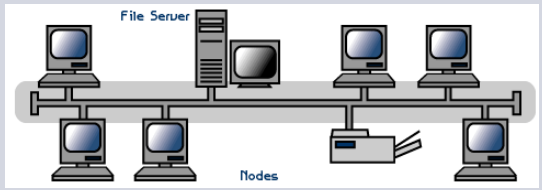
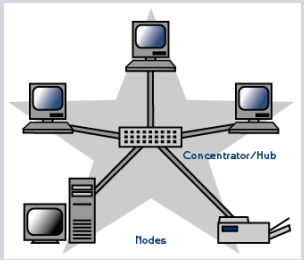
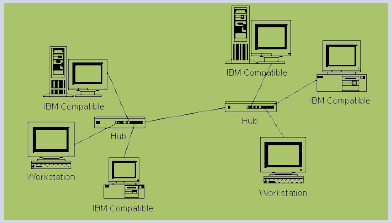
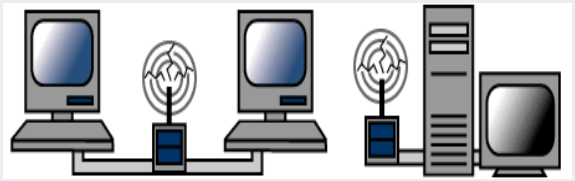
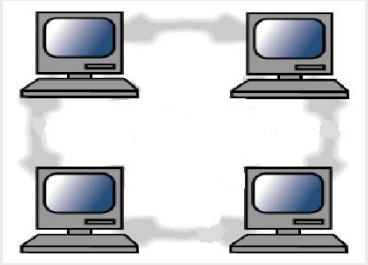
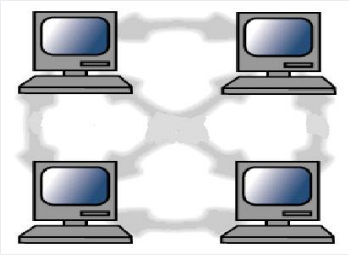
- Collection of stand-alone computer networked together
- Network equipment to connect computers
- Software
  - Operating system software
  - Application software
  - Communication software (MPI, OpenMP)

Hardware

- Any old computer will do
  - Laptops
  - Desktops
  - Playstation 3s ??
- Network
  - Switches / hubs
  - Cable
  - Ethernet adapters (most computer already have this, including the PS3)

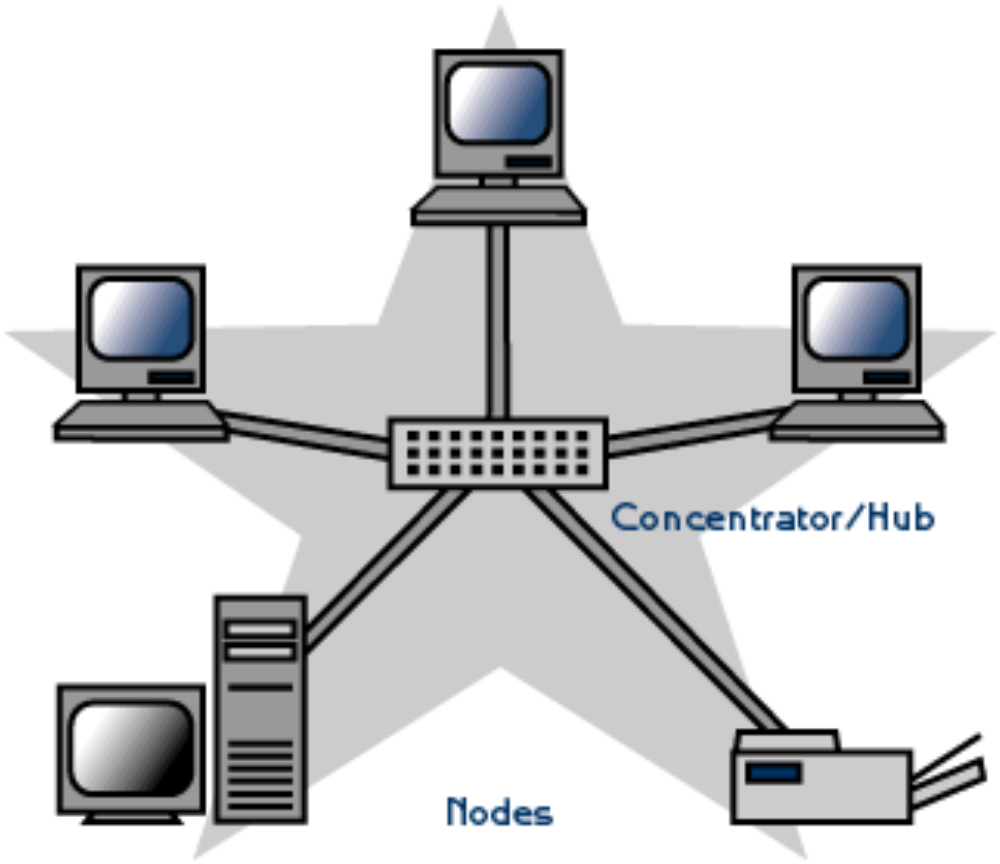
TOPOLOGY

Network Topologies

BUS	STAR	EXTENDED STAR
		
Wireless	RING	MESH
		

Reference: www.teach-ict.com/, uva.ulb.ac.be/

Star Topology



- Ethernet
- IEEE 802.3
- CSMA / CD
- Switch vs. Hub
- Broadcast vs. Cut-Through
- Cable: CAT V, UTP, RJ45

Model for Networking

OSI Model – Developed by *ISO*

O Open

S System

I Interconnect

I International

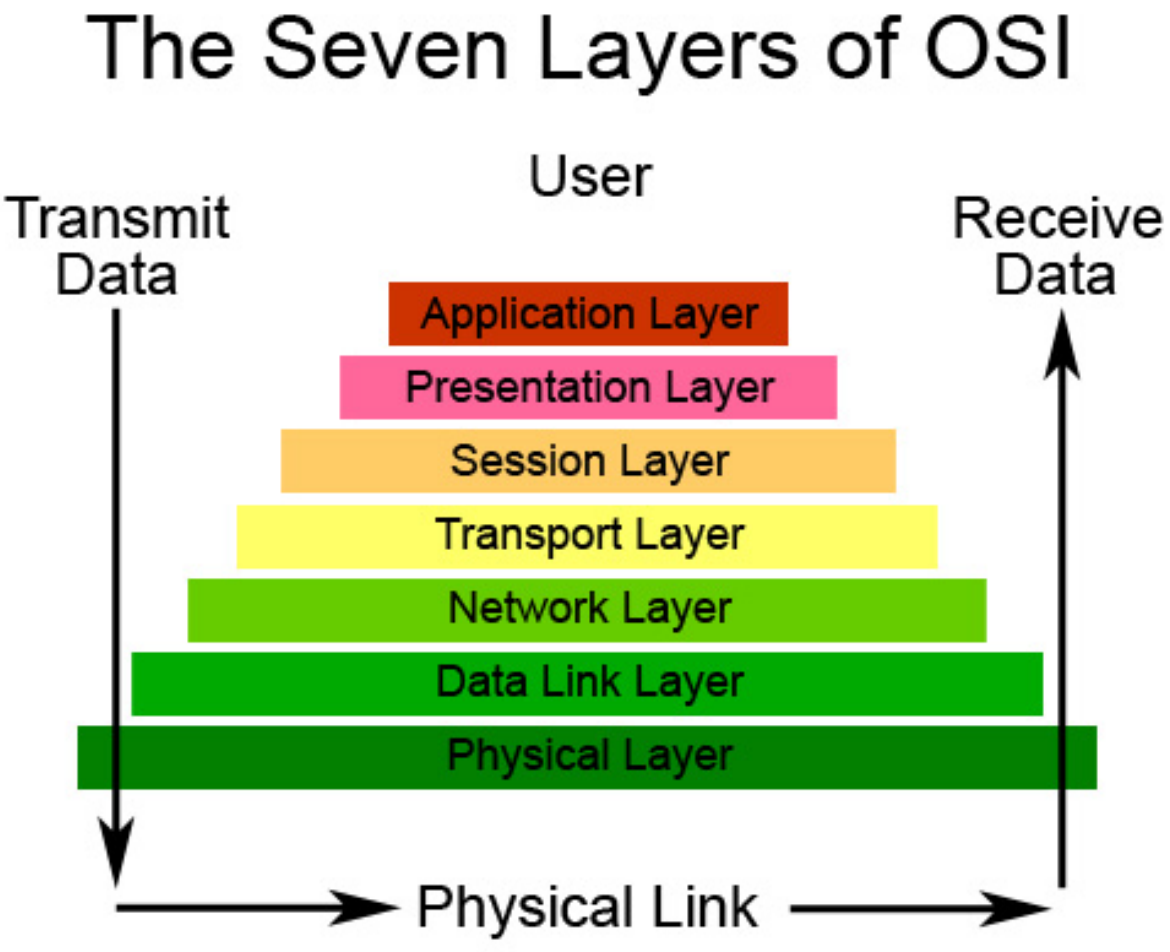
S Standards

O Organization

OSI Model

Layer	Name	Mnemonic
7	Application	All
6	Presentation	People
5	Session	Seem
4	Transport	To
3	Network	Need
2	Data-Link	Data
1	Physical	Processing

Data Flow

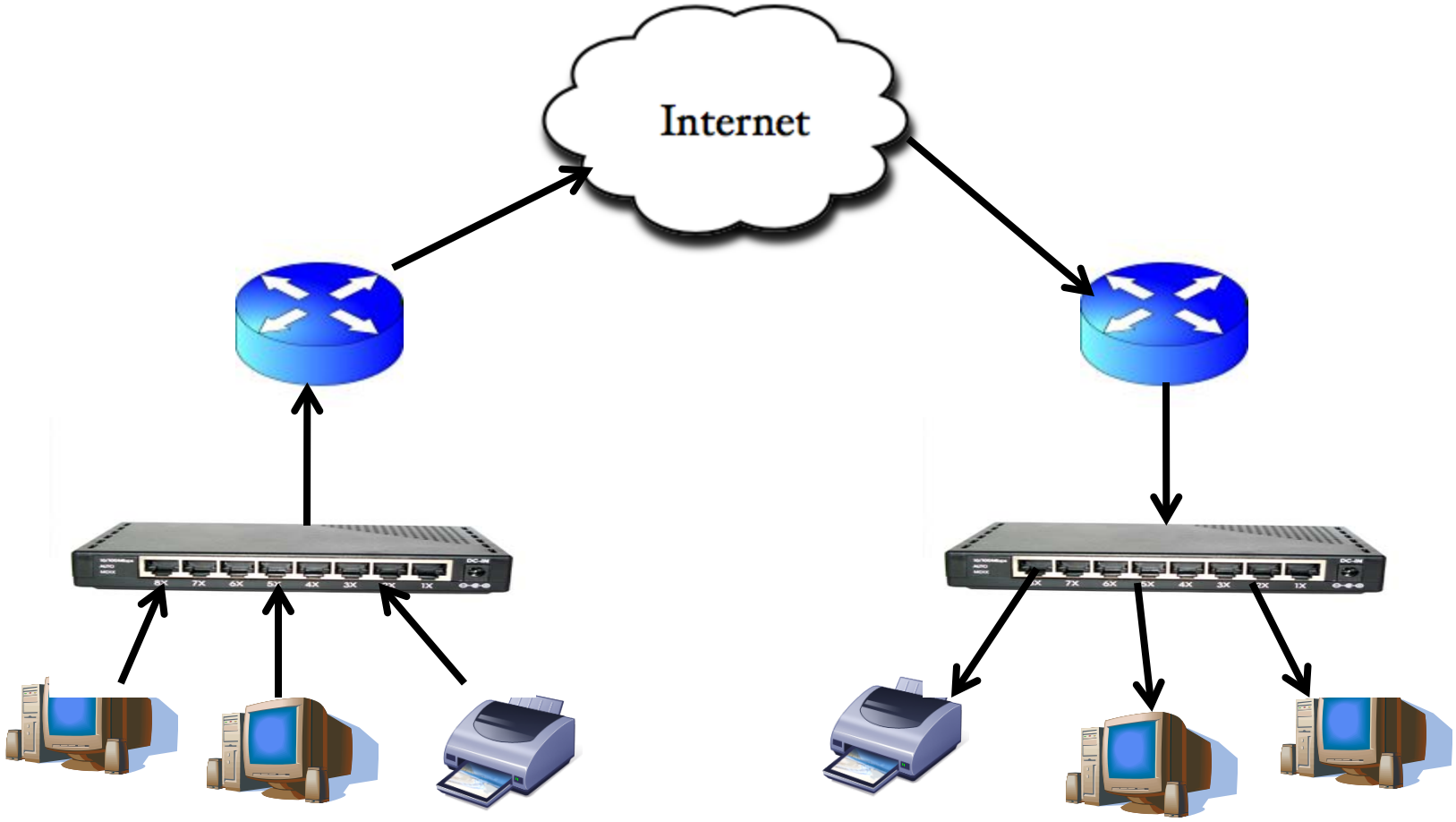


Reference: http://catalyst.washington.edu/help/computing_fundamentals/networking/img/osi_model.jpg

The Model - Examples

Layer	Description	
7. Application	HTTP, FTP, SMTP, POP3, HTTPS	
6. Presentation	Data Representation : ASCII	
5. Session	Starts and Stops the Session (Logon / Logoff)	
4. Transport	TCP – reliable / Handshake Transmission Control Protocol	UDP – unreliable (streaming data – mp3) User Datagram Protocol
3. Network	IP – Internet Protocol , Router, Best Path Selection	
2. Data-Link	MAC (Media Access Control) Sub layer – Ethernet Switch	LLC (Logical Link Control) Sub layer
1. Physical	Wire , Cable, The bits going across the wire, The NIC	

Basic Network Diagram



TCP/IP: Addressing Scheme

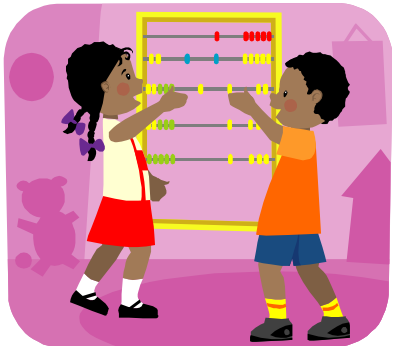
IP = Internet Protocol

Protocol is What? Set of Rules

1. Dotted Decimal Notation
2. No Decimal Number can be >255
3. Must Have Subnet Mask
4. Broken Down into Classes based on High order of bits in the first octet.

Dotted Decimal Notation

Example of IP address:



192.16.32.5 255.255.255.0

IP SM

Dotted . Decimal . Notation . Rule

Remember – 4 Octets , a Decimal number that represents the value of an 8 bit Binary number

No Number can be 255

Sample IP Address:

192.16.32.5 255.255.255.0

IP SM

The first Octets = 192 & 255

What is 192 in Binary?

What is 255 in Binary?

2^7 128 +	2^6 64 +	2^5 0 +	2^4 0 +	2^3 0 +	2^2 0 +	2^1 0 +	2^0 0 =	192
1	1	0	0	0	0	0	0	
2^7 128 +	2^6 64 +	2^5 32 +	2^4 16 +	2^3 8 +	2^2 4 +	2^1 2 +	2^0 1 =	255
1	1	1	1	1	1	1	1	

IP Address Classes

Class	1st Octet	High Order Of Bits	Number Bits Used for Network	Default Subnet Mask
Class A	1-126	00000001 01111110	8	255.0.0.0
Class B	128 - 191	10000000 10111111	16	255.255.0.0
Class C	192 -223	11000000 11011111	24	255.255.255.0
Class D	224 - 239	11100000 11101111		Reserved

SAMPLE IP Address:

Sample IP Address:

192.16.32.5 255.255.255.0

N H

By Performing a Binary AND Function

IP Address AND Subnet Mask

11000000.00010000.00100000.00000101

11111111.11111111.11111111.00000000

11000000.00010000.00100000.00000000

192 . 16. 32. 0

Sample IP Address:

11000000.00010000.00100000.00000101

11111111.11111111.11111111.00000000

11000000.00010000.00100000.00000000

192 . 16. 32. 0

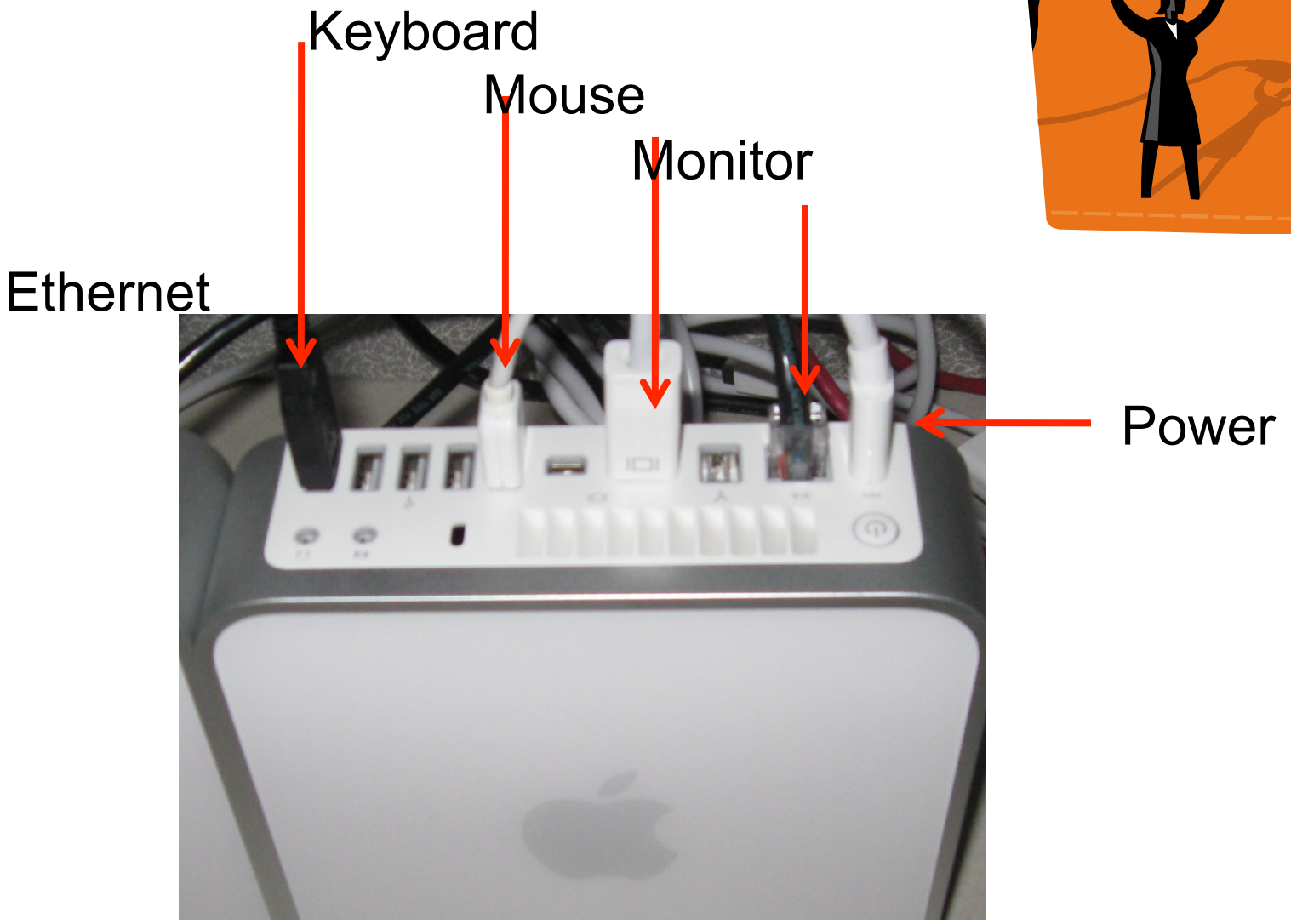
192.16.32.0 = Network ID

192.16.32.255 = Broadcast ID

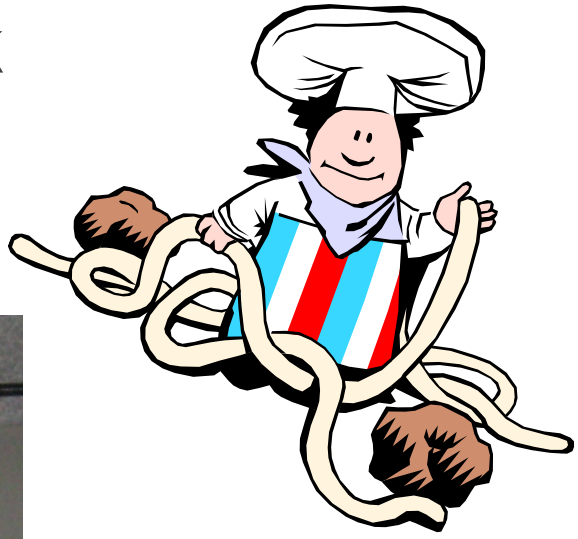
192.16.32. 1 – 254 = Host Addresses

MAC Mini Network

MAC Mini Network



MAC Mini Network



Steps to Configuring the MAC Mini's

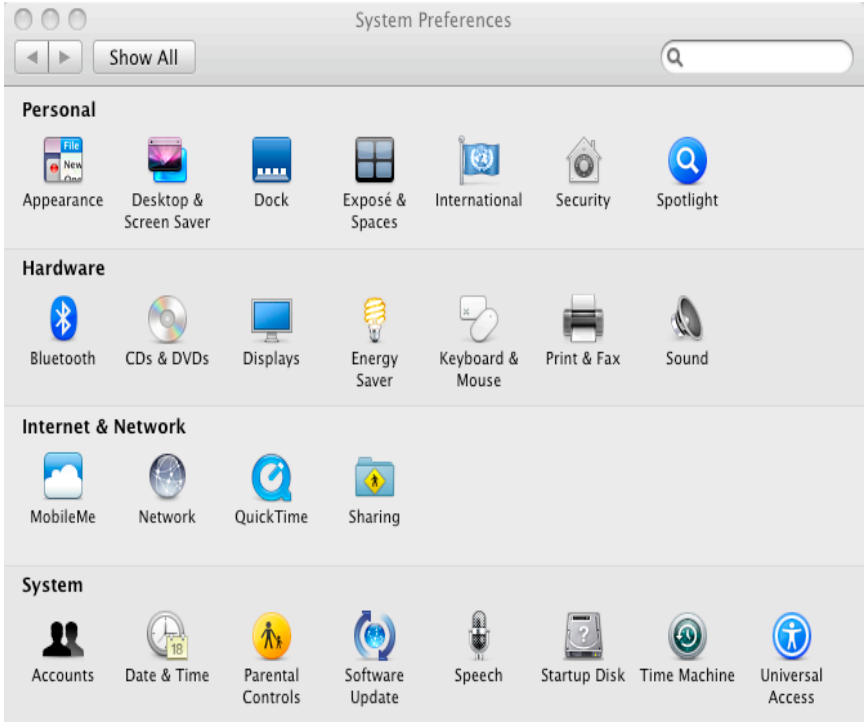
1) Create Accounts
   a. Name Machine
   b. User Name
   c. Password

2) System Preferences
   a. File Sharing
   b. Remote Sharing
   c. Energy Saver off
   d. Firewall off

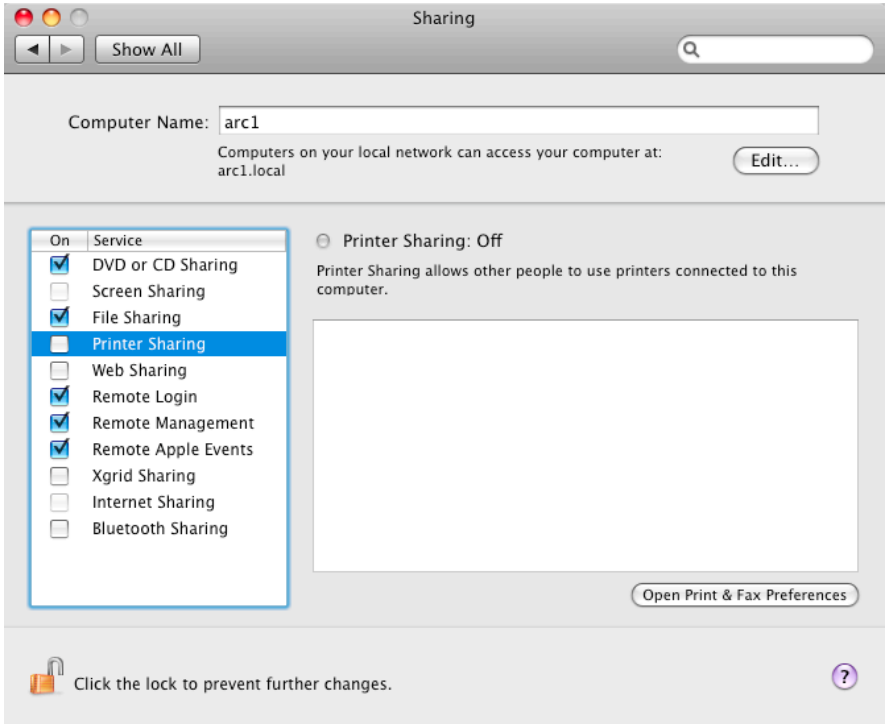
3) Configure IP Address

Configure System – Set hostname

Click on Sharing

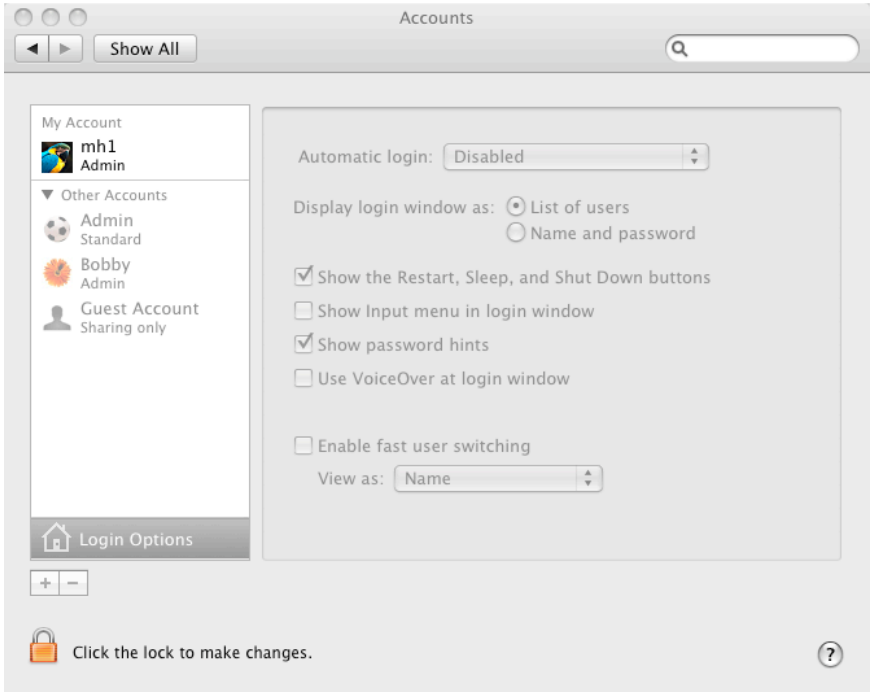


Name: ARC1, ARC2, etc



Configure System – Add user

Click on Accounts

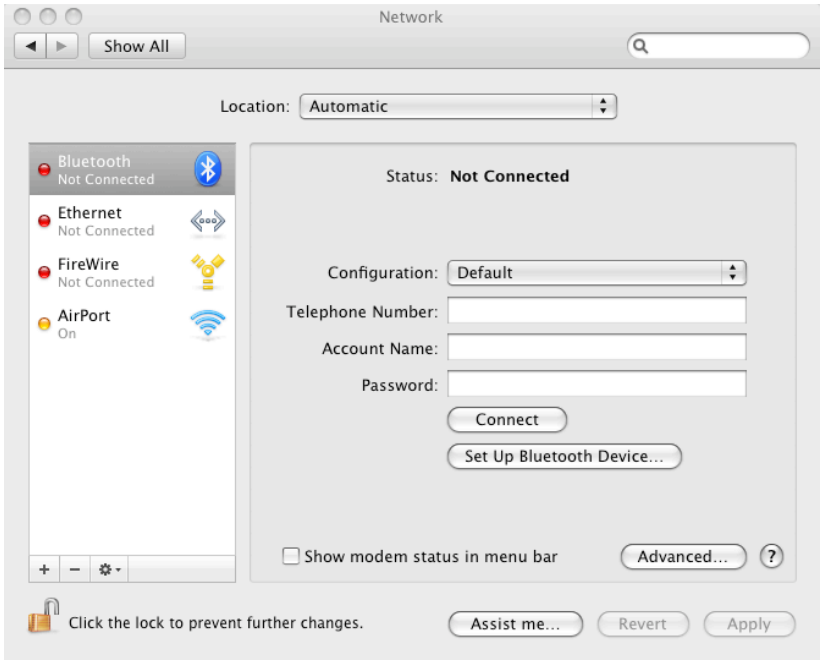


Click on lock to unlock

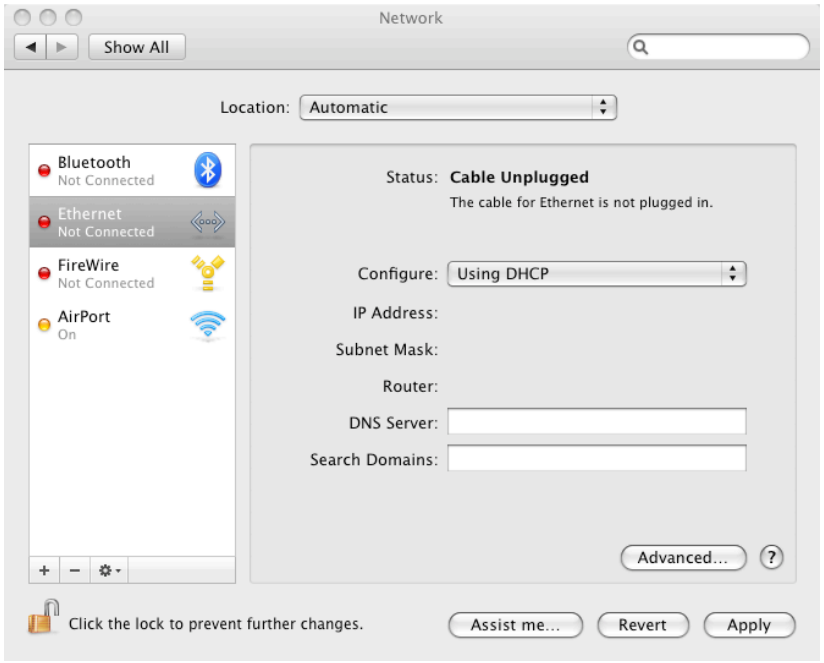
Click on +

Configure IP Address

Click on Network

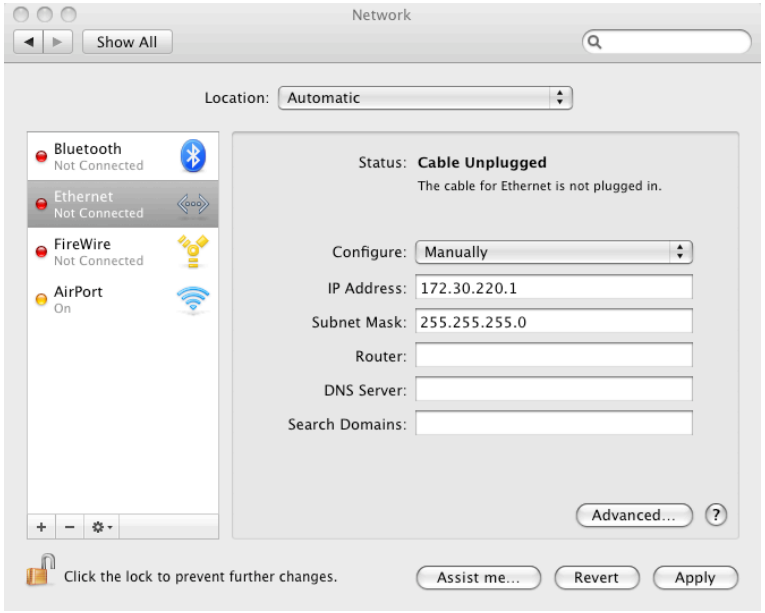


Click on Ethernet



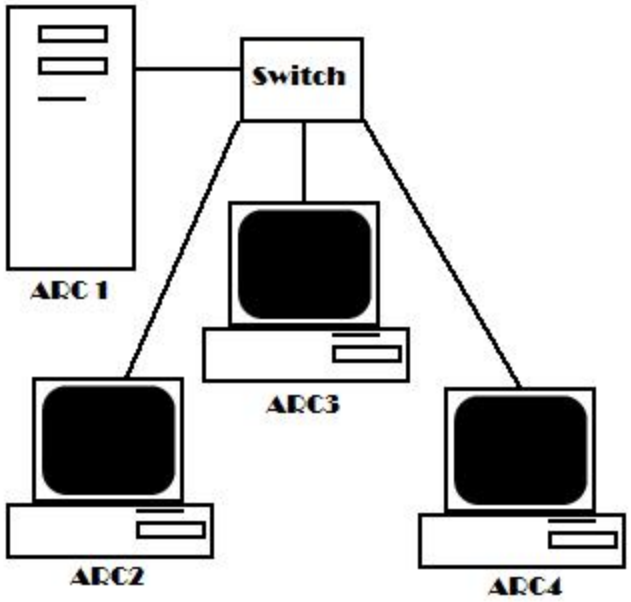
Configure IP Address

Machine	IP Address	Subnet Mask
ARC1	172.30.220.1	255.255.255.0
ARC2	172.30.220.2	255.255.255.0
ARC3	172.30.220.3	255.255.255.0
ARC4	172.30.220.4	255.255.255.0
ARC5	172.30.220.5	255.255.255.0
ARC6	172.30.220.6	255.255.255.0

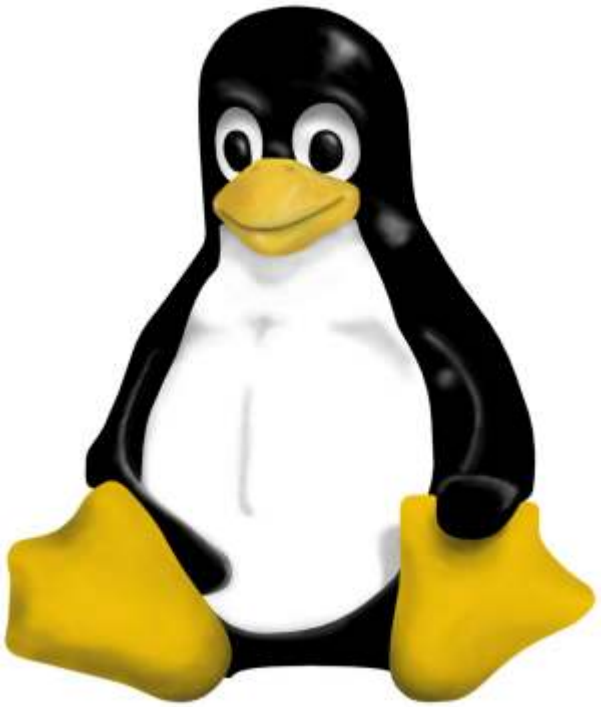


Server vs. Nodes

In the next steps, we will first setup the Server (ARC1) . Then to setup the nodes all we need to do is a secure copy to the nodes.



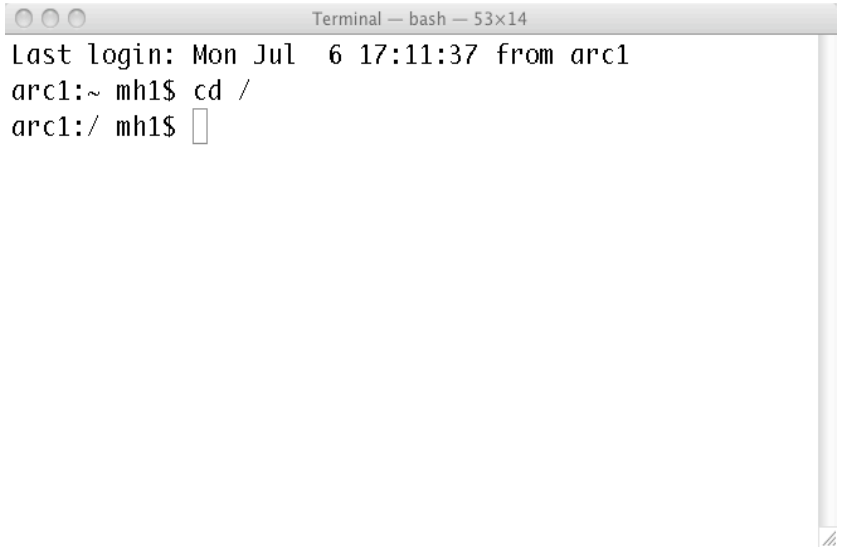
Configure a node



1. Setup Host Files
2. Setup SSH
3. Install & Configure GCC
4. Install & Configure MPICH
5. Configure MPI to work with SSH
6. Test SSH, GCC and MPI

Setup Host Files

cd to root (cd /)



Type: sudo pico /etc/hosts

Setup Host Files

Add the following at the bottom of the file:

172.30.220.1 ARC1

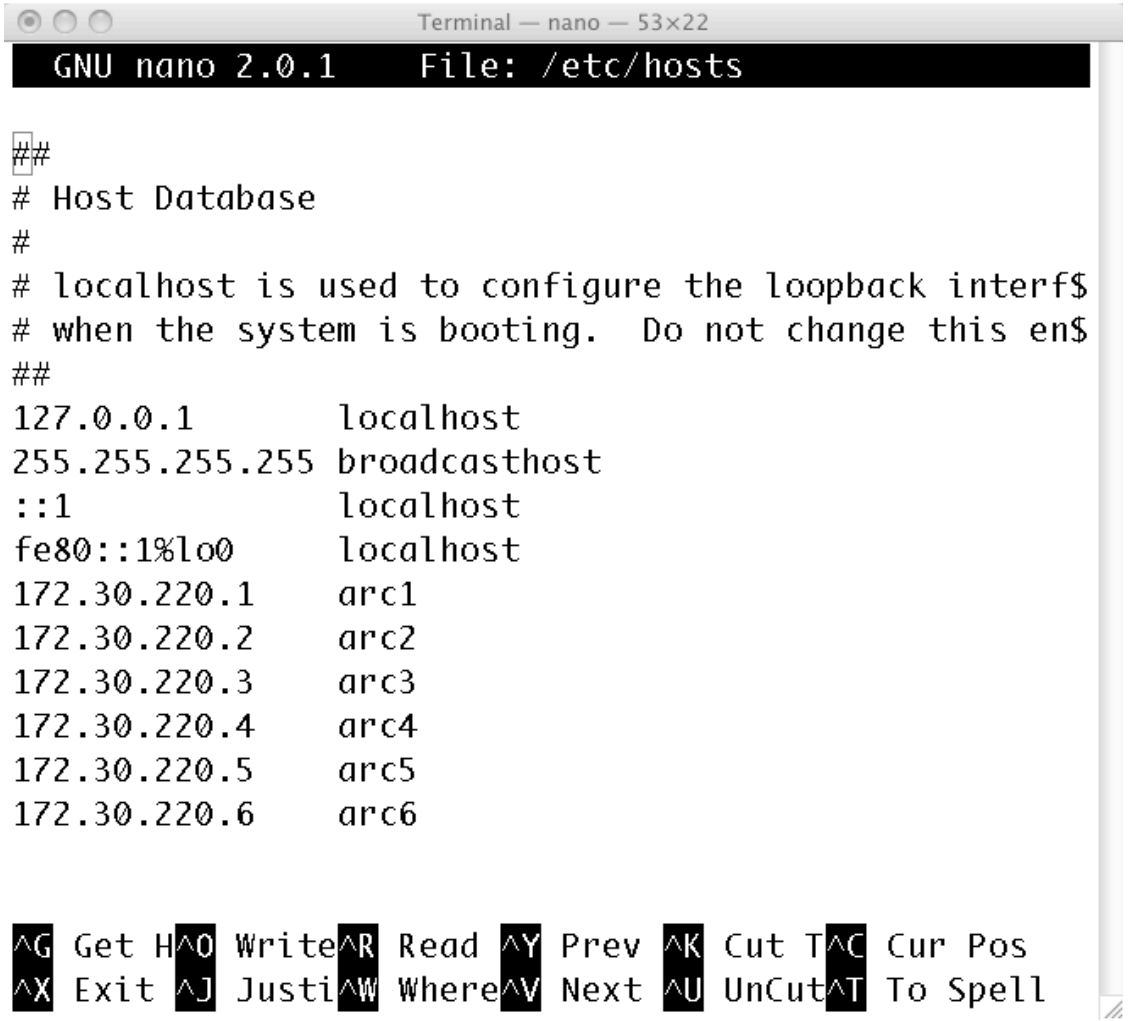
172.30.220.2 ARC2

172.30.220.3 ARC3

172.30.220.4 ARC4

172.30.220.5 ARC5

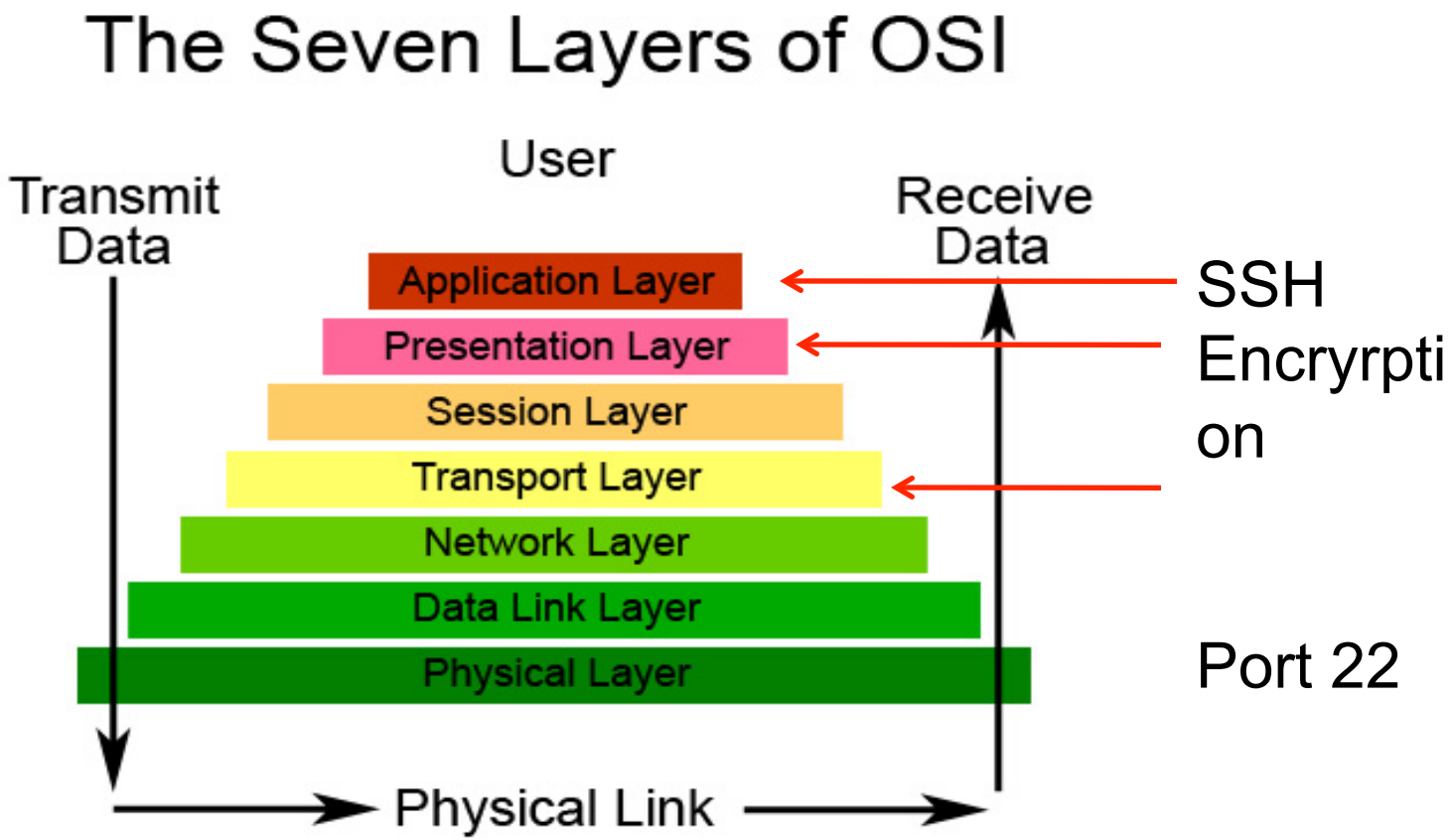
172.30.220.6 ARC6



Setting up SSH

What is SSH?

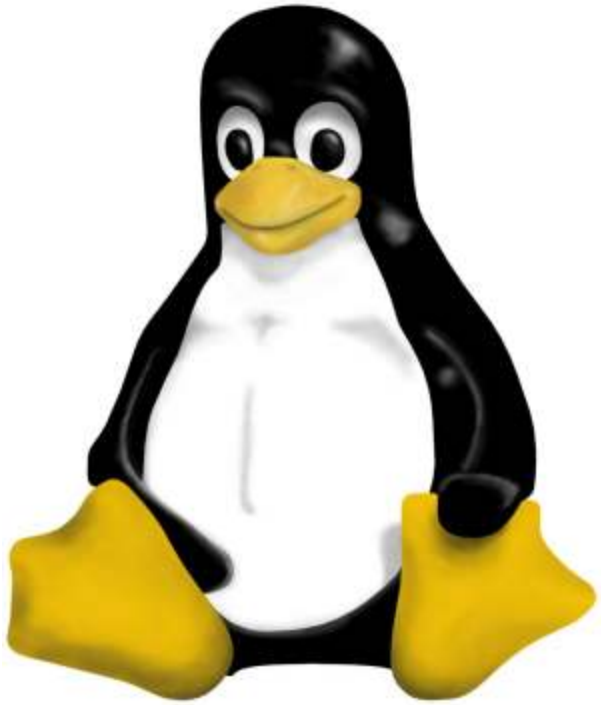
Why do we Need it?



Setting up SSH

We will be modifying 3 files:

1. /etc/ssh_config
2. /etc/sshd_config
3. /etc/hosts.equiv



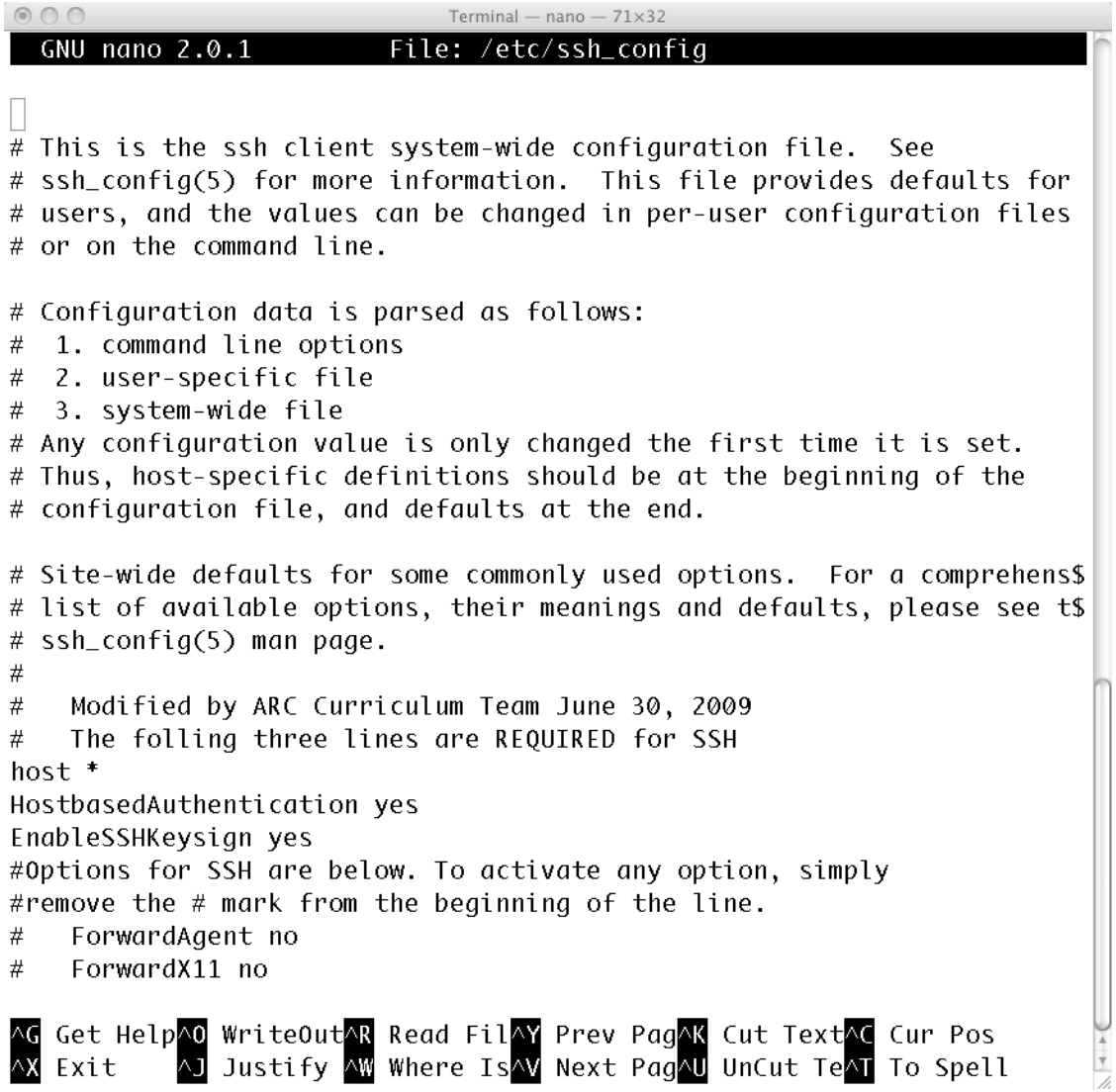
Setting up SSH

Type: sudo pico /etc/ssh_config

host *

HostbasedAuthentication yes

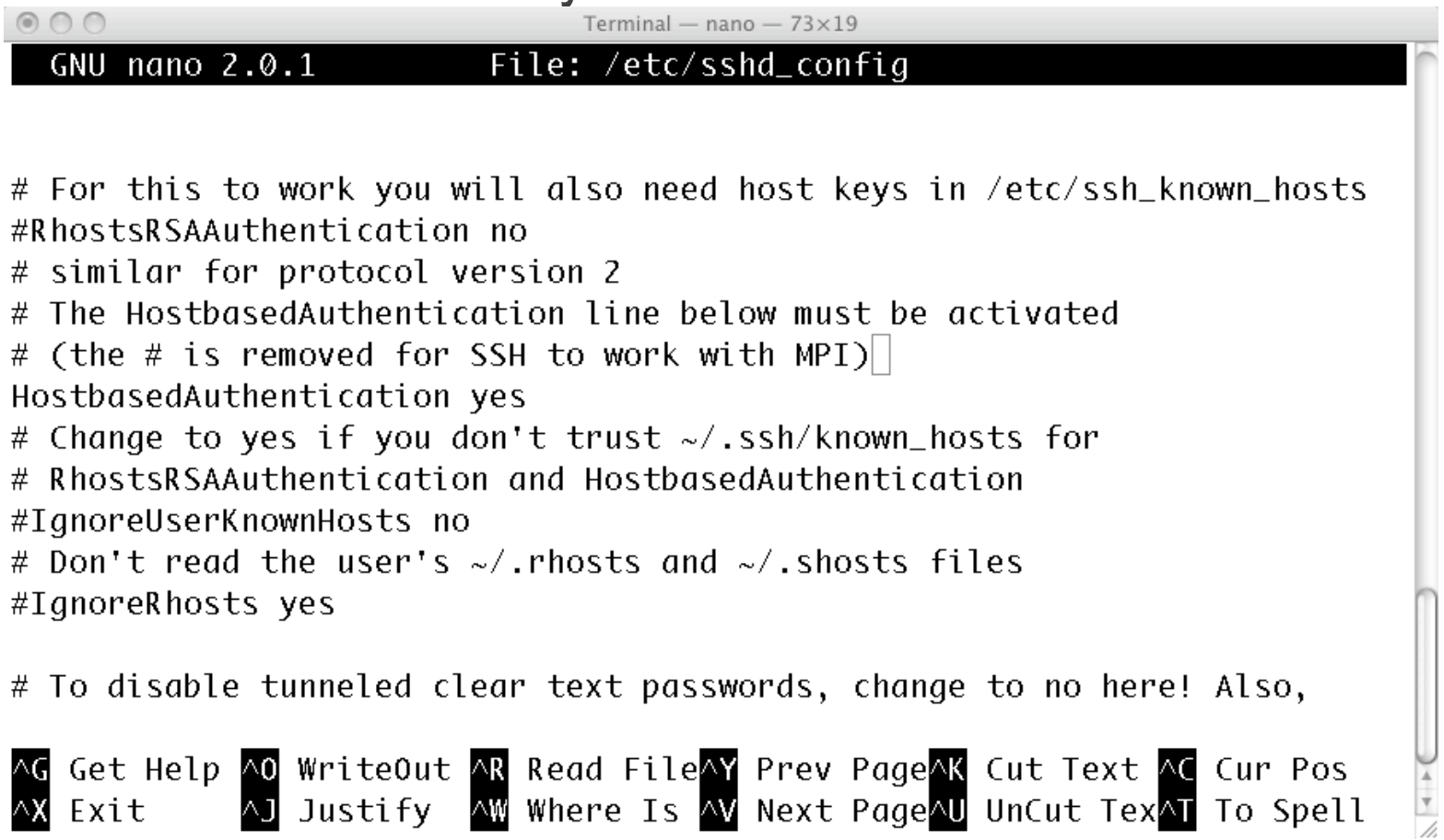
EnableSSHKeysign yes



Setting up SSH

Type: sudo pico /etc/sshd_config

HostbasedAuthentication yes



Setting up SSH

Type: sudo pico /etc/hosts.equiv

Add the following hostnames:

ARC1

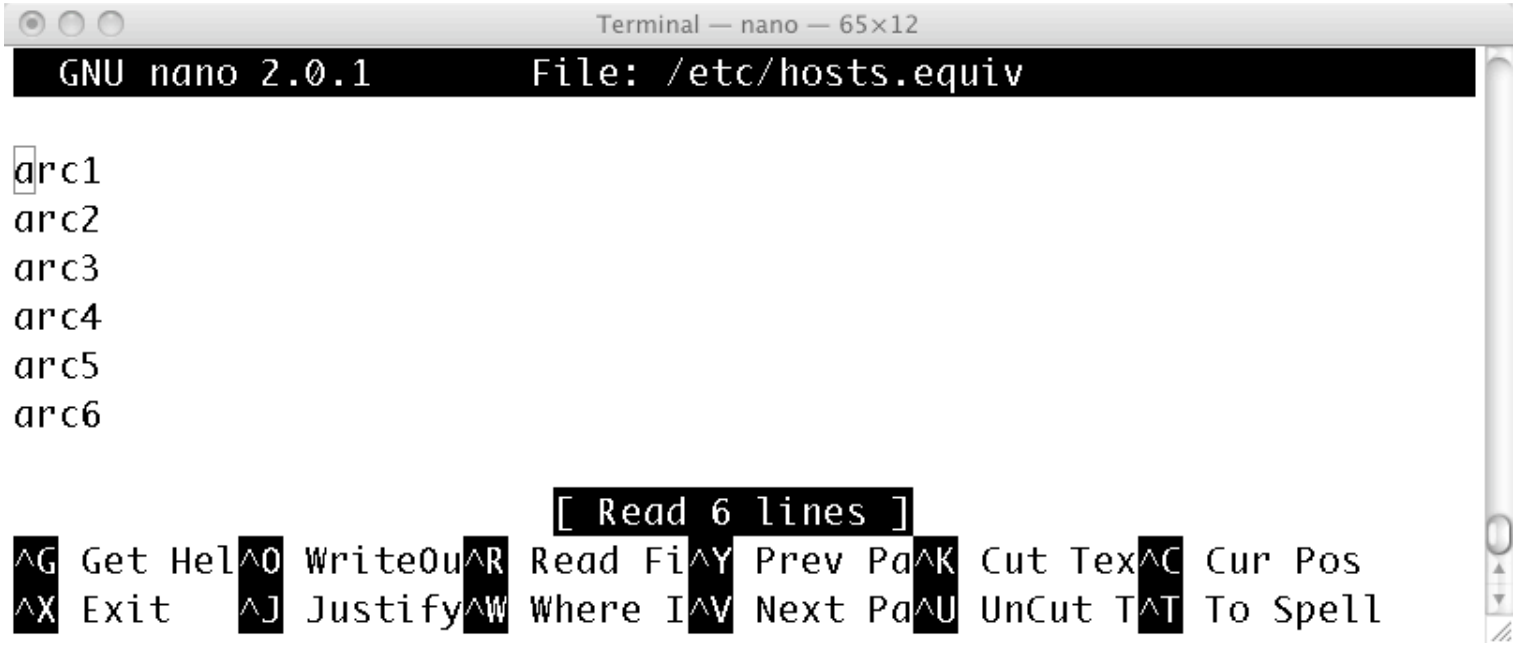
ARC2

ARC3

ARC4

ARC5

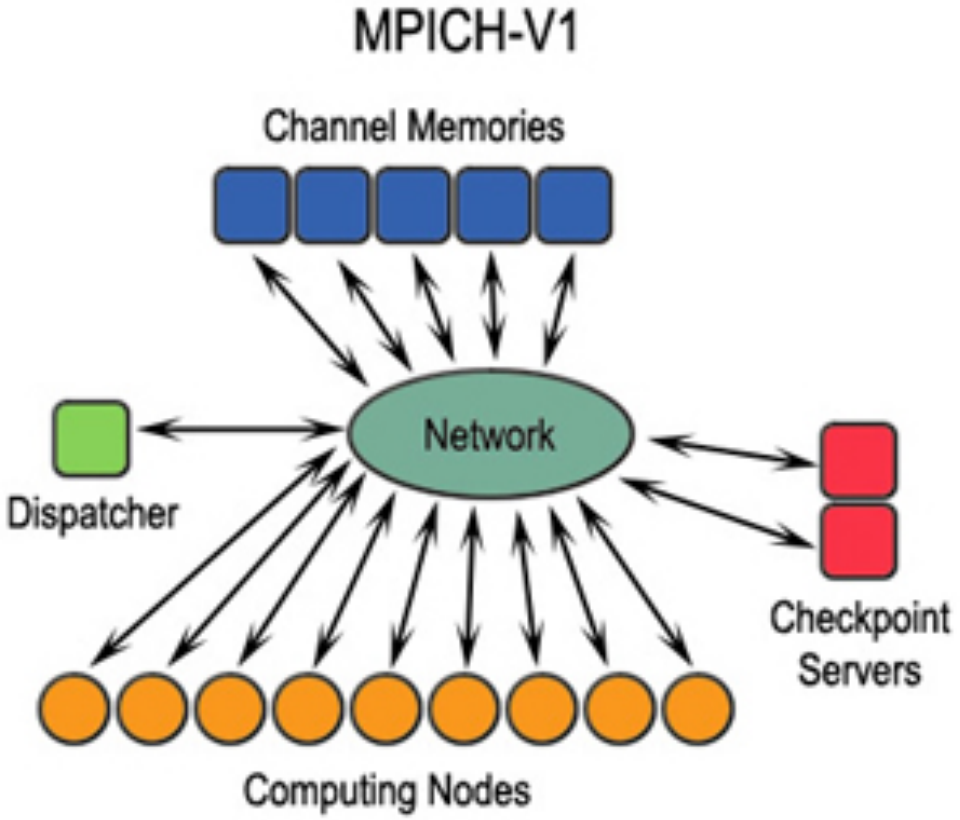
ARC6



Install and Configure MPICH

What is MPICH?

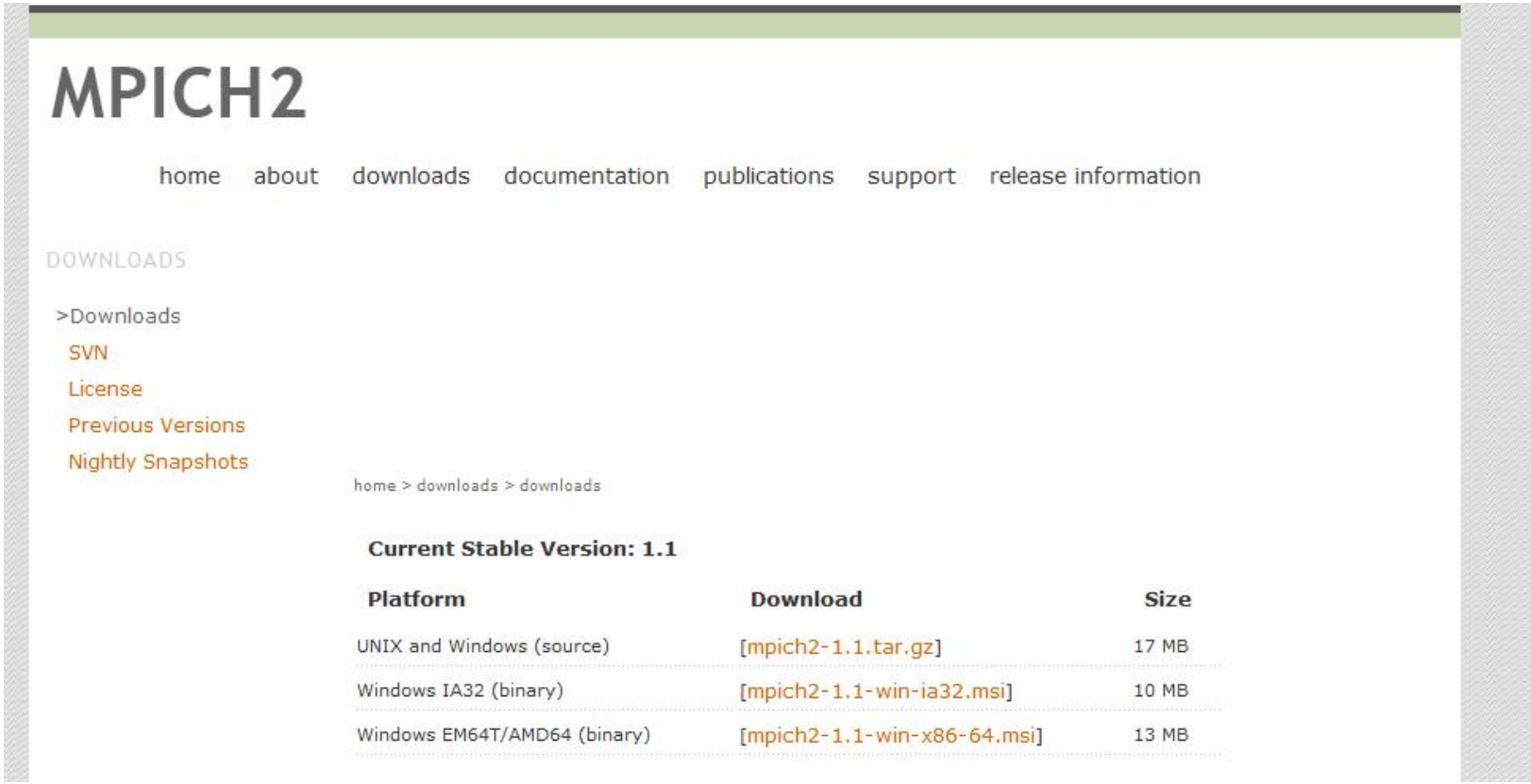
Why do we Need MPICH?



Reference: http://en.wikipedia.org/wiki/MPICH

Download MPICH

http://www.mcs.anl.gov/research/projects/mpich2/downloads/index.php?s=downloads

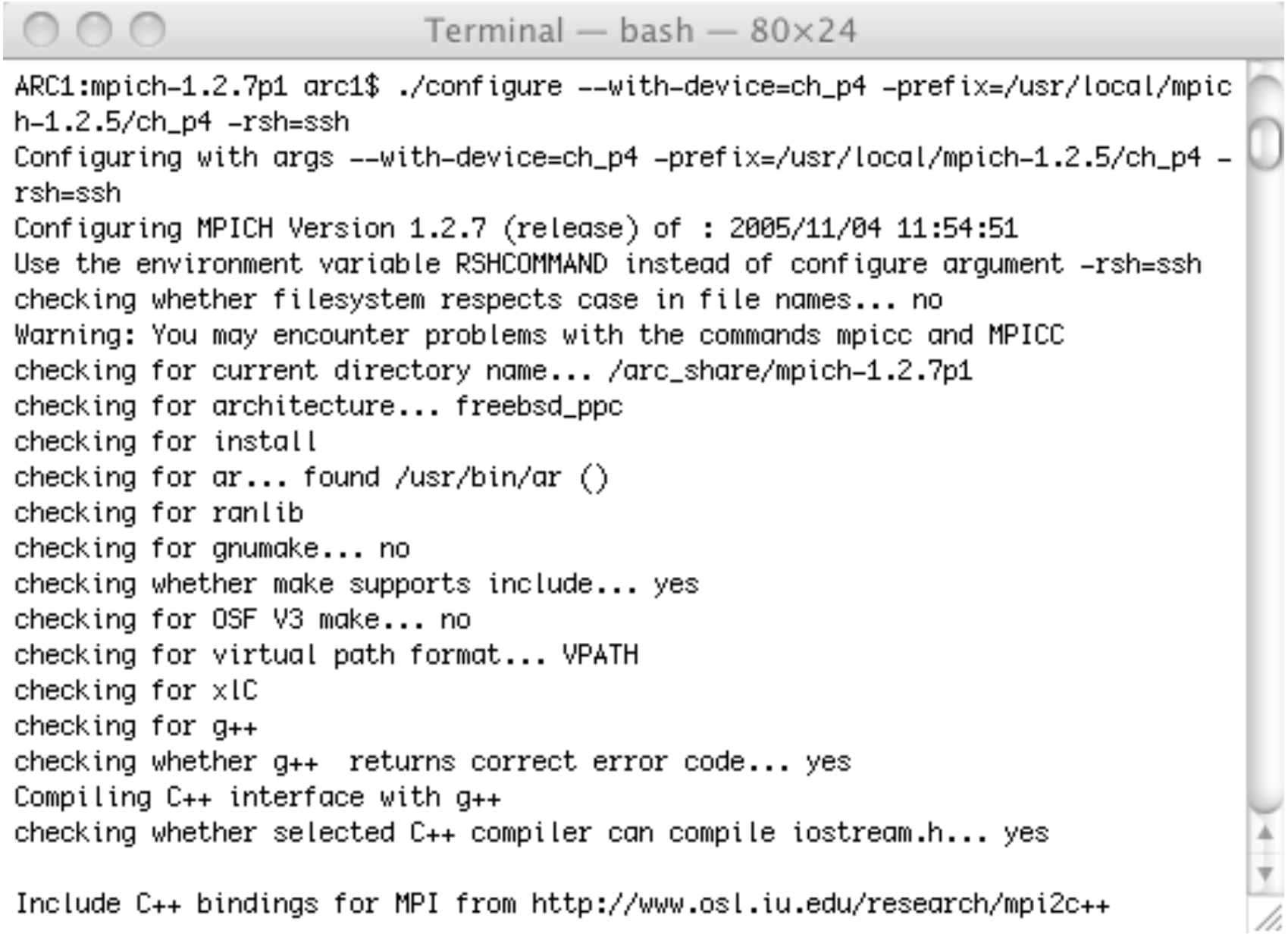


Install MPICH

Type:

cd /arc_share/mpich1.2.7p1

./configure - -with-device=ch_p4 – prefix=/usr/local/mpich-1.2.5/ch_p4 -rsh=ssh



Building the Cluster

Modify the file that contains our hosts:

cd /arc_share/mpich-1.2.7p1/util/machines/

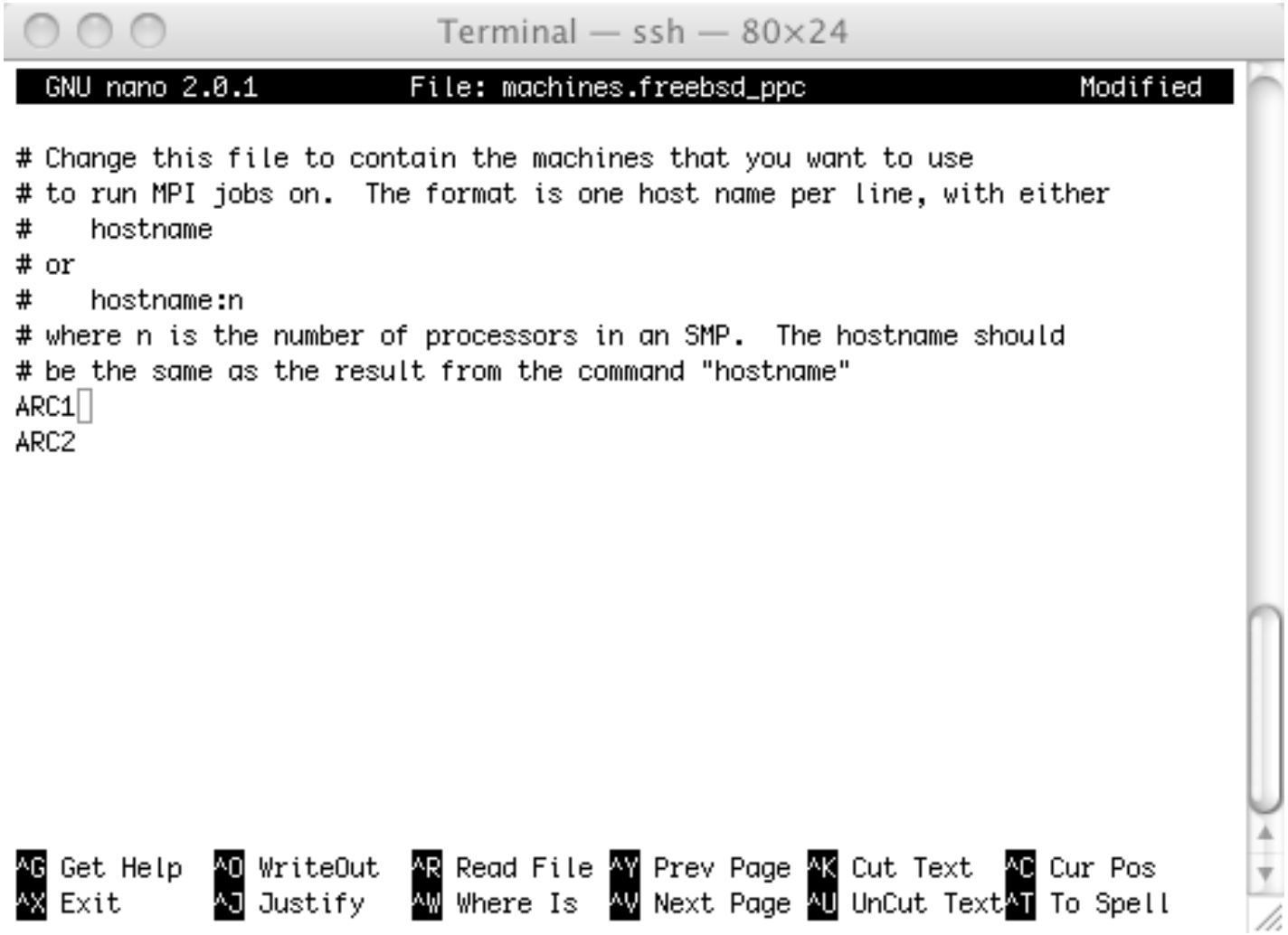
sudo pico machines.freebsd_ppc

Change the list to ARC1 through ARC6 and remove the .local

Ctrl o to write

Ctrl x to exit

Machines File



http://www.nccs.gov