Appendix A: Resources

We recommend these resources for learning more about the various aspects of wireless networking. For more links and resources, see our website at *http://wndw.net/.*

Antennas and antenna design

- Cushcraft technical papers on antenna design and radio propagation, *http://www.cushcraft.com/comm/support/technical-papers.htm*

- Free antenna designs, *http://www.freeantennas.com/*

- Hyperlink Tech, *http://hyperlinktech.com/*

- Pasadena Networks LLC, *http://www.wlanparts.com/*

- SuperPass, *http://www.superpass.com/*

- Unofficial NEC2 code archives, *http://www.nec2.org/*

- Unofficial NEC2 radio modeling tool home page, *http://www.nittany-scientific.com/nec/*

- USB WiFi dish designs, *http://www.usbwifi.orcon.net.nz/*

Network troubleshooting tools

- Bing throughput measurement tool, *http://fgouget.free.fr/bing/index-en.shtml*

- Cacti network monitoring package, *http://www.cacti.net/*

- DSL Reports bandwidth speed tests, *http://www.dslreports.com/stest*

- EaKiu spectrum analysis tool, *http://www.cookwareinc.com/EaKiu/*

- EtherApe network traffic monitor, *http://etherape.sourceforge.net/*

- Flowc open source NetFlow collector, *http://netacad.kiev.ua/flowc/.*

- Iperf network performance testing tool, *http://dast.nlanr.net/Projects/Iperf/*

- iptraf network diagnostic tool, *http://iptraf.seul.org/*

- MRTG network monitoring and graphing tool,
  http://people.ee.ethz.ch/~oetiker/webtools/mrtg/
- My TraceRoute network diagnostic tool, *http://www.bitwizard.nl/mtr/*
- Nagios network monitoring and event notification tool,
  http://www.nagios.org/
- NetFlow, the Cisco protocol for collecting IP traffic information,
  http://en.wikipedia.org/wiki/Netflow
- ngrep network security utility for finding patterns in data flows,
  http://ngrep.sourceforge.net/
- Network monitoring implementation guides and tutorials,
  http://wiki.debian.org/Network_Monitoring
- Ntop network monitoring tool, *http://www.ntop.org/*
- RRDtool round robin database graphing utility,
  http://people.ee.ethz.ch/~oetiker/webtools/rrdtool/
- SmokePing network latency and packet loss monitor,
  http://people.ee.ethz.ch/~oetiker/webtools/smokeping/
- SoftPerfect network analysis tools, *http://www.softperfect.com/*
- Squid transparent http proxy HOWTO,
  http://tldp.org/HOWTO/TransparentProxy.html
- ttcp network performance testing tool, *http://ftp.arl.mil/ftp/pub/ttcp/*
- Wireshark network protocol analyzer, *http://www.wireshark.org/*

Security

- AntiProxy http proxy circumvention tools and information,
  http://www.antiproxy.com/
- Anti-spyware tools, *http://www.spychecker.com/*
- Driftnet network monitoring utility, *http://www.ex-parrot.com/~chris/driftnet/*
- Etherpeg network monitoring utility, *http://www.etherpeg.org/*
- Introduction to OpenVPN, *http://www.linuxjournal.com/article/7949*
- Lavasoft Ad-Aware spyware removal tool, *http://www.lavasoft.de/*
- Linux security and admin software,
  http://www.linux.org/apps/all/Networking/Security_/_Admin.html
- OpenSSH secure shell and tunneling tool, *http://openssh.org/*
- OpenVPN encrypted tunnel setup guide, *http://openvpn.net/howto.html*

- Privoxy filtering web proxy, *http://www.privoxy.org/*
- PuTTY SSH client for Windows, *http://www.putty.nl/*
- Sawmill log analyzer, *http://www.sawmill.net/*
- Security of the WEP algorithm,
  http://www.isaac.cs.berkeley.edu/isaac/wep-faq.html
- Stunnel Universal SSL Wrapper, *http://www.stunnel.org/*
- TOR onion router, *http://www.torproject.org/*
- Weaknesses in the Key Scheduling Algorithm of RC4,
  http://www.crypto.com/papers/others/rc4_ksaproc.ps
- Windows SCP client, *http://winscp.net/*
- Your 802.11 Wireless Network has No Clothes,
  http://www.cs.umd.edu/~waa/wireless.pdf
- ZoneAlarm personal firewall for Windows, *http://www.zonelabs.com/*

Bandwidth optimization

- Cache heirarchies with Squid,
  http://squid-docs.sourceforge.net/latest/html/c2075.html
- dnsmasq caching DNS and DHCP server,
  http://www.thekelleys.org.uk/dnsmasq/doc.html
- Enhancing International World Wide Web Access in Mozambique Through the Use of Mirroring and Caching Proxies,
  http://www.isoc.org/inet97/ans97/cloet.htm
- Fluff file distribution utility, *http://www.bristol.ac.uk/fluff/*
- Linux Advanced Routing and Traffic Control HOWTO, *http://lartc.org/*
- Microsoft Internet Security and Acceleration Server,
  http://www.microsoft.com/isaserver/
- Microsoft ISA Server Firewall and Cache resource site,
  http://www.isaserver.org/
- Optimising Internet Bandwidth in Developing Country Higher Education,
  http://www.inasp.info/pubs/bandwidth/index.html
- Pittsburgh Supercomputing Center's guide to Enabling High Performance Data Transfers, *http://www.psc.edu/networking/perf_tune.html*
- Planet Malaysia blog on bandwidth management,
  http://planetmy.com/blog/?p=148

- RFC 3135: Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations, *http://www.ietf.org/rfc/rfc3135*
- Squid web proxy cache, *http://squid-cache.org/*

Mesh networking

- Champaign-Urbana Community Wireless Network software, *http://cuwireless.net/download*
- Freifunk OLSR mesh firmware for the Linksys WRT54G, *http://www.freifunk.net/wiki/FreifunkFirmware*
- MIT Roofnet Project, *http://pdos.csail.mit.edu/roofnet/doku.php*
- OLSR mesh networking daemon, *http://www.olsr.org/*
- Real-time OLSR topology viewer, *http://meshcube.org/nylon/utils/olsr-topology-view.pl*
- AirJialdi Mesh Router, *http://drupal.airjaldi.com/node/9*

Wireless operating systems and drivers

- DD-WRT wireless router OS, *http://www.dd-wrt.com/*
- HostAP wireless driver for the Prism 2.5 chipset, *http://hostap.epitest.fi/*
- m0n0wall wireless router OS, *http://m0n0.ch/wall/*
- MadWiFi wireless driver for the Atheros chipset, *http://madwifi.org/*
- Metrix Pyramid wireless router OS, *http://pyramid.metrix.net/*
- OpenWRT wireless router OS for Linksys access points, *http://openwrt.org/*
- Tomato wireless router OS for Linksys access points, *http://www.polarcloud.com/tomato*

Wireless tools

- Chillispot captive portal, *http://www.chillispot.info/*
- Interactive Wireless Network Design Analysis Utilities, *http://www.qsl.net/n9zia/wireless/page09.html*
- KisMAC wireless monitor for Mac OS X, *http://kismac.macpirate.ch/*
- Kismet wireless network monitoring tool, *http://www.kismetwireless.net/*
- MacStumbler wireless network detection tool for Mac OS X, *http://www.macstumbler.com/*

- NetStumbler wireless network detection tool for Windows and Pocket PC, *http://www.netstumbler.com/*
- NoCatSplash captive portal, *http://nocat.net/download/NoCatSplash/*
- PHPMyPrePaid prepaid ticketing system, *http://sourceforge.net/projects/phpmyprepaid/*
- RadioMobile radio performance modeling tool, *http://www.cplus.org/rmw/*
- Terabeam wireless link calculation tools, *http://www.terabeam.com/support/calculations/index.php*
- Wellenreiter wireless network detection tool for Linux, *http://www.wellenreiter.net/*
- WiFiDog captive portal, *http://www.wifidog.org/*
- Wireless Network Link Analysis tool by GBPRR, *http://my.athenet.net/~multiplx/cgi-bin/wireless.main.cgi*

General wireless related information

- DefCon long distance WiFi shootout, *http://www.wifi-shootout.com/*
- Homebrew wireless hardware designs, *http://www.w1ghz.org/*
- Linksys wireless access point information*, http://linksysinfo.org/*
- Linksys WRT54G resource guide, http://seattlewireless.net/index.cgi/LinksysWrt54g
- NoCat community wireless group, *http://nocat.net/*
- Ronja optical data link hardware, *http://ronja.twibright.com/*
- SeattleWireless community wireless group, *http://seattlewireless.net/*
- SeattleWireless Hardware comparison page, *http://www.seattlewireless.net/HardwareComparison*
- Stephen Foskett's Power Over Ethernet (PoE) Calculator, *http://www.gweep.net/~sfoskett/tech/poecalc.html*

Networking services

- Access Kenya ISP, *http://www.accesskenya.com/*
- Broadband Access Ltd. wireless broadband carrier, *http://www.blue.co.ke/*
- Virtual IT outsourcing, http://www.virtualit.biz/
- wire.less.dk consultancy and services, *http://wire.less.dk/*

Training and education

- Association for Progressive Communications wireless connectivity projects, *http://www.apc.org/wireless/*
- International Network for the Availability of Scientific Publications, *http://www.inasp.info/*
- Makere University, Uganda, *http://www.makerere.ac.ug/*
- Radio Communications Unit of the Abdus Salam International Center for Theoretical Physics, *http://wireless.ictp.trieste.it/*
- World Summits on Free Information Infrastructures, *http://www.wsfii.org/*

Miscellaneous links

- Cygwin Linux-like environment for Windows, *http://www.cygwin.com/*
- Graphvis graph visualization tool, *http://www.graphviz.org/*
- ICTP bandwidth simulator, *http://wireless.ictp.trieste.it/simulator/*
- ImageMagick image manipulation tools and libraries, *http://www.imagemagick.org/*
- NodeDB war driving map database, *http://www.nodedb.com/*
- Open Relay DataBase, *http://www.ordb.org/*
- Partition Image disk utility for Linux, *http://www.partimage.org/*
- RFC 1918: Address Allocation for Private Internets, *http://www.ietf.org/rfc/rfc1918*
- Rusty Russell's Linux Networking Concepts, *http://www.netfilter.org/documentation/HOWTO/ networking-concepts-HOWTO.html*
- Ubuntu Linux, *http://www.ubuntu.com/*
- VoIP-4D Primer, *http://www.it46.se/voip4d/voip4d.php*
- wget web utility for Windows, *http://xoomer.virgilio.it/hherold/*
- WiFiMaps war driving map database, *http://www.wifimaps.com/*
- WiSpy spectrum analysis tool, *http://www.metageek.net/*

Books

- *802.11 Networks: The Definitive Guide, 2nd Edition*. Matthew Gast, O'Reilly Media. ISBN #0-596-10052-3

- *802.11 Wireless Network Site Surveying and Installation.* Bruce Alexander, Cisco Press. ISBN #1-587-05164-8

- The *ARRL Antenna Book, 20th Edition.* R. Dean Straw (Editor), American Radio Relay League. ISBN #0-87259-904-3

- The *ARRL UHF/Microwave Experimenter's Manual*. American Radio Relay League. ISBN #0-87259-312-6

- *Building Wireless Community Networks, 2nd Edition.* Rob Flickenger, O'Reilly Media. ISBN #0-596-00502-4

- *How To Accelerate Your Internet,* A free book about bandwidth optimization. *http://bwmo.net/.* ISBN #978-0-9778093-1-8

- *Deploying License-Free Wireless Wide-Area Networks.* Jack Unger, Cisco Press. ISBN #1-587-05069-2

- TCP/IP Illustrated, Volume 1. W. Richard Stevens, Addison-Wesley. ISBN #0-201-63346-9

- *Wireless Hacks, 2nd Edition*. Rob Flickenger and Roger Weeks, O'Reilly Media. ISBN #0-596-10144-9

Appendix B: Channel Allocations

The following tables list the channel numbers and center frequencies used for 802.11a and 802.11b/g. Note that while all of these frequencies are in the unlicensed ISM and U-NII bands, not all channels are available in all countries. Many regions impose restrictions on output power and indoor / outdoor use on some channels. These regulations are rapidly changing, so always check your local regulations before transmitting.

Note that these tables show the center frequency for each channel. Channels are 22MHz wide in 802.11b/g, and 20MHz wide in 802.11a.

802.11b / g			
Channel #	Center Frequency (GHz)	Channel #	Center Frequency (GHz)
1	2.412	8	2.447
2	2.417	9	2.452
3	2.422	10	2.457
4	2.427	11	2.462
5	2.432	12	2.467
6	2.437	13	2.472
7	2.442	14	2.484

802.11a	
Channel #	Center Frequency (GHz)
34	5.170
36	5.180
38	5.190
40	5.200
42	5.210
44	5.220
46	5.230
48	5.240
52	5.260
56	5.280
60	5.300
64	5.320
149	5.745
153	5.765
157	5.785
161	5.805

Appendix C: Path Loss

Free Space Path Loss

Path Loss (dB) vs Distance

Legend:
— 2400 MHz
- - - 5300 MHz
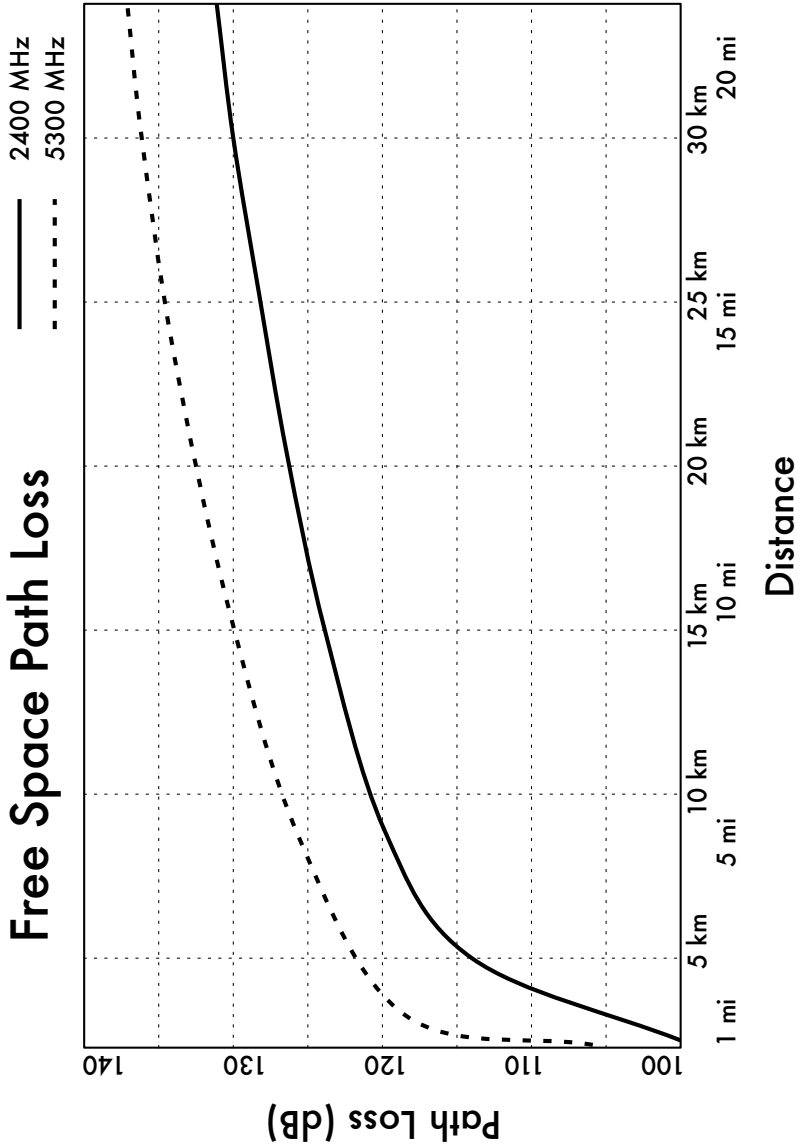
Appendix D: Cable Sizes

Wire gauge, diameter, current capacity, and resistance at 20°C. These values can vary from cable to cable. When in doubt, consult the manufacturer's specifications.

AWG Gauge	Diameter (mm)	Ohms / Meter	Max Amperes
0000	11.68	0.000161	302
000	10.40	0.000203	239
00	9.27	0.000256	190
0	8.25	0.000322	150
1	7.35	0.000406	119
2	6.54	0.000513	94
3	5.83	0.000646	75
4	5.19	0.000815	60
5	4.62	0.001028	47
6	4.11	0.001296	37
7	3.67	0.001634	30
8	3.26	0.002060	24
9	2.91	0.002598	19
10	2.59	0.003276	15

Appendix E: Solar Dimensioning

Use these tables to collect the necessary data to estimate the required size of your solar energy system.

General Data

Site Name	
Site Latitude (°)	

Irradiation Data

$G_{dm}(0)$, in kWh / m^2 per day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Worst Irradiation Month											

Reliability and System Operational Voltage

Days of Autonomy (N)	
Nominal Voltage (V_{NEquip})	

Component Characteristics

Solar Panels	
Voltage @ Maximum Power (V_{pmax})	
Current @ Maximum Power (I_{pmax})	
Panel Type/Model and Power (W_p)	

Batteries	
Nominal Capacity @ 100 H (C_{NBat})	
Nominal Voltage (V_{NBat})	
Maximum Depth of Discharge (DoD_{MAX}) or Usable Capacity (C_{UBat})	

Regulator	
Nominal Voltage (V_{NReg})	
Maximum Current (I_{maxReg})	

DC/AC Inverter (if needed)	
Nominal Voltage (V_{NConv})	
Instantaneous Power (P_{IConv})	
Performance @ 70% Load	

Loads

Estimated Energy Consumed by the Loads (DC)				
Month of Greatest Consumption				
Description	# of Units	x Nominal Power	x Usage Hours / Day	= Energy (Wh/day)
E_{TOTAL} DC				

Estimated Energy Consumed by the Loads (AC)				
Month of Greatest Consumption				
Description	# of Units	x Nominal Power	x Usage Hours / Day	= Energy (Wh/day)
E_{TOTAL} AC (before converter)				
E_{TOTAL} AC (after converter) = E_{TOTAL} AC / 70%				

Finding the Worst Month

	(Month)	J	F	M	A	M	J	J	A	S	O	N	D
Site Name													
Site Latitude (°)													
Nominal Voltage of the Installation V_N													
Inclination ß													
G_{dm} (ß) (kWh/m^2 × day)													
E_{TOTAL} (DC) (Wh/day)													
E_{TOTAL} (AC) (Wh/day)													
E_{TOTAL} (AC + DC)=													
I_m (A) = E_{TOTAL} (Wh/day) × 1kW/m^2/ (G_{dm}(ß) x V_N)													

Worst Month Summary	
Worst Month	
I_m (A)	
I_{mMAX} (A) = 1.21 x I_m	
E_{TOTAL} (AC + DC)	

Final Calculations

Panels		
Panels in Series (N_{PS})	$N_{PS} = V_N / V_{Pmax} =$	
Panels in Parallel (N_{PP})	$N_{PP} = I_{mMAX} / I_{Pmax} =$	
Total Number of Panels	$N_{TOT} = N_{PS} \times N_{PP} =$	

Batteries		
Necessary Capacity (C_{NEC})	E_{TOTAL}(WORST MONTH) / $V_N \times N$	
Nominal Capacity (C_{NOM})	C_{NEC} / DoD_{MAX}	
Number of Batteries in Series (N_{BS})	V_N / V_{NBAT}	

Cables			
	Panels > Batteries	Batteries > Converter	Main Line
Voltage Drop ($V_a - V_b$)			
Thickness (Section) $r \times L \times I_{mMAX} / (V_a - V_b)$			

For cable thickness computation, $r = 0.01286$ Ω mm²/m (for copper) and L is the length in meters.

Glossary

0 - 9

802.11. While 802.11 is a wireless protocol in its own right, 802.11 is often used to refer to a family of wireless networking protocols used mainly for local area networking. Three popular variants include 802.11b, 802.11g, and 802.11a. See also: *Wi-Fi.*

A

AC see *Alternating Current*

access point (AP). A device that creates a wireless network that is usually connected to a wired Ethernet network. See also: *CPE, master mode*

accumulator. Another name for a *battery*.

ad-hoc mode. A radio mode used by 802.11 devices that allows the creation of a network without an access point. Mesh networks often use radios in ad-hoc mode. See also: *managed mode, master mode, monitor mode*

Address Resolution Protocol (ARP). A protocol widely used on Ethernet networks to translate IP addresses into MAC addresses.

address space. A group of IP addresses that all reside within the same logical subnet.

advertised window. The portion of a TCP header that specifies how many additional bytes of data the receiver is prepared to accept.

Alternating Current (AC). An electrical current which varies over time in a cyclic manner. AC current is typically used for lighting and appliances. See also: *Direct Current*

amortization. An accounting technique used to manage the expected cost of replacement and obsolescence of equipment over time.

amplifier. A device used to increase the transmitted power of a wireless device.

amplitude. The distance from the center of a wave to the extreme of one of its peaks.

anchor clients. Business clients of a subscription system who are reliable and can be considered low-risk.

AND logic. A logical operation that only evaluates as true if all of the items being compared also evaluate as true. See also: **OR logic**.

anonymizing proxy. A network service that hides the source or destination of communications. Anonymizing proxies can be used to protect people's privacy and to reduce an organization's exposure to legal liability for the actions of its users.

anonymity. In computer networks, communications that cannot be linked to a unique individual are said to be anonymous. The trade-off of anonymity versus accountability in communications is an ongoing debate online, and rules about anonymous communications vary widely around the world. See also: **authenticated**

antenna diversity. A technique used to overcome multipath interference by using two or more physically separated receiving antennas.

antenna gain. The amount of power concentrated in the direction of strongest radiation of an antenna, usually expressed in dBi. Antenna gain is reciprocal, which means that the effect of gain is present when transmitting as well as receiving.

antenna pattern. A graph that describes the relative strength of a radiated field in various directions from an antenna. See also: **rectangular plot, polar plot, linear polar**

coordinates, logarithmic polar coordinates

AP see **Access Point**

application layer. The topmost layer in the OSI and TCP/IP network models.

Argus see **Audit Record Generation and Utilization System**

ARP see **Address Resolution Protocol**

associated. An 802.11 radio is associated to an access point when it is ready to communicate with the network. This means that it is tuned to the proper channel, in range of the AP, using the correct SSID and other authentication parameters, etc.

at. A Unix facility that allows timed, one-shot execution of programs. See also: **cron**

attenuation. The reduction of available radio power as it is absorbed along a path, such as through trees, walls, buildings, or other objects. See also: **free space loss, scattering**

Audit Record Generation and Utilization System (Argus). An open source network monitoring tool used for tracking flows between hosts. Argus is available from *http://www.qosient.com/argus* .

authenticated. A network user that has proven their identity to a service or device (such as an access point) beyond a shadow of a doubt, usually by some means of cryptography. See also: **anonymity**