Community Wireless Training Curricula

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Short summary: This report includes a proposal for a training curricula in community wireless networks.
Keywords: community wireless, training, curricula

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1 Background

During the last three years a group of wireless enthusiasts[1] has been actively developing a methodology for hands-on training in community wireless networks.

The methodology consist of a set of training materials, laboratory exercises and field implementations. The curriculum proposed in this document consists of 20 basic and 10 advanced training units. The basic units are the result of two large trainings efforts in Africa (2005-06) and Latin America (2006-07).

The advance curricula included in this document should be considered as supplementary content to support teams that have completed the basic training and have already a basic wireless network in place.

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The basic training has been delivered over 300 people in 7 different countries in Africa and Latin America. The advance training results from IT46 assessment of the needs of two community wireless projects in Uganda and Nigeria during 2007.

The modular design of the training should allow a training team to adapt the content to the very local conditions of the recipients. Wireless training courses can run from one day to several weeks.

Important notice: theoretical participatory lectures should always combined with field and practical work.

All documentation is available under Creative Commons License Attribution Non-Commercial Share-Alike free of charge. Copies of the materials are available at: http://www.it46.se/courses

The first edition of the materials are available in French, English, Arabic and Spanish. A second edition developed during 2007 is available in Spanish and English (March 2008)

Examples of the trainings conducted with the materials:

- Wireless Training Africa http://www.it46.se/ref/IDRC_wifi_ifrane
- Wireless Training Latin America http://www.wilac.net/tricalcar

2 Basic Training Curricula

This section includes 20 theoretical training units. The table of contents of each of the presentations is included as a reference.

2.1 Introduction to community wireless networks

- Introduction to wireless community networks,
- History and vision of the training.

2.2 Standards in Wireless Technologies

- What is a standard?
- Open and closed standards
- IEEE and its work groups; IEEE 802 LAN/MAN
- Traditional IEEE 802,11 (Wireless Local area networks); Confusion of naming.
- IEEE 802.11 - Technical aspects: Layer 1 (802,11 PHY); Techniques of modulation; Frequencies; Layer 2 (802,11 MAC); Media access control.
- Amendments of IEEE 802.11: IEEE 802.11b; IEEE 802.11a; IEEE 802.11g; IEEE 802.11s; IEEE 802.11n. Space Diversity; space division multiplexing

(SDM); Summary of the amendments to 802.11.

- WiMAX (IEEE 802,16) versus. WiFi (IEEE 802,11): Range and Coverage; Scalability and performance; Quality of the service.

2.3 Introduction to Radio Physics

- Fields and electromagnetic waves: Characteristics of the electromagnetic waves. The electric and magnetic fields; Propagation Media; Wavelength and frequency.

- Polarization.

- Radiation of a dipole.

- The electromagnetic spectrum: The frequencies of the radio networks.

- Propagation of electromagnetic waves: Absorption; Reflection; Diffraction; Refraction; Interference.

- Effects dependent on the frequency.

- Radio propagation in free space: Free space loss (FSL); Fresnel Zones; Line of sight; Multipath.

- When the physics makes a difference!.

2.4 Topology and Basic Infrastructure of Radio networks

- Basic network topologies: Relevant network topologies wireless networking.

- Components of radio networks: Access point; Wireless clients.

- Ways of operation of radio networks: Ad hoc (IBSS), Point to point. Infrastructure (BSS), Point-to-mutipoint, Mesh.

- Examples of the real wireless infrastructure.

2.5 Configuration of Stations/Laboratory - WDS

- Configuration of access points:
    - Installing the hardware and firmware, physical Installation, Updating firmware, Connecting computers to the devices; Configuration of the hardware following the model OSI,
    - Reviewing the OSI Model: physical layer, channel number, Power of transmission, Rate or speed of transmission,
    - Ways of operation, SSID (Service Set Identifier), Access Control, Restriction of access through authentication.
- Installation of clients:
    - Linux: Selecting the wireless hardware; Types of hardware, Wireless

chipsets, supported and unsupported hardware. Differences between drivers; Installing the wireless device, Preparing the installation, Inserting the card, Identifying chipset; Configuring the wireless device, Example 1: Ubuntu with Gnome.

- Windows XP: Selecting the wireless hardware; Installation of the wireless device; Configuration of the wireless device.

- Exercises: Configuration of access points

2.6   Link Budget Calculation

- What is a link budget?

- The elements of the link budget: The transmission side, Transmission Power, Cable Losses, Connectors Losses, Amplifiers, Antenna Gain; Propagation Losses, Losses in the free space, Fresnel Zone; The Receiving side, Antenna of the receiver, Amplifiers for the receiver, Sensitivity, Margin and Relation S/N.

- Terminology and Concepts.

- Calculation with Decibels (dB, dBm, dBi): Conversion of Watt to dBm.

- Calculating the budget: Example 1: Connection of 50 km; Example 2: Connection of 1 km; Other important calculations and approaches, Sources of latitude/longitude and data of elevation,

- Using RadioMobile and spreadsheet calculators.

- Exercises.

2.7   Site Survey

- Viability study.

- Inspection of the existing physical infrastructure.

- Inspection of the existing technical infrastructure.

- Access to power/energy.

- Internet connectivity.

- Site Survey Templates.

2.8   Antennas and Cables

- What is an antenna?: Fundamental characteristics; Characteristics of the Antennas; Antenna Gain; Radiation pattern; Width of the beam (beamwidth); Impedance; Polarization, Vertical Polarization, Horizontal Polarization, Elliptical Polarization, Crossed Polarization; Other characteristics of the antennas, From to back (F/B), VSWR or Return Loss, Bandwidth.

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- Types of antennas: Half-wave dipole, Double Dipole, Monopole, Yagi-Uda Antenna, Log-Periodic, Loop Antenna, Omnidirectional Antennas, Sectoral Antennas, Parabolic Reflector, Flat Antenna or "Patch", Antenna guide-wave, Spiral Antenna, Slot Antenna.

- Isolation of antenna, vertical isolation, horizontal isolation.

- Connectors for coaxial cables.

- Power dividers.

- Path losses.

- Losses in cables and connectors: Coaxial cable; Losses in the cable; Pigtails.

- Exercises.

2.9 Simulation of outdoor radio links with Radio Mobile

- What is Mobile Radio?

- What is SRTM?

- Installing Mobile Radio.

- Designing with Mobile Radio: Position and Cartography; Properties and topology of the radio network, Creating a logical network, Creation of system specifications, create and position units, network membership.

- Analysis of link budget and radio coverage

2.10 Outdoor installations

- The importance of standards.

- Definitions: Towers and Masts.

- Supports for antennas: Assemblies on the ceiling (Not-penetrating); Assembly on the wall.

- Water-proof boxes.

- Energy provision.

- Assembly considerations.

- Types of towers: Monopoles; Auto-Supported towers; Guyed towers, Thickness and tightened of guys.

- Foundations.

- How to choose a tower or a mast.

- Antenna wind load: location and height of the tower.

- Security considerations.

- Protection against lighting and fluctuations of electrical tension: fuses, earthing; stabilizers and voltage regulators.

• Corrosion: Prevention of the corrosion. Maintenance of towers and masts.

2.11   Troubleshooting

• Looking for a source of stable power

• Firmware upgrade.

• Methodology: Resolution of problems using the OSI model.

• Tools for troubleshooting

• Scenario 1: Radio interferences, Occupied channels?

• Scenario 2: Congested network? Flooding?

• Scenario 3: Why a network service is not working?

• Control of interferences: Interference and noise; Maximizing the level of the received signal; Diminishing the levels of interference and noise; Strategies to control the interference.

2.12   Wireless Security

• Defining wireless security.

• What is security of the information (INFOSEC): Confidentiality; Authentication; Integrity; Availability; Non-repudiation.

• Security of information in WLAN.

• Implementing security attributes

• Confidentiality in wireless networks: WEP or non-WEP; the death of WEP; WPA and WPA2.

• Authentication in wireless networks: SSID broadcasting, MAC filters and captive portals.

• Data integrity in wireless networks

• Availability in wireless networks.

• Non-repudiation in wireless networks

• Main security threats.

2.13   Mesh Networks

• Defining MESH networks: Topology and dynamics of mesh network; Typical scenarios; Mesh related terms.

• Motivation, expectations and limitations: Price; Organization and business models; Deployment and simplicity; Resilient networks; Power; Integration; Urban and rural environments; Limitations.

• Mesh routing protocols: Elements of mesh routing; Types of protocols; Pro-

active (handling by tables); Reactive (on demand); Measurements.

- Protocol examples: MMRP (MobileMesh); OSPF; OLSR; OLSR with ETX measurements; AODV.

- Mesh hardware: 4G AccessCube; MeshNode; Linksys WRT54G, GS, GL; Locustworld MeshAP; Customized x86.

- Mesh software: MeshLinux; Zebra/Quagga; CUWin; Pebble; OpenWRT; Freifunk Firmware.

- Case Studies: Freifunk - Germany; CUWiN - USA; Dharamsala - India; Institute Meraka - South Africa.

- The Pico-Peering agreement.

- Limitations of Mesh networks: Latency; Performance; Scalability; Security; IP Distribution.

2.14 WiMAX and Non-standard solutions

- History of IEEE 802.16.

- IEEE 802.11 native problems: Hidden node problem, QoS, dynamic channel bandwidth, NLOS.

- IEEE 802.16 . The "a" and "e" amendments.

- Costs and scalability

- IEEE 802.20 - MBWA

- Non-standard proprietary solutions: Motorola Canopy, TurboCell/Karlnet, WORP.

2.15 Solar Energy for telecommunication systems

- Global Solar Radiation

- Introduction to autonomous PV system: Components and general costs.

- Solar Panel: Parameters, Efficiency, Arrays, Effects of temperature

- How to choose a good solar panel

- Deep Cycle Batteries

- Recycling car batteries

- Solar Chargers: Characteristics

- Typical consumption of telecommunication systems

- Low power wireless access points

- Introduction to PV system sizing

- Dimensioning of a wireless solar repeater

2.16 VoIP for the development

- The magical potion: VoIP; Open standards and FOSS; Asterisk.

- Introduction to PSTN telephony: Signalling in traditional telephony, analog signalling, signalling between telephone offices; signalling in IP telephony

- SIP: SIP Proxy Servers, RTP and NAT, Inter-Asterisk eXchange (IAX) protocol

- VoIP equipment: VoIP Telephones, ATA and Softphones

- Interfacing with the PSTN

- Codecs, Quality of service, Latency, Jitter.

- Hands on - Building your own PBX

- Installing Asterisk: Downloading and compiling Asterisk; Basic commands in Asterisk; Configuration files; Peers, Users and Friends.

- Scenario A: Private wireless network in a rural community

- Scenario B: Connecting to the PSTN; Including support for the TDM400P. Incoming and outgoing calls, Adding analogue terminals, introduction to the dialplan.

- Scenario C: Connecting a community via VSAT, Interconnection of Asterisk Servers, Trunking and audio compression.

- Extra resources to learn more.

2.17 Long Distance Wireless Links

- What is needed for a long distance wireless connection?

- Alignment of Antennas: Alignment when we can see the other end of the connection; Alignment when we cannot see the other end of the connection.

- Low cost spectrum analysers and signal generators.

- Adjusting wireless parameters for long distance links.

- Modifying the Wireless MAC

2.18 Planning a wireless network

- Viability Study

- Implementation plan: Network topology using radio simulation; Practical issues to take intro consideration during the installation.

- Budget: Hardware, Power, Earthing and protection against lighting, Tools; Human resources, local transport, additional expenses.

- Licenses and permissions: Mast or tower; Permissions to operate in the frequencies of IEEE 802.11.

- Procurement: Local Procurement; Import, Inspection pre-shipment, Certificate of origin, invoicing, transport insurance, taxes and VAT.

- Implementation Phase: Weather, Team members.

- General advice on contracts

- Quality assurance

- Exercises

2.19 Community and ICTs

- Social inclusion with/in ICTs

- What ICTs contribute to the development of the communities?

- Equal opportunities in the information society

- Exercises.

2.20 Strategies of sustainability

3 Advance training units

The next 10 units extend the basic curriculum and include advance topics. This units should be delivered to trainees that have completed the Basic Training Curricula and have completed a basic installation of a community wireless network.

1. Wireless network management and monitoring

2. Wireless traffic management and QoS

3. Web proxying

4. Wireless Captive portals

5. Advanced VoIP configuration

6. Advanced Solar dimensioning

7. Advanced Wireless configuration and performance parameters

8. Advanced Wireless networking

9. Wireless Billing

10. Installation and procurement of of towers

4 Laboratory guidelines

This are basic recommendations in terms of hardware and human resources for a community wireless laboratory

4.1 Human resources

- Laboratory practices in a classroom should not be bigger than 30 people
- Field work should not include more than 5 people per team.
- Classroom groups should not bigger than 3 members per team.
- An individual trainer should handle a maximum of 10 people. (3 teams)
- A laboratory of 30 people should include two main trainers and two assistants

4.2 Hardware requirements

Assuming a group of 30 people with 4 trainers (10 teams of 3 people)

- 15-25 wireless access points
- 10-14 PCs
- 10-14 ATAs or VoIP Terminals
- 15 pigtails and connectors
- 30 2m RJ45 cables
- 250m RJ45 cable (roll)
- 10 UPS (300 Wh)
- 10 2.5-3m tables
- 35 chairs
- 1 projector
- 1 audio system/wireless microphone
- 12 power bars and power extenders
- 30 RJ45 connectors and crimping tools
- Cable tester
- 2 drillers including drills
- 15 metallic cans
- 12 LAN network interfaces
- 12 WLAN network interfaces
- 5 soldering kits
- Storage space
- CD-Burner
- 2 USB-drives