Designing of a semi-automation tool for wireless LAN interoperability testing

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Degree Programme in Computer Science

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ABSTRACT

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Interoperability testing for devices using wireless local area networks may require a complex test environment consisting of several Access Points and authentication servers. These entities are used to verify the correct operation of a device under test.

Each entity has several settings for various authentication types and encryptions. There is no global standard for remote (or local) user interface to enable machine-to-machine automation for changing the settings. When user has to manually setup each feature, it is prone to errors. These erroneous situations may slow down the actual testing and therefore create pressure for the schedules.

By creating a user interface based on radio-buttons it is possible to reduce the complexity of setting up the test environment to an acceptable level. The user interface takes care of powering up the desired Access Point, communicates with it and restores the desired setup and, if needed, sets the definitions for authentication servers. Focus can be set to actual interoperability testing instead of setting up the test environment.

A clear reduction of errors caused by faulty setups of the test environment was achieved when the user interface was taken into use. Also reliability and repeatability of testing got better.

This thesis focuses on describing the functionality and the structure of the WLAN verification Wizard user interface -tool. Actual interoperability testing of wireless local area networks is out of scope due to non-disclosure agreements.

Key words: interoperability testing, wireless LAN, Access Point, settings

CONTENTS

ABBREVIATIONS AND TERMS

AAA	Authentication, Authorization and Accounting, a synonym for RADIUS.
ACS	Access Control Server, a product from Cisco Systems Corporation, providing RADIUS functionality.
AP	Access Point, commonly used term for devices connecting wireless devices to wired network. In this context refers to Wireless Local Area Network Access Points.
APC	American Power Conversion, a company by Schneider Electric, a manufacturer of uninterruptible power supplies (UPS) and surge protection products.
ASCII	American Standard Code for Information Interchange, defines character encoding.
AutoIt	A freeware BASIC-like scripting language designed for automating the Windows GUI and general scripting.
BASIC	Acronym for Beginner's All-purpose Symbolic Instruction Code.
C++	A programming language developed by Bjarne Stroustrup starting in 1979 at Bell Labs.
CCMP/AES	Counter Mode with Cipher Block Chaining Message Authentication Code Protocol/Advanced Encryption Standard, a security protocol used in the IEEE 802.11 wireless networking standard.
Ciphering	An algorithm for performing encryption or decryption—a series of well-defined steps that can be followed as a procedure.
EAP	Extensible Authentication Protocol, an authentication framework providing for the transport and usage of keying material and parameters generated by EAP methods.
EAP-AKA	Extensible Authentication Protocol/Authentication and Key Agreement, a method for authenticating user in 3G network by using 3G-SIM, de-fined in RFC 4187.

EAP-LEAP	Extensible Authentication Protocol/Lightweight Extensible Authentication Protocol, based on PEAP but with lighter security, defined by Cisco Systems.
EAP-PEAP	Extensible Authentication Protocol/Protected Extensible Authentication Protocol, defined by Microsoft, Cisco Systems and RSA Security.
EAP-SIM	Extensible Authentication Protocol/Subscriber Identification Module, a method for authenticating user in 2G network by using GSM-SIM, defined by Nokia/Haverinen et al, IETF RFC 4186.
EAP-TLS	Extensible Authentication Protocol/Transport Layer Security, based on X.509 certificate, defined by Microsoft, IETF RFC 2716.
EAP-TTLS	Extensible Authentication Protocol/Tunnelled Transport Layer Security, based on security certificate but information is transferred inside a secured tunnel, defined by Funk Software/Juniper and Certicom corporations.
ETSI	The European Telecommunications Standards Institute, produces globally-applicable standards for Information and Communications Technologies.
FSF	Free Software Foundation, a non-profit organization founded by Richard Stallman on 4 October 1985 to support the free software movement, promoting the universal freedom to create, distribute and modify computer software, with the organization's preference for software being distributed under copyleft ("share alike") term.
GIMP	GNU Image Manipulation Program, an image retouching and editing tool released under the LGPLv3 and later versions as free and open-source software.
GNU	Recursive acronym for “GNU is Not Unix”, a free, Unix-like operating system for computers containing no Unix-code.
GSM	Global System for Mobile Communications is a standard set developed by the ETSI to describe protocols for second generation (2G) digital cellular networks used by mobile phones.

GTK+	GIMP Toolkit, a cross-platform widget toolkit for creating graphical user interfaces.
HTTP	Hypertext Transfer Protocol.
IAS	Internet Authentication Server, part of Microsoft Windows Server, a product from Microsoft Corporation, provides RADIUS functionality.
IEEE	Institute of Electrical and Electronics Engineers, publishes nearly a third of the world's technical literature in electrical engineering, computer science, and electronics.
IEEE 802.11	Standard for Information technology, Telecommunications and information exchange between systems local and metropolitan area network.
IEEE 802.11i	Amendment to IEEE 802.11 defining security mechanisms for IEEE 802.11.
IETF	Internet Engineering Task Force, an international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.
INI-file	Initialization file. The INI-file format is an informal standard for configuration files for some platforms or software. INI-files are simple text files with a basic structure composed of "sections" and "properties".
IP	Acronym for TCP/IP.
ISM	License-free radio spectrum intended for Industrial, Scientific and Medical usage.
ITU	International Telecommunication Union, United Nations specialized agency for information and communication technologies.
ITU-T	One of the three sectors (divisions or units) of the ITU coordinating standards for telecommunications.
LAN	Local Area Network, computers connected in the same physical or logical entity wired means.
LGPL	The GNU Lesser General Public License (formerly the GNU Library General Public License) is a free software license published by the Free Software Foundation (FSF). The

	LGPL allows developers and companies to use and integrate LGPL software into their own (even proprietary) software without being required (by the terms of a strong copyleft) to release the source code of their own software parts.
Netsh	A tool for an administrator to use to configure and monitor Windows-based computers at a command prompt.
PDU	Power Distribution Unit, controllable via LAN or serial cable.
Ping	A computer network administration utility used to test the reachability of a host on an Internet Protocol (IP) network and to measure the round-trip time for messages sent from the originating host to a destination computer. The name comes from active sonar terminology which sends a pulse of sound and listens for the echo to detect objects underwater.
PKI	A set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates.
Plink	PuTTY Link, command-line version of PuTTY.
PMI	Privilege Management Infrastructure, a process of managing user authorizations based on the ITU-T Recommendation X.509.
Proxy	An intermediary element for clients to use resources on remote servers. In this context proxy directs requests to correct authentication server.
PsExec	A command-line remote administration tool allowing remote execution of processes on other systems. Originally developed by Mark Russinovich of Sysinternals -corporation.
PuTTY	SSH and Telnet client, developed originally by Simon Tatham for the Windows platform.
Qt	Platform independent graphical user interface and program development environment.
RADIUS	Remote Authentication Dial In User Service, a service which authenticates users, computers, client software allowing usage of resources.

RFC	Request for Comments, in this context refers to IETF's recommendations which are widely adopted to use but not yet set as official standards.
RPC	Remote Procedure Call, an inter-process communication enabling a program to execute a process, procedure or subroutine in another computer.
SCIntilla	A free source code editing component for Windows and GTK+ developed by SCIntilla project.
SciTE	A SCIntilla based Text Editor.
SIM	Subscriber Identification Module, an integrated circuit securely storing international mobile subscriber identity and the related key to authenticate user on network.
SOHO-mode	Small Office, Home Office; WFA commercial term for personal authentication
SSH	Secure Shell, cryptographic network protocol for secure data communication, remote shell services or command execution and other secure network services between two networked computers.
TCP/IP	Transmission Control Protocol / Internet Protocol; TCP/IP provides end-to-end connectivity specifying how data should be formatted, addressed, transmitted, routed and received at the destination.
Telnet	Network protocol used on the Internet or local area networks to provide a bidirectional interactive text-oriented communication facility using a virtual terminal connection.
Tftp	Trivial File Transfer Protocol, a file transfer protocol generally used for automated transfer of configuration or boot files between machines in a local environment.
TKIP	Temporary Key Integrity Protocol, a security protocol used in the IEEE 802.11 wireless networking standard.
UNIX	A multitasking, multi-user computer operating system that exists in many variants.
UMTS	Universal Mobile Telecommunications System, a third generation (3G) mobile cellular system for networks based on the GSM standard.

WEP	Wired Equivalent Privacy, a security protocol to authenticate user in the IEEE 802.11 wireless networking standard, usually 64bit (WEP64) or 128bit (WEP128).
WFA	Wi-Fi Alliance, a non-profit organization coordinating certification and development of Wlan-related issues.
Wi-Fi	Wireless Fidelity, a trademark for Wi-Fi Alliance, used as a synonym for Wireless LAN Local Area Network.
Wlan	Wireless Local Area Network, computers connected in the same physical or logical entity using wireless means. In this context refers to IEEE 802.11 wireless networking standard.
WPA	Wi-Fi Protected Access, authentication method using TKIP ciphering.
WPA2	Wi-Fi Protected Access 2, authentication method using CCMP/AES ciphering.
X.509	An ITU-T standard for a public key infrastructure (PKI) and Privilege Management Infrastructure (PMI). X.509 specifies standard formats for public key certificates, certificate revocation lists, attribute certificates, and a certification path validation algorithm.

1 INTRODUCTION

When a data communication product is being developed it is very important to take into account also other devices available on the market.

Product development cycles have been shortened massively due to market pressure. Therefore it is quite common to find products on the market which are not manufactured by the specifications or which are not certified. Some of these certifications are not mandatory and therefore it is tempting to leave out those money and time consuming testing sessions.

Certification testing focuses on testing whether a device fulfills the requirements mandated by the certification body. It does not take into account how a device functions with other devices. Therefore interoperability testing has become a natural addition to testing scope for companies manufacturing data communications equipment.

Interoperability testing uses end-user perspective and takes into account most relevant use cases for the device. Testing is usually performed against other devices available in the market.

Wireless LAN interoperability testing for cellular phones contains many aspects ranging from Access Pont selection to encryption and authentication methods. The number of possible selections grows large and adds complexity to test environment setup.

A complex test environment is prone to human-induced errors when setting up testing systems. These errors may cause abnormal behavior of the whole system and create unexpected delays to testing schedule.

By letting a computer to take care of setting up the test environment can human errors be avoided and testing can focus on finding possible errors on the tested device.

Due to corporate-specific nature of the interoperability testing environment there were no products available in the market which could be used right away or even with some modification. It became necessary to create a tool for this specific use.

2 WI-FI ALLIANCE

2.1 Introduction

One example of these non-mandatory or regulatory certifications is the Certification for Wireless Local Area Networks (WLAN) maintained by Wi-Fi Alliance (WFA) (Wi-Fi Alliance 2013). It is a non-profit organization coordinating WLAN development and certification. It was found in 1999 and founding members 3Com, Aironet, Intersil, Lucent Technologies, Nokia and Symbol Technologies. Nowadays WFA consists of over 400 member companies.

WFA develops and maintains test plans for their member companies to certify their products. Common test plans are mainly developed for certifying pc-centric devices, and therefore member companies can create their own test plans. These company-specific test plans require approval from technical department of WFA.

2.2 Wireless Local Area Network Access Point

Wireless Local Area Network Access Point (AP) is a device connecting wireless client devices to existing wired network. There are many different brands and models available and their availability varies also geographically. Local laws and regulations have an effect on the product availability not to mention about local teleoperators who may have proprietary rights to certain products.

The basic functionality of an AP is defined by the chipset it is using. Also antenna design and AP's host software have an effect. The number of chipset vendors is limited and therefore it is possible to get good market coverage for testing. The basic functionality of the chipset remains approximately the same regardless the AP manufacturer.

WFA certification testing uses only a few APs which are not available publicly. It focuses on throughput measurements. All encryption types and authentication methods suitable to certifying product are also tested.

2.3 Authentication methods, Personal

WFA uses terms “Personal” and “Enterprise”. The term “Personal” in this context means the authentication does not require an authentication server and/or encryption certificate whereas “Enterprise” applies those. Table 1 describes the authentication methods defined for Personal use with APs.

Table 1: Personal authentication methods

Method name	Protection type
Open Network	no encryption
Wired Equivalent Privacy (WEP) 64-bit	password containing 10 hexadecimal characters (removed from current certification requirements)
WEP 128-bit	password containing 26 hexadecimal characters (removed from current certification requirements)
Wi-Fi Protected Access (WPA) Personal	password containing 8 - 63 printable ASCII-characters using TKIP-encryption for each packet transmission between the client and Access Point (removed from current certification requirements)
Wi-Fi Protected Access II (WPA2) Personal	password containing 8 - 63 printable ASCII-characters using CCMP/AES–encryption for each packet transmission between the client and Access Point

Both WEP-encryptions are removed from certification requirements due to their vulnerability to attacks. Also WPA is removed, as it was a temporary replacement of WEP offering much higher degree of security. It contained almost the full IEEE802.11i -standard but lacked a strong message integrity check algorithm thus enabling retrieving the key stream for short packets and use those for re-keying and spoofing.

Even though WEP/WPA -encryptions were removed from certification plans those can still be found in almost all APs despite their security vulnerabilities. Current certification requirements mandates WPA2-encryption which is considered to be safe and it contains full support for IEEE802.11i -standard.

Figure 1 shows the principle of a successful Personal authentication. The AP makes the decision whether the client may access resources via it.

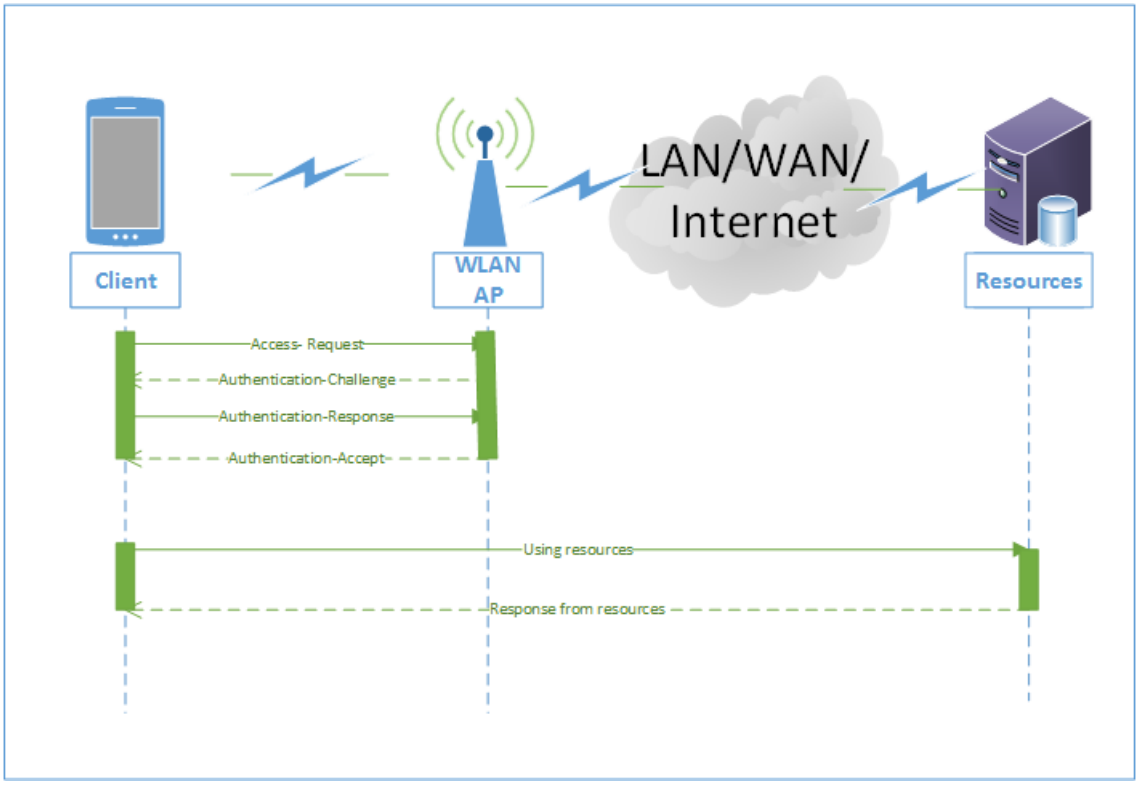

Figure 1: Personal authentication principle

Personal authentication is seen adequate for home and small office use due to its minimal hardware requirements. For additional security and access control manageability Enterprise authentication is used.

2.4 Authentication methods, Enterprise

For Enterprise usage mere password-based authentication is not seen as secure-enough method and therefore Extensible Authentication Scheme is used. It adds to security by implementing certificate-based authentication using Extensible Authentication Protocol (EAP). When Enterprise authentication is used an authentication server is required. It adds more complexity to the environment but also more security, when implemented properly.

No single server product can handle all possible certificate-based methods. Therefore there are multitudes of products available on the market. Most common ones are Mi-

crosoft Server 2003 (Internet Authentication Server, IAS)/2008/2008 R2/2010, Cisco ACS and FreeRADIUS. Quite often these authentication servers are referred as RADIUS (Remote Authentication Dial In User Service). Sometimes also abbreviation AAA (Authentication, Authorization and Accounting) is used. Most common EAP-methods are described in Table 2.

Table 2: Common EAP-methods

EAP-method	Description
EAP-TLS	Transport Layer Security, developed by Microsoft, IETF RFC 2716
EAP-PEAP	Protected Extensible Authentication Protocol v0 and v1, developed by Microsoft, Cisco and RSA Security
EAP-TTLS	Tunnelled Transport Layer Security, developed by Funk Software and Certicom
EAP-LEAP	Lightweight Extensible Authentication Protocol, developed by Cisco
EAP-SIM	Method for GSM Subscriber Identification Module, developed by Nokia/Haverinen et al, RFC 4186
EAP-AKA	Method for UMTS Authentication and Key Agreement, RFC 4187

Figure 2 shows the principle of an Enterprise authentication. The most notable difference when comparing to Personal authentication is the role of an AP. In the Enterprise authentication it acts only as an intermediary directing the authentication requests to authentication server, which makes the decision whether the client may access the network resources via AP or not.

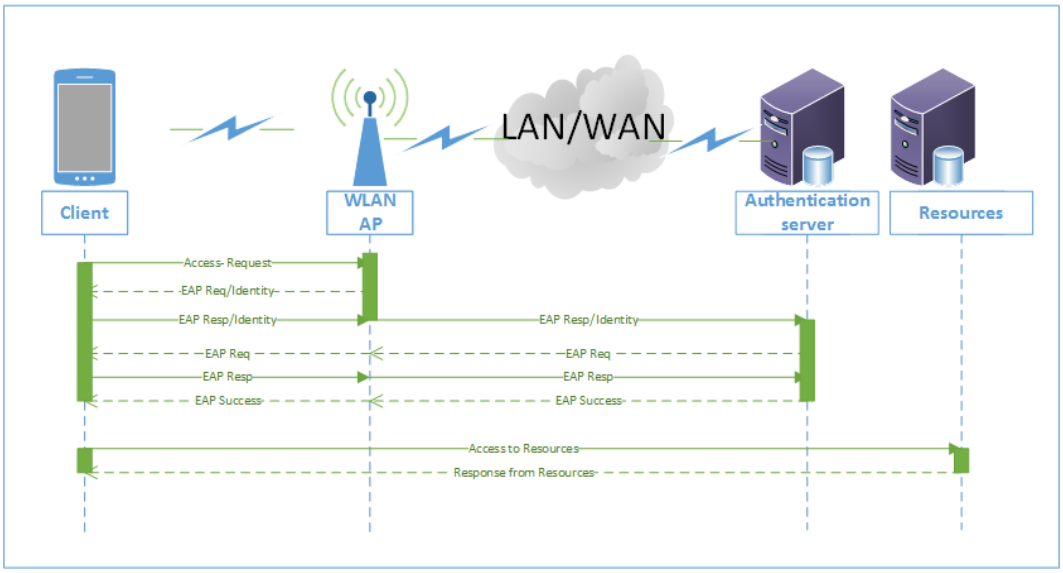

Figure 2: Enterprise authentication principle

3 TASK AT HAND

3.1 Background

Common practice and reality has proven the following: device certification does not guarantee interoperability with the devices already on the market. Most important reasons being:

- Certification definitions are not 100% applicable to every situation, but leave room for interpretations in some cases
- Not all companies certify their products

Therefore testing the corporate product with as many products on the market as possible is the only viable solution to guarantee reasonable degree of interoperability.

3.2 Interoperability testing

Interoperability testing is one of the most mundane tasks when new data communications products are being developed. Regardless the technology a reasonable level of interoperability has to be achieved and maintained before the product can enter to market.

The actual testing has to consider the requirements of the needed certifications and take into account other manufacturer’s devices which may, or not, function as specified. In addition human behaviour has to be accounted for i.e. how people will use the product.

4 GETTING STARTED

4.1 The starting point

Interoperability testing for wireless LAN -enabled Nokia phones had to be taken care of. Very soon it was discovered each AP has their own user interface, different types of settings and no common interface to handle administrative tasks and change settings. In practice every AP is its own individual unit and needs to be setup accordingly.

Due to other engagements external workforce had to be used for actual testing every now and then. Sometimes they did not necessary had the experience of setting up various APs and/or had too busy schedules for the testing. This resulted many hectic error hunting sessions and wasted time.

A slight relief was discovered as most of the APs support saving the active settings to a backup file. It can be imported back to AP to change e.g. encryption method. Despite of this time-saving feature some problems remained: sometimes a wrong file was imported due to misunderstandings or not seeing the whole picture of the scope for testing.

A quick search did not return any products already in the market which could be used either off-the-shelf or with some modification. There were some programs which could be partially used, for example PCAnywhere, but they lacked some capabilities and had a price tag which could not be justified by very strict budget limitations.

These small setbacks induced a thought of a self-made user interface, which would hide the complexity of setting up the environment. Setup may contain not only the AP settings but also RADIUS-settings depending on selected authentication method.

A self-guiding graphical user interface or front-end started to form. Windows operating systems environment was chosen as most of the computers, tools and measurement equipment were using it. The actual tool would combine a user interface and various data communications subsystems to be able to control the whole setup from a console.

Figure 3 shows the environment for which the tool is designed for. It comprises of a laboratory network to which all the elements are connected to either directly or via LAN or WAN.

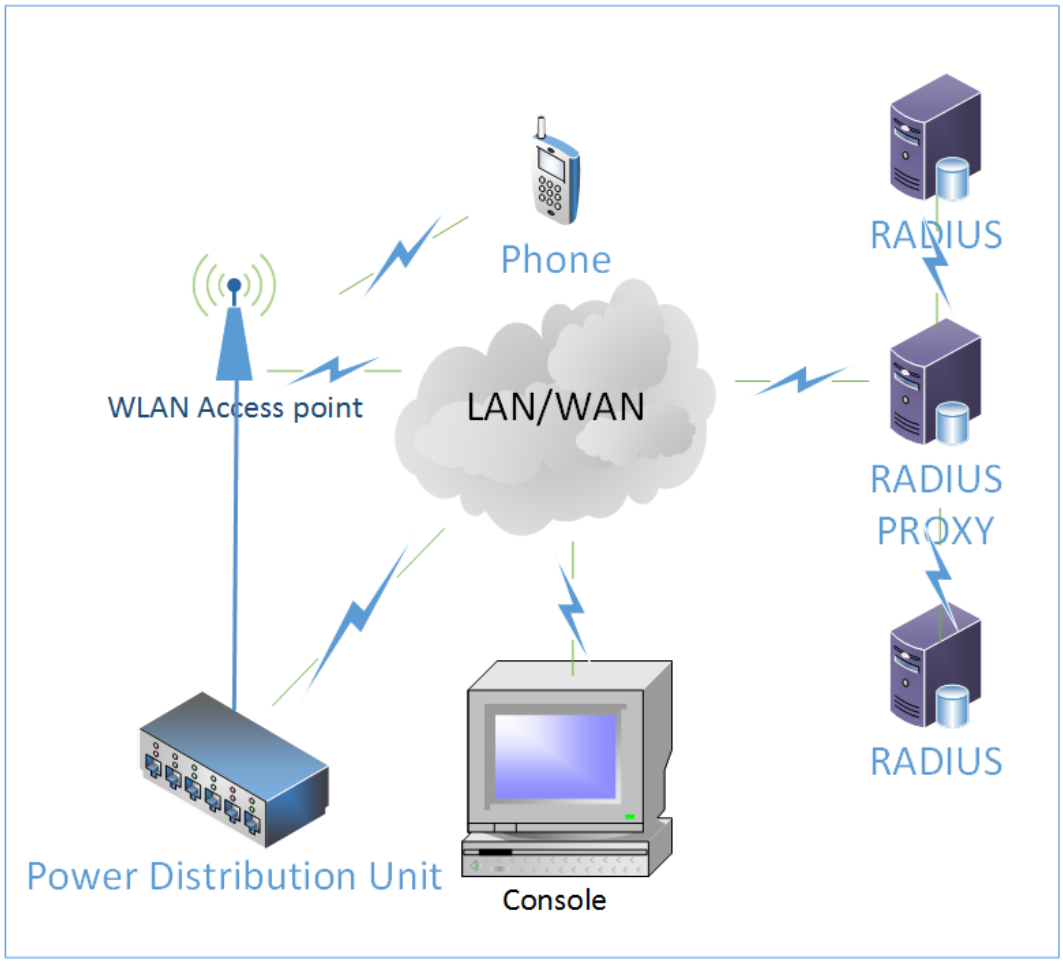

Figure 3: Interoperability test network

The first assumption was to use some commonly known programming language like C++, but soon it was discovered programming skills were not up-to-date. Next to consider was Qt due to its popularity by the time of the development but it also proved to be too hard to learn within usable timeframe. After some searching a BASIC-like scripting language called AutoIt (Bennet Jonathan & AutoIt Consulting Ltd. 2013) was found.

4.2 AutoIt

After a few try outs AutoIt Scripting language was decided to take into use. It is free, BASIC-like scripting language and has pre-defined controls like buttons, radio-buttons, lists and alike for Windows operating systems. It can simulate and automate button presses, mouse movements and windows controls manipulation. With it was fairly simple to create a user interface and compile a royalty-free executable file.

Other valid properties were fairly large base of supported Windows versions (2000 / XP / Windows Server 2003 / Vista / Windows Server 2008 / Windows 7), quite large and active community on support forum and a dedicated editor, based on SciTE with some modifications. Also memory consumption was very modest and during week-long idle tests it remained stable indicating no memory leaks.

Normally script created with AutoIt works with checking the controls (buttons, selection windows and others) inside a loop. When the number of controls is over 10 response time of the script goes beyond acceptable. Luckily AutoIt supports also event-based actions based on sending messages.

When a control is manipulated (button pressed, selection made) it returns a code unique for that particular control to main loop. This code is sent as a message to a desired function which does its job and returns a value. This “On Event” -mode enables very decent response times and keeps CPU utilization at modest levels.

4.3 Other considerations

User interface language selection was naturally English, as it is the de-facto language of the trade. Comments were added directly to the source code to make the code self-commentary so it would be easier to debug if something goes wrong or needs to be changed.

No actual design documentation was created during the implementation as this was a tool for own use. Look and feel of the program evolved quite fast to what it is now containing only the bare essential elements to do the job.

For Master's Thesis Requirement documentation (Appendix 1: Requirement documentation for semi-automation tool) and System Architecture Specification (Appendix 2: Architecture Specification for the semi-automation tool) were created. The Requirement Specification is based on Volere Requirements Specification Template, Edition 15 - March 2010 by James & Suzanne Robertson, principals of the Atlantic Systems Guild (Atlantic Systems Guild Limited 2013):

The template may not be sold, or used for commercial gain or purposes other than as a basis for a requirements specification without prior written permission. The Template may be modified or copied and used for your requirements work, provided you include the following copyright notice in any document that uses any part of this template:

We acknowledge that this document uses material from the Volere Requirements Specification Template, copyright © 1995 – 2010 the Atlantic Systems Guild Limited.

5 WLAN VERIFICATION WIZARD

5.1 The User Interface

The first versions of the user interface contained only the necessary components: AP -, encryption-, authentication- and RADIUS- selections as well as GO- and Exit –buttons. After some feedback a logging window was added. It contains information of which setups have been completed. Next item to add was PDU control program as a separate executable to manually power-up the APs. Eventually PDU control program was integrated to main user interface to minimize the number of open programs on the desktop of the console.

Start-up situation of the tool can be seen in Figure 4. User can make various selections, which have logic behind: if some selection is not viable or not supported that selection is greyed out.

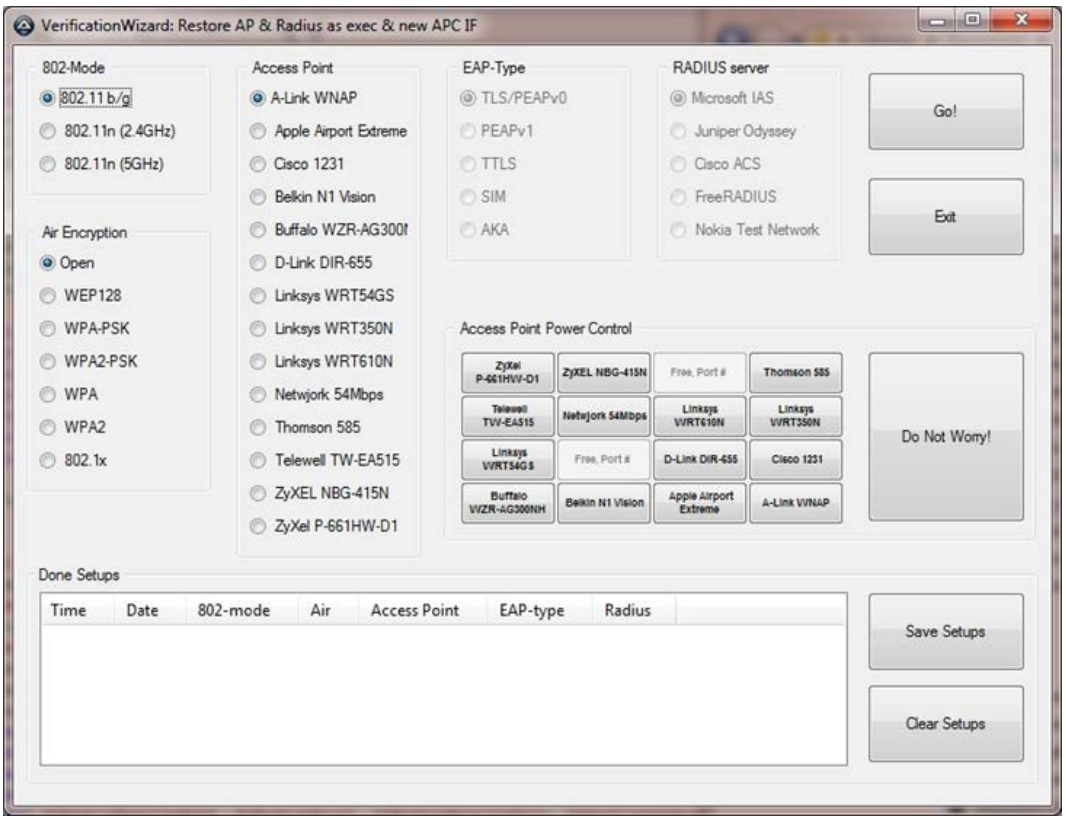

Figure 4: The User Interface

User can select the radio type (Section 802-mode: normal 802.11 b/g, 802.11n in 2.4 GHz or 802.11n in 5GHz), air encryption type (Section Air Encryption: none, WEP, PSK or Enterprise), desired AP (Section Access Point: up to 16 different ones, dynamic list), possible EAP-type (Section EAP-Type) and RADIUS-server (Section RADIUS server).

User interface also contains manual controls for PDU (Section Access Point Power Control), which can be operated individually regardless the main program. In previous versions it was a separate program but added into main view after receiving constructive feedback from other users.

A button with text “Do Not Worry!” is a reset-button for PDU if for some reason power needs to be cut down immediately from all outlets (inspired by Douglas Adams’ masterpiece “The Hitchhiker’s Guide to the Galaxy”).

In the bottom of the screen is a list view (Section Done Setups). It contains timestamp and all the selections made for a setup. It also contains a free-text editable field for own textual comments. This list is also a log file from which can be checked which setups have been completed. Log file is saved when program exits but intermittent saves can be done any time by pressing “Save Setups” –button or the log can be cleared by pressing “Clear Setups” –button.

5.2 Functionality

Figure 5 contains a simplified flowchart of the Wlan verification Wizard. For the sake of clarity some smaller tasks, like the checking for opened window (is the opened window the desired one or something else) were left out. All the basic core functions are visible.

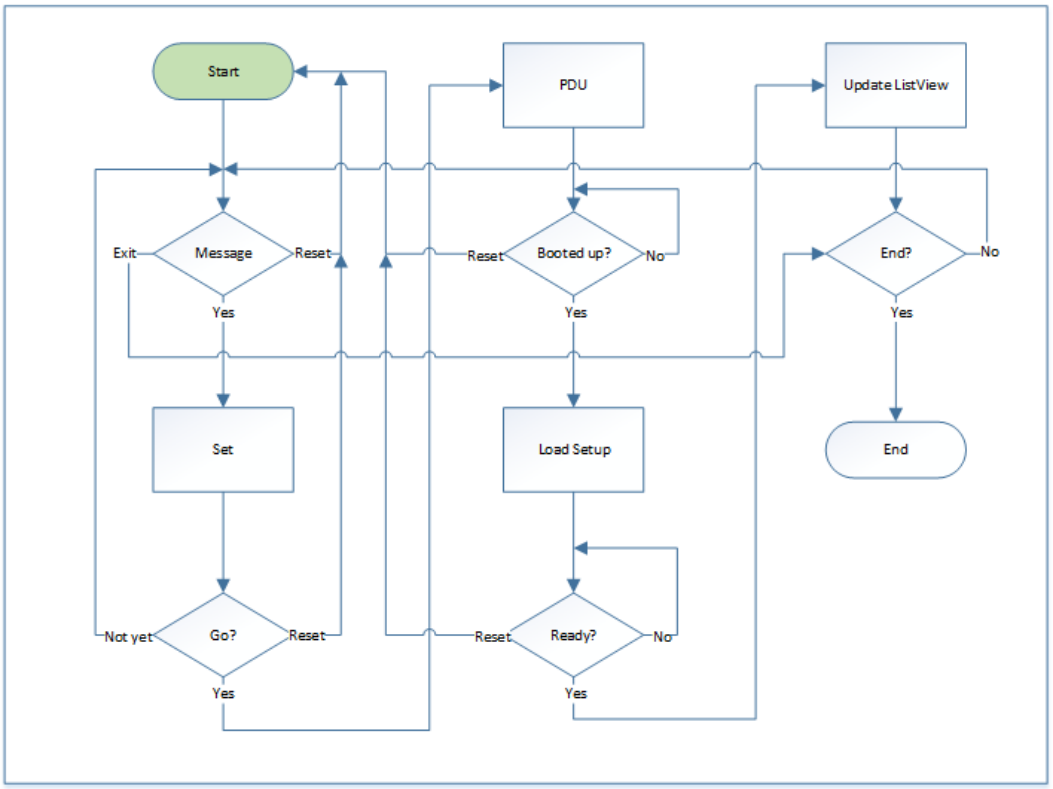

Figure 5: Simplified flowchart

Each object manipulation, such as pressing a button, selecting a radio-button creates a message. This message is examined and as a result a desired function is performed. Each object has its own address and functionality based on object type.

5.3 Connectivity

Most of the connections to APs were done using a web-browser (2). In some cases it was possible to use Telnet or vendor-specific setup program. Other connections to elements were using Telnet (1) and RPC (3). Figure 6 shows the basic principal operation and connectivity aspects of the program.

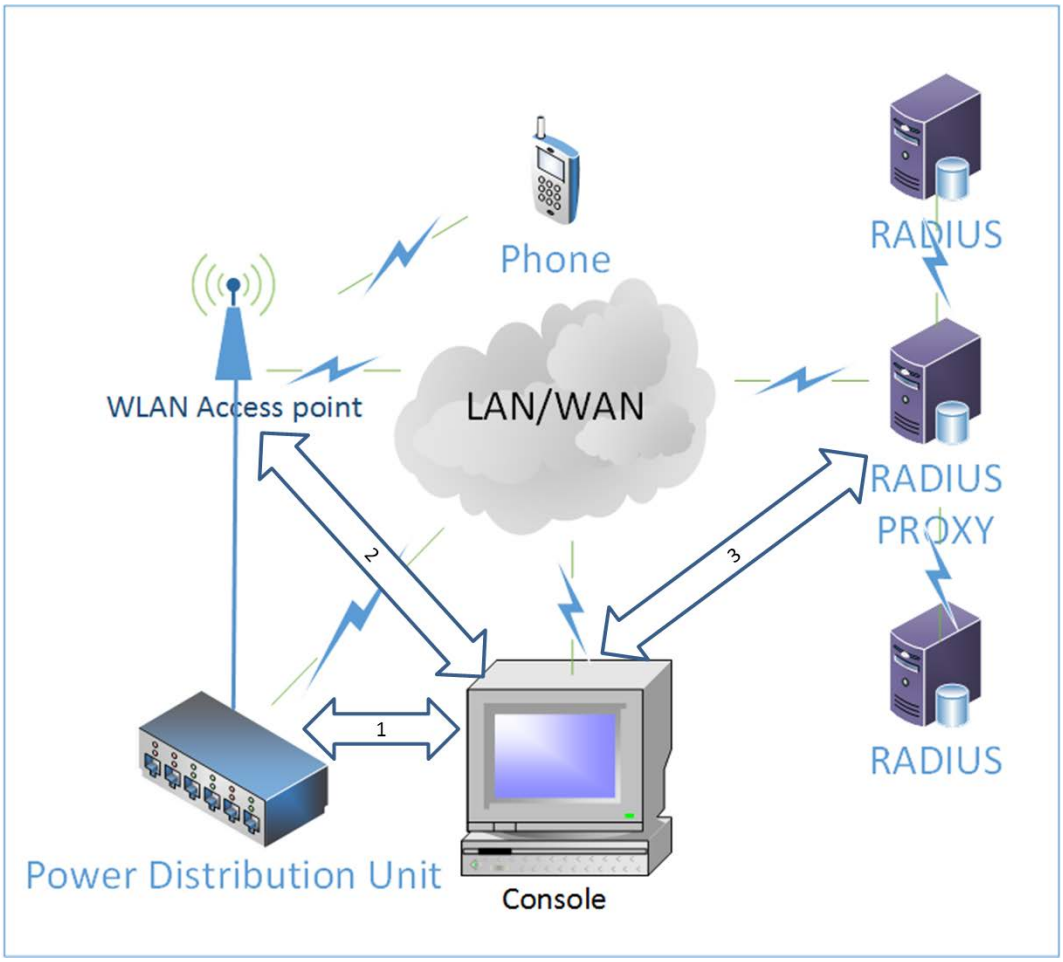

Figure 6: Connectivity to other elements

Wlan verification Wizard -program runs on separate console computer. The program controls the PDU (1) over Telnet. The PDU switches on the selected power outlet which powers up the selected AP.

After the AP has completely booted up the program commands the AP (2) using HTTP/Telnet/Tftp to import the selected settings back up file.

When settings restore is completed on the AP the program contacts the RADIUS-proxy (3) using PsExec- and Netsh-programs and network configuration files created during the deployment phase and configures it for possible RADIUS authentication.

When these steps are completed phone can connect to the AP, authenticate against the RADIUS-server and perform the needed test round. These functionalities are described more thoroughly later on.

Changing the test setup requires 1 – 3 steps depending on what will be adjusted. If only the air encryption mode is changed within the selected AP then only step 2 is needed, as the AP is powered up already. If another AP is selected but no Enterprise authentication is selected then steps 1 and 2 are needed. If another AP is selected and Enterprise authentication is used then all 3 steps are needed.

6 PROGRAM OPERATION

6.1 Program initialization

When the program starts all start up settings are read from VerificationWizard.ini -file. A sample file can be found in Example 1. Ini -file type was chosen for this task due to its easy modifiability. It is a simple text file and editable with any text editor which can produce pure ASCII-text. It also can contain comments and keywords for creating sections for different parts of the setup. Any line beginning with a semicolon is considered as a comment. Keywords are separated from normal text with square brackets "[ ]". Any parameter after the brackets belongs to that specific section.

```
; WLAN VerificationWizard.ini
; Contains settings and variables
;
; Author: Jukka Issakainen
;
[AP]
APSetupInfo = APSetupInfo.ini
[EAP]
Types = TLS/PEAPv0, PEAPv1, TTLS, SIM, AKA
[Misc]
; These are just informational texts to show on screen, after AP-setup is completed
SSID = QAS_Verification
WEP64_Key = 1234567890, Key 2 (10 HEX digits)
WEP128_Key = 1234567890abcdef1234567890, Key 2 (26 HEX digits)
WPA(2)-PSK_Key = 12345678
TestUser = testi
TestUser_PWD = *****
TestUser_Logon_Domain = WLAN-AUTH20

[RADIUS]
RadiusSetupInfo = RadiusSetupInfo.ini
```

Example 1: VerificationWizard.ini –file

In the beginning a single file was considered to be sufficient but was soon found out there were so many parameters it would be simpler to separate AP and RADIUS settings to their own files (APSetupInfo.ini and RadiusSetupInfo.ini in the example).

Figure 7 illustrates the division of ini-files. The VeificationWizard.ini - file contains entries which define the file name for AP and RADIUS initialization files.

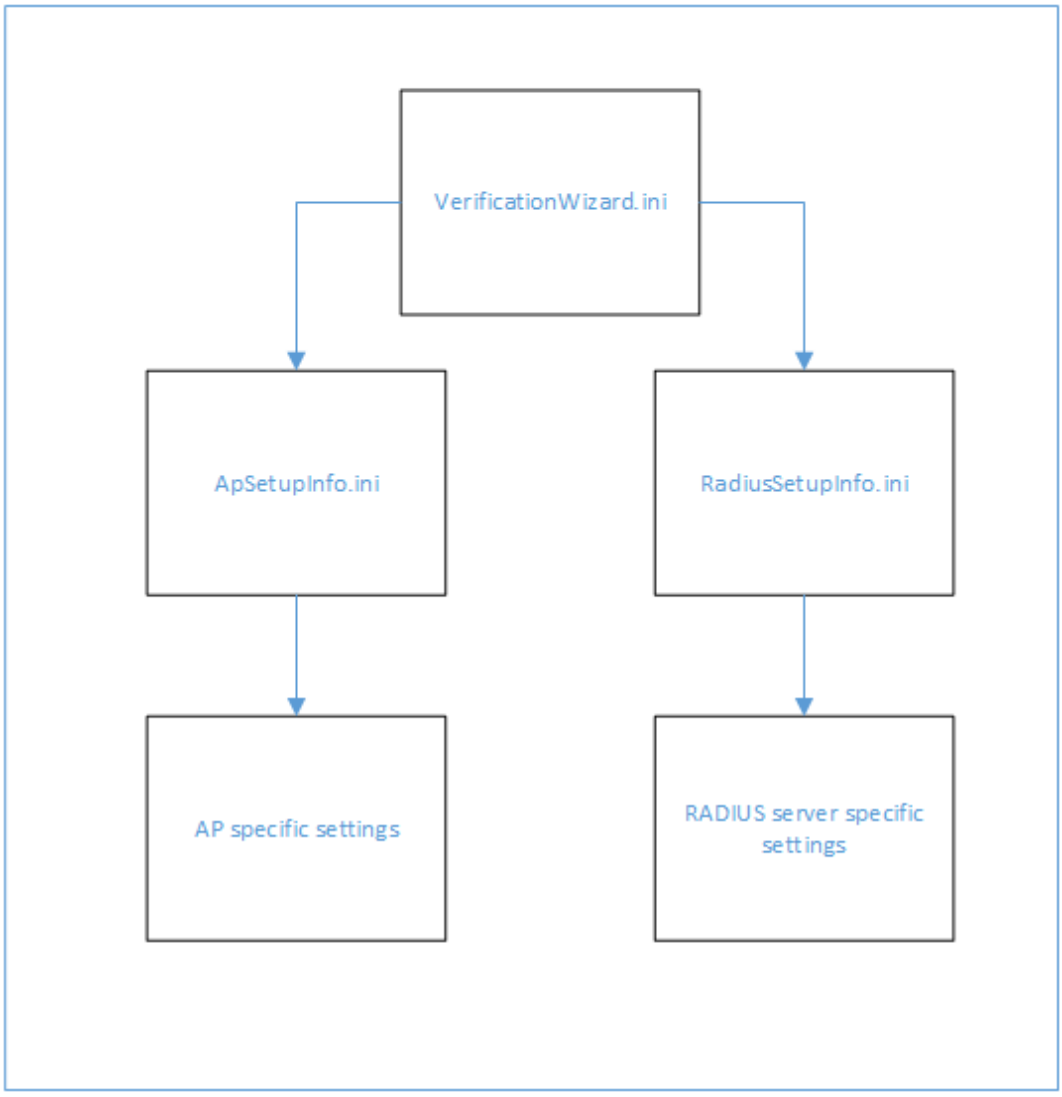

Figure 7: Ini-files division

6.2 AP initialization

Capabilities of installed APs are read from APSetupInfo.ini -file as defined in Verification Wizard.ini -file. These capabilities are recorded to APSetupInfo.ini-file when a new

AP is added to the system. Also restore-files containing the correct encryption methods are created when new AP is added. Following a shortened sample in Example 2 of APSetupInfo.ini –file. The first part containing a semicolon in front of the line is a comment and help text for editing the file.

```
; Access Point Info file
; Contains settings and variables
; Author: Jukka Issakainen
; PDU_Port =          Physical AC outlet # in APC Switched Rack PDU
; Model =             Info abt AP model, not used, but clarifies ini-file
; Firmware =          Info abt Firmware
; IP =                IP-address of AP
; SSH = yes/no        If AP is capable of SSH
; 802.11n_2 =         If AP supports 802.1n 2.4GHz mode, prefix for setupfile
; 802.11n_5 =         If AP supports 802.1n 5GHz mode, prefix for setupfile
; UserID =            User name of AP administrative account
; Password = Password of AP administrative account
; GoRestore =         Path to config restore page inside Access Point, if exists
; RestoreFolder =     Folder used to store config-files; empty folder, if
Telnet/SSH is used
; Open =              Open, no wep-key etc
; 802.1x=             802.1x with dynamic wep-key 128-bit and RADIUS
; WEP128 =            wep-key 128-bit, no RADIUS
; WPA-PSK =           WiFi Protected Access, Pre Shared Key using TKIP +
AES (a.k.a mixed WPA SOHO-mode), no RADIUS
; WPA =               WiFi Protected Access, RADIUS for EAP-types using
TKIP + AES (a.k.a mixed WPA Enterprise-mode)
; WPA2-PSK =          WiFi Protected Access 2, Pre Shared Key using AES, no
RADIUS
; WPA2 =              WiFi Protected Access 2, RADIUS for EAP-types using
AES
; LEAP =              Cisco specific mode
```

Example 2: APSetupInfo.ini –file

Example 3 shows the usage of keyword [AP]. It describes the names of APs which are available for testing and displayed in the main user interface, available encryption modes used for restore-file, path to root folder of restore files and Wlan modes available.

```
[AP]
Models = A-Link WNAP, Apple Airport Extreme, Cisco 1231, Belkin N1 Vision, Buffalo WZR-AG300NH, D-Link DIR-655, Linksys WRT54GS, Linksys WRT350N, Linksys WRT610N, Netwjork 54Mbps, Thomson 585, Telewell TW-EA515, ZyXEL NBG-415N, ZyXel P-661HW-D1
RestoreModes = Open, WEP128, WPA-PSK, WPA2-PSK, WPA, WPA2, 802.1x
RestorePath = D:\Jukan\automation\AP_Setups
802Modes = 802.11 b/g, 802.11n (2.4GHz), 802.11n (5GHz)
```

Example 3: APSetupInfo.ini -file

Example 4 shows the usage of keyword [PDU] describing the PDU parameters which are used when powering up or down an AP.

```
[PDU]
; PDU_Enabled = Yes or No
; New interface after FW upgrade 2.70 or newer: <password><space>-c
PDU_Enabled = yes
PDU_IP = 10.10.32.17
PDU_User = wizard
PDU_Pwd = *******
```

Example 4: APSetupInfo.ini –file

Example 5 shows how keyword [ap name] (A-Link WNAP in this example) is used to describe the PDU port, AP Model, firmware version, IP-address, whether the selected AP is capable for SSH, prefix to be used for 2.4GHz or 5GHz restore files, administrative user name and password, the shortest path to restore page, the folder into which restore files are stored (relative to RestorePath -root folder) and file names of the sup-

ported modes. If some entry is empty then the feature is either not supported or deliberately not used.

```
[A-Link WNAP]
PDU_Port = 16
Model = WL524
Firmware = e2.04
IP = 10.10.32.151
SSH = no
802.11n_2 = WNAP_N2_
802.11n_5 = WNAP_N5_
UserID = admin
Password = *****
GoRestore = /saveconf.asp
RestoreFolder = \A-LinkWNAP
Open = A-Link_Open.dat
802.1x =
WEP64 =
WEP128 = A-Link_WEP128.dat
WPA-PSK = A-Link_wpa-psk_mixed.dat
WPA = A-Link_WPA_enterprise_mixed.dat
WPA2-PSK =
WPA2 = A-Link_WPA2_enterprise.dat
LEAP =
```

Example 5: APSetupInfo.ini –file

As this program was to be used in laboratory residing in employer's premises with strict access control means for both physical entrance and for data communications it was decided not use encryption to protect these settings. Would such a need to emerge, it would have been fairly simple to apply encryption either to the console computer itself or just for data files. For more info see Appendix 6. AccessPointInfo.ini -file

6.3 The Capability-matrix

The [AP] -section is a basis for a capability matrix for selected AP. If some encryption or authentication type is not supported with that particular AP then it will not be selectable but dimmed. Similar procedure is also used when other selections are made: the program enables or disables selections which are not supported by selected combination. This functionality greatly reduces errors as the end-user cannot make a conflicting selection.

The following code in Example 6 reads AP's capabilities to a two-dimensional array which is used every time when end-user makes a selection (802 -mode, Air encryption, Access Point, RADIUS Server) and validates it.

```
Dim $asApCapa[$iNumOfAP][$iNumOfAir + 2] ; +2 for 802.1n -modes
For $i = 1 To $asListAP[0]
		$asApCapa[$i][0] = $asListAP[$i] ; AP name for column #0
		For $j = 1 To $asListAir[0]
				$asApCapa[0][$j] = $asListAir[$j]
				$asApCapa[$i][$j] = StringStripWS(IniRead($sLocalPath
& $sApIniFile, $asListAP[$i], $asListAir[$j], "NotFound"), 8)
		Next
		$asApCapa[0][$j] = ".1n prefix 2.4GHz"
		$asApCapa[$i][$j] = StringStripWS(IniRead($sLocalPath & $sApIni-
File, $asListAP[$i], "802.1n_2", "NotFound"), 8) ; 2.4 GHz 802.1n -mode prefix
		$asApCapa[0][$j + 1] = ".1n prefix 5GHz"
		$asApCapa[$i][$j + 1] = StringStripWS(IniRead($sLocalPath &
$sApIni-File, $asListAP[$i], "802.1n_5", "NotFound"), 8) ; 5 GHz 802.1n -mode
prefix
Next
```

Example 6: ReadCapabilities

The above Example 6 also shows how variables are named. AutoIt uses a dollar-sign ($) in front of all variables. In addition it was decided to use naming convention, which itself would give information of what kind of variable is in question. ”$asApCapa”

means an array of strings (”$as” = array string). ”ApCapa” is an abbreviation of Access Point Capabilities, ”iNumOfAP” means an integer variable (”$i” = integer) and ”NumOfAP” means “Number of Access points”. AutoIt itself does not force to use this kind of naming convention but it has proven to clarify variable naming.

6.4 RADIUS initialization

As with AP initialization, RADIUS capabilities are read from the initialization file to a capability matrix. This matrix is used, as with AP-case, to rule out invalid selections. This approach reduces errors which are caused by incompatible authentication methods and therefore saves time when the end user does not have to debug the erroneous situation.

As with AP setup file comments are used to inform the user of how the parameters have to be applied. To shorten the example comments were left out. For more info see Appendix 7. RADIUSSetupInfo.ini -file. The following Example 7 shows how RADIUS-parameters are used. [RADIUS]-section contains common parameters for the program operation.

```
[RADIUS]
RestorePath = D:\wlan\ap_setups\radius
RadiusProxy = 10.10.32.10
Username = wizard
UserPwd = *****
; Proxy address is needed for psexec, which will run e.g. netsh exec ias.set on remote
Servers = Microsoft IAS, Juniper Odyssey, Cisco ACS, FreeRADIUS, Nokia Test Network
; RADIUS *.set files are created with NETSH-cmd. It dumps current IAS-setting
; to a file, which can be restored to instantly change authentication settings
; To record current settings enter to command prompt: netsh aaaa dump > filename.set
; To Restore saved settings enter to command prompt: netsh exec filename.set
```

Example 7: RadiusSetupInfo.ini

[Microsoft IAS] -section is presented in Example 8. It contains all the needed info to perform a change. This server is also used as the RADIUS-proxy-server directing the authentication requests to the selected RADIUS server. Change of RADIUS server can occur if another method of Enterprise authentication is required. As can be seen from the following Example 8 Microsoft IAS supports only EAP-TLS and EAP-PEAPv0 authentication methods. If anything else is needed then proxy settings must be changed to divert the authentication requests to a suitable RADIUS-server.

```
[Microsoft IAS]
IP = 10.10.32.20
Port = 1812
RestoreFile = ias.set
TLS/PEAPv0 = yes
PEAPv1 = no
TTLS = no
PureTTLS = no
LEAP = no
SIM = no
AKA = no
```

Example 8: RadiusSetupInfo.ini

7 AP CONFIGURATION CHANGE

When all the selections are done, pressing the “GO!” –button starts the configuration change procedure. First the selected AP needs to be powered up. A Telnet-connection is made to PDU. It contains 16 230VAC outlets which are independently controllable via Telnet or Web-browser. PDU is commanded to turn on the selected power outlet and if there are any active outlets from previous testing those are turned off. American Power Conversion model AP7950 (APC by Schneider Electric: Switched Rack PDU) was used due to its availability and decent price. There are also other units available in the market but their pricing proved to be out of scope. Figure 8 shows the element to which the first operation focuses.

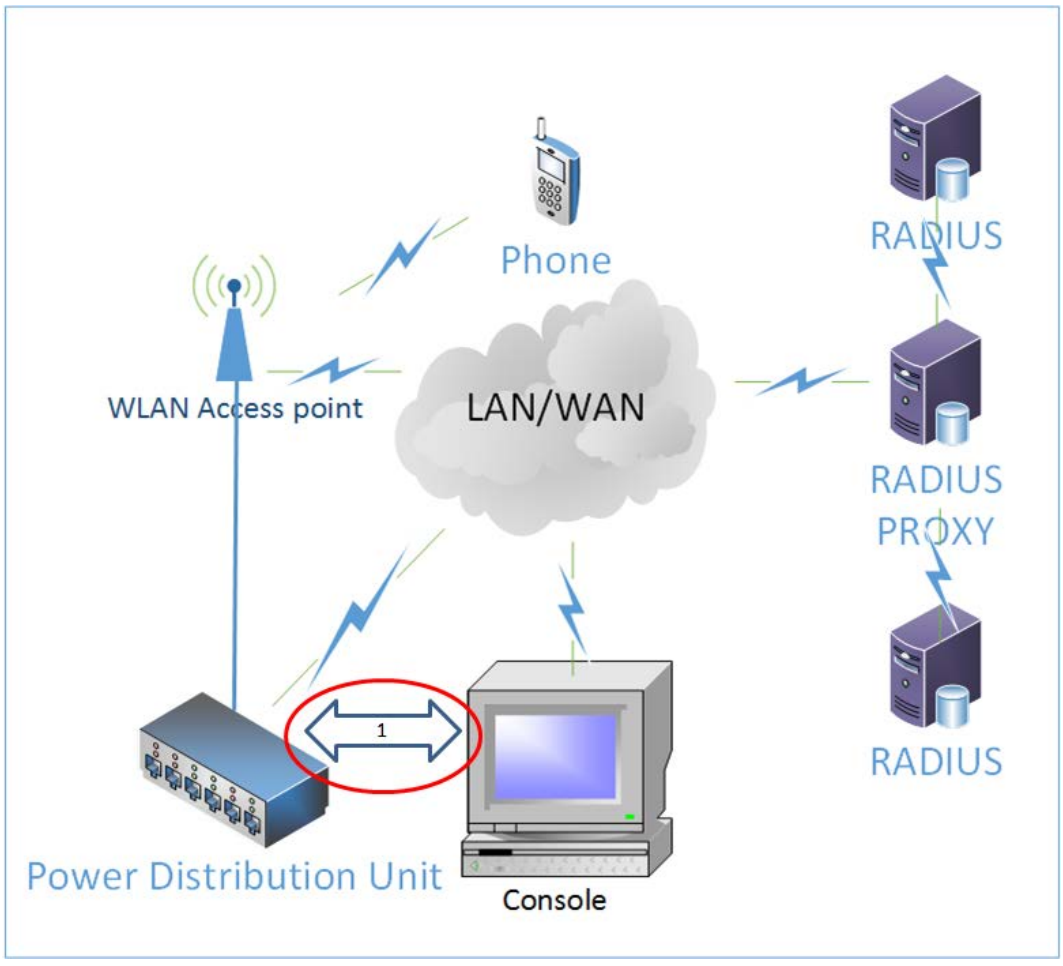

Figure 8: Connecting to PDU

When an AP is powered up it takes some time for the AP to initialize itself and to bring up the full functionality. This time depends on the AP itself and the selected encryption mode. Some APs are simply faster to become fully functional than others.

Bringing up an AP is monitored by sending ping-packets from the program to AP's IP-address. When responses are received a wait loop is applied, as data communications port starts working usually a bit earlier than the actual functionality of the AP. If response to ping-packet returns an error the end-user is notified. Possible notifications include checking for cable fault, other network errors, off-line situation, correct network and correct ip-address.

When the AP has the full functionality a connection is made either via HTTP, Telnet, Tftp or manufacturer's own setup program. Most of the cases a web browser is used. Figure 9 shows to which element the second operation focuses.

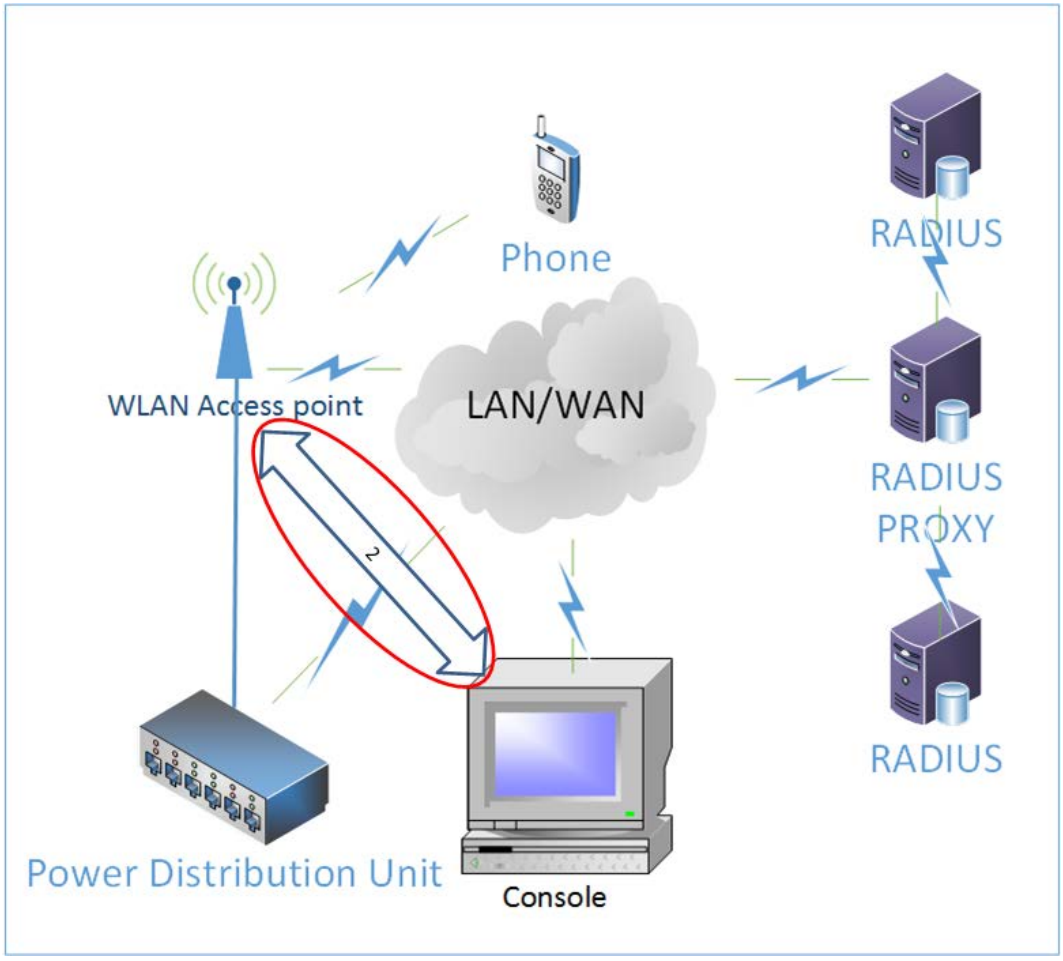

Figure 9: Configuring the AP

During the deployment phase each encryption mode for each AP is saved to a restore file. These restore files are used to change settings reliably and without human-induced errors. Naturally deployment phase has to be precise and all the settings need to be thoroughly checked before saving the setup to a restore file.

Similar idea was used with RADIUS-proxy setup. By using Netsh-program (Russinovich Mark 2008) the current network configuration of a RADIUS-proxy can be saved to a file and restored when RADIUS authentication requests need to be diverted to a different RADIUS-server.

An interesting challenge was also presented by the variety of different user interfaces for APs. There is no single standard which could be used to administer an AP but every one of them has their own way. Usually it is a web-interface to vendor's own setup program and which changes when new firmware upgrades are applied.

If a Telnet-connection to an AP was available then the restore is very straight forward as there is no need to examine the web page content and adjust the cursor movement.

In such case only the commands of changing the AP configuration are saved to ApSetupInfo.ini file and are sent to AP via Telnet. Restoring a file is often a slower operation than commanding the AP directly with Telnet. Example 9 shows the configuration for D-Link DWL-2200AP.

```
[D-Link DWL-2200AP]
PDU_Port = 13
Model = DWL-2200AP
Firmware =
IP = 10.10.32.153
SSH = no
UserID = admin
Password = *****
GoRestore =
RestoreFolder = \DWL2200
```

Example 9: Settings for D-Link DWL-2200AP

The latter part of an AP setup in Example 10 contains the commands to be sent over Telnet instead of the name of a restore file. The program logic checks the parameter if it contains a word “set” and a space thus indicating the use of Telnet. These commands vary by the manufacturer and are seldom described in the user manual but they are based on the chipset used in the AP which makes the task of finding out the commands simpler.

```
Open = set channel 2457, set authentication open-system, set encryption disable, reboot
802.1x =
WEP64 = set channel 2457, set authentication open-system, set encryption enable, set cipher wep, set key 2 40 1234567890, reboot
WEP128 = set channel 2457, set authentication open-system, set encryption enable, set cipher wep, set key 2 104 1234567890abcdef1234567890, reboot
WPA-PSK = set channel 2457, set authentication wpa-auto-psk, set cipher auto, reboot
WPA = set channel 2457, set authentication wpa-auto, set encryption enable, set cipher auto, reboot
WPA2-PSK = set channel 2457, set authentication wpa-psk, set cipher aes, reboot
WPA2 = set channel 2457, set authentication wpa, set encryption enable, set cipher aes, reboot
LEAP =
```

Example 10: Settings for D-Link DWL-2200AP

Normally Telnet-connection is cumbersome to control from inside another program but a solution for this problem is a program called Plink. It is a freeware program made by Simon Tatham (Tatham Simon 2005). It is directly controllable from command line, which makes it popular when automating various systems.

7.1 AP configuration change in details

Although AutoIt enables direct screen object manipulation it was found easier to use the browser delivering the commands. Microsoft Internet Explorer was chosen due to its availability with the base operating system of the console computer.

Depending on AP's implementation screen objects may be very hard to find programmatically and they might change every time a firmware update is applied to an AP. Also some AP implementations hide the component class or instance id. Therefore tabulations were used to move the cursor in the AP web page and Enter-button pressed programmatically simulating a user without a mouse would have done.

All encryption modes are each saved in restore files using a descriptive name for it like"A_Link_WEP128.dat". From the name it is quite clear to see that particular file is for A-Link AP and it is using 128-bit WEP encryption.

Manipulation of the APs has been separated from the main program to its own program called"RestoreAP.exe". It used to be a part of the main program but when the number of APs grew larger, it was clearer to separate it as an individual program.

7.1.1 Controlling the AP with RestoreAP.exe

RestoreAP opens the administrative page of the AP with a browser using the shortest path -method. All APs contain an input field for restoring a settings backup file. Input field is selected programmatically and the path and the file name are fed to it.

Shortest path -method is simply a path to AP's restore page added to AP's IP-address. The shortest path is defined in GoRestore-parameter residing in the ini-file defined by the ApSetupInfo-parameter in the VerificationWizard.ini -file.

When the browser has started up, contacted the AP and opened the restore page, program sends enough tabulation key presses for cursor to land on restore file input field. Then the file name and path are submitted to the field, tabulation key sent to move the

cursor to Ok-button and key press is sent to emulate mouse button click. Then AP restores the file and restarts after a while with the desired setup.

Example 11 shows how setting up of Linksys WRT54GS – AP is done. It shows the usage of component class and instance id methods. Linksys proved to be quite stable and caused no problems even the both methods were used. It was decided to leave Linksys AP manipulation as is to serve also as an example, whether any change requests may emerge.

```
Case $sSelectedAp = "LinksysWRT54GS" ;
WinWaitActive("Connect")
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
```

Example 11: Setting up Linksys WRT54GS

First the script waits for a browser window with a header “Connect” to open and become active. When the page is active the cursor is automatically on AP’s User name -field. Then program sends the user name of the administrative user ($sUserID, read from the ApSetupInfo.ini-file), sends a tabulation to move the cursor to next text field, and sends the password ($sPassword, read from the ApSetupInfo.ini-file). Next two tabulations are sent to move the cursor on OK-button and Enter -key press is sent to enter the user name and password to AP. The setup continues in Example 12.

```
Sleep(2000)
WinWait("Config Management")
Sleep(2000)
ControlClick("Config Management","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,373,300);
```

Example 12: Setting up Linksys WRT54GS

The program waits for two seconds and starts to monitor when the AP has opened the window with the title “Config Management”. After the window has been detected a two second wait is applied to ensure AP is fully up to the pace. “Left mouse button -click” -command is used with object class and instance id to move the cursor to Restore File -input field by emulating a mouse movement and user pressing the left mouse button on the field.

Example 13 shows how the program sends the path and the file name to the input field and two tabulations followed by Enter key press follows to command the AP to start the restore.

After sending the path and file name program waits for a window with a header “restore.cgi” to appear. This window becomes available after a successful restore. As the restore process is time and resource consuming from the AP point of view a wait period of five seconds is applied for AP to settle down.

```
Sleep(2000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")

Sleep(2000)
Winwait("restore.cgi")
Sleep(5000)

ControlClick("restore.cgi","","[CLASS:InternetExplorer_Server;INSTANCE:1]",
"left",1,391,237)
WinWait("Basic Setup")
Sleep(3000)
WinClose("Basic Setup")
```

Example 13: Setting up Linksys WRT54GS

Using direct window control manipulation “OK”-button is pressed and program starts to wait for a window with “Basic Setup”-header, which is the main window of this AP. When the window has become active a short wait time is applied to allow the AP to stabilize. After the wait time the browser window is closed.

These wait times had to be used as sometimes AP’s performance varied. It was better to have too long wait times than none at all. If commands were given with too fast pace sometimes some command may be lost.

When the setup has been successfully finished date, time selected configuration are written to a list view at the bottom of the program’s main screen (Done Setups). It also contains an editable text field for own comments.

7.1.2 Done Setups -log

Done Setups - list view is also the log file for the program. User can save the list view as a text file or clear it, if no logs are needed. If the log file is not saved when closing the program a File Save -dialog will open allowing the user to save the log file or discard it.

7.2 RADIUS authentication

When Enterprise level authentication is required also an authentication server is needed. This simple fact becomes a slightly more complicated when interoperability testing of enterprise authentications needs to be performed. There is no single server which can handle all the required authentications and different servers perform the same task slightly differently.

Figure 10 contains a simplified diagram of RADIUS authentication. For the sake of clarity only the signalling related to RADIUS authentication is visible.

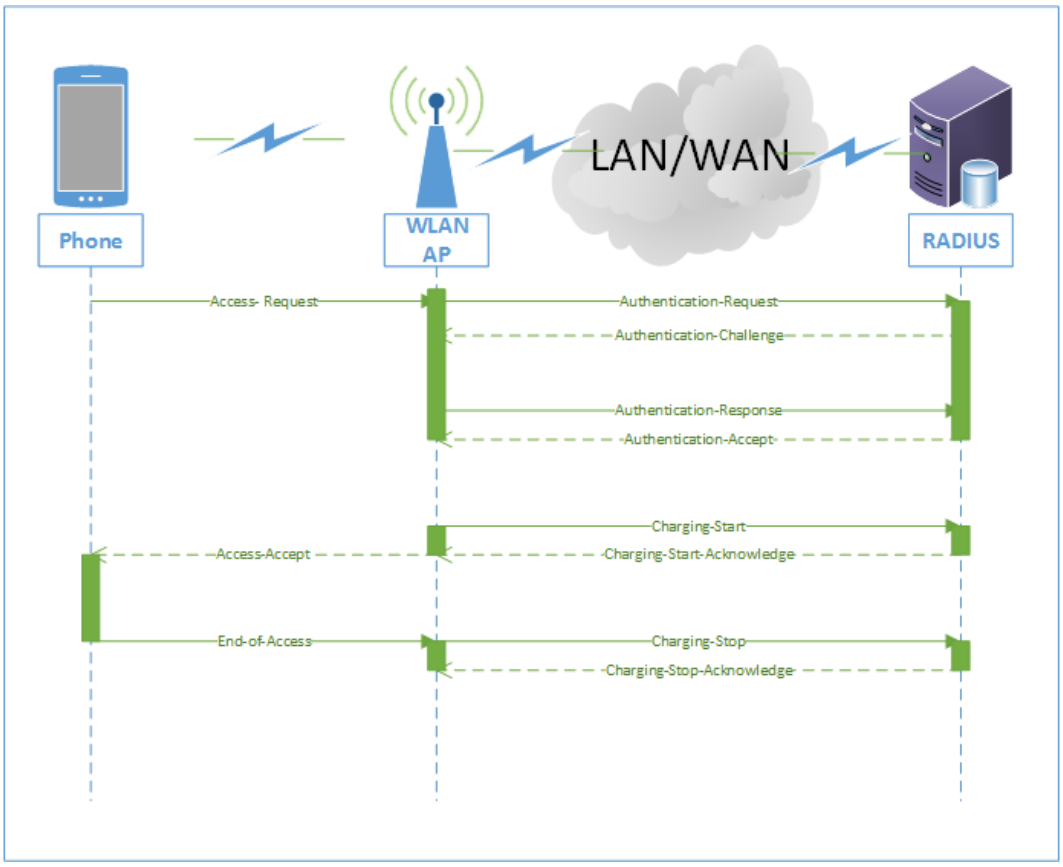

Figure 10: Simplified RADIUS authentication

RADIUS works with client-server -principle. In this case an AP is a client to a RADIUS server. As can be seen from the simplified signalling diagram in **Virhe. Viitteen lähdettä ei löytynyt.** RADIUS server does not take any part in the communication after the authentication has been completed. It only accepts the authentication or rejects if the credentials are not correct.

The AP sends Start-Charging request to RADIUS server and opens the communications channel for the phone when it has received the acknowledgement from the RADIUS server. Now the phone can connect via the AP to the resources available.

After closing the connection from the phone the AP sends Charging-Stop request to RADIUS and it acknowledges the ending of the charging and thus ending the RADIUS-session.

Even though these Charging-Start/Charging-Stop messages are used, the end-user is not charged in these scenarios. It is possible to use these messages to create the basis for billing the customer but in enterprise authentication scenarios they are used just to mark the beginning and the end of an authenticated access session.

7.3 RADIUS-proxy

RADIUS-proxy is an appliance which directs RADIUS requests to other destination. By changing the configuration of the RADIUS-proxy are RADIUS authentication requests directed to a server supporting selected authentication method.

For the end-user and RADIUS server the proxy remains transparent as it relays the messages from one end point to another. Figure 11 shows a simplified principle on how proxy server works. For the sake of clarity only the signalling related to RADIUS authentication is visible.

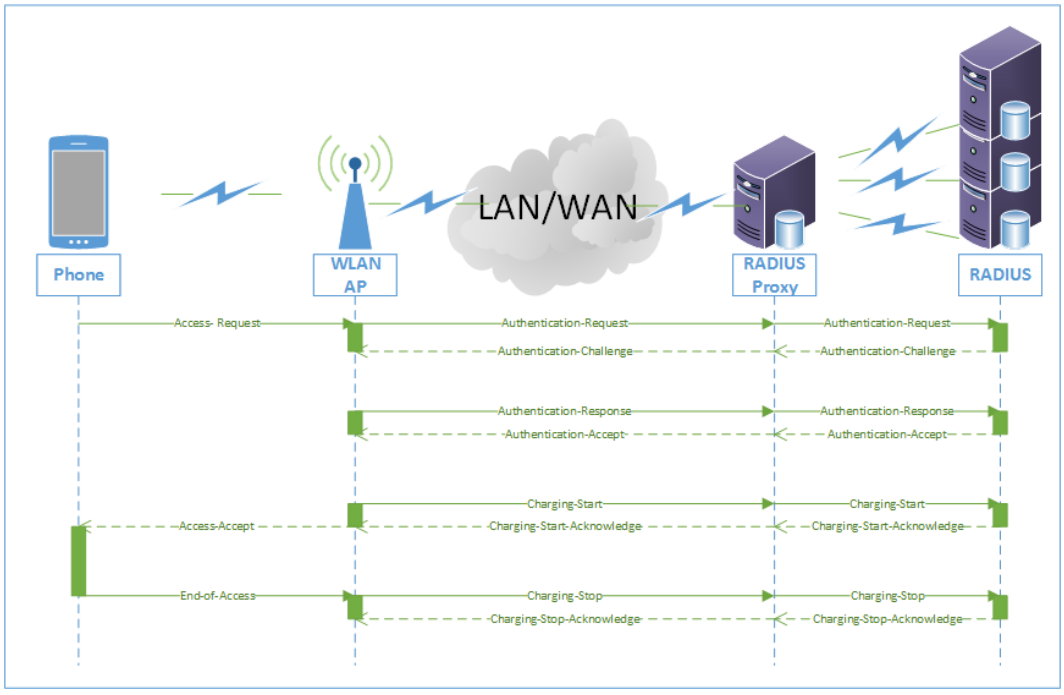

Figure 11: Basic principle of RADIUS proxy

In proxy server's configuration is defined how to handle different authentication methods. From the RADIUS server point of view all RADIUS messages are alike. It depends on RADIUS server's configuration of which authentication method can be used. And,

as mentioned earlier, no RADIUS server can support every authentication method. Normally this is not an issue, as corporates tend to stick with one or two selected authentication methods thus reducing the overhead on maintenance and support.

7.4 Changing the RADIUS authentication methods

Servers used in the laboratory ran on Microsoft Windows Server 2003/2008 operating systems. Those were also quite widely used in corporate environments. Thus a natural choice was Microsoft IAS due to its support of EAP-TLS and EAP-PEAP v0 authentication methods and it was also capable to act as a RADIUS-proxy. Figure 12 shows to which network element the third operation focuses.

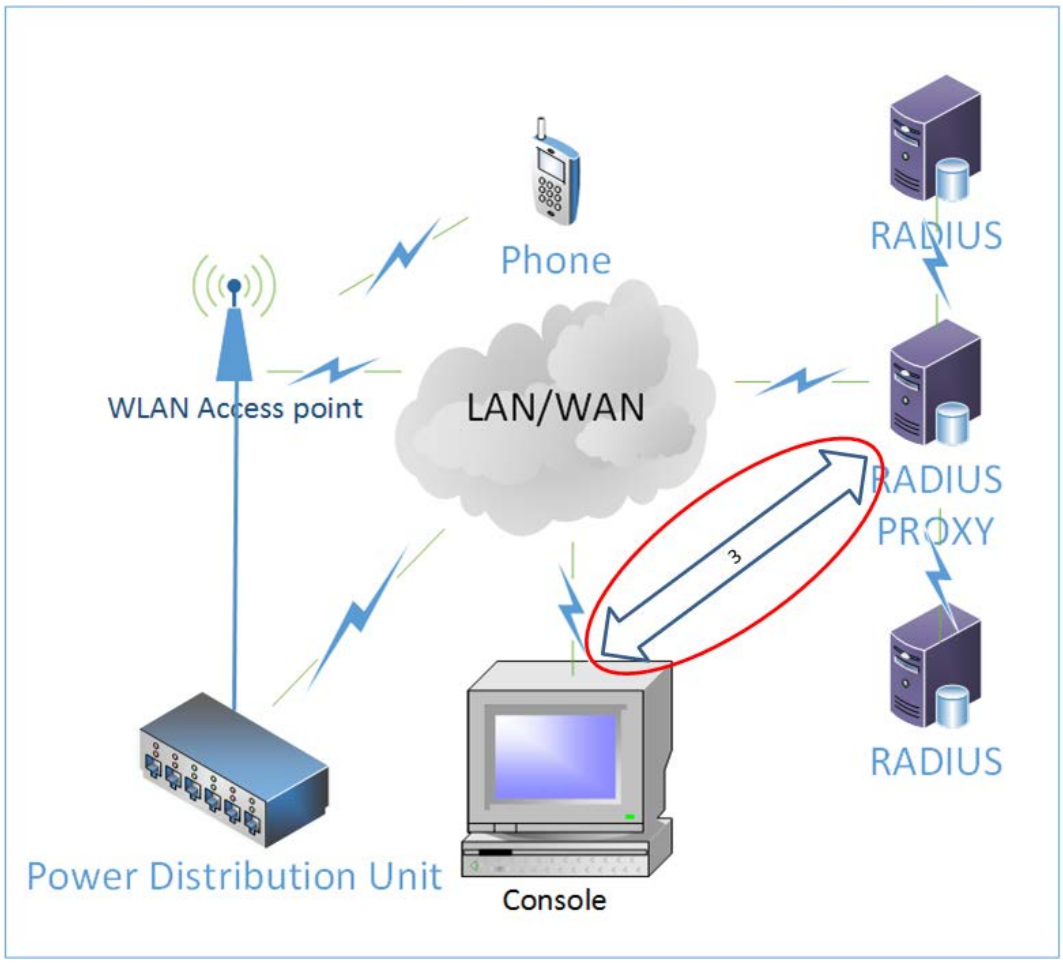

Figure 12: Changing the RADIUS-proxy settings

For EAP-PEAP v1 and EAP-TTLS authentications Funk/Juniper and Cisco Systems -servers (respectively) were used due to their wide usage in corporate domain. For GSM

and 3G cellular network sim-card based EAP-SIM and EAP-AKA authentications were done with Nokia's cellular test network's authentication server.

If an authentication method is changed from one to another it is possible to end up in a situation where the selected RADIUS server does not support the selected authentication method.

For example if the current RADIUS server is Microsoft IAS, which supports EAP-TLS and EAP-PEAP v0 -authentication methods, it cannot authenticate a user requesting EAP-PEAP v1 authentication. This scenario is not likely to happen in the enterprise environment but can exist with interoperability testing environments.

Problem is how to change server settings in managed way. Changing the server functionality from RADIUS server to a proxy and back or changing the proxied authentication request routing is usually done with a small administrative program running on server console. It is a bit cumbersome to automate and cannot be run remotely. This posed a serious problem in the interoperability test network as all the servers were far away and no console access could be arranged easily.

After some searching an article by Mr Daniel Petri (Petri Daniel 2009) was found. It described a small program known as Netsh.

7.4.1 Netsh

Netsh is not very commonly known property of Windows although it has been a part of the operating system since Windows 2000. It is a command-line program with which can many things be done quite simply. One of its strengths is to change TCP/IP-settings very quickly. It can save the current settings to a file which can be imported back to environment and restore those settings. Also RADIUS settings can be exported with "netsh dump aaaa >name_of_the_file" -command and restored thus changing the RADIUS-proxy configuration.

Figure 13 shows the basic principle of saving and restoring the RADIUS settings with Netsh.

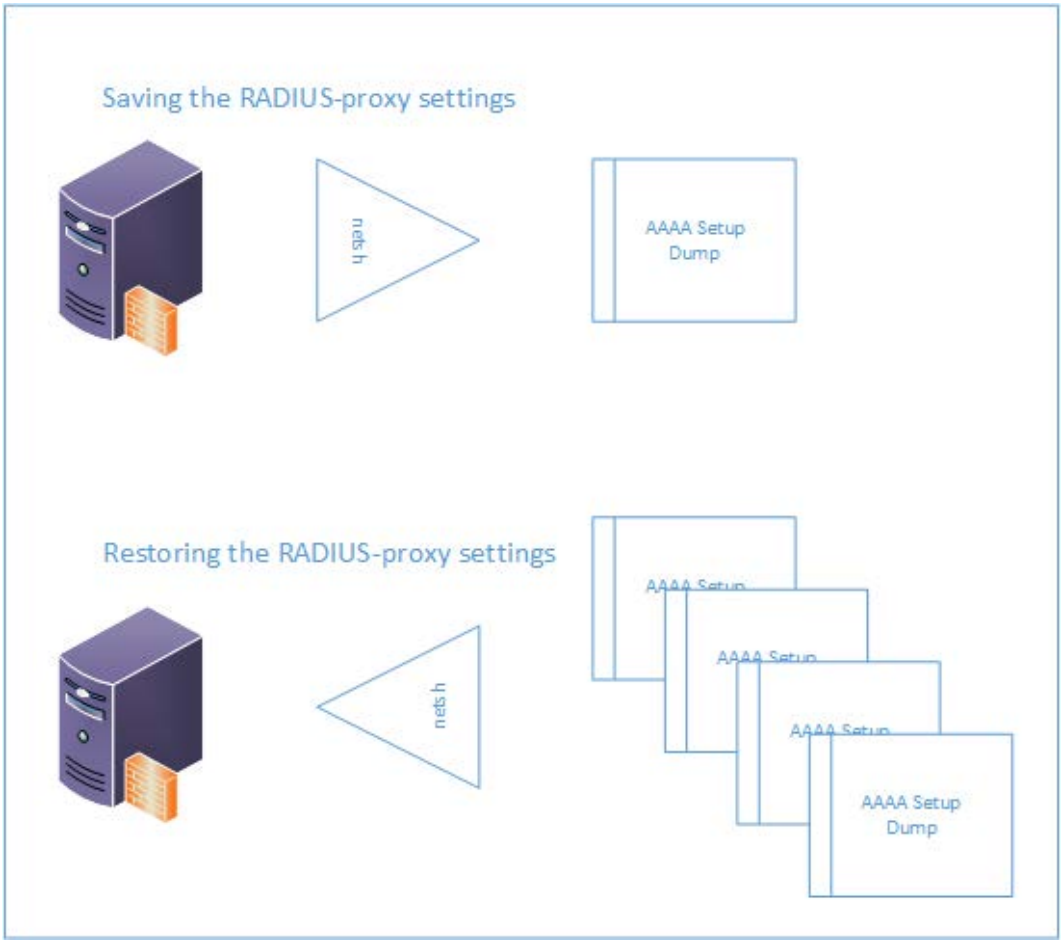

Figure 13: The principle of saving the RADIUS settings with Netsh

Netsh requires local console access. If the servers are on a remote location there will be problems with the console access unless WLAN Verification Wizard is not run on the server console.

Therefore a process level access to RADIUS-proxy needs to be created. It can be done by utilizing programs like PcAnywhere but it was not suitable in this case due to financial restrictions and for the need of the program requiring to be installed also on the server.

A freeware program PsExec by Winternals/Mark Russinovich (Russinovich Mark 2004) was chosen to use due to its capabilities and not requiring any additional installations.

7.4.2 PsExec

PsExec is a Telnet-like command-line program which enables to execute processes on another computer. It handles the input and output streams and can direct those to another location.

PsExec starts an executable on a remote system and controls the input and output streams of the executable's process so that you can interact with the executable from the local system. PsExec does so by extracting from its executable image an embedded Windows service named Psexesvc and copying it to the Admin$ share of the remote system. PsExec then uses the Windows Service Control Manager API, which has a remote interface, to start the Psexesvc service on the remote system. (Mark Russinovich, Windows IT Pro 2004.)

The Psexesvc service creates a named pipe, psexecsvc, to which PsExec connects and sends commands that tell the service on the remote system which executable to launch and which options you've specified. If you specify the -d (don't wait) switch, the service exits after starting the executable; otherwise, the service waits for the executable to terminate, then sends the exit code back to PsExec for it to print on the local console.
(Mark Russinovich, Windows IT Pro 2004.)

Figure 14 shows the principle of using PsExec. In the figure Netsh-command is run on remote server.

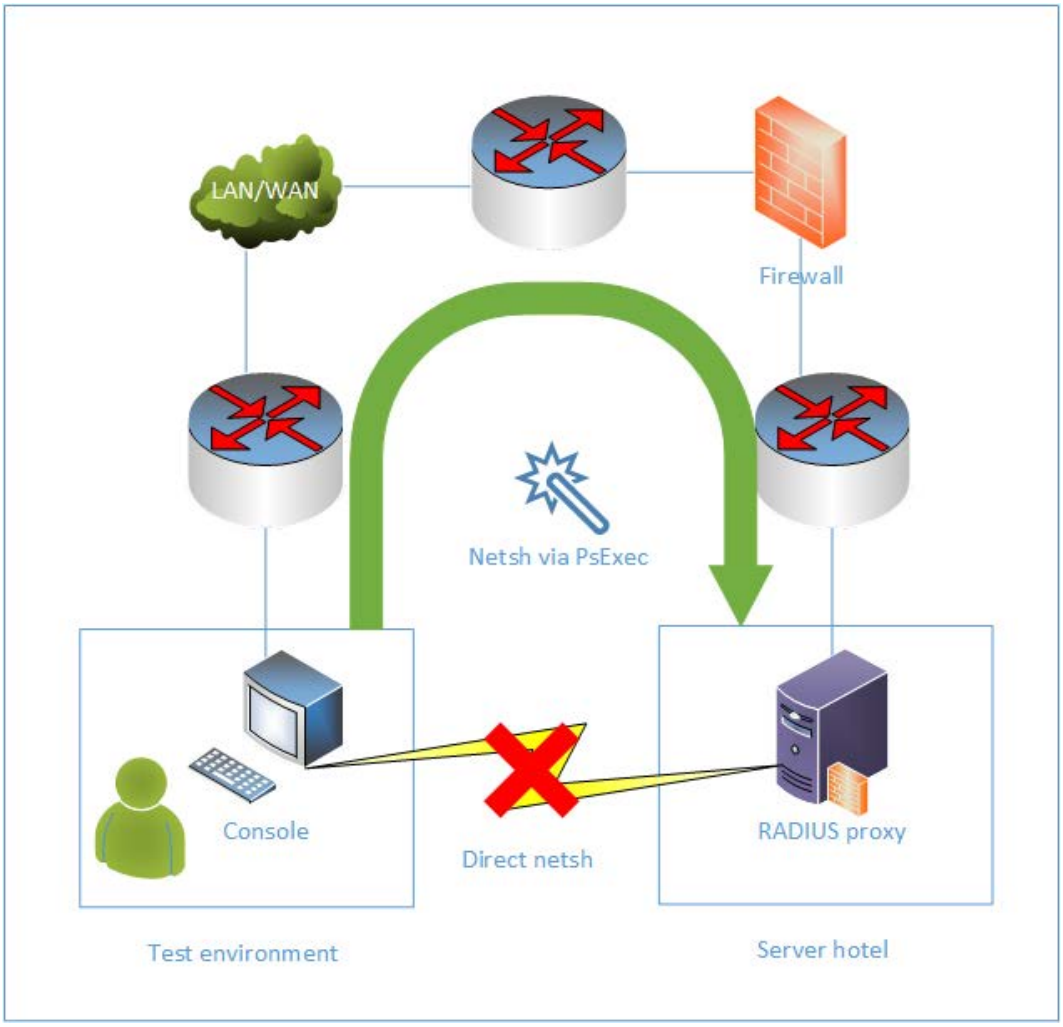

Figure 14: Using Netsh via PsExec

With PsExec Netsh-command can be run on the RADIUS-proxy console like the user would have been accessing the console locally. The RADIUS-proxy can reside in a real computer centre where electricity is properly filtered and backed up by Uninterruptable Power Supplies and cooled with proper air conditioning.

WLAN Verification Wizard uses this method to configure the proper RADIUS server connection and uses PsExec to start Netsh -program on RADIUS-proxy to load the desired setup for it. As PsExec can handle input and output streams the RADIUS-proxy setup files can reside in the console computer or on the network resource accessible by it.

While the AP is rebooting and RestoreAP.exe has completed its task the RADIUS-proxy is configured to direct authentication requests to the selected RADIUS server.

After all processes are completed date, time, AP name, authentication type and possible RADIUS-server are written in log (Done Setups) and program returns to wait for next selection from end-user. If needed, user can also write short comments directly to Done Setups.

Now the testing environment is fully configured with the desired air encryption –mode and possible authentication and interoperability testing can start.

7.5 Ending the program

User can exit the program either by pressing the “Exit”-button, by clicking the red “X”-sign on the upper right-hand corner or by pressing Alt-F4 -command when the program window is active.

If the Done Setups -log is not saved after the latest change, a File Save -dialog opens to prompt the user to save the log file. It can be saved locally or to any network resource to which the console computer has access to. User has also a possibility to cancel the save procedure and it is confirmed with a pop-up window to prevent the accidental loss of the log file.

8 DISCUSSION

The tool described was created as an interim solution to tackle the problems encountered while setting up the testing environment for interoperability testing. The certification body, Wi-Fi Alliance (WFA) was creating their own solution to manage various setups in the laboratory environment for device certification purposes. As their solution was still in development and the company needed a quick solution to cut down the time consumed by setting up the testing environment this tool, WLAN verification Wizard, was created.
It served the purpose and did its job. It was never meant to be anything more than an interim tool while waiting for the actual release of a professional configuration management tool from the certification body.

This tool was created with minimum budget and due to its nature it requires quite much preparation work in the form of setting up access points and taking a backup of verified encryption configuration.

There is no common interface which could be used with all access points. Some access points support Telnet-based administration and others do not. As new access points are added to the setup a new function has to be created for the tool taking care of the access point user interface manipulation unless the access point supports Telnet. Also when a new firmware for an access point is introduced its functionality needs to be checked as there can be some alterations when comparing to previous version.

Due to schedule pressures and the nature of the program the user interface remained very much tool-like. There are a couple of rare error situations in the program logic but those can be dealt with. Ironing out the last bugs would have taken too long when comparing to benefit.

Based on feedback received from the users' further development ideas consisted of implementing "Replay"-functionality. It would have enabled to re-run already done setups.

There was also discussion to embed a special control program to device under test, which would have enabled getting the internal status the device and controlling the in-

ternal setup of the device. Then it would have been fairly simple to build fully automated system for endurance and long term testing.

A setup-file editor was also discussed as the ini-files contain a lot of crucial information which has to be correct in order the whole setup to work.

Unfortunately these development ideas were never saw the daylight due to reorganisations in the company.

It was very interesting and challenging to create a tool for clear need: by reducing end-user induced setup mistakes with APs and RADIUS-servers, delays and unnecessary error hunting could be avoided. All the testing activity could focus on finding the real errors on tested devices. It simplified the test setup and users were satisfied when they did not have to memorize all the different settings.

As a bonus from the Thesis point of view I got to learn a new programming language, had to think about usability, and got to think how to do programming under the pressure from multiple other projects and their deadlines.

AutoIt has proven to be quite feasible development environment and easy to learn. It is also quick to use when prototyping various things and it has proven to be robust enough to create some other small tools for laboratory usage.

WLAN Verification Wizard was in production use for several years and the last version was in production use for over one year.

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APPENDICES

Appendix 1. Requirement documentation for semi-automation tool

1. The Purpose of the Project

Testing is an invaluable tool for any project, if it is done properly. Repeatability, result documentation and error-free execution are key issues to professional-grade testing.
When testing environment has many variables likelihood for end-user configuration error increases when schedules are tight and additional work force is needed.
The scope of this project is to reduce end-user configuration errors by eliminating manual settings to test environment. It will shorten the test cycle and provide more clear visibility to real errors found in tested product.
This project will produce a small application which takes care of Wireless LAN Access Point settings on behalf of the user. It will be an interim solution until the Certification Body (WFA) releases their solution.

1.1. Goals of the Project

The goal for the Project is to reduce test environment configuration errors by offering a semi-automatic configuration application.

1.2. Motivation

When test environment is known and stable the real errors of tested product can be found.

1.3. Measurement

Shortened testing time from five (5) work days to three (3).

(Continues)

2. The Stakeholders

2.1. The Client

The client is the test-environment user.

2.2. The Customer

The customer is the Head of Test Laboratory accepting the product.

2.3. Other Stakeholders

Other stakeholders may include Error Managers and Test Managers of the tested product (depending on project).

2.4. The Hands-On Users of the Product

The users of the products are the users of the test-environment. They must have an adequate knowledge of the following:

- Tracing and capability to take relevant log files
- Knowledge of Wireless LAN authentication methods
- Knowledge if TCP/IP, including routing

2.5. Personas

Personas are not applicable due to the nature of the Product.

(Continues)

2.6. Priorities Assigned to Users

All users are Key users, as the number of users of the Product is very limited.

2.7. User Participation

All users are required to report any anomalies found using the product.

2.8. Maintenance Users and Service Technicians

All users are able to request new devices to be added to the test environment. Maintenance of the test environment and the Product are done by undersigned.

3. Mandated Constraints

3.1. Solution Constraints

The product shall use TCP/IP v4 network in the laboratory environment.

3.2. Implementation Environment of the Current System

Base Operating System shall be Microsoft Windows XP/7. The Product shall be a stand-alone application running on Personal Computer using Intel X86-based architecture. Networking infrastructure shall be based on IPv4 using switched networking infrastructure inside Corporation’s Laboratory Network infrastructure. Server Operating System shall be Microsoft Windows Server 2003 – 2008 (Microsoft RADIUS Server), OpenSUSE (FreeRADIUS) and Cisco IOS (Cisco IAS). Remote controlled power outlet is American Power Corporation AP7950.

(Continues)

Figure 1 contains the environment for the tool.

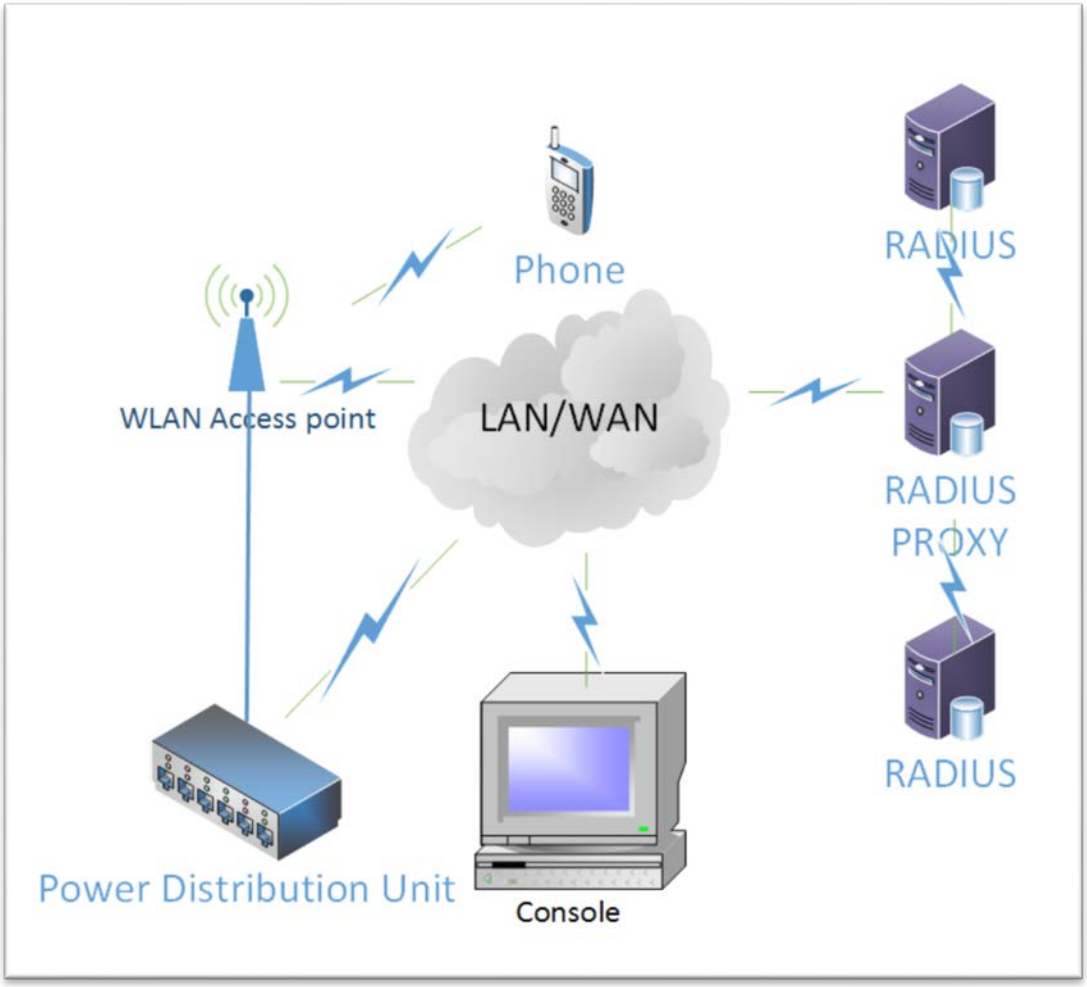


Figure 1: General view of the Program

3.3. Partner or Collaborative Applications

The product shall use Telnet-based communication via PLINK (see chapter 4 Naming Conventions and Terminology) and RPC-based communication via host Operating System in conjunction with PsExec (see chapter 4 Naming Conventions and Terminology).

3.4. Off-the-Shelf Software

Off-the-Shelf Software is described in chapter Implementation Environment of the Current System.

(Continues)

3.5. Anticipated Workplace Environment

The product will be used in laboratory environment inside Corporate's facilities. Laboratory shall have adequate means of electricity, network connectivity, air-conditioning and access control. User shall have a place for a Personal Computer in which the product is installed.

3.6. Schedule Constraints

The production version of the product shall be ready for project's test round. Exact date cannot be disclosed due to security classification of testing.

3.7. Budget Constraints

Budget is set to be minimal. No additional resources are permitted for programming work. Re-use of existing hardware is required.

(Continues)

4. Naming Conventions and Terminology

4.1. Definitions of All Terms, Including Acronyms, Used in the Project

IEEE	Institute of Electrical and Electronics Engineers, publishes nearly a third of the world's technical literature in electrical engineering, computer science, and electronics.
IEEE 802.11	Standard for Information technology, Telecommunications and information exchange between systems Local and metropolitan area network.
IEEE 802.11i	Amendment to IEEE 802.11 defining security mechanisms for IEEE 802.11.
ETSI	The European Telecommunications Standards Institute; produces globally-applicable standards for Information and Communications Technologies.
ITU-T	One of the three sectors (divisions or units) of the International Telecommunication Union (ITU) coordinating standards for telecommunications.
LAN	Local Area Network, computers connected in the same physical or logical entity using cabling.
Wlan	Wireless Local Area Network, computers connected in the same physical or logical entity using wireless means. In this context refers to IEEE 802.11 wireless networking standard.
WFA	Wi-Fi Alliance, a non-profit organization coordinating certification and development of Wlan-related issues.
Wi-Fi	Wireless Fidelity, a trademark for Wi-Fi Alliance, used as a synonym for Wireless Local Area Network.
RADIUS	Remote Authentication Dial In User Service, a service which authenticates users, computers, client software allowing usage of resources.
AAA	Authentication, Authorization and Accounting, a synonym for RADIUS.

(Continues)

ISM	License-free radio spectrum intended for Industrial, Scientific and Medical usage.
WEP	Wired Equivalent Privacy, a security protocol to authenticate user in the IEEE 802.11 wireless networking standard, usually 64bit (WEP64) or 128bit (WEP128).
TKIP	Temporary Key Integrity Protocol, a security protocol used in the IEEE 802.11 wireless networking standard.
CCMP/AES	Counter Mode with Cipher Block Chaining Message Authentication Code Protocol/Advanced Encryption Standard, a security protocol used in the IEEE 802.11 wireless networking standard.
Ciphering	An algorithm for performing encryption or decryption—a series of well-defined steps that can be followed as a procedure.
WPA	Wi-Fi Protected Access, authentication method using TKIP ciphering.
WPA2	Wi-Fi Protected Access 2, authentication method using CCMP/AES ciphering.
EAP	Extensible Authentication Protocol, an authentication framework providing for the transport and usage of keying material and parameters generated by EAP methods.
IETF	Internet Engineering Task Force, an international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.
RFC	Request for Comments, in this context refers to IETF's recommendations which are widely adopted to use but not yet set as official standards. Working Standards.
IAS	Internet Authentication Server, part of Microsoft Windows Server, a product from Microsoft Corporation, provides RADIUS functionality (among others).
ACS	Access Control Server, a product from Cisco Systems Corporation, provides RADIUS functionality (among others).

(Continues)

GSM	Global System for Mobile Communications is a standard set developed by the ETSI to describe protocols for second generation (2G) digital cellular networks used by mobile phones.
SIM	Subscriber Identification Module, an integrated circuit securely storing international mobile subscriber identity and the related key to authenticate user on network.
UMTS	Universal Mobile Telecommunications System, a third generation (3G) mobile cellular system for networks based on the GSM standard.
PKI	A set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates.
PMI	A process of managing user authorisations based on the ITU-T Recommendation X.509
X.509	An ITU-T standard for a public key infrastructure (PKI) and Privilege Management Infrastructure (PMI). X.509 specifies standard formats for public key certificates, certificate revocation lists, attribute certificates, and a certification path validation algorithm.

Certificate-based EAP methods:

EAP-TLS	Extensible Authentication Protocol/Transport Layer Security, based on X.509 certificate, defined by Microsoft, IETF RFC 2716
EAP-PEAP	Extensible Authentication Protocol/Protected Extensible Authentication Protocol, based on xxx, defined by Microsoft, Cisco Systems and RSA Security.
EAP-TTLS	Extensible Authentication Protocol/Tunnelled Transport Layer Security, based on security certificate but information is transferred inside secured tunnel, defined by Funk Software/Juniper and Certicom corporations.

(Continues)

EAP-LEAP	Extensible Authentication Protocol/Lightweight Extensible Authentication Protocol, based on PEAP but with lighter security, defined by Cisco Systems.
EAP-SIM	Extensible Authentication Protocol/Subscriber Identification Module, a method for authenticating user in 2G network by using GSM-SIM, defined by Nokia/Haverinen et al, RFC 4186
EAP-AKA	Extensible Authentication Protocol/Authentication and Key Agreement, a method for authenticating user in 3G network by using 3G-SIM, defined in RFC 4187
AutoIt	Automation and scripting language
BASIC	Acronym for Beginner's All-purpose Symbolic Instruction Code.
DUT	Acronym for Device Under Test.
SSH	Cryptographic network protocol for secure data communication, remote shell services or command execution and other secure network services between two networked computers.
PuTTY	A SSH and telnet client, developed originally by Simon Tatham for the Windows platform.
Plink	PuTTY Link, Command-line version of PuTTY
APC	American Power Conversion, a company by Schneider Electric, a manufacturer of uninterruptible power supplies (UPS) and surge protection products.
PDU	Power Distribution Unit, controllable via Lan or serial cable.
Telnet	Network protocol used on the Internet or local area networks to provide a bidirectional interactive text-oriented communication facility using a virtual terminal connection.
TCP/IP	Transmission Control Protocol / Internet Protocol; TCP/IP provides end-to-end connectivity specifying how data should be formatted, addressed, transmitted, routed and received at the destination.
IP	Acronym for TCP/IP

(Continues)

Ini-file	Initializion file; The INI file format is an informal standard for configuration files for some platforms or software. INI files are simple text files with a basic structure composed of "sections" and "properties".
Ping	A computer network administration utility used to test the reachability of a host on an Internet Protocol (IP) network and to measure the round-trip time for messages sent from the originating host to a destination computer. The name comes from active sonar terminology which sends a pulse of sound and listens for the echo to detect objects underwater.
Netsh	A tool an administrator can use to configure and monitor Windows-based computers at a command prompt.
PsExec	A command line based remote administration tool and allows for the remote execution of processes on other systems. Originally developed by Mark Russinovich of Sysinternals.

(Continues)

5. Relevant Facts and Assumptions

5.1. Relevant Facts

Due to budget constraints the product has to be royalty-free. Timing is important. No additional resources are allocated therefore it is not possible to learn new programming skills in time. Selected programming environment is AutoIt, a free BASIC-like scripting language, which can be compiled to royalty-free executable.

5.2. Business Rules

Not applicable.

5.3. Assumptions

As Wireless LAN Access Points evolve their User Interface might change causing changes to product. New emerging Wireless LAN Access Points may introduce new ways for interfacing the user in which case has to be taken into consideration whether the market share of the Wireless LAN Access Point is globally significant justifying the additional work for new interface. The product’s life-span is restricted until a viable solution from the certification bodies will be ready and implemented.

(Continues)

6. The Scope of the Work

6.1. The Current Situation

Wireless LAN verification process of a mobile phone includes many commercially available Wireless LAN Access Points, which have a significant market share globally either via their chipset and/or the product as a whole. Testing different authentication scenarios requires changing the settings in the Access Point and/or in the server infrastructure in the laboratory backbone network. These settings are performed manually and are therefore prone to human errors. Even if the settings are done seemingly correctly they might be logically wrong resulting distorted outcome. Finding the root cause of an error resulting from wrong logical configuration is time consuming.

6.2 The Context of the Work

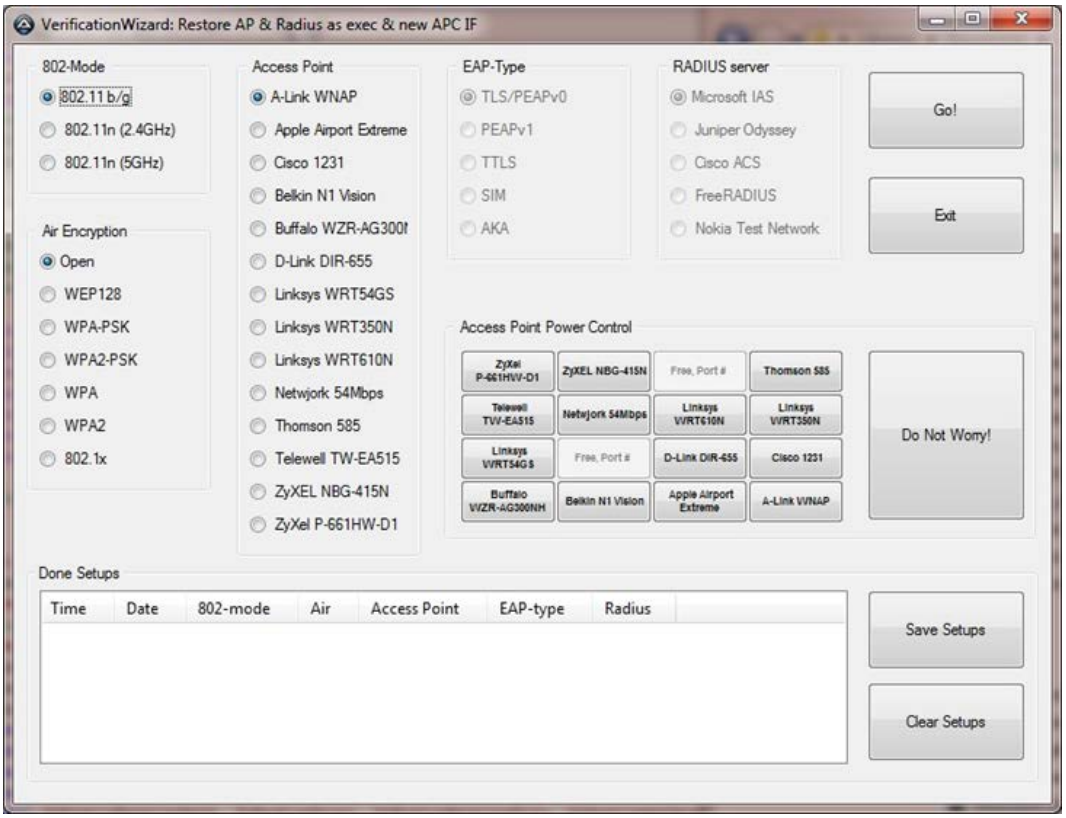


Figure 2: The Context of the Work

(Continues)

Context of the work is to create a user interface with radio buttons. Logic running in the background prevents user making invalid choices by disabling conflicting selections.

6.3 Work Partitioning

Table 1: Work Partitioning

Number	Event Name	Input and Output	Summary
1	802-mode	Network mode (in)	2.4GHz or 5GHz network selection
2	Access Point	Access point selection (in)	Selection of desired Access Point
3	Air Encryption	Air-encryption mode (in)	Selection of required encryption
4	EAP-type	EAP-type selection (in)	Selection of desired EAP-type
5	RADIUS server	RADIUS selection (in)	Selection of RADIUS server supporting selected authentication method
6	Go!	Continue (in)	If user is happy, continue with settings
7	Power Up AP	Command PDU (out)	Power up selected Access Point
8	WLAN AP alive	Access point ready for config (in)	Enable Access Point for configuration
9	Load AP configuration	Send config path (out)	Loads pre-defined configuration to Access Point
10	AP Config ready	Access point config status (in)	Access point ready for action
11	RADIUS alive	RADIUS ready for config (in)	RADIUS server ready for configuration
12	Load RADIUS configuration	Send config path (out)	Loads pre-defined configuration to RADIUS server
13	RADIUS Config ready	RADIUS config status (in)	RADIUS server ready for action
14	Save Setups	Save Setups (in)	Saves done setups to a log file
15	Clear Setups	Clear Setups (in)	Clears done setups
16	Write log	Record selections (out)	Record made selections with timestamp
17	Exit	Exit (in)	Close all connections and shut down

(Continues)

18	Do Not Worry!	Reset (in/out)	Panic button to reset everything back to defaults and power down PDU
19	Access Point Power Control -button	Change selected AP power state (in)	Changes selected Access Point PDU state

6.4. Specifying a Business Use Case (BUC)

1. 802-mode: user needs to select which WLAN network is used (2.4GHz for 802.11 b/g or .n or 5GHz for 802.11n).
2. Access Point: user selects desired Access Point for testing.
3. Air Encryption: user selects desired air encryption mode for testing.
4. EAP-type: user selects the desired authentication method for testing.
5. RADIUS server: user selects the desired RADIUS-server performing authentication.
6. Go!: when user is satisfied with made selections continue with setup.
7. Power Up AP: Send power up command to PDU and turn selected AC outlet on (and possible previous off).
8. WLAN AP alive: Access point is responding to PING-events correctly and is ready to input new setup.
9. Load AP configuration: Send path and file name of selected setup to Access Point and commit.
10. AP Config ready: After successful configuration download Access Point confirms successful configuration change and responds to PING-events correctly.
11. RADIUS alive: RADIUS server is responding to PING-events correctly.
12. Load RADIUS configuration: send selected RADIUS configuration command to RADIUS.

(Continues)

13. RADIUS Config ready: RADIUS server is responding to PING-events correctly after configuration change.
14. Save Setups: user presses Save setups -button triggering log file save dialog.
15. Clear Setups: user presses Clear Setup -button to clear Done Setups -dialog.
16. Write log: write the selected configuration to Done Setups -dialog on display field with timestamp.
17. Exit: User ends the program.
18. Do Not Worry!: A panic button: close all communication and reset everything back to defaults, including PDU.
19. Access Point Power Control –button: user presses Access Point’s PDU-button to change the power status (on/off). Can be used to load next configuration to next Access Point while previous one is used for testing.

(Continues)

7. Business Data Model and Data Dictionary

7.1. Data Model

Figure 3 shows the most important use cases.

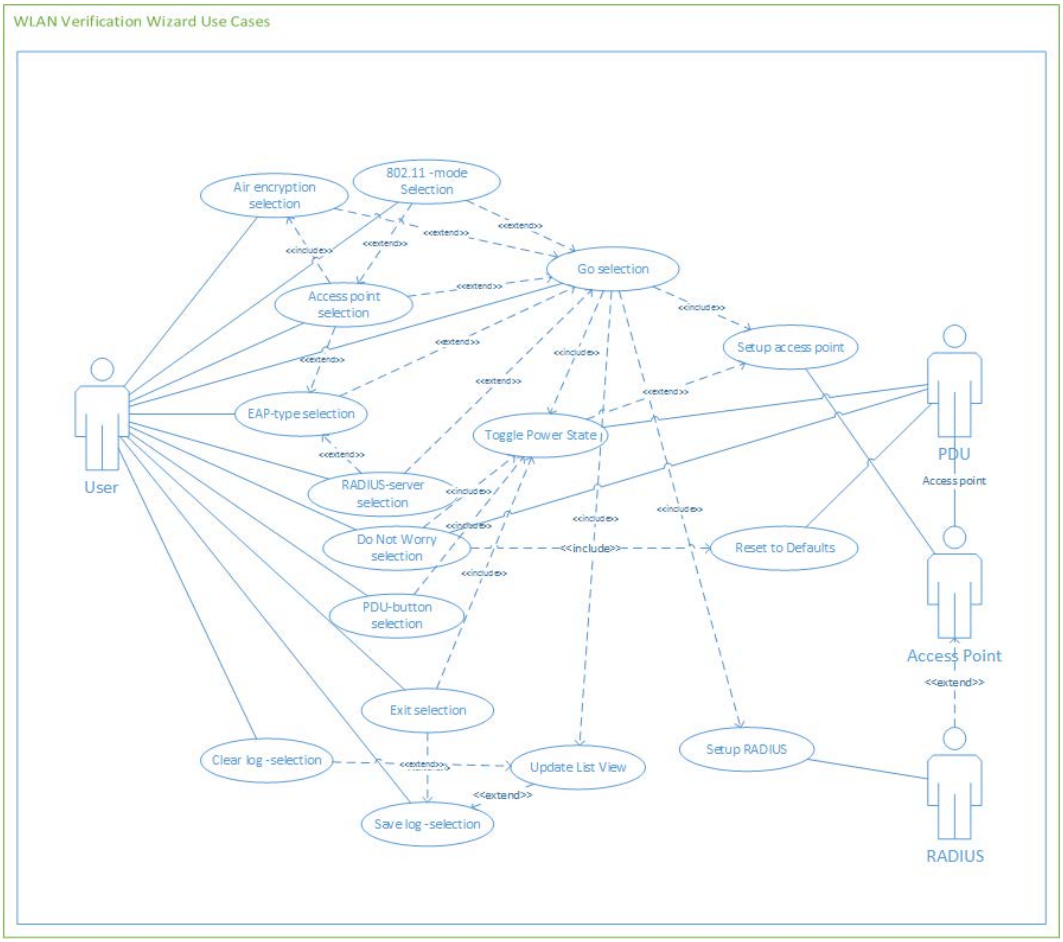


Figure 3: Use Cases

See Section 6 The Scope of the Work for more information.

(Continues)

7.2. Data Dictionary

Table 2: Data dictionary

Variables		
Name	**Content**	**Type**
$sIniFile	Name of the initialization file	String
$sVersion	Version number to be displayed	String
$sDefaultGrey	RGB map of default grey color	String
$sDefaultGreen	RGB map of default green color	String
$iAllPortsOff	Address for all APC ports	Integer
$iNumOfPduPorts	Amount of PDU ports	Integer
$iNumOfAP	Number of selected Access Points	Integer
$iNumOfAir	Number of selected air encryption	Integer
$iNumOfEAP	Number of selected	Integer
$iNumOfRAD	Number of selected	Integer
$sSelected802	Selected 802.11 -mode	String
$sSelectedAir	Selected air encryption	String
$sSelectedAp	Selected Access Point	String
$sSelectedEap	Selected eap-method	String
$sSelectedRad	Selected RADIUS server	String
$sPrevious802	Previous selected 802.11-mode	String
$sPreviousAir	Previous selected air encryption	String
$sPreviousAp	Previous selected Access Point	String
$sPreviousEap	Previous selected eap-method	String
$sPreviousRad	Previous selected RADIUS	String
$iCurrentLvItem	Current ListView item in Done Setups	Integer
$iFirstLvItem	First ListView item in Done Setups	Integer
$tTextToSave	Text from Done Setups to be saved	String
$iIsListSaved	Boolean is Done Setups saved	Boolean
$iPort	PDU port number	Integer
$sRestoreFile	pre-defined setup file name	String
$iPlinkHandle	Process handle number for PLINK comms	Integer
$sRadiusRestorePath	Path to RADIUS pre-defined setup files	String
$sRadiusProxy	Path to RADIUS proxy	String
$sRadiusRestoreFile	Name of the pre-defined RADIUS setup	String
$iRadiusSetStatus	Status of RADIUS setup	Integer
$sErrorItem	Error string	String
$sOnColor	RGB map for “On”-state	String
$sOffColor	RGB map for “On”-state	String
$PduPrevState	State of previous PDU port	String
$PduActionPhrase	Command string to PDU	String
$iMsgBoxTimeOut	Timeout counter in seconds	Integer
$iWatchDog	Watchdog timer to update PDU button states	Integer
$DE-BUG_List_Event_Arrays	Cmd-line variable for debug purposes, prints out event arrays to txt-file in local path	Integer

(Continues)

$DE-BUG_iAccessPointOff	Cmd-line variable for debug purposes, prints out setup string to be sent out to Access Point	Integer
$DEBUG_iRadiusOff	Cmd-line variable for debug purposes, prints out setup string to be sent out to RADIUS server	Integer
$sLocalPath	Location of the program	String
$sApIniFile	Name of the Access Point ini-file	String
$sRadiusIniFile	Name of the RADIUS ini-file	String
$asList802Mode	Array of 802-modes	String Array
$asListAir	Array of air encryption -modes	String Array
$asListAP	Array of Access Points	String Array
$sAPRestorePath	Path to Access Point pre-defined setup files	String
$sPDU_Enabled	PDU enabled	String
$sPDU_IP	PDU IP-address	String
$sPDU_User	PDU user name	String
$sPDU_Pwd	PDU password	String
$aAPs_and_Ports	Array of Access Points, their assigned port numbers and statuses	Integer Array
$aUsedPduPorts	Array of used port addresses	Integer Array
$asApCapa	Array of Access Points and their capabilities	String Array
$asListEap	Array of available EAP-methods	String Array
$asListRADIUS	Array of available RADIUS servers	String Array
$asRadCapa	Array of RADIUS servers and their capabilities	String Array
$iRadioGrpTop	Location of Radio button group left uppermost corner	Integer
$iRadioGrpWidth	Radio button group width	Integer
$iGrpSeparator	Separator width between groups	Integer
$iRadioBtnSeparator	Separator width between radio buttons	Integer
$iRadioBtnTop	Location of the first radio button, top	Integer
$iRadi-oBtnLeftFromGrp	Location of the radio button relative to group, left	Integer
$iRadioBtnHeight	Height of radio button	Integer
$iRadioTxtWidth	Radio button text field width	Integer
$i802GrpTop	802-mode group location	Integer
$i802GrpLeft	Location of 802-mode group relative to program window, left	Integer
$i802GrpHeight	Height of the group	Integer
$i802Left	802-mode radio button location relative to its group	Integer
$iAirGrpTop	Air encryption group location	Integer

(Continues)

$iAirGrpLeft	Location of Air encryption group relative to program window, left	Integer
$iAirGrpHeight	Height of the group	Integer
$iAirLeft	Access point radio button location relative to its group	Integer
$iApGrpTop	Access point group location	Integer
$iApGrpLeft	Location of Access point group relative to program window, left	Integer
$iApGrpHeight	Height of the group	Integer
$iApLeft	Access point radio button location relative to its group	Integer
$iEapGrpTop	EAP-type group location	Integer
$iEapGrpLeft	Location of EAP-type group relative to program window, left	Integer
$iEapGrpHeight	Height of the group	Integer
$iEapLeft	EAP-type radio button location relative to its group	Integer
$iRadGrpTop	RADIUS server group location	Integer
$iRadGrpLeft	Location of RADIUS server group relative to program window, left	Integer
$iRadGrpHeight	Height of the group	Integer
$iRadLeft	RADIUS server radio button location relative to its group	Integer
$iListViewHeight	Done Setups -list view height	Integer
$iListViewWidth	Done Setups -list view width	Integer
$iMainHeight	Height of the main program	Integer
$iMainWidth	Width of the main program	Integer
$ai802Event	Array of event numbers for 802-group	Integer Array
$aiAirEvent	Array of event numbers for Air encryption -group	Integer Array
$aiApEvent	Array of event numbers for Access point -group	Integer Array
$aiEapEvent	Array of event numbers for EAP-type -group	Integer Array
$aiRadEvent	Array of event numbers for RADIUS server -group	Integer Array
$aiPowerEvent	Array of event numbers for PDU-group	Integer Array
$GUI_EVENT_CLOSE	Main display event handlers	String
$GUI_EVENT_MINIMIZE	Main display event handlers	String
$GUI_EVENT_MAXIMIZE	Main display event handlers	String
$GUI_EVENT_RESTORE	Main display event handlers	String
$GUI_DOCKAUTO	Resize automatically according to window size	String
$GUI_CHECKED	Radio button state, only one can be ena-	String

(Continues)

	bled inside a group	
$GUI_UNCHECKED	Radio button state, only one can be enabled inside a group	String
$GUI_DISABLE	Radio button in use, based on capability matrix of selections	String
$GUI_ENABLE	Radio button not in use, based on capability matrix of selections	String
Functions		
Name	**Content**	**Type**
_Debug_Events()	Collect data from all event arrays and save it to text file	out
_APC_GetState()	Read port states from APC, gets called from main loop and after GO	out
_NButton()	802-mode button selected	out
_AirButton()	Air encryption button selected	out
_ApButton()	Access point button selected	out
_EapButton()	EAP-type button selected	out
_RadiusButton()	Radius button selected	out
_AllPortsOff()	Turn off all PDU ports	out
_PduButton()	PDU button selected	out
_ConnectToAPC()	Connection to PDU via PLINK	out
_TogglePduBtnState($iCtrlId)	check the state of pressed button and change it	in/ out
_TogglePDU($Port, $PduAction)	toggles the state of selected pdu port	in/ out
_PDU_Control($Port, $PduAction)	Port# On/Off as parameters	in/ out
Btn_Save_ListClick()	format: time | date | 802-mode | Air | AP | EAP | Radius @CRLF	out
_ButtonGoClick()	Start all configurations	out
MainClose()	Shut down	out
MainMaximize()	Stub for operating system window handling	out
MainMinimize()	Stub for operating system window handling	out
MainRestore()	Stub for operating system window handling	out
_ToggleApState($iEvent)	Event number as input ; if input is in range 4 - 6 = 802button ; if input is in range 9 - 15 = AirButton	in/ out
_ToggleEapState($sEapState)	if enable, need to check if air enterprise & which radius, use enable also selectively (which radius -> may disable)	in/ out
_ToggleRadiusState($sRadiusState)	if enable, need to check eap-mode & if air = enterprise	in/ out
_SaveTxt($tTextToSave, $sSaveFile)	Save Done Setups List view to a text file	in/ out
_RestoreAP()	load selected Access Point configuration	out
_CheckPduComms($sP	Check if PDU is alive	in/ out

(Continues)

DU_IP)		
_SetRadius()	load selected RADIUS configuration	out
_UpdateListView()	Update Done Setups with selected setup	out
_ClearListView()	Clear Done Setups list view	out

8. The Scope of the Product

8.1. Product Boundary

The Product shall be only interim solution for test usage until a viable solution will be ready from the Certification Body.

8.2. Product Use Case Table

Number	PUC Name	Actors	Input and Output	Summary
1	802-mode	Test engineer	Network mode (in)	2.4GHz or 5GHz network selection
2	Access Point	Test engineer	Access point selection (in)	Selection of desired Access Point
3	Air Encryption	Test engineer	Air-encryption mode (in)	Selection of required encryption
4	EAP-type	Test engineer	EAP-type selection (in)	Selection of desired EAP-type
5	RADIUS server	Test engineer	RADIUS selection (in)	Selection of RADIUS server supporting selected authentication method
6	Go!	Test engineer	Continue (in)	If user is happy, continue with settings
7	Power Up AP	Client computer	Command PDU (out)	Power up selected Access Point
8	WLAN AP alive	Access Point	Access point ready for config (in)	Enable Access Point for configuration
9	Load AP configuration	Client computer	Send config path (out)	Loads pre-defined configuration to Access Point
10	AP Config ready	Access Point	Access point config status (in)	Access point ready for action

(Continues)

11	RADIUS alive	RADIUS server	RADIUS ready for config (in)	RADIUS server ready for configuration
12	Load RADIUS configuration	Client computer	Send config path (out)	Loads pre-defined configuration to RADIUS server
13	RADIUS Config ready	RADIUS server	RADIUS config status (in)	RADIUS server ready for action
14	Save Setups	Test engineer	Save Setups (in)	Saves done setups to a log file
15	Clear Setups	Test engineer	Clear Setups (in)	Clears done setups
16	Write log	Client computer	Record selections (out)	Record made selections with timestamp
17	Exit	Test engineer	Exit (in)	Close all connections and shut down
18	Check log on Exit	Client computer	Save Log (out)	Checks whether the log is already saved
19	Do Not Worry!	Test engineer	Reset (in/out)	Panic button to reset everything back to defaults and power down PDU
20	Access Point Power Control - button	Test engineer	Change selected AP power state (in)	Changes selected Access Point PDU state

Table 3: Product Use Case table

8.3. Individual Product Use Cases

1. 802-mode — User needs to select which WLAN network is used (2.4GHz for 802.11 b/g or .n or 5GHz for 802.11n). The program will take care of disabling conflicting settings based on each Access Point's properties in compatibility matrix.

2. Access Point — User selects desired Access Point for testing. The program will take care of disabling conflicting settings based on each Access Point's properties in compatibility matrix.

(Continues)

3. Air Encryption	User selects desired air encryption mode for testing. The program will take care of disabling conflicting settings based on each Access Point's properties in compatibility matrix.
4. EAP-type	User selects the desired authentication method for testing. The program will take care of disabling conflicting settings based on each Access Point's and RADIUS-server's properties in compatibility matrix.
5. RADIUS server	User selects the desired RADIUS-server performing authentication. The program will take care of disabling conflicting settings based on each Access Point's and RADIUS-server's properties in compatibility matrix.
6. Go!	When user is satisfied with made selections continue with setup.
7. Power Up AP	Send power up command to PDU and turn selected AC outlet on (and possible previous off).
8. WLAN AP alive	Access point is responding to PING-events correctly and is ready to input new setup.
9. Load AP configuration	Send path and file name of selected setup to Access Point and commit.
10. AP Config ready	After successful configuration download Access Point confirms successful configuration change and responds to PING-events correctly.
11. RADIUS alive	RADIUS server is responding to PING-events correctly.
12. Load RADIUS configuration	Send selected RADIUS configuration command to RADIUS.
13. RADIUS Config ready	RADIUS server is responding to PING-events correctly after configuration change.
14. Save Setups	User presses Save setups -button triggering log file save dialog.
15. Clear Setups	User presses Clear Setup -button to clear Done Setups -dialog.
16. Write log	Write the selected configuration to Done Setups -dialog on display field with timestamp. Allow also free text field for user comments.

(Continues)

17. Exit	User ends the program.
18. Check log on Exit	When exiting the program user is prompted to save the log from Done Setups -dialog display field if not yet saved.
19. Do Not Worry!	A panic button: close all communication and reset everything back to defaults, including PDU.

9. Functional and Data Requirements

9.1. Functional Requirements

Requirement: (ID)	1
Requirement type:	Functional
Event/BUC/PUC:	Wizard must open with default settings.
Description:	Each time the application is started user is presented with same default settings options.
Rationale:	Each test has to be started with default options to prevent undesired settings.
Originator:	Jis
Fit criterion:	User is able to begin testing always from known situation.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013
Requirement: (ID)	2
Requirement type:	Functional
Event/BUC/PUC:	User must not be able to select invalid options for selected Access Point.
Description:	User may not be able to select invalid options for selected Access Point.
Rationale:	To avoid impossible or unsupported configuration upload to Access Point. Also to reduce testing errors.

(Continues)

Originator:	Jis
Fit criterion:	User is always presented only with those selections which apply for selected Access Point.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	3
Requirement type:	Functional
Event/BUC/PUC:	Wizard must prevent the selection of invalid network options.

Wizard must prevent the selection of invalid network options.

Description:	Wizard uses Access Point capability matrix to prevent wrong network selections automatically.
Rationale:	To reduce testing errors by not allowing selecting improper network.
Originator:	Jis
Fit criterion:	User is always presented with valid network selection options.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	4
Requirement type:	Functional
Event/BUC/PUC:	User must be able to toggle manually the power state of any attached Access Point.

(Continues)

Description:	Power Controller -module has push buttons for each individual power port with status indication (Green = on, Grey = off, Disabled = not connected)
Rationale:	Each power outlet must be also individually controllable. While test is running other Access Point can be setup or intentional network loss may be tested.
Originator:	Jis
Fit criterion:	User can control each connected Access Point also manually overriding the Power Controller -module.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013
Requirement: (ID)	5
Requirement type:	Functional
Event/BUC/PUC:	Power Controller must have a Main switch (Panic-button).
Description:	Clearly marked ("Do Not Worry") button on main screen.
Rationale:	If all power outlets are needed to be shutdown at once, this button is pressed.
Originator:	Jis
Fit criterion:	User is able to cut the power from all outlets with a single click.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	6
Requirement type:	Functional
Event/BUC/PUC:	User selections must be possible to save to a text file.

(Continues)

Description:	Selections are written into "Done Setups" -window and can be saved for later use or log.
Rationale:	Tested setups with time stamps are recorded as a log file.
Originator:	Jis
Fit criterion:	User can save done test to a text file and write also additional info, if needed. Can be used as log file.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	7
Requirement type:	Functional
Event/BUC/PUC:	User actions (Done Setups) must have info on made selections, including time and date stamp.
Description:	User selections are written into "Done Setups" -window and contain all made selections before running the setup.
Rationale:	It is crucial to have exact info on which selections are fed into which Access Point and when.
Originator:	Jis
Fit criterion:	User has a clear log of actions.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	8
Requirement type:	Functional
Event/BUC/PUC:	User selections must be able to clear before run attempt.
Description:	"Clear"-button is on the main user interface.

(Continues)

Rationale:	If user changes his mind Clear-button can be used to erase made selections thus returning to initial state.
Originator:	Jis
Fit criterion:	User has an option to cancel made decisions and start over without restarting the whole system.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013
Requirement: (ID)	9
Requirement type:	Functional
Event/BUC/PUC:	Wizard must notify user of possible communication errors.
Description:	Wizard will notify user of possible network problems like disconnected cable.
Rationale:	If user is not notified of a networking problem time is wasted while waiting the setup upload to complete.
Originator:	Jis
Fit criterion:	User gets a notification of possible networking error and may be able to correct the problem.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

Requirement: (ID)	10
Requirement type:	Functional
Event/BUC/PUC:	When exiting user must be notified if "Done Setups" are not saved.
Description:	User is presented a File Save -dialog, if the log file is not saved while ending the Wizard.

(Continues)

Rationale:	Log file can be lost unless it is saved. It contains vital information of tests.
Originator:	Jis
Fit criterion:	User has the option to save the log file when exiting.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	High
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

9.2. Data Requirements

Requirement: (ID)	11
Requirement type:	Data
Event/BUC/PUC:	All data and log files shall be in textual format.
Description:	All data and log files shall be possible to open with a text editor program.
Rationale:	Due to the nature of the product no database is used. Flat files.
Originator:	Jis
Fit criterion:	User has the option to save the log file when exiting.
Customer satisfaction:	5
Customer dissatisfaction:	5
Priority:	Medium
Conflicts:	None
Supporting material:	Glossary, DUT- dependent Test Plan
History:	May 2013, Modified Aug 2013

(Continues)

10. Look and Feel Requirements (Non-functional Requirements)

10.1. Appearance Requirements

Not applicable

10.2. Style Requirements

Not applicable

(Continues)

11. Usability and Humanity Requirements

11.1. Ease of Use Requirements

The Product shall be usable without any written instructions. Users are required to have skills of how to setup the testing environment.

11.2. Personalization and Internationalization Requirements

Used language shall be English and no other options shall be available. Personalization is kept at minimum level due to the nature of the Program.

11.3. Learning Requirements

Users must have prior knowledge of setting up the test environment. The Program shall present a large number of options to choose from for the user. The program shall disable options which are not valid for selected configuration.

11.4. Understandability and Politeness Requirements

Not applicable.

11.5. Accessibility Requirements

Not applicable.

(Continues)

12. Performance Requirements

12.1. Speed and Latency Requirements

Not applicable.

12.2. Safety-Critical Requirements

Not applicable.

12.3. Precision or Accuracy Requirements

Not applicable.

12.4. Reliability and Availability Requirements

Not applicable.

12.5. Robustness or Fault-Tolerance Requirements

Not applicable.

12.6. Capacity Requirements

Not applicable.

12.7. Scalability or Extensibility Requirements

(Continues)

Administrative personnel can add more test Access Points to laboratory setup by filling out the initialization file for the particular Access Point and performing all configuration backups to a file. Path and file name must be recorded at initialization file along with the displayed name of the Access Point.

12.8. Longevity Requirements

The program shall operate on minimum maintenance budget until a solution from the certification body will become available.

(Continues)

13. Operational and Environmental Requirements

13.1. Expected Physical Environment

Expected working environment shall be a laboratory with air-conditioning and adequate means for data communications to company's laboratory backbone. The laboratory shall have means for access control 24 hours / day.

13.2. Requirements for Interfacing with Adjacent Systems

The product shall be able to communicate over TCP/IP v4 networks to test bench Access Points and authentication servers.
The Product shall be able to use Internet Explorer for interfacing to test bench Access Points.

The Product shall be able to utilize Access Point manufacturer-specific communication program for setting up the configuration.

13.3. Productization Requirements

The Product shall remain as interim solution for helping out verification testing and shall not be productized.

13.4. Release Requirements

Releases shall be provided on-need –basis. No pre-defined release schedule shall be set.

(Continues)

14. Maintainability and Support Requirements

14.1. Maintenance Requirements

The administrator shall be able to modify the Program’s available options depending on the test laboratory’s setup and available Access Points. Otherwise the program shall be provided “as-is”.

14.2. Supportability Requirements

Due to budget constraints no support personnel shall be dedicated for the Program.

14.3. Adaptability Requirements

Not applicable.

(Continues)

15. Security Requirements

15.1. Access Requirements

The laboratory space shall have adequate means of access control. The computer hosting the Program shall have access control via user login. All users with proper credentials to the laboratory environment shall have rights to operate the Program.

15.2. Integrity Requirements

Not applicable.

15.3. Privacy Requirements

The program shall not collect any user-related data.

15.4. Audit Requirements

Not applicable.

15.5. Immunity Requirements

The computer hosting the Program shall have anti-virus program and firewall setup according to the Company’s rules for laboratory equipment.

(Continues)

16. Cultural and Political Requirements

16.1. Cultural Requirements

Not applicable.

16.2. Political Requirements

Not applicable.

(Continues)

17. Legal Requirements

17.1. Compliance Requirements

Not applicable.

17.2. Standards Requirements

Not applicable.

(Continues)

18. Open Issues

Setup Runner for replaying the completed setup has been discussed. Due to time- and budget constraints it has been left out.

A Setup wizard has been discussed as an alternative to textual initialization file editing. Due to time- and budget constraints it has been left out.

(Continues)

19. Off-the-Shelf Solutions

19.1. Ready-Made Products

None available at time being.

19.2. Reusable Components

None available at time being.

19.3. Products That Can Be Copied

None available at time being.

(Continues)

20. New Problems

20.1. Effects on the Current Environment

Setting up a new Access Point very carefully is mandatory. All desired configurations must be saved on a back-file which is used to configure the Access Point via the Program. Supported functionality of a new Access Point must be inserted to initialization file.

20.2. Effects on the Installed Systems

Users shall have a new option to power up the selected Access Point using the Program.

20.3. Potential User Problems

If setting up a new Access Point to the test environment is not done correctly a test round may fail or produce errors.

If a new brand of Access Point is introduced, which does not support set up via Telnet it may require creating a new method for accessing it. This may consist of using manufacturer's own setup program or other means which requires the Program's interaction with the Access Point to be studied and implemented.

20.4. Limitations in the Anticipated Implementation Environment That May Inhibit the New Product

Unforeseen updates to Internet Explorer introducing changed User Interface, which may require setting up the Program's interaction with the new browser.

(Continues)

Design changes with the Access Point’s user interface, which may require changes to the Program’s interaction with the Access Point.

20.5. Follow-Up Problems

As the scope of the Program is an interim release until a sustainable solution from the certification body is available it is not likely any follow-up is required.

(Continues)

21. Tasks

21.1. Project Planning

The project planning and development shall be very agile. The users of the Product shall be brought up with the new capabilities or Access Points every time when there shall be a test round.

21.2. Planning of the Development Phases

Initial planning shall be ready – 2 months before the first official test round.
First test version shall be ready -1 month before the first official test round.
Intermediate releases shall be created based on feedback from testing.
The final version shall be ready in approximately 6 months after the first official test round.

(Continues)

22. Migration to the New Product

22.1. Requirements for Migration to the New Product

Not applicable.

22.2. Data That Has to Be Modified or Translated for the New System

Not applicable.

(Continues)

23. Risks

Excessive schedule pressure may delay the Product releases.

Low productivity related to learning curve of new programming skills related to interfacing components may delay the Product releases.

(Continues)

24. Costs

No additional costs are allowed for the Program.

(Continues)

25. User Documentation and Training

25.1. User Documentation Requirements

Not applicable.

25.2. Training Requirements

All users of the Program shall receive hands-on training. No other method shall be available.

(Continues)

26. Waiting Room

Initialization data editor, an interface for initialization data to make sure all necessary fields are filled. Put waiting due to resourcing constraints.

Setup Re-Runner, a tool to replay the completed test. Put waiting due to resourcing constraints.

Appendix 2. Architecture Specification for the semi-automation tool

1 INTRODUCTION

Interoperability testing for wireless local area networks may require a complex test environment consisting of several Access Points and authentication servers. These entities are used to verify the correct operation of a device under test.

Each entity has several settings for various authentication types and encryptions. There is no global standard for remote (or local) user interface to enable machine-to-machine automation for changing the settings. When user has to manually setup each feature, it is prone to errors. These erroneous situations may slow down the actual testing and therefore create pressure for schedules.

By creating a user interface based on radio-buttons it is possible to reduce the complexity of setting up the test environment to an acceptable level. User interface takes care of powering up the desired Access Point, communicates with it and restores the desired setup and, if needed, sets the definitions for authentication servers. Focus can be set to actual interoperability testing instead of setting up the test environment.

A clear reduction of errors caused by faulty setups of the test environment was achieved when the user interface was used. Also reliability and repeatability of testing got better.

(Continues)

The whole environment for the tool is presented in high level in **Virhe. Viitteen lähdettä ei löytynyt.**.

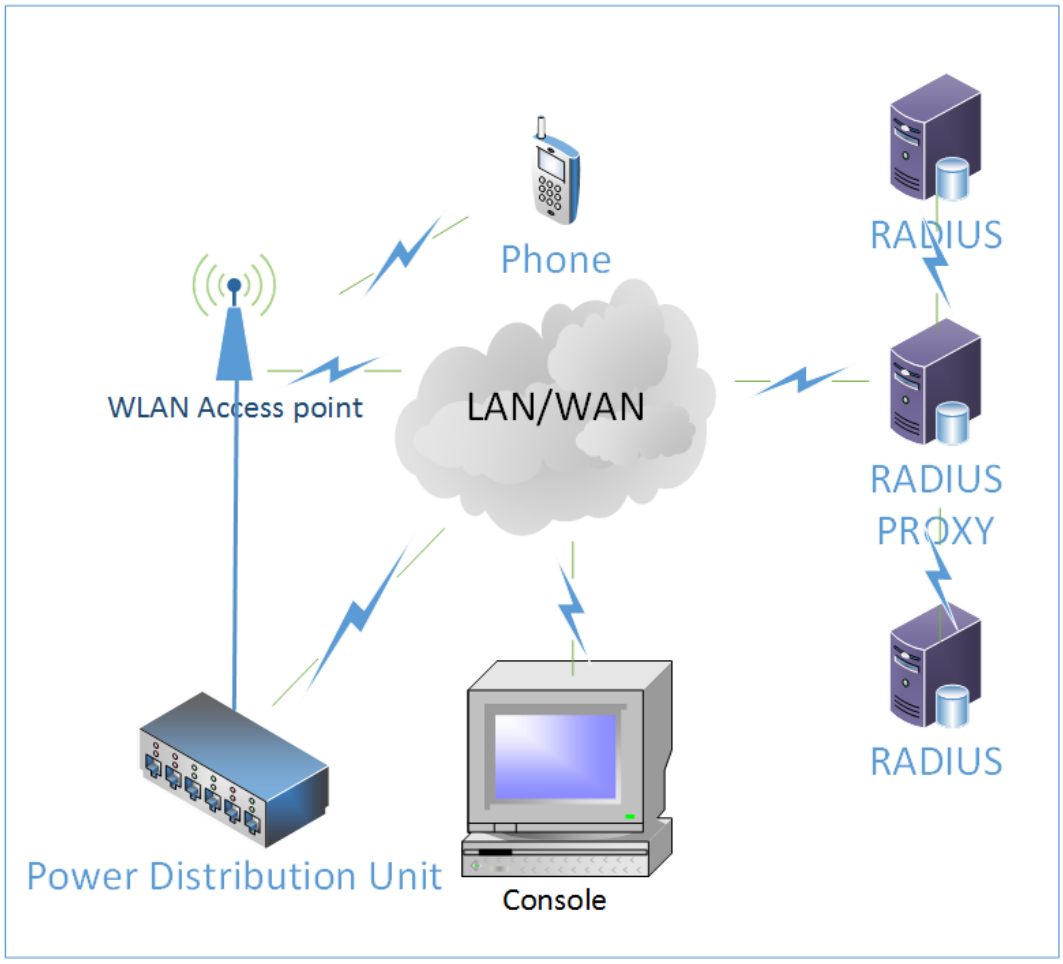


Figure 1: Communications overview

Architecture of the tool can be seen as Client-Server as part of the functionality lies inside the tool client running in console computer and part in the network in form of authentication servers (RADIUS).

The tool makes active connections to Power Distribution Unit (PDU) over Telnet to command the PDU to either activate or de-activate the selected power outlet to power up the selected Access Point.

After the selected Access Point has restored its full functionality a connection is made to it to configure it with selected parameters consisting of the air encryption type and

(Continues)

possible authentication. Connection may happen either with a Browser, Telnet, Tftp or manufacturer's own setup program controlled by the tool

If authentication is used the RADIUS-Proxy is configured to direct the RADIUS authentication messages to the correct RADIUS-server.

The user interface is presented in **Virhe. Viitteen lähdettä ei löytynyt.**.

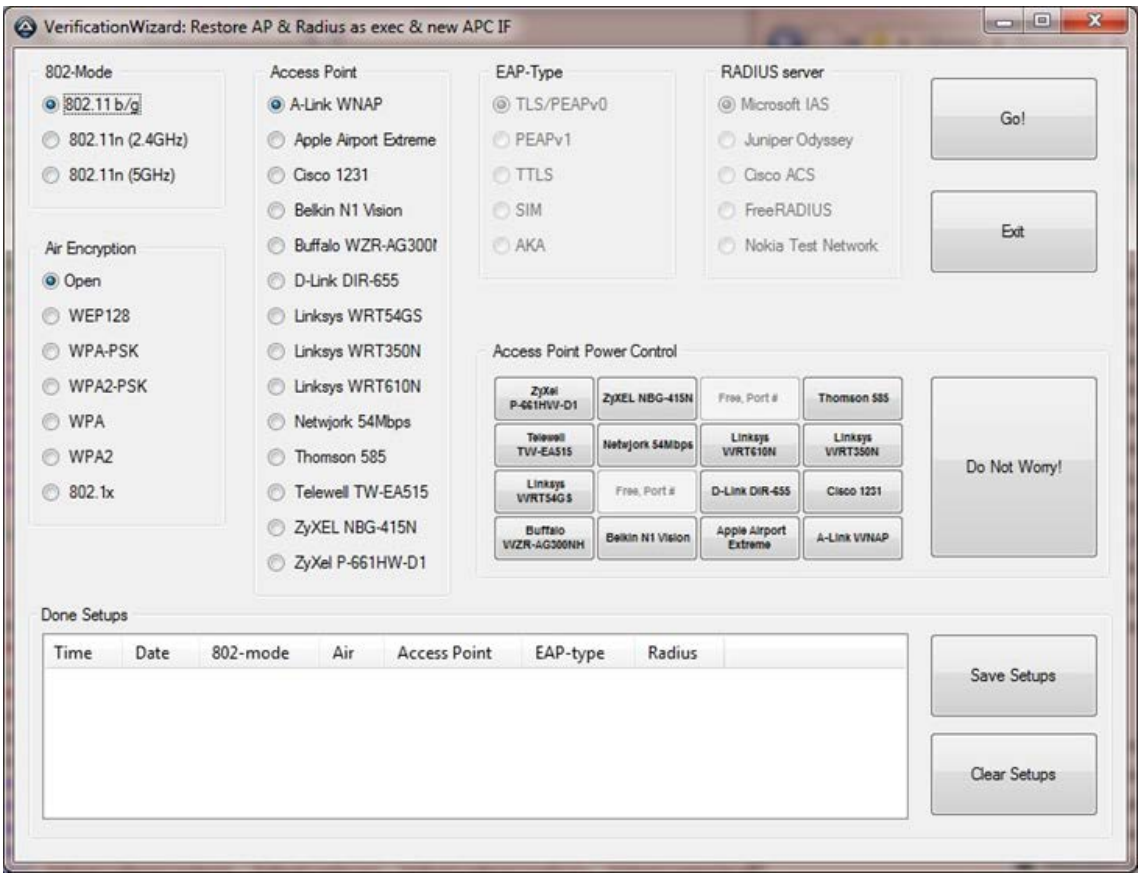


Figure 2: User Interface

The tool is a user interface with some logic behind. It is trying to simplify and speed up the testing environment configuration task.

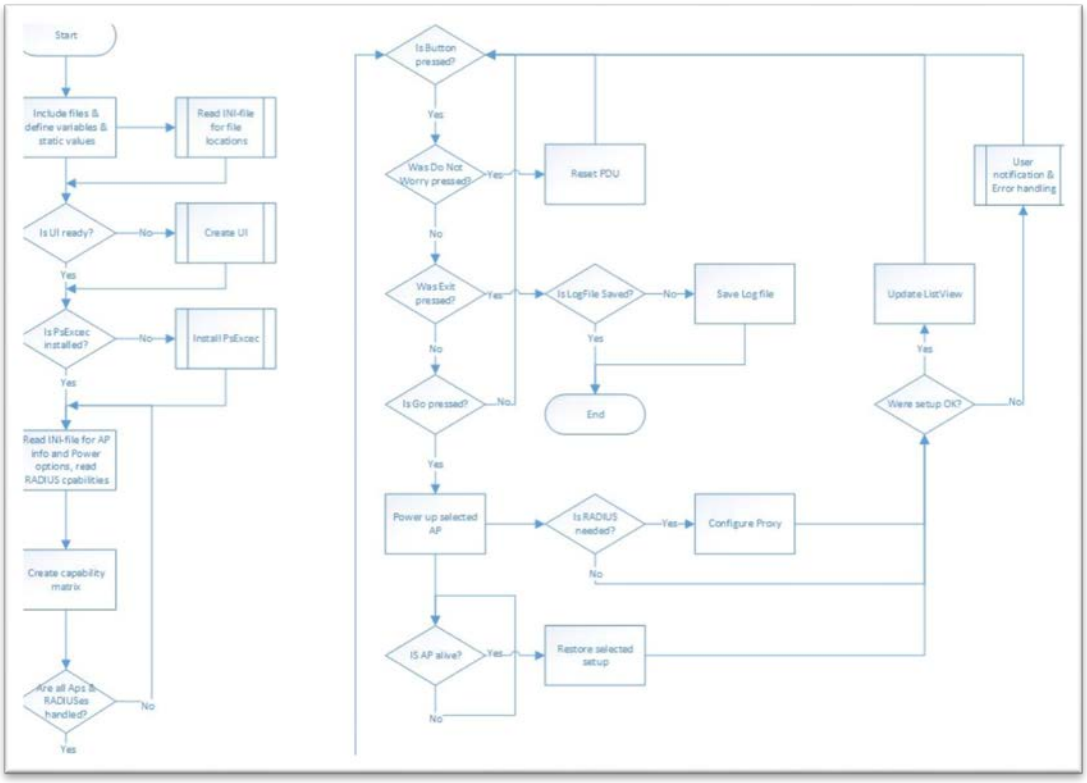
The program itself consists of many controls (radio-buttons, push-buttons) which, when manipulated, dispatch an event containing a message specific to the control. The main program catches the event, analyses the message and dispatches the message to appropriate function, which returns a value string. These strings are combined and they form a path and file name to desired restore file.

(Continues)

(Continues)

3 FLOW DIAGRAM

The flow diagram of the tool (Figure 3) is simplified for clarity. It does not contain smaller events such as saving the log file (Done Setups ListView) or powering up an additional Access Point while the selected one is powering up or applying the requested setup change.



Picture 3: Flow Diagram

During the startup phase program reads parameters from INI-files containing the needed info for restoring a setup. Each Access Point has a backup file for each supported encryption and radio mode. INI-file contains the file name of the backup file and the path to storage. Storage can be local or networked.

Also RADIUS server setup can be changed as not all RADIUS servers support all the possible configurations and authentications. Therefore it is needed to use several RADIUS servers to perform various authentications. For example Microsoft Internet Authentication Server can perform PEAPv0 and EAP-TLS authentications while Juniper

(Continues)

can perform PEAPv1 and EAP-TTLS authentications. And cellular network authentication server can perform EAP-SIM and EAP-AKA authentications.

Most feasible way to change from one RADIUS server to another is to use RADIUS-proxy. For the tool point of view al the authentication requests for the RADIUS server will go to same IP-address, in this case RADIUS-proxy. By defining different RADIUS end points for RADIUS-proxy authentication can be directed to a RADIUS server which can perform the selected authentication.

For each RADIUS end point configuration a setup backup file is created with Netsh-program (Russinovich Mark 2008), which is part of the Operating System. Netsh can then be directed to load up a different configuration from a setup backup file and thus changing the end point for RADIUS authentication request.

The tool creates strings to selected Access Point encryption type and if RADIUS server is needed a string to RADIUS-proxy server's backup file.

During restore process the selected Access Point is instructed to download the backup file for the selected encryption. While the Access Point is restoring the backup RADIUS-proxy is instructed to load the setup backup file for selected RADIUS server. When both processes are completed without errors the ListView (Done Setups) is updated and the tool returns to wait for new commands from the user.

(Continues)

4 USE CASES

Use cases -diagram in Figure 4 presents the same functionality as the flow chart but with more detailed view for each possible selection.

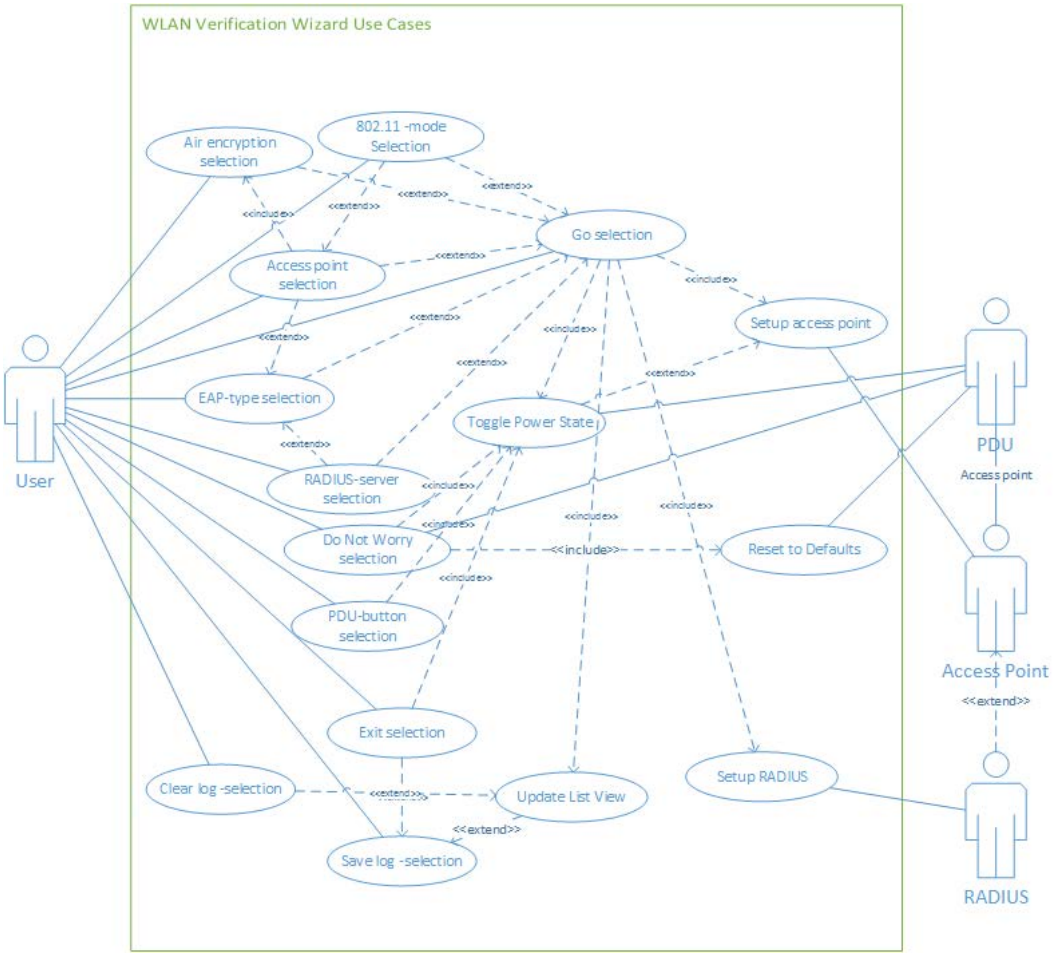


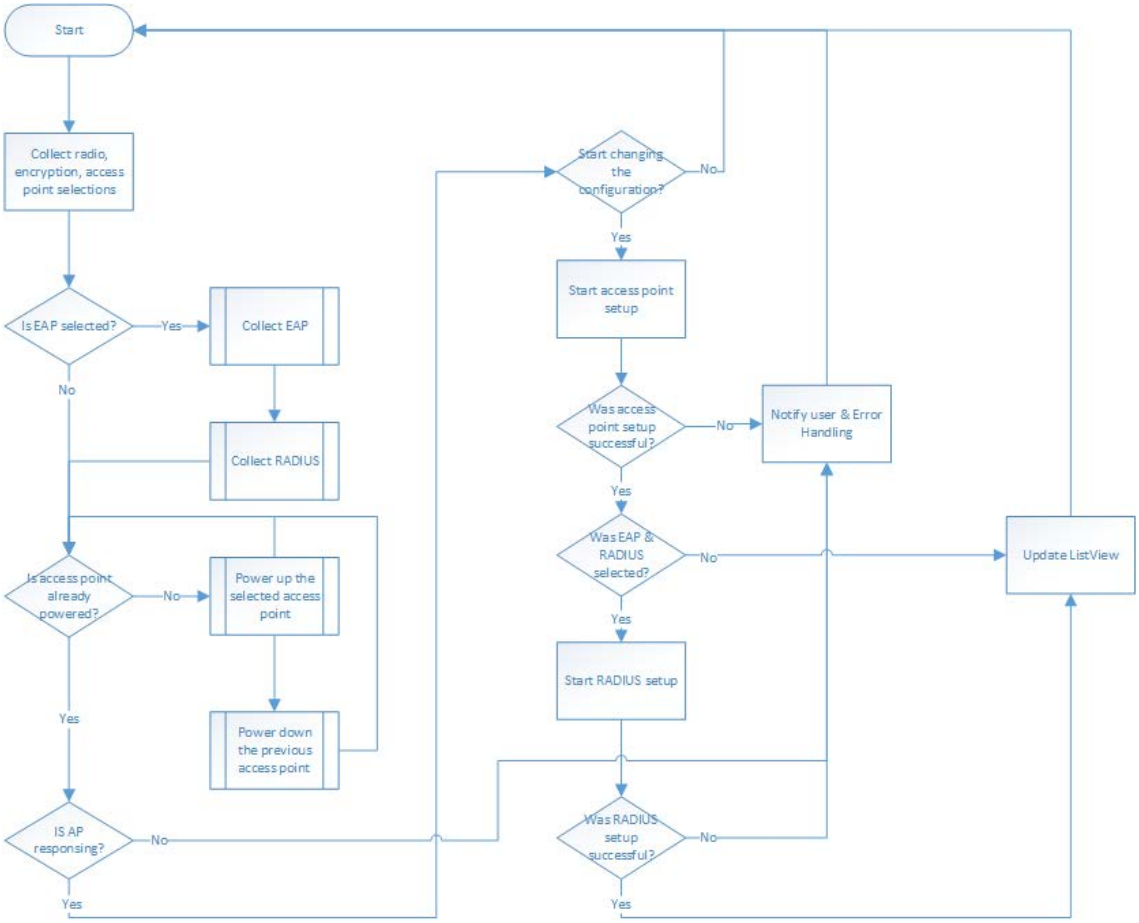
Figure 4: Use Cases

Use cases -diagram presents the same functionality as the flow chart but with more detailed view for each possible selection.

On the left-hand side “User” is the person who makes the selections of which setup is to be restored. On the right-hand side RADIUS, Access Point and PDU (APC by Schneider Electric) represent the elements connected to the same network, directed by the tool and forming the actual test environment.

(Continues)

As an example the most complex function of the tool, Setup Access Point is presented next in flow chart (Figure 5).



Picture 5: SetupAP -process Flow Diagram

Functionality is quite straight forward. As the user presses Go-button on user interface SetupAP-process starts. It first collects the user selections (radio-mode, air encryption, Access Point name, and possible EAP-type and RADIUS server). Then the power state of the selected Access Point is checked. If the Access Point is not yet powered up process commands the attached power distribution unit to turn on the outlet to which the Access Point is connected. Then some time is given to Access Point to properly boot up and settle. If any other Access Point was powered up e.g. for the previous test it is turned off.

When the Access Point is powered up user still has the possibility to cancel the setup and return to main user interface to make some adjustment to selections.

(Continues)

4.1 Setting up the selected Access Point

The user interface commands a separate program, RestoreAP, which gets the path and the restore file name as input and returns the state of setup after its run. This program is a small tool created during the development and it mimics the user by sending keyboard commands to Access Point's web user interface. This is also a piece of software which requires lots of updates if a new Access Point is added to the testing environment. There is no common interface which could be used for administering all Access Points. Some Access Points support Telnet connection which makes interfacing them very easy; just by inputting commands over Telnet to Access Point command line interface everything can be changed quickly without any concern about changing web user interface. During the initial setup for an Access Point a shortest path to restore function is found out. Most of the times it is simply another web page in the Access Point.

A web browser is opened and the address of the Access Point is inserted to browser. After the setup page has been opened the tool logs in as an administrative user having rights to perform a setup change. The program navigates inside Access Point web pages by examining the page header. They always contain information on which page the user is. This is also true when the Access Point is using framesets in the user interface creating a web page containing several other web pages.

Next the address to the page containing the restore function is opened. RestoreAP inserts the path and file name to dialog box for restore and selects OK-button to start the restore. Possible confirmation prompts are handled the same way.

After the Access Point has completed the restore successfully it informs the user with some textual information, which is captured and returned by RestoreAP to the main program indicating a successful restore. Usually at this point the Access Point boots up in order to get the new encryption into effect. If the change is small reboot may not be required.

(Continues)

5 FUTURE PERSPECTIVES

The tool described here was created as an interim solution to tackle the problems encountered while setting up the testing environment. The certification body, Wi-Fi Alliance (WFA) was creating their own solution to manage various setups in the laboratory environment for device certification purposes. As their solution was still in development and my company needed a quick solution to cut down the time consumed by setting up the testing environment this tool, WLAN verification Wizard, was created. It served the purpose and did its job. It was never meant to be anything more than an interim tool while waiting for the actual release of a professional configuration management tool from the certification body.

This tool was created with minimum budget and due to its nature it requires quite much preparation work in the form of setting up Access Points and taking a backup of verified encryption configuration.

There is no common interface which could be used with all Access Points. Some Access Points support Telnet-based administration and others do not. As new Access Points are added to the setup a new function has to be created for the tool taking care of the Access Point user interface manipulation unless the Access Point supports Telnet. Also when a new firmware for an Access Point is introduced its functionality needs to be checked as there can be some alterations when comparing to previous version.

As this tool was created to overcome a very specific issue, cutting down the time needed for setting up Access Points in laboratory environment, it was never seen as a possible sellable product. Therefore no continuity or dedicated support plan was ever done.

Business value of this tool comes from reduced time for setting up the test environment and from ensured settings for the selected authentication or authorization. User does not have to worry whether the possible error is caused by the test environment due to wrong settings. Error hunting efforts can be directed to actual device-under-test.

(Continues)

6 MORE INFORMATION

General information of wireless LAN can be found from the web site of Wi-Fi Alliance: http://www.wi-fi.org/. Pages also contain general information about certification programs. This info can be found at http://www.wi-fi.org/certification/programs
More specific info on wireless LAN certification testing cannot be disclosed public and it is restricted to member companies of Wi-Fi Alliance only.

Information of the language used can be found from AutoIt website http://www.autoitscript.com/site/autoit/ and related Forum and Blog pages accessible from the main web site.

(Continues)

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Appendix 3. Source code for the main program

```
#Region ;**** Directives created by AutoIt3Wrapper_GUI ****
#AutoIt3Wrapper_outfile=Wizard_802.11n_RestoreAP_as_exec_testversion.exe
#EndRegion ;**** Directives created by AutoIt3Wrapper_GUI ****
;===============================================================================
; Program Name:     VerificationWizard 802.1n -version
; Description:      Load pre-defined WLAN settings to Access Points and select RADIUS-server according to the user
;                   choices
; Parameter(s):     radius, ap, all: for debug; disables related function or both
; Requirement(s):
; Return Value(s):  Selected AirEncryption, Access Point, EAP-type, RADIUS-server and possible WireShark / Ethe-
real-log
; Author(s):        Jukka Issakainen, Nokia TP/SP/CM/QA Services
;===============================================================================

#include <ButtonConstants.au3>
#include <GUIConstantsEx.au3>
#include <ListViewConstants.au3>
#include <StaticConstants.au3>
#include <WindowsConstants.au3>
#include <Array.au3>
#include <Constants.au3>

;#Include <WinAPI.au3> ; _WinAPI_SetSysColors($vElements, $vColors) for PDU buttons?


Opt("GUIOnEventMode", 1)
Const $sIniFile = "VerificationWizard.ini"
$sVersion = "VerificationWizard: Restore AP & Radius as exec & new APC IF, 27.4.2009"
;Const $sDefaultGrey = 0xc2c0c8; harder than you think....
$sDefaultGrey = 0xD4D0C8
Const $sDefaultGreen = 0x00ff00
Const $iAllPortsOff = "all" ; address for all APC ports
Const $iNumOfPduPorts = 16
Global $iNumOfAP, $iNumOfAir, $iNumOfEAP, $iNumOfRAD, $sTextOfButton
Global $sSelected802, $sSelectedAir, $sSelectedAp, $sSelectedEap, $sSelectedRad, $sPrevious802, $sPreviousAir,
$sPreviousAp, $sPreviousEap, $sPreviousRad
Global $iCurrentLvItem, $iFirstLvItem, $tTextToSave, $iIsListSaved
Global $Port, $sRestoreFile, $iPlinkHandle
Global $sRadiusRestorePath, $sRadiusProxy, $sRadiusRestoreFile, $iRadiusSetStatus, $sErrorItem
;Const $COLOR_BTNFACE = 15
$sOnColor = 0x00ff00
$sOffColor = $sDefaultGrey
$PduPrevState = "off"
$PduActionPhrase = ""
$iMsgBoxTimeOut = 3
$iWatchDog = 0
$iIsListSaved = 0 ; ListView not saved

#Region - Debug helpers
$DEBUG_List_Event_Arrays = 0 ; If = 1, txt-file will be written to @scriptdir & exit
$DEBUG_iAccessPointOff = 0
$DEBUG_iRadiusOff = 0
#EndRegion - Debug helpers

#Region - INI-file
$sLocalPath = @ScriptDir & "\" ; Add trailing backslash
$sApIniFile = IniRead($sLocalPath & $sIniFile, "AP", "APSetupInfo", "NotFound") ; Read the name of APinifile
from Wizard.ini
$sRadiusIniFile = IniRead($sLocalPath & $sIniFile, "RADIUS", "RadiusSetupInfo", "NotFound"); Read the name of
Radiusinifile from Wizard.ini

#EndRegion - INI-file

#Region - Install helperfiles
FileInstall("psexec.exe", $sLocalPath)
```

(Continues)

```
#EndRegion - Install helperfiles

#Region - Read from INI-file

$asList802Mode = StringSplit(StringStripWS(IniRead($sLocalPath & $sApIniFile, "AP", "802Modes", "Not-Found"), 1), ",") ; 802.11 b/g, 802.11n (2.4GHz), 802.11n (5GHz)
$iNumOf802Mode = $asList802Mode[0] + 1

$asListAir = StringSplit(StringStripWS(IniRead($sLocalPath & $sApIniFile, "AP", "RestoreModes", "NotFound"), 1), ",") ; Open, WEP128, WPA-PSK, WPA2-PSK, WPA, WPA2, 802.1x
$iNumOfAir = $asListAir[0] + 1

$asListAP = StringSplit(StringStripWS(IniRead($sLocalPath & $sApIniFile, "AP", "Models", "NotFound"), 1), ","); Read from VerificationWizard.ini
$iNumOfAP = $asListAP[0] + 1;13+1 ; Read from INI-file
;_ArrayDisplay($asListAP)
$sAPRestorePath = IniRead($sLocalPath & $sApIniFile, "AP", "RestorePath", "NotFound"); Read from ApINI-file, not anymore VerificationWizard.ini
If StringRight($sAPRestorePath, 1) = "\" Then; check for trailing backslash in
                StringTrimRight($sAPRestorePath, 1); Remove trailing backslash, as it is used in APs Restore-Folder (ini-file)
EndIf

$sPDU_Enabled = StringUpper(StringStripWS(IniRead($sLocalPath & $sApIniFile, "PDU", "PDU_Enabled", "Not-Found"), 8)); is PDU around Yes/No
If $sPDU_Enabled = "YES" Then
$sPDU_IP = StringStripWS(IniRead($sLocalPath & $sApIniFile, "PDU", "PDU_IP", "NotFound"), 8)
$sPDU_User = IniRead($sLocalPath & $sApIniFile, "PDU", "PDU_User", "NotFound")
$sPDU_Pwd = IniRead($sLocalPath & $sApIniFile, "PDU", "PDU_Pwd", "NotFound")
EndIf

$iPDU_Previous = 0 ; Initial value for PDU Port

#Region - Define APC PDU
Dim $aAPs_and_Ports[$iNumOfPduPorts + 1][4]
Dim $aUsedPduPorts[$iNumOfPduPorts + 1]; just in case, mark all used ports to this table
; $aAPs_and_Ports[$i][0] = AP_Name, $aAPs_and_Ports[$i][1] = Port, $aAPs_and_Ports[$i][2] = Button @GUI_CTRLID; $aAPs_and_Ports[$i][3] = Button State; NOTE APC PDU has 16 ports
For $i = 1 to $asListAP[0]
$iPdu_Port = StringStripWS(IniRead($sLocalPath & $sApIniFile, $asListAP[$i], "PDU_Port", "NotFound"), 1)
$aAPs_and_Ports[$iPdu_Port][0] = $asListAP[$i]
$aAPs_and_Ports[$iPdu_Port][1] = $iPdu_Port
$aAPs_and_Ports[$iPdu_Port][3] = "off" ; Default Port State
;$sAPs_and_Ports = $sAPs_and_Ports & @CRLF & $aAPs_and_Ports[$i][0] & " Port = " & $aAPs_and_Ports[$i][1]
Next
;_ArrayDisplay($aAPs_and_Ports)
#EndRegion - Define APC PDU

#Region - Read Access Point capabilities from INI-file, if a file name is available = AP is capable of that mode, $asApCapa[][]
Dim $asApCapa[$iNumOfAP][$iNumOfAir + 2] ; +2 for 802.1n -modes
For $i = 1 To $asListAP[0]
$asApCapa[$i][0] = $asListAP[$i] ; AP name for column #0
For $j = 1 To $asListAir[0]
$asApCapa[0][$j] = $asListAir[$j]
$asApCapa[$i][$j] = StringStripWS(IniRead($sLocalPath & $sApIniFile, $asListAP[$i], $asListAir[$j], "Not-Found"), 8)
Next
$asApCapa[0][$j] = ".1n prefix 2.4GHz"
$asApCapa[$i][$j] = StringStripWS(IniRead($sLocalPath & $sApIniFile, $asListAP[$i], "802.1n_2", "NotFound"), 8) ; 2.4 GHz 802.1n -mode prefix
$asApCapa[0][$j + 1] = ".1n prefix 5GHz"
$asApCapa[$i][$j + 1] = StringStripWS(IniRead($sLocalPath & $sApIniFile, $asListAP[$i], "802.1n_5", "Not-Found"), 8) ; 5 GHz 802.1n -mode prefix
Next
;_ArrayDisplay($asApCapa)
```

(Continues)

```
#EndRegion - Read Access Point capabilities from INI-file, if a file name is available = AP is capable of that mode, $asApCapa[][]

$asListEap = StringSplit(StringStripWS(IniRead($sLocalPath & $sIniFile, "EAP", "Types", "NotFound"), 8), ","); Read from VerificationWizard.ini
$iNumOfEAP = $asListEap[0] + 1 ;$iNumOfEAP = 5 ; tls/peapv0, ttls, peapv1, sim, aka

$asListRADIUS = StringSplit(StringStripWS(IniRead($sLocalPath & $sRadiusIniFile, "RADIUS", "Servers", "Not-Found"), 1), ","); Read from VerificationWizard.ini
$iNumOfRAD = $asListRADIUS[0] + 1

#Region - Read RADIUS server capabilities from INI-file, $asRadCapa[][]
Dim $asRadCapa[$iNumOfRAD][$iNumOfEAP]
For $i = 1 To $asListRADIUS[0]
$asRadCapa[$i][0] = $asListRADIUS[$i] ; name of Radius server for column #0
For $j = 1 To $asListEap[0]
$asRadCapa[0][$j] = $asListEap[$j] ; insert EAP-type to top column, easier to read
$asRadCapa[$i][$j] = StringStripWS(IniRead($sLocalPath & $sRadiusIniFile, $asListRADIUS[$i], $asListEap[$j], "NotFound"), 8) ; Read server's support for EAP-types from RadiusSetupInfo.ini
Next
Next
;_ArrayDisplay($asRadCapa)

#EndRegion - Read RADIUS server capabilities from INI-file, $asRadCapa[][]


#EndRegion - Read from INI-file


#Region - Screen component variables

$iRadioGrpTop = 10
$iRadioGrpWidth = 140
$iGrpSeparator = 20
$iRadioBtnSeparator = 25

$iRadioBtnTop = $iRadioGrpTop + $iGrpSeparator ; 33
$iRadioBtnLeftFromGrp = 10
$iRadioBtnHeight = $iGrpSeparator;17
$iRadioTxtWidth = $iRadioGrpWidth - 2 * $iRadioBtnLeftFromGrp;130

$i802GrpTop = $iRadioGrpTop ; New group above Air
$i802GrpLeft = 10
$i802GrpHeight = $asList802Mode[0] * $iRadioBtnSeparator + $iRadioBtnTop
$i802Left = $i802GrpLeft + $iRadioBtnLeftFromGrp

$iAirGrpTop = $iRadioGrpTop + $i802GrpHeight + $iGrpSeparator
$iAirGrpLeft = $i802GrpLeft ; 8 !New group above Air
$iAirGrpHeight = $asListAir[0] * $iRadioBtnSeparator + $iRadioBtnTop
$iAirLeft = $iAirGrpLeft + $iRadioBtnLeftFromGrp ; 8+10

$iApGrpTop = $iRadioGrpTop
$iApGrpLeft = $i802GrpLeft + $iRadioGrpWidth + $iGrpSeparator ; 8+145+20= 173
$iApGrpHeight = $asListAP[0] * $iRadioBtnSeparator + $iRadioBtnTop
$iApLeft = $iApGrpLeft + $iRadioBtnLeftFromGrp;166 173+10 = 183

$iEapGrpTop = $iRadioGrpTop
$iEapGrpLeft = $iApGrpLeft + $iRadioGrpWidth + $iGrpSeparator ; 173+145+20=338
$iEapGrpHeight = $asListEap[0] * $iRadioBtnSeparator + $iRadioBtnTop
$iEapLeft = $iEapGrpLeft + $iRadioBtnLeftFromGrp;342 338+10=348

$iRadGrpTop = $iRadioGrpTop
$iRadGrpLeft = $iEapGrpLeft + $iRadioGrpWidth + $iGrpSeparator ; 338+145+20=503 $asListRADIUS
$iRadGrpHeight = $asListRADIUS[0] * $iRadioBtnSeparator + $iRadioBtnTop
$iRadLeft = $iRadGrpLeft + $iRadioBtnLeftFromGrp;510 503+10=513

$iListViewHeight = 132
$iListViewWidth = 615
```

(Continues)

```
If $asListAP[0] > 12 Then
$iMainHeight = $iRadioGrpTop + $iGrpSeparator + $iNumOfAP * $iRadioBtnSeparator + $iGrpSeparator + $iListViewHeight + $iGrpSeparator
Else
$iMainHeight = 580
EndIf
$iMainWidth = 790

$iListViewTop = $iMainHeight - $iRadioGrpTop - $iGrpSeparator - $iListViewHeight - $iGrpSeparator
#EndRegion - Screen component variables

Global $ai802Event[$iNumOf802Mode], $aiAirEvent[$iNumOfAir], $aiApEvent[$iNumOfAP], $aiEapEvent[$iNumOfEAP], $aiRadEvent[$iNumOfRAD], $aiPowerEvent[$iNumOfPduPorts + 1]

#Region ### START Koda GUI section ### Form=c:\data\automation\802.1n-versio\wizard_on_event_mode\main.kxf

;$Main = GUICreate($sVersion & " Main Width= " & $iMainWidth & " Main Height = " & $iMainHeight, $iMain-Width, $iMainHeight, 97, 45, BitOR($WS_OVERLAPPEDWINDOW, $WS_CLIPSIBLINGS)) ; 817, 587, 97, 45
$Main = GUICreate($sVersion , $iMainWidth, $iMainHeight, 97, 45, BitOR($WS_OVERLAPPEDWINDOW, $WS_CLIPSIBLINGS)) ; 817, 587, 97, 45
GUISetOnEvent($GUI_EVENT_CLOSE, "MainClose")
GUISetOnEvent($GUI_EVENT_MINIMIZE, "MainMinimize")
GUISetOnEvent($GUI_EVENT_MAXIMIZE, "MainMaximize")
GUISetOnEvent($GUI_EVENT_RESTORE, "MainRestore")
;GUICtrlCreateGroup("", -99, -99, 1, 1)


#Region - Create 802 Group Buttons
; $asList802Mode, $iNumOf802Mode
$Group_802 = GUICtrlCreateGroup(" 802-Mode ", $i802GrpLeft, $i802GrpTop, $iRadioGrpWidth, $i802GrpHeight)
For $i = 1 To $asList802Mode[0]
$ai802Event[$i] = GUICtrlCreateRadio($asList802Mode[$i], $i802Left, $iGrpSeparator + $i802GrpTop + ($i - 1) * $iRadioBtnSeparator, $iRadioTxtWidth, $iRadioBtnHeight)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_NButton") ; default value
Next
GUICtrlSetState($ai802Event[1], $GUI_CHECKED) ; 1st selection as default
$sSelected802 = 1
$sPrevious802 = 1
GUICtrlCreateGroup("", -99, -99, 1, 1)
;_ArrayDisplay($ai802Event)
;_ArrayDisplay($asList802Mode)
#EndRegion - Create 802 Group Buttons


#Region - Create Air Encryption Buttons

$Group_Air = GUICtrlCreateGroup(" Air Encryption ", $iAirGrpLeft, $iAirGrpTop, $iRadioGrpWidth, $iAirGr-pHeight);209)
For $i = 1 To $asListAir[0]
$aiAirEvent[$i] = GUICtrlCreateRadio($asListAir[$i], $iAirLeft, $iGrpSeparator + $iAirGrpTop + ($i - 1) * $iRadi-oBtnSeparator, $iRadioTxtWidth, $iRadioBtnHeight)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_AirButton")
Next
GUICtrlSetState($aiAirEvent[1], $GUI_CHECKED); 1st selection as default
$sSelectedAir = 1
$sPreviousAir = 1
GUICtrlCreateGroup("", -99, -99, 1, 1)
;_ArrayDisplay($aiAirEvent)
;_ArrayDisplay($asListAir)

#EndRegion - Create Air Encryption Buttons

#Region - Create AP Buttons
$Group_AP = GUICtrlCreateGroup(" Access Point ", $iApGrpLeft, $iApGrpTop, $iRadioGrpWidth, $iApGr-pHeight) ; 152, 8, 153, 369
```

(Continues)

```
For $i = 1 To $asListAP[0];$iNumOfAP -1
$aiApEvent[$i] = GUICtrlCreateRadio($asListAP[$i], $iApLeft, $iRadioBtnTop + ($i - 1) * $iRadioBtnSeparator, $iRadioTxtWidth, $iRadioBtnHeight)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_ApButton")
Next
GUICtrlSetState($aiApEvent[1], $GUI_CHECKED); 1st selection as default
$sSelectedAp = 1
$sPreviousAp = 1
GUICtrlCreateGroup("", -99, -99, 1, 1)
;_ArrayDisplay($aiApEvent)
;_ArrayDisplay($asListAP)
#EndRegion - Create AP Buttons


#Region - Create EAP Buttons
$Group_EAP = GUICtrlCreateGroup(" EAP-Type", $iEapGrpLeft, $iEapGrpTop, $iRadioGrpWidth, $iEapGrpHeight) ; 328, 8, 145, 185
For $i = 1 To $asListEap[0]
$aiEapEvent[$i] = GUICtrlCreateRadio($asListEap[$i], $iEapLeft, $iRadioBtnTop + ($i - 1) * $iRadioBtnSeparator, $iRadioTxtWidth, $iRadioBtnHeight)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_EapButton")
GUICtrlSetState(-1, $GUI_DISABLE); Startup situation
Next
GUICtrlSetState($aiEapEvent[1], $GUI_CHECKED); 1st selection as default
$sSelectedEap = 1
$sPreviousEap = 1
GUICtrlCreateGroup("", -99, -99, 1, 1)
;_ArrayDisplay($aiEapEvent)
;_ArrayDisplay($asListEap)
#EndRegion - Create EAP Buttons


#Region - Create RADIUS Buttons
$Group_RADIUS = GUICtrlCreateGroup(" RADIUS server ", $iRadGrpLeft, $iRadGrpTop, $iRadioGrpWidth, $iRadGrpHeight) ; 496, 8, 145, 185
For $i = 1 To $asListRADIUS[0]
$aiRadEvent[$i] = GUICtrlCreateRadio($asListRADIUS[$i], $iRadLeft, $iRadioBtnTop + ($i - 1) * $iRadioBtnSeparator, $iRadioTxtWidth, $iRadioBtnHeight)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_RadiusButton")
GUICtrlSetState(-1, $GUI_DISABLE); Startup situation
Next
GUICtrlSetState($aiRadEvent[1], $GUI_CHECKED); 1st selection as default
$sSelectedRad = 1
$sPreviousRad = 1
GUICtrlCreateGroup("", -99, -99, 1, 1)
;_ArrayDisplay($aiRadEvent)
;_ArrayDisplay($asListRADIUS)
#EndRegion - Create RADIUS Buttons

#Region - Create Go/Exit
$iGoBtnLeft = $iRadGrpLeft + $iRadioGrpWidth + $iGrpSeparator
$iGoBtnTop = $iRadioGrpTop + $iGrpSeparator - 10
$iGoHeight = 3 * $iGrpSeparator ; 60
$iGoWidth = 6 * $iGrpSeparator ; 120

$ButtonGo = GUICtrlCreateButton("Go!", $iGoBtnLeft, $iGoBtnTop, $iGoWidth, $iGoHeight, 0) ; 664, 24, 120, 73, 0 left, top, width, height
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_ButtonGoClick")
$ButtonExit = GUICtrlCreateButton("Exit", $iGoBtnLeft, $iGoBtnTop + $iGoHeight + $iGrpSeparator, $iGoWidth, $iGoHeight, 0) ; 664, 112, 120, 73, 0
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "MainClose")
#EndRegion - Create Go/Exit
```

(Continues)

```
#Region - Create Setups ListView & Buttons

$Group_Setups = GUICtrlCreateGroup("Done Setups", $i802GrpLeft, $iListViewTop, $iMainWidth - 2 * $iRadioGrpTop, $iListViewHeight + 2 * $iGrpSeparator - 5) ; 16, 392, 785, 169 left top width height
$ListView1 = GUICtrlCreateListView("Time | Date | 802-mode | Air | Access Point | EAP-type | Radius", $iAirGrpLeft + $iRadioBtnLeftFromGrp, $iListViewTop + $iGrpSeparator, $iListViewWidth, $iListViewHeight) ; 32, 416, 601, 132
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "ListView1Click")
$Btn_Save_List = GUICtrlCreateButton("Save Setups", $iGoBtnLeft, $iListViewTop + $iGrpSeparator, $iGoWidth, $iGoHeight, 0) ; 666, 422, 120, 49, 0
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "Btn_Save_ListClick")
$Btn_Clear_List = GUICtrlCreateButton("Clear Setups", $iGoBtnLeft, $iListViewTop + $iGrpSeparator + $iGoHeight + $iGrpSeparator - 10, $iGoWidth, $iGoHeight, 0) ; 666, 492, 120, 49, 0
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_ClearListView")
GUICtrlCreateGroup("", -99, -99, 1, 1)
#EndRegion - Create Setups ListView & Buttons

;#cs
#Region - Create Power Control Buttons
$k = 0
$iPwrBtnTop = 232
$iPwrBtnWidth = 73
$iPwrBtnHeight = 33

$iApcGrpWidth = 450 ;
$iApcGrpHeight = 169
$iSeparator = $iGrpSeparator / 2 ; default 20
$iButtonsInRow = 4
$iButtonRows = 4
$PduPrevState = ""
$PduActionPhrase = ""
$iButtonWidth = ($iApcGrpWidth - 2 * $iSeparator) / $iButtonsInRow; 110
$iButtonHeight = ($iApcGrpHeight - 3 * $iSeparator - $iApcGrpHeight / 4) / $iButtonsInRow; 30
$iPanicButtonWidth = $iApcGrpWidth - 2 * $iSeparator; $iButtonRows * $iButtonWidth
$iPanicButtonHeight = 2 * $iButtonHeight

$sfont = "Ariel"
$iDefaultFontSize = $iPwrBtnWidth / 11

$_AP_Control = GUICtrlCreateGroup(" Access Point Power Control", 328, 208, $iApcGrpWidth, $iApcGrpHeight); 328, 208, 473, 169
$APC_Btn_AllOff = GUICtrlCreateButton("Do Not Worry!", $iGoBtnLeft, 232, 120, 130, 0) ; 664, 232, 120, 129, 0 name, left, top, width, height
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetOnEvent(-1, "_AllPortsOff")
; $aAPs_and_Ports[$i][0] = AP_Name, $aAPs_and_Ports[$i][1] = Port, $aAPs_and_Ports[$i][2] = Button @GUI_CTRLID; $aAPs_and_Ports[$i][3] = Button State; NOTE APC PDU has 16 ports
For $i = 1 To $iButtonsInRow ; PduBtnCtrlId goes to $aAPs_and_Ports[$i][2]
For $j = 1 To $iButtonRows
$aUsedPduPorts[$k + $j] = GUICtrlCreateButton("Free, Port # ", $iEapLeft + ($j - 1) * $iPwrBtnWidth, $iPwrBtnTop + ($i - 1) * $iPwrBtnHeight, $iPwrBtnWidth, $iPwrBtnHeight, $BS_MULTILINE)
GUICtrlSetResizing(-1, $GUI_DOCKAUTO) ; Resize automatically according to window size
GUICtrlSetFont(-1, $iDefaultFontSize, 700, 1, $sfont)
GUICtrlSetOnEvent(-1, "_PduButton")
Next
$k = $k + 4
Next
For $i = 1 To $iNumOfPduPorts
If $aAPs_and_Ports[$i][0] = "" Then
GUICtrlSetState($aUsedPduPorts[$i],$GUI_DISABLE)
Else
$aAPs_and_Ports[$i][2] = $aUsedPduPorts[$i]
GUICtrlSetData($aAPs_and_Ports[$i][2], $aAPs_and_Ports[$i][0]) ; Put the correct name to correct port#
EndIf
Next
```

(Continues)

```
;_ArrayDisplay($aAPs_and_Ports)
GUICtrlCreateGroup("", -99, -99, 1, 1)
#EndRegion - Create Power Control Buttons
;#ce

If $DEBUG_List_Event_Arrays Then ; create a file of all event arrays
_Debug_Events()
EndIf
$iFirstLvItem = 0 ; reset ListView items
GUISetState(@SW_SHOW)
#EndRegion ### END Koda GUI section ###

_APC_GetState()
While 1
Sleep(1000)
$iWatchDog = $iWatchDog + 1
If $iWatchDog = 60 Then ; Simple timer just to update PDU button states
$iWatchDog = 0
_APC_GetState()
EndIf
WEnd

#Region - N Button Clicked

Func _NButton()
$sPrevious802 = $sSelected802
$sSelected802 = @GUI_CtrlId ; if selected >4 then we are in .1n -mode

_ToggleApState(@GUI_CtrlId) ; if n-mode -> dim all but n-aps, else enable all, $asApCapa

EndFunc   ;==>_NButton
#EndRegion - N Button Clicked


#Region - Air Encryption Button Clicked - functions
Func _AirButton()
$sPreviousAir = $sSelectedAir
$sSelectedAir = @GUI_CtrlId
$iIndex = _ArraySearch($aiAirEvent, $sSelectedAir)

If $iIndex > 4 Then ; Enterprise authentication, enable EAP & Radius
_ToggleEapState($GUI_ENABLE)
_ToggleRadiusState($GUI_ENABLE)
;If $iIndex = 7 Then ; 802.1x
;_ToggleApState($iIndex) ; send
;EndIf
Else ; Personal authentication, disable EAP & Radius
_ToggleEapState($GUI_DISABLE)
_ToggleRadiusState($GUI_DISABLE)
EndIf
_ToggleApState(@GUI_CtrlId) ;

EndFunc   ;==>_AirButton

#EndRegion - Air Encryption Button Clicked - functions


#Region - Access Point Clicked -functions
Func _ApButton()
$sSelectedAp = @GUI_CtrlId
EndFunc   ;==>_ApButton

#EndRegion - Access Point Clicked -functions

#Region - EAP Button Clicked - functions
Func _EapButton()
$sSelectedEap = @GUI_CtrlId
_ToggleRadiusState($GUI_ENABLE)
EndFunc   ;==>_EapButton
```

(Continues)

```
#EndRegion - EAP Button Clicked - functions

#Region - RADIUS Button Clicked - functions
Func _RadiusButton()
$sSelectedRad = @GUI_CtrlId
_ToggleEapState($GUI_ENABLE)
EndFunc   ;==>_RadiusButton

#EndRegion - RADIUS Button Clicked - functions

#Region - APC Button Clicked - functions

Func _AllPortsOff()
For $i = 1 to $iNumOfPduPorts
GUICtrlSetBkColor($aAPs_and_Ports[$i][2],$sOffColor)    ; Grey
$aAPs_and_Ports[$i][3] = "off"
Next
_TogglePDU($iAllPortsOff, "off") ; Direct cut to the source... :-)
EndFunc ; ==> _AllPortsOff()

Func _PduButton()
_TogglePduBtnState(@GUI_CtrlId)
EndFunc   ;==>_PduButton

Func _ConnectToAPC() ; Return $iPlinkHandle if connect succesful, 0 if NOK
$IsPduOnLine = Ping($sPDU_IP, 500); wait 500ms
If $IsPduOnLine = 0 Or @error Then ; = "Off" Then

$sPDU_Enabled = "No"
Return 0
Else
$sPDU_Enabled = "YES"
$iPlinkHandle = Run(@ComSpec & ' /c ' & $sLocalPath & 'plink.exe -telnet ' & $sPDU_IP, '', @SW_HIDE, 7);$STDERR_CHILD + $STDOUT_CHILD) ;
Sleep(2000)
While Not ProcessExists($iPlinkHandle) ; just in case someone has logged in to cmd-interface at the same moment
MsgBox(48, "Communication Error to APC PDU", "Command Line Interface is reserved for someone else..." & @CRLF & @CRLF & "Will try again after 10 secs...", $iMsgBoxTimeOut)
Sleep(10000)
$iPlinkHandle = Run(@ComSpec & ' /c ' & $sLocalPath & 'plink.exe -telnet ' & $sPDU_IP, '', @SW_HIDE, 7);$STDERR_CHILD + $STDOUT_CHILD) ;
Sleep(2000)
WEnd
While 1 ;waits for "User"
$text = StdoutRead($iPlinkHandle)
$oktogo = StringRegExp($text, ".*User*")
If $oktogo = 1 Then ExitLoop
WEnd
StdinWrite($iPlinkHandle, $sPDU_User & @CR)
While 1 ;waits for "password"
$text = StdoutRead($iPlinkHandle)
$oktogo = StringRegExp($text, ".*Password.*")
If $oktogo = 1 Then ExitLoop
WEnd
StdinWrite($iPlinkHandle, $sPDU_Pwd & @CR)
Sleep(500)
Return $iPlinkHandle
EndIf

EndFunc   ;==>_ConnectToAPC()


Func _TogglePduBtnState($iCtrlId)
; check the state of pressed button and change it
; initially try to read from PDU the start up state or if not too time consuming every time button is pressed...
; @GUI_CTRLID replaced with $iCtrlId
; $aAPs_and_Ports[$i][0] = AP_Name, $aAPs_and_Ports[$i][1] = Port, $aAPs_and_Ports[$i][2] = Button @GUI_CTRLID; $aAPs_and_Ports[$i][3] = Button State
```

(Continues)

```
For $i = 1 To $iNumOfPduPorts
If $iCtrlId = $aAPs_and_Ports[$i][2] Then ; $iCtrlId = $aAPs_and_Ports[$i][2]
If $aAPs_and_Ports[$i][3] = "Off" Then
GUICtrlSetBkColor($iCtrlId, $sOnColor) ; Green
$aAPs_and_Ports[$i][3] = "On"
Else
GUICtrlSetBkColor($iCtrlId, $sOffColor) ; Grey
$aAPs_and_Ports[$i][3] = "Off"
EndIf
_TogglePdu($aAPs_and_Ports[$i][1], $aAPs_and_Ports[$i][3])
EndIf
Next
EndFunc   ;==>_TogglePduBtnState


Func _TogglePDU($Port, $PduAction)

If _ConnectToAPC() = 0 Then        ; = "Off" Then
MsgBox(0, "TogglePDU", "$PduPrevState = " & $PduPrevState & @CRLF & "$PduAction = " & $PduAction & @CRLF & "$Port = " & $Port & @CRLF & "PDU error = " & @error,$iMsgBoxTimeOut)
Else

StdinWrite($iPlinkHandle,$PduAction & " " & $Port & @CR) ; e.g. on 10, off 10, off all
Sleep(500)
While 1 ;waits for "APC>" confirmation
$text = StdoutRead($iPlinkHandle)
$oktogo = StringRegExp($text,".*APC>*")
If $oktogo = 1 Then ExitLoop
Wend
sleep(500)
StdinWrite($iPlinkHandle,"Bye" & @CR) ; 4- Logout
EndIf
Sleep(500)
ProcessClose("PLINK.EXE") ; just in case Plink gets to hang
$PduPrevState = $PduAction
EndFunc ; ==> Func _TogglePDU($iPort, $PduAction)

Func _APC_GetState() ; Read port states from APC, gets called from main loop and after GO
If _ConnectToAPC() = 0 Then        ; = "Off" Then
MsgBox(0, "APC_GetState", "PDU Off-line", $iMsgBoxTimeOut)
Else

Sleep(500)
;#cs
While 1 ; After this loop $line contains what we want
$line = StdoutRead($iPlinkHandle)
$oktogo = StringRegExp($line,".*>*")
If $oktogo = 1 Then ExitLoop
Wend
;#ce
;MsgBox(0, "Lopputulos:", $line)
StdinWrite($iPlinkHandle,"bye" & @CR)
Sleep(500)

$APC_Out = StringSplit($line, @CR, 0)
;_ArrayDisplay($APC_Out, "APC_OUT Arrayna")
;#cs
$k = 0
While 1 ; After this loop $line contains what we want
$oktogo = StringRegExp($APC_Out[$k],"1:")
If $oktogo = 1 Then ExitLoop ; now we know from which index the actual data begins, should be [10] with the new version of APC fw
$k = $k +1
Wend
;MsgBox(0, "$k", $k)
;#ce
; $aAPs_and_Ports[$i][0] = AP_Name, $aAPs_and_Ports[$i][1] = Port, $aAPs_and_Ports[$i][2] = Button @GUI_CTRLID; $aAPs_and_Ports[$i][3] = Button State; NOTE APC PDU has 16 ports
For $l = $k To $APC_Out[0] -2; If String contains "N" as 9th char from left-> Port is ON
```

(Continues)

```
If StringInStr(StringLeft($APC_Out[$l],10), "ON") Then ; $l -10 contains the port number
GUICtrlSetBkColor($aAPs_and_Ports[$l - $k +1][2],$sOnColor)    ; Green
$aAPs_and_Ports[$l - $k +1][3] = "On"
Else
GUICtrlSetBkColor($aAPs_and_Ports[$l - $k +1][2],$sOffColor)    ; Grey
$aAPs_and_Ports[$l - $k +1][3] = "Off"
EndIf

Next
EndIf ; ==> $IsPduOnLine
;_ArrayDisplay($APC_Out, "Porttien tila")
EndFunc ; ==>_APC_GetState()

Func _PDU_Control($Port, $PduAction); Port# On/Off as parameters

$PduPrevState = $PduAction
If $PduAction = "On" Then
;$PduAction = 1 ; 1 = Immediate On
$PduActionPhrase = "Immediate On"
Else
;$PduAction = 2 ; Immediate Off
$PduActionPhrase = "Immediate Off"
EndIf
$iPlinkHandle = _ConnectToAPC()
If $iPlinkHandle Then
StdinWrite($iPlinkHandle, $PduAction & " " & $Port & @CR) ; 1- Immediate On, 2- Immediate Off
Sleep(500)
StdinWrite($iPlinkHandle, "Bye" & @CR) ; 4- Logout
EndIf
EndFunc   ;==>_PDU_Control

#EndRegion - APC Button Clicked - functions

#Region - Main Window Button Clicked - functions
;Func Btn_Clear_ListClick()

;EndFunc
Func Btn_Save_ListClick() ; format: time | date | 802-mode | Air | AP | EAP | Radius @CRLF
$tTextToSave = ""
$sSaveFile = "Done Setups.txt"
For $i = 1 To $iCurrentLvItem - $iFirstLvItem + 1

$tTextToSave = $tTextToSave & @CRLF & StringTrimRight(GUICtrlRead($iFirstLvItem + $i - 1), 1)
$tTextToSave = StringReplace($tTextToSave, "|", ",", 0); create comma-delimed list
Next
$iIsListSaved = _SaveTxt($tTextToSave, $sSaveFile) ; returns 0 or 1


EndFunc   ;==>Btn_Save_ListClick

Func _ButtonGoClick()
For $i = 1 To $asList802Mode[0]
If GUICtrlGetState($ai802Event[$i]) = $GUI_ENABLE + $GUI_SHOW And GUICtrlRead($ai802Event[$i]) = $GUI_CHECKED Then
$sSelected802 = $asList802Mode[$i]
EndIf
Next
For $i = 1 To $asListAir[0]
If GUICtrlGetState($aiAirEvent[$i]) = $GUI_ENABLE + $GUI_SHOW And GUICtrlRead($aiAirEvent[$i]) = $GUI_CHECKED Then
$sSelectedAir = $asListAir[$i]
EndIf
Next
For $i = 1 To $asListAP[0]
If GUICtrlGetState($aiApEvent[$i]) = $GUI_ENABLE + $GUI_SHOW And GUICtrlRead($aiApEvent[$i]) = $GUI_CHECKED Then
$sSelectedAp = $asListAP[$i]
EndIf
```

(Continues)

```
Next
#cs
For $i = 1 To $iNumOfPduPorts ; select correct APs Power button and PDU port, 3.4.2009
If $sSelectedAp = $aAPs_and_Ports[$i][0] Then
$iCtrlId = $aAPs_and_Ports[$i][2]
$iPDU_Port = $aAPs_and_Ports[$i][1]
EndIf
Next
#ce
$sSelectedEap = "None"
For $i = 1 To $asListEap[0]
If GUICtrlGetState($aiEapEvent[$i]) = $GUI_ENABLE + $GUI_SHOW And GUICtrlRead($aiEapEvent[$i]) = $GUI_CHECKED Then
$sSelectedEap = $asListEap[$i]
EndIf
Next
$sSelectedRad = "None"
For $i = 1 To $asListRADIUS[0]
If GUICtrlGetState($aiRadEvent[$i]) = $GUI_ENABLE + $GUI_SHOW And GUICtrlRead($aiRadEvent[$i]) = $GUI_CHECKED Then
$sSelectedRad = $asListRADIUS[$i]
EndIf
Next

$sPDU_Enabled = _CheckPduComms($sPDU_IP) ; added 8.3.2009
If $sPDU_Enabled = "YES" Then ;
$iMsgBoxAnswer = MsgBox(33, "Final confirmation...", "You happy with your selections?")
$iPDU_Port = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "PDU_Port", "NotFound") ; Get correct port from ApIni-file
$apip = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "IP", "NotFound")
; $aAPs_and_Ports[$i][0] = AP_Name, $aAPs_and_Ports[$i][1] = Port, $aAPs_and_Ports[$i][2] = Button @GUI_CTRLID; $aAPs_and_Ports[$i][3] = Button State
If $iPDU_Previous <> $iPDU_Port Then
;Else ; if same AP is used again, no need to shut it down
If $iPDU_Previous <> 0 Then ; $iPDU_Previous = 0 in startup
;_PDU_Control($iPDU_Previous, "Off") ;
_TogglePdu($iPDU_Previous, "Off")
;_TogglePduBtnState($iCtrlId);
EndIf
;_PDU_Control($iPDU_Port, "On") ;
_TogglePdu($iPDU_Port, "On")

$iPDU_Previous = $iPDU_Port
_APC_GetState()

ProgressOn("Booting up... " & $sSelectedAp, "Please wait...", $sSelectedAp & " is booting up...")
$i = 1

Do
$iIsApOnLine = Ping($apip, 5000) ; returns 0, when not online, when online returns roundtrip time
$i = $i + 1
ProgressSet($i * 10, "Booting...")
If $i = 8 Then
$i = 1
EndIf
Until $iIsApOnLine Or $i = 7
ProgressSet(90, "Hold on...", "Almost there, please be patient...")
For $j = 1 To 10
Sleep(1000) ; 10 sec delay may need to be adjusted due to slow boot of some APs
ProgressSet(90 + $j & "Hold on...", 10 - $j & " secs to go...", "Almost there, please be patient...")
Next
ProgressOff()
EndIf
If Not Ping($apip, 4000) Then
MsgBox(33, "Access Point " & $sSelectedAp, "Access Point " & $sSelectedAp & " in Port: " & $iPDU_Port & @CRLF & @CRLF & "is not responding. Please check cabling etc.")
EndIf
Else
; Prompt user to switch on AP if PDU is not used
```

(Continues)

```
$iMsgBoxAnswer = MsgBox(33, "One more thing...", "Before continuing, make sure Access Point" & @CRLF & @CRLF & $sSelectedAp & @CRLF & @CRLF & "is powered and functional")
EndIf ; $sPDU_Enabled
; continue setting up AP
Select
Case $iMsgBoxAnswer = 1
$iRestoreApCounterValue = _RestoreAP() ; _RestoreAP() returns zero, if NOK
If $iRestoreApCounterValue > 0 Then; returns something, when ok, zero if failure
_SetRadius()
_UpdateListView()
;MsgBox(0, "$iRestoreApCounterValue", "$iRestoreApCounterValue = " & $iRestoreApCounterValue)
EndIf
Case $iMsgBoxAnswer = 2 ;Cancel, dang... Back to square 1 with previously selected options
EndSelect ;MsgBox
EndFunc   ;==>_ButtonGoClick

Func MainClose()
If $iIsListSaved = 0 Then
Btn_Save_ListClick()
EndIf
_AllPortsOff()
Exit
EndFunc   ;==>MainClose
#EndRegion - Main Window Button Clicked - functions

Func _ToggleApState($iEvent) ; Event number as input
; if input is in range 4 - 6 = 802button
; if input is in range 9 - 15 = AirButton

$iSetAp = 0
$iIndex = _ArraySearch($ai802Event, $iEvent);, 0, 0, 0, 1)
If @error Then ; not in $ai802Event, but in $aiAirEvent, do capa check for aps
$iIndex = _ArraySearch($aiAirEvent, $iEvent); $asListAir[0]
$sPreviousAp = 0
If $sSelected802 > 4 Then ; if > 4 then in 802.1n mode
Else
For $i = 1 To $asListAP[0] ;To 1 Step -1
;MsgBox(0, "$asApCapa[$i][$iIndex]", $asApCapa[$i][$iIndex],2)
;#cs
If StringStripWS($asApCapa[$i][$iIndex], 8) = "" Then ; if selected air-mode is not supported by the ap -> disable
GUICtrlSetState($aiApEvent[$i], $GUI_DISABLE) ; if disable AND selected, move selection to next available (or first available)
If GUICtrlRead($aiApEvent[$i]) = $GUI_CHECKED Then
GUICtrlSetState($aiApEvent[$i], $GUI_UNCHECKED)
$sPreviousAp = $i
EndIf
Else ; air-mode supported by AP
GUICtrlSetState($aiApEvent[$i], $GUI_ENABLE) ; + $GUI_CHECKED)
;MsgBox(0, "$asListAP", $asListAP[$i] & " = " & GUICtrlRead($aiApEvent[$i]),1)
EndIf
Next
For $i = 1 To $asListAP[0]
If GUICtrlRead($aiApEvent[$i]) = $GUI_CHECKED Then ; check if any checked
$iSetAp = $i
EndIf
Next
If $iSetAp = 0 Then
For $i = $asListAP[0] To 1 Step -1
If GUICtrlGetState($aiApEvent[$i]) = $GUI_ENABLE + $GUI_SHOW Then; 80 = 64 + 16
GUICtrlSetState($aiApEvent[$i], $GUI_CHECKED)
EndIf
Next
EndIf
EndIf
Else ; Found in $ai802Event
;#cs
If $iIndex > 1 Then
;MsgBox(0, "$ai802Event", "802.11n-mode, enable only 802.11n capable APs",2)
For $i = 1 To $asListAP[0]
```

(Continues)

```
;MsgBox(0,"$asApCapa[$i][$asListAir[0]+1", $asApCapa[$i][$asListAir[0]+1])
If StringStripWS($asApCapa[$i][$asListAir[0] + 1], 8) = "" Or StringStripWS($asApCapa[$i][$asListAir[0] + 2], 8)
= "" Then ; If 802.1x prefix not found, then disable
GUICtrlSetState($aiApEvent[$i], $GUI_DISABLE + $GUI_UNCHECKED)
Else
GUICtrlSetState($aiApEvent[$i], $GUI_ENABLE)
EndIf
Next
For $i = 1 To $asListAP[0]
If GUICtrlRead($aiApEvent[$i]) = $GUI_CHECKED Then ; check if any checked
$iSetAp = $i
EndIf
Next
If $iSetAp = 0 Then
For $i = $asListAP[0] To 1 Step -1
If GUICtrlGetState($aiApEvent[$i]) = $GUI_ENABLE + $GUI_SHOW Then; 80 = 64 + 16
GUICtrlSetState($aiApEvent[$i], $GUI_CHECKED)
EndIf
Next
EndIf
Else
;MsgBox(0, "$ai802Event", "B/G-mode, enable all APs, unless some EAP prevents",2)
For $i = 1 To $asListAP[0] ; if b/g pressed -> enable
GUICtrlSetState($aiApEvent[$i], $GUI_ENABLE)
Next
EndIf
;#ce
EndIf

EndFunc   ;==>_ToggleApState

Func _ToggleEapState($sEapState) ; if enable, need to check if air enterprise & which radius, use enable also selec-
tively (which radius -> may disable)

For $i = 1 To $asListEap[0]
GUICtrlSetState($aiEapEvent[$i], $sEapState)
Next

EndFunc   ;==>_ToggleEapState

Func _ToggleRadiusState($sRadiusState) ; if enable, need to check eap-mode & if air = enterprise
;#cs
If $sRadiusState = $GUI_ENABLE Then
For $i = 1 To $asListEap[0] ; read which eap selected
If GUICtrlRead($aiEapEvent[$i]) = $GUI_CHECKED Then
$sSelectedEap = $i ; find selected eap
EndIf
Next
$sSelectedRad = 0
For $j = 1 To $asListRADIUS[0]
If StringUpper($asRadCapa[$j][$sSelectedEap]) = "YES" Then
GUICtrlSetState($aiRadEvent[$j], $sRadiusState)
If $sSelectedRad = 0 Then
GUICtrlSetState($aiRadEvent[$j], $GUI_CHECKED) ; check first matching
$sSelectedRad = $j
EndIf
Else ; disable radius, if eap-type not supported
GUICtrlSetState($aiRadEvent[$j], $GUI_DISABLE)
If GUICtrlRead($aiRadEvent[$j]) = $GUI_CHECKED Then
GUICtrlSetState($aiRadEvent[$j], $GUI_UNCHECKED)
$sPreviousRad = $j
EndIf
EndIf
Next
Else
For $j = 1 To $asListRADIUS[0]
GUICtrlSetState($aiRadEvent[$j], $sRadiusState)
Next
EndIf
```

(Continues)

```
EndFunc   ;==>_ToggleRadiusState

Func _Debug_Events()

Global $tEventArrays ; 802
$tEventArrays = "$ai802Event" & @CRLF
For $i = 0 To $iNumOf802Mode - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $ai802Event[$i] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$asList802Mode" & @CRLF
For $i = 0 To $iNumOf802Mode - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $asList802Mode[$i] & @CRLF
Next                ; Air
$tEventArrays = $tEventArrays & @CRLF & "$aiAirEvent" & @CRLF
For $i = 0 To $iNumOfAir - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aiAirEvent[$i] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$asListAir" & @CRLF
For $i = 0 To $iNumOfAir - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $asListAir[$i] & @CRLF
Next                ; AP
$tEventArrays = $tEventArrays & @CRLF & "$aiApEvent" & @CRLF
For $i = 0 To $iNumOfAP - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aiApEvent[$i] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$asListAP" & @CRLF
For $i = 0 To $iNumOfAP - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $asListAP[$i] & @CRLF
Next                ; EAP
$tEventArrays = $tEventArrays & @CRLF & "$aiEapEvent" & @CRLF
For $i = 0 To $iNumOfEAP - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aiEapEvent[$i] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$asListEap" & @CRLF
For $i = 0 To $iNumOfEAP - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $asListEap[$i] & @CRLF
Next                ; Radius
$tEventArrays = $tEventArrays & @CRLF & "$aiRadEvent" & @CRLF
For $i = 0 To $iNumOfRAD - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aiRadEvent[$i] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$asListRADIUS" & @CRLF
For $i = 0 To $iNumOfRAD - 1
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $asListRADIUS[$i] & @CRLF
Next                ; PDU Ports
$tEventArrays = $tEventArrays & @CRLF & "$aAPs_and_Ports[$i][2]" & @CRLF
For $i = 0 To $iNumOfPduPorts
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aAPs_and_Ports[$i][2] & @CRLF
Next
$tEventArrays = $tEventArrays & @CRLF & "$aAPs_and_Ports[$i][3] Note Array Size" & @CRLF ;
$asApcPorts[][]
For $i = 0 To $iNumOfPduPorts
$tEventArrays = $tEventArrays & "[" & $i & "]" & "|" & $aAPs_and_Ports[$i][0] & " | " & $aAPs_and_Ports[$i][3]
& @CRLF
Next
_SaveTxt($tEventArrays, "EventArrays.txt")
Exit

EndFunc   ;==>_Debug_Events

Func _SaveTxt($tTextToSave, $sSaveFile)
$sListFileName = FileSaveDialog("Save ", @ScriptDir, "Text Documents (*.txt)", 16, $sSaveFile)
; option 16 = dialog remains until valid path/file selected & prompts for overwrite, if file exists

If @error Then
MsgBox(48, "Save File", "Save cancelled!")
Return 0 ; return $iIsListSaved
Else
```

(Continues)

```
$file = FileOpen($sListFileName, 2) ; Check if file opened for writing OK
If $file = -1 Then
MsgBox(48, "Error", "Unable to open file.")
Exit
EndIf
FileWrite($file, $tTextToSave)
FileClose($file)
Return 1 ; return $iIsListSaved
EndIf
EndFunc ; ==>    _SaveTxt()

Func _RestoreAP() ; returns 0 if failure

If StringInStr($sSelected802, "5") Then ; 5GHZ 802.11n
$s802Prefix = StringStripWS(IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "802.11n_5", "Not Found"), 8) ;
Read 802.11n 5GHz file prefix from ini-file
Else
If StringInStr($sSelected802, "b/g") Then
$s802Prefix = ""
Else
$s802Prefix = StringStripWS(IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "802.11n_2", "Not Found"), 8) ;
Read 802.11n 2.4GHz file prefix from ini-file
EndIf
EndIf
$sRestoreFile = $s802Prefix & StringStripWS(IniRead($sLocalPath & $sApIniFile, $sSelectedAp, $sSelectedAir,
"Not Found"), 8) ; read file name from ini-file and add 802.11n prefix, if needed

While ProcessExists("RestoreAp.exe") ;terminate old hanging processes
ProcessClose("RestoreAp.exe")
WEnd
$iPidRestoreAp = Run(@ComSpec & " /c " & 'RestoreAp.exe ' & $sSelectedAp & ' ' & $sRestoreFile, @ScriptDir,
@SW_HIDE, $STDOUT_CHILD)

Sleep(2000)
$iRestoreApCounter = 0
While ProcessExists($iPidRestoreAp)
;GUICtrlSetData($iCurrentLvItem,StdoutRead($iPidRestoreAp))
Sleep(1000)
$iRestoreApCounter = $iRestoreApCounter + 1
If $iRestoreApCounter = 180 Then ; if restore process gets hang, then kill it
ProcessClose($iPidRestoreAp)
$iRestoreApCounter = 0
ExitLoop
EndIf
End
Return ($iRestoreApCounter)
EndFunc   ;==>_RestoreAP

Func _CheckPduComms($sPDU_IP)
If Not Ping($sPDU_IP, 3000) Then
Return ("No")
Else
Return ("YES")
EndIf
EndFunc   ;==>_CheckPduComms
Func _SetRadius()
MsgBox(0, "SetRadius", "Set RADIUS to " & $sSelectedRad, 2)

If ShellExecuteWait("SetRadius ", $sSelectedRad, $sLocalPath) Then
$iTime = @HOUR & ":" & @MIN & " |" & @MDAY & "." & @MON & " " & @YEAR
$sErrorItem = "Error in Radius-setup: " & $iTime & "|" & $sSelected802 & "|" & $sSelectedAir & "|" & $sSelecte-
dAp & "|" & $sSelectedEap & "|" & $sSelectedRad ; collect setup & time to oneliner
$iErrorFile = FileOpen("Wizard-error.txt",1)
FileWrite($iErrorFile, $sErrorItem)
FileClose($iErrorFile)
MsgBox(16, "Error in RADIUS Setup", "Radius error has occurred!")
EndIf
EndFunc   ;==>_SetRadius
```

(Continues)

```
Func _UpdateListView()
		;$ListView1
		$iUpdateListViewOK = 0
		$iTime = @HOUR & ":" & @MIN & " |" & @MDAY & "." & @MON & " " & @YEAR
		$sListViewItem = $iTime & "|" & $sSelected802 & "|" & $sSelectedAir & "|" & $sSelectedAp & "|" & $sSelectedEap & "|" & $sSelectedRad ; collect setup & time to oneliner
		;$iUpdateListViewOK = _GUICtrlListViewInsertItem($ListView1, 0, $sListViewItem) ; insert new item to top of ListView
		;MsgBox(0, "$sListViewItem", $sListViewItem)
		$iCurrentLvItem = GUICtrlCreateListViewItem($sListViewItem, $ListView1) ; insert new item to end of ListView
		If $iFirstLvItem = 0 Then
			$iFirstLvItem = $iCurrentLvItem
		EndIf
		If $iCurrentLvItem <> 0 Then ; if not error
			$iUpdateListViewOK = 1
			$iIsListSaved = 0
		Else
			$iUpdateListViewOK = 0
		EndIf

EndFunc   ;==>_UpdateListView
```

Appendix 4. Source code for RestoreAP.exe

```
#Region ;**** Directives created by AutoIt3Wrapper_GUI ****
#AutoIt3Wrapper_outfile=RestoreAP.exe
#EndRegion ;**** Directives created by AutoIt3Wrapper_GUI ****
; RestoreAp($sAP,$sRestoreFile)
; Uses AP-INI -file, returns nothing
; AP ini-file can be found from VerificationWizard.ini
; [AP]
; APSetupInfo = APSetupInfo.ini
; Jukka Issakainen, Quality Assurance Services

#include <Constants.au3>
#include <array.au3>
#include<ie.au3>

Global $sAP, $sRestoreFile
Const $sIniFile = "VerificationWizard.ini"
Opt("SendkeyDelay",20)

$DEBUG_iAccessPointOff = 0
$DEBUG_iRadiusOff = 0

$sLocalPath = @ScriptDir & "\" ; Add trailing backslash
$sApIniFile = IniRead($sLocalPath & $sIniFile, "AP", "APSetupInfo", "NotFound") ; Read the name of APinifile from Wizard.ini
$sAPRestorePath = IniRead($sLocalPath & $sApIniFile, "AP", "RestorePath", "NotFound"); Read from ApINI-file, not anymore VerificationWizard.ini

FileInstall("3cserver.exe", $sLocalPath); Install TFTP Server
FileInstall("3cserver.ini", $sLocalPath)
FileInstall("plink.exe", $sLocalPath) ; Install PLINK.EXE

If $cmdline[0] > 0 Then ; Selected AP and restorefile as input, main prg takes care of matching selected mode to restorefile
$sSelectedAp = ""
$iEndOfInput = $cmdline[0]
For $i = 1 to $iEndOfInput -1
$sSelectedAp = $sSelectedAp & $cmdline[$i] & " "
Next
$sRestoreFile = $cmdline[$iEndOfInput]
;MsgBox(0, "Parametrit", "$sSelectedAp = " & $sSelectedAp & @CRLF & "$sRestoreFile = " & $sRestoreFile)
AutoItSetOption("WinTitleMatchMode", 2) ; set title matching to sub-string, no need for whole title
;IniRead ( "filename", "section", "key", "default" )
```

(Continues)

```
$sAPRestoreFolder = $sAPRestorePath & IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "RestoreFolder", "NotFound")
$aTelnetParam = StringSplit($sRestoreFile, ",") ; This function reads from $sRestoreFile separated parameters by comma, if Telnet > only one parameter = restorefile
AutoItSetOption("WinTitleMatchMode", 2) ; set title matching to sub-string, no need for whole title
;_ArrayDisplay($aTelnetParam, "$aTelnetParam")
$sAP_IP = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "IP", "NotFound")
$sGoRestore = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "GoRestore", "NotFound")
$sUserID = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "UserID", "NotFound")
$sPassword = IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "Password", "NotFound")

If $sAP_IP = "Not Found" Or $sGoRestore = "Not Found" Or $sUserID = "Not Found" Or $sPassword = "Not Found" Or $sAPRestoreFolder = "Not Found" Or $sRestoreFile = "Not Found" Then
MsgBox(0, "Error", "Parameter not found, check " & $sApIniFile & " -file!" & @CRLF & @CRLF & "Access Point " & $sSelectedAp & " might not support selected mode")
EndIf

If StringRight($sAPRestoreFolder, 1) <> "\" Then; Check that path contains a backslash
$sAPRestoreFolder = $sAPRestoreFolder & "\"
EndIf
$sRestoreFile = $sAPRestoreFolder & $sRestoreFile ; combine path & restorefile
;                   MsgBox(0, "AccessPoint Setup values", "$AP= " & $sSelectedAp & @CRLF & "$sAP_IP= " & $sAP_IP & $sGoRestore & @CRLF & "$sUserID= " & $sUserID & @CRLF & "$sPassword =" & $sPassword & @CRLF & "$sRestoreFile =" & $sRestoreFile)
If $DEBUG_iAccessPointOff = 0 Then ; $DEBUG_iAccessPointOff = 1 for debugging
$iIsApOnLine = Ping($sAP_IP, 4000) ;

If $iIsApOnLine Then ; Is AP online?

If $DEBUG_iRadiusOff = 0 Then ; if not in any debugmode, then set Progressbar
ProgressOn("Access Point Configuration Restore", "Please wait...", "0 percent", -1, -1, 16) ; 16 = window can be moved
AdlibEnable("_ProgressBar", 500) ; Call _ProgressBar every 500ms
EndIf ; set ProgressBar
If $aTelnetParam[0] = 1 And $aTelnetParam[1] <> "set" And Not StringInStr($sSelectedAp, "Apple") Then ; wep interface used, if not telnet or SSH or Apple (-> Airport.exe)

;;ShellExecute("iexplore.exe", $sAP_IP & $sGoRestore)
$oIE =_IECreate($sAP_IP & $sGoRestore)
Sleep(3000)

$sSelectedAp = StringStripWS($sSelectedAp, 8) ; to strip all WhiteSpaces away from AP name to avoid any misconfig
; A-Link WNAP, Apple Airport Extreme, Cisco 1231, Belkin N1 Vision, Buffalo WZR-AG300NH, D-Link DIR-655, Linksys WRT54GS, Linksys WRT350N, Linksys WRT610N, Netwjork 54Mbps, Thomson 585, Telewell TW-EA515, ZyXEL NBG-415N, ZyXel P-661HW-D1
```

(Continues)

```
;#cs

Select
Case $sSelectedAp = "A-LinkWNAP";
;;WinWaitActive("Connect")
$oIE =_IEAttach("Connect","DialogBox")
$oDoc = _IEDocGetObj($oIE)
;Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
;;WinWaitActive("Save/Reload")
$oIE =_IEAttach("Save/Reload","Title")
Sleep(3000); [CLASS:Internet Explorer_Server; INSTANCE:1]
;Send("{TAB 9}")
ControlClick("Save/Reload","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,220,164);
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
Sleep(3000)
WinWaitActive($sAP_IP)
Sleep(1000)
Send("{TAB 8}" & "{ENTER}")
WinWaitActive("Save/Reload Setting")
WinClose("Save/Reload Setting")

Case $sSelectedAp = "Cisco1231"
;                       ConsoleWrite('@@ (927) :(' & @MIN & ':' & @SEC & ') In Cisco1231')
Send($sUserID & "{TAB}" & $sPassword & "{ENTER}")
Sleep(2000)
WinWaitActive("System Software - System Configuration")
Sleep(7000)
Send("+{TAB 10}" & $sAPRestoreFolder & $sRestoreFile & "+{TAB}{enter}") ; insert filename & go to "Load" -
button
WinWaitActive("Microsoft")
Send("{enter}")
Sleep(10000) ; wait for boot count-down timer
WinWaitNotActive("System Restarting Now") ; wait for Cisco to boot-up
IsOffLine($sAP_IP) ; Wait until AP comes back online
Sleep(5000) ; Wait for other processes to startup in AP
$iPing = Ping($sAP_IP)

While @error = 1 ; host is offline
Sleep(1000)
$iPing = Ping($sAP_IP)
WEnd
;_CloseOpenWindow("System Software - System Configuration")
WinWaitActive("Cisco")
WinClose("Cisco") ; Close Browser after restore
;WinWaitClose("Cisco") ; Wait for browser to close before continuing
```

(Continues)

```
;ConsoleWrite('@@ (950) :(' & @MIN & ':' & @SEC & ') Exit Cisco1231')
;#ce
Case $sSelectedAp = "BelkinN1Vision";
WinWaitActive("Login")
Sleep(3000)
Send("{TAB 2}" & "{ENTER}")
WinWaitActive("Restore")
Sleep(3000) ;
ControlClick("Restore","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,370,184) ;
; Uses ControlClick Coordinates to navigate to input field
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
WinWaitActive("Explorer","continue")
Send("{ENTER}")
WinWaitActive("Explorer", "90") ; 90s info window
Send("{ENTER}")
WinWaitActive("Setup Home")
WinClose("Setup Home")

Case $sSelectedAp = "BuffaloWZR-AG300NH";
WinWaitActive("Connect")
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
WinWaitActive("AirStation Settings")
Sleep(10000)
ControlClick("AirStation Settings","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,357,323)
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
Sleep(120000) ; estimated boot time 80s
WinClose("AirStation Settings")

Case $sSelectedAp ="D-LinkDIR-655" ;
WinWaitActive("Login")
Sleep(2000)
ControlClick("Login","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,580,237); Click Login-button
Sleep(2000)
WinWaitActive("Setup / Internet")
Sleep(2000)
Send("{TAB}" & $sAP_IP & $sGoRestore & "{ENTER}")
WinWaitActive("Tools / System")
Sleep(2000)
ControlClick("Tools / System","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,350,395);
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
Sleep(10000)
;MsgBox(0,"WinGetTitle(Restore Success)",WinGetTitle("Restore Success"),2)
If WinGetTitle("Restore Success") Then
```

(Continues)

```
ControlClick("Restore Success","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,156,222);
Else
WinWaitActive("Tools / System")
Sleep(3000)
ControlClick("Tools / System","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,410,552); Reboot the system
Sleep(2000)
WinWaitActive("Internet Explorer")
Sleep(1000)
Send("{ENTER}")
EndIf
WinWaitActive("Login")
WinClose("Login")

Case $sSelectedAp = "LinksysWRT54GS" ;
WinWaitActive("Connect")
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
Sleep(2000)
WinWait("Config Management")
Sleep(2000)
ControlClick("Config Management","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,373,300);
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
Sleep(3000)
Winwait("restore.cgi")
Sleep(5000)
ControlClick("restore.cgi","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,391,237); Succesful OK-btn
WinWait("Basic Setup")
Sleep(3000)
WinClose("Basic Setup")

Case $sSelectedAp = "LinksysWRT350N";
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
WinWaitActive("Management") ; wait for this window become active
Sleep(3000)
Send("+{TAB 11}" & $sRestoreFile); error unmatched <PID>
Sleep(1000)
Send("+{TAB}" & "{ENTER}")
WinWaitActive("Internet Explorer") ; Confirmation window
Send("{ENTER}") ; close
WinWaitActive("Basic Setup")
WinClose("Basic Setup")

Case $sSelectedAp = "LinksysWRT610N" ;
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
```

(Continues)

```
WinWaitActive("Restore Configurations") ; wait for this window become active
Sleep(3000)
Send("{TAB 8}" & $sRestoreFile & "{TAB 2}" & "{ENTER}") ; go to file field, input file and got to Restore
WinWaitActive("restore.cgi")
Sleep(3000)
Send("{TAB 8}" & "{ENTER}")
WinWaitActive("Internet Explorer") ; do you want to close the the tab
Sleep(3000)
Send("{ENTER}") ; close

Case $sSelectedAp = "Netwjork54Mbps" ; Netwjork uses 3Com TFTP-server for restore, it MUST be located in Script-dir
ProcessClose("3CServer.exe") ; just in case....
WinWaitActive("Connect")
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
Sleep(3000)
;ShellExecute($sAPRestoreFolder & "3CServer.exe","","","",@SW_HIDE)
ShellExecute($sLocalPath & "3CServer.exe","","","",@SW_HIDE)
WinWaitActive("3CServer")
Sleep(3000)
WinActivate("System |")
Sleep(2000)
FileCopy($sRestoreFile,$sAPRestoreFolder & "backup.bin",1) ; overwrite with no questions
; easier to do like this, as file input field is length-limited
ControlClick("System |","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,325,170); TFTP-server's IP
Sleep(2000)
Send("{BS 20}")
Sleep(1000)
Send(@IPAddress1)
Sleep(1000)
ControlClick("System |","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,108,225); Click restore-button
WinWaitActive("Internet Explorer")
Send("{ENTER}")
While Not StringInStr(ControlGetText("System |","","[CLASS:Edit; Instance:1]"),"system_reboot.asp") ; wait for Reboot-button
Sleep(1000)
WEnd
Sleep(3000)
ControlClick("System |","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,156,142); press Reboot-button
WinWaitActive("Internet Explorer")
Send("{ENTER}")
WinWaitActive("54M")
WinClose("54M")
ProcessClose("3CServer.exe") ; then no "Are you sure window"
```

(Continues)

```
Case $sSelectedAp = "Thomson585" ;
WinWaitActive("Restore")
Sleep(3000)
ControlClick("Restore","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,580,585);
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
WinWaitActive("Internet Explorer")
Send("{ENTER}")
WinWaitActive("Home")
Sleep(3000)
WinClose("Home")

Case $sSelectedAp = "TelewellTW-EA515" ;
WinWaitActive("Connect")
Send($sUserID & "{TAB}" & $sPassword & "{TAB 2}" & "{ENTER}")
WinWaitActive("config/index.html")
Sleep(2000)
ControlClick("config/index.html","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,300,300);
Sleep(1000)
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
Sleep(3000)
While Not WinGetTitle("3G/ADSL2+")
Sleep(10000)
;MsgBox(0, "WinGetTitle",WingetTitle("3G/ADSL2+"),2)
WEnd
WinClose("3G/ADSL2+")

Case $sSelectedAp = "ZyXELNBG-415N" ;
WinWaitActive("Login")
Sleep(2000)
Send($sPassword & "{TAB 2}" & "{ENTER}")
WinWaitActive("Router Configuration")
Sleep(2000);
Send("{TAB}" & $sAP_IP & $sGoRestore & "{enter}")
WinWaitActive("TOOLS / System")
Sleep(2000) ;
ControlClick("TOOLS / System","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,284,306)
;Send("{TAB 9}" & $sRestoreFile & "{TAB 2}" & "{ENTER}")
Send($sRestoreFile & "{TAB 2}" & "{ENTER}")
WinWaitActive("Success")
Send("{TAB 8}" & "{ENTER}")
WinWaitActive("Internet Explorer")
Send("{ENTER}")
WinWaitActive("Login")
WinClose("Login")
```

(Continues)

```
Case $sSelectedAp = "ZyXelP-661HW-D1" ;
WinWaitActive("Welcome")
Sleep(2000)
Send($sPassword & "{TAB}" & "{ENTER}")
WinWaitActive("Welcome")
Sleep(5000);
Send("{TAB}" & $sAP_IP & $sGoRestore & "{ENTER}")
Sleep(2000)
ControlClick("Welcome","","[CLASS:Internet Explorer_Server; INSTANCE:1]","left",1,160,214)
Sleep(5000)
Send("{TAB 11}" & $sRestoreFile & "{TAB 2}" & "{ENTER}")
While  Not StringInStr(ControlGetText(".::","", "[CLASS:Edit; INSTANCE:1]"), "home.html")
Sleep(10000)
;MsgBox(0,"ControlGetText",ControlGetText(".::","", "[CLASS:Edit; INSTANCE:1]"),2)
WEnd
WinClose(".::")
EndSelect
Else ; telnet or SSH ; on first round SSH-fingerprint needs to be cached; using Plink for automated conns
If StringInStr($sSelectedAp, "Apple") Then ; WORKS!!! 8.4.2009
$sSelectedAp = "AppleAirportExtreme"
ProcessClose("APUtil.exe") ; Close AirPort Utility, if found running
 ; GoRestore contains Path & filename, in this case "C:\Program Files\Airport\APUtil.exe"
ShellExecute($sGoRestore)
WinWaitActive("AirPort Utility")
Sleep(2000)
ControlClick("AirPort Utility","","[CLASS:Button;Instance:3]")
Sleep(5000)
; Check here, if password has been remembered
If WinGetTitle("Enter Password") Then
ControlSend("Enter Password","","[CLASS:Edit;Instance:1]", $sPassword)
Sleep(1000)
ControlClick("Enter Password","","[CLASS:Button;Instance:1]","left",1) ;
EndIf
WinWaitActive("AirPort Utility")
Sleep(2000)
Send("!f") ; Send Control -I for Import
Sleep(1000)
Send("i")
WinWaitActive("Open")
Sleep(2000)
ControlSend("Open","","[CLASS:Edit;Instance:1]", $sRestoreFile) ; insert filename to inputfield
Sleep(1000)
ControlClick("Open","","[CLASS:Button;Instance:2]","left",1) ; Click Open button
WinWaitActive("Import")
```

(Continues)

```
Sleep(1000)
ControlClick("Import","","[CLASS:Button;Instance:1]","left",1) ; Click OK
WinWaitActive("AirPort Utility")
Sleep(1000)
ControlClick("AirPort Utility","","[CLASS:Button;Instance:7]","left",1) ; Click Update button
WinWaitClose("Writing to the Apple") ; wait until restore completed
Sleep(3000)
WinWaitClose("Reading") ; wait until utility reads from AP the status
WinWaitActive("AirPort Utility")
Sleep(3000)
$sStatus = ControlGetText("AirPort Utility","","[CLASS:Static;Instance:6]")
If $sStatus = "Normal" Then
ProcessClose("APUtil.exe")
Else
MsgBox(0, "ERROR has occurred", "Something wrong, AP status = " & $sStatus)
EndIf
Else
Send("#r") ; Windows Run-key
WinWaitActive("Run")
If IniRead($sLocalPath & $sApIniFile, $sSelectedAp, "SSH", "NotFound") = "Yes" Then ; SSH or Telnet?
Send($sLocalPath & "plink -ssh " & $sAP_IP & "{enter}") ;
Else ; Telnet
Send($sLocalPath & "plink -telnet " & $sAP_IP & "{enter}") ;
EndIf ; SSH or Telnet?
WinActivate("Plink", "")
Sleep(1000)
Send($sUserID & "{enter}")
Sleep(1000)
Send($sPassword & "{enter}")
Sleep(1000)
Send("{enter}") ; jostain syystä tuli yksi '+'-merkki cmdriville, tää tuntui auttavan
;_AP_Login($sUserID, $sPassword)
Sleep(1000)
For $i = 1 To $aTelnetParam[0] ; loop until all parameters from INI-file are sent, $aTelnetParam[0] contains # of parameters
;MsgBox(0, "$aTelnetParam", $aTelnetParam[$i])
Send(StringStripWS($aTelnetParam[$i], 3), 1) ; jos pisti samalle riville {enterin}, niin '+'-merkki lähti hitoille esim (WPA+WPA2)-PSK
Send("{enter}")
Sleep(1000)
Next
Sleep(1000)
EndIf; Apple of Telnet
EndIf ; web interface used, if not telnet or SSH or Apple
Else ; Is AP online?
If @error = 0 Then $problem = "Network Errors Occured "
```

(Continues)

12(10)

```
If @error = 1 Then $problem = "Host is Off-Line "
If @error = 2 Then $problem = "Host is Unreachable "
```

(Continues)

```
If @error = 3 Then $problem = "Incorrect Destination "
If @error = 4 Then $problem = "Network Errors Occured "
If $iIsApOnLine = "NotFound" Then $problem = "Error in INI-file"
MsgBox(48, "Problem occurred !!!", "Selected Access Point does not respond." & @CRLF & @CRLF & "Error is: " & @error & " = " & $problem & @CRLF & @CRLF & "Check your AP selection...")
$iApPIDReturn = 0 ; error occurred
EndIf ; Is AP online?
Else; $DEBUG_iAccessPointOff = 1 for debugging
MsgBox(0, "AccessPoint DEBUG: Setup values", "$AP= " & $sSelectedAp & @CRLF & "$sAP_IP= " & $sAP_IP & @CRLF & "$sGoRestore = " &  $sGoRestore & @CRLF & "$sUserID= " & $sUserID & @CRLF & "$sPassword =" & $sPassword & @CRLF & "$sAPRestoreFolder =" & $sAPRestoreFolder & @CRLF & "$sRestoreFile =" & $sRestoreFile)

EndIf ; $DEBUG_iAccessPointOff = 1
Else
MsgBox(16, "Error occurred", "No input from Wizard, exiting",2)
Exit
EndIf
```

Appendix 5. WLAN Verification Wizard.ini -file

```
; WLAN VerificationWizard.ini
; Contains settings and variables
;
; Author: Jukka Issakainen
;

[AP]
APSetupInfo = APSetupInfo.ini

[EAP]
;Types = TLS/PEAPv0, PEAPv1, TTLS-EAP-MSChapv2, TTLS-MSChapV2, LEAP, SIM, AKA
;Types = TLS/PEAPv0, PEAPv1, TTLS-EAP-MSChapv2, TTLS-MSChapV2, LEAP, SIM
Types = TLS/PEAPv0, PEAPv1, TTLS, SIM, AKA

[Misc]
; these are just informational texts to show on screen, after AP-setup is completed
SSID = ***** ; removed
WEP64_Key = 1234567890, Key 2 (10 HEX digits)
WEP128_Key = 1234567890abcdef1234567890, Key 2 (26 HEX digits)
WPA(2)-PSK_Key = 12345678
TestUser = testi
TestUser_PWD = ****** ; removed
TestUser_Logon_Domain = ******* ; removed

[RADIUS]
RadiusSetupInfo = RadiusSetupInfo.ini
```

Appendix 6. AccessPointInfo.ini -file

```
; Access Point Info file
; Contains settings and variables
;
; Author: Jukka Issakainen
;
; PDU_Port =                    Physical AC outlet # in APC Switched Rack PDU
; Model =                       Info abt AP model, not used, but clarifies ini-file
; Firmware =                    Info abt Firmware, not yet used
; IP =                                  IP-address of AP
; SSH = yes/no                  If AP is capable of SSH
; 802.11n_2 =                   If AP supports 802.1n 2.4GHz mode, prefix for setupfile (e.g. WNAP_N2.4_)
; 802.11n_5 =                   If AP supports 802.1n 5GHz mode, prefix for setupfile (e.g. WNAP_N5_
; UserID =                      User name of AP administrative account
; Password =                    Password of AP administrative account
; GoRestore =                   Path to config restore page inside Access Point, if exists
; RestoreFolder = Folder used to store config-files, empty folder, if Telnet/SSH is used
; Open =                        Open, no wep-key etc
; 802.1x=                       802.1x with dynamic wep-key 128-bit and RADIUS
; WEP128 =                      wep-key 128-bit, no RADIUS
; WPA-PSK =                     WiFi Protected Access, Pre Shared Key using TKIP + AES (a.k.a mixed WPA
SOHO-mode), no RADIUS
; WPA =                         WiFi Protected Access, RADIUS for EAP-types using TKIP + AES (a.k.a mixed
WPA Enterprise-mode)
; WPA2-PSK =                    WiFi Protected Access 2, Pre Shared Key using AES, no RADIUS
; WPA2 =                        WiFi Protected Access 2, RADIUS for EAP-types using AES
; LEAP =                        Cisco specific mode

[AP]
Models = A-Link WNAP, Apple Airport Extreme, Cisco 1231, Belkin N1 Vision, Buffalo WZR-AG300NH, D-Link
DIR-655, Linksys WRT54GS, Linksys WRT350N, Linksys WRT610N, Netwjork 54Mbps, Thomson 585, Telewell
TW-EA515, ZyXEL NBG-415N, ZyXel P-661HW-D1
RestoreModes = Open, WEP128, WPA-PSK, WPA2-PSK, WPA, WPA2, 802.1x
RestorePath = D:\Jukan\automation\AP_Setups
802Modes = 802.11 b/g, 802.11n (2.4GHz), 802.11n (5GHz)

[PDU]
; PDU_Enabled = Yes or No
; New interface after FW upgrade 2.70 or newer: <password><space>-c
PDU_Enabled = yes
PDU_IP = 10.10.32.17
PDU_User = wizard
PDU_Pwd = *****

;##################################AP SETUP starts ##############################################

[A-Link WNAP]
PDU_Port = 16
Model = WL524
Firmware = e2.04
IP = 10.10.32.151
SSH = no
802.11n_2 = WNAP_N2_
802.11n_5 = WNAP_N5_
UserID = admin
Password = *****
GoRestore = /saveconf.asp
RestoreFolder = \A-LinkWNAP
Open = A-Link_Open.dat
802.1x =
WEP64 =
WEP128 = A-Link_WEP128.dat
WPA-PSK = A-Link_wpa-psk_mixed.dat
WPA =  A-Link_WPA_enterprise_mixed.dat
WPA2-PSK =
WPA2 = A-Link_WPA2_enterprise.dat
LEAP =
```

(Continues)

```
[Apple Airport Extreme]
PDU_Port = 15
Model = 123
Firmware = 123
IP = 10.10.32.152
SSH = no
802.11n_2 = Apple_N2_
802.11n_5 = Apple_N5_
UserID =
Password = *****
GoRestore = "C:\Program Files\Airport\APUtil.exe"
RestoreFolder = \Apple
Open = Apple_Open.baseconfig
802.1x =
WEP64 =
WEP128 =
WPA-PSK = Apple_wpa-psk_mixed.baseconfig
WPA =  Apple_wpa_mixed.baseconfig
WPA2-PSK = Apple_wpa2-psk.baseconfig
WPA2 = Apple_wpa2.baseconfig
LEAP =

[Belkin N1 Vision]
PDU_Port = 14
Model = DIR-655
Firmware = F5D8232-4_WW_1.00.15
IP = 10.10.32.153
SSH = no
802.11n_2  = Belkin_N2_
802.11n_5 = Belkin_N5_
UserID = admin
Password = *****
GoRestore = /setup.cgi?next_file=ut_prev.html
RestoreFolder = \BelkinN1Vision
Open = BelkinN1Vision_Open.conf
802.1x=
WEP64 =
WEP128 = BelkinN1Vision_WEP128.conf
WPA-PSK = BelkinN1Vision_wpa-psk_mixed.conf
WPA =
WPA2-PSK = BelkinN1Vision_wpa2-psk.conf
WPA2 =
LEAP =

[Buffalo WZR-AG300NH]
PDU_Port = 13
Model = WZR-AG300NH
Firmware = 1.49
IP = 10.10.32.154
SSH = no
802.11n_2  = Buffalo_N2_
802.11n_5 = Buffalo_N5_
UserID = root
Password = *****
GoRestore = /cgi-bin/cgi?req=tfr&id=47
RestoreFolder = \BuffaloWZR
Open = BuffaloWZR_Open.bin
802.1x=
WEP64 =
WEP128 = BuffaloWZR_WEP128.bin
WPA-PSK = BuffaloWZR_wpa-psk_mixed.bin
WPA =
WPA2-PSK = BuffaloWZR_wpa2-psk.bin
WPA2 =
LEAP =

[Cisco 1231]
PDU_Port = 12
```

(Continues)

Model = Air 1231G-K9
Firmware = 12.3(8)JEA
IP = 10.10.32.150
SSH = no
802.11n_2 =
802.11n_5 =
UserID = Cisco
Password = *****
GoRestore = /ap_system-sw_sysconfig.shtml
RestoreFolder = \Cisco1231
Open = Cisco1231_Open.txt
802.1x= Cisco1231_8021x.txt
WEP64 = Cisco1231_WEP64.txt
WEP128 = Cisco1231_WEP128.txt
WPA-PSK = Cisco1231_WPA-PSK_mixed.txt
WPA = Cisco1231_WPA_mixed.txt
WPA2-PSK = Cisco1231_WPA2-PSK.txt
WPA2 = Cisco1231_WPA2.txt
LEAP = Cisco1231_WPA2_Funk.txt

[D-Link DIR-655]
PDU_Port = 11
Model = DIR-655
Firmware = 1.21EU
IP = 10.10.32.162
SSH = no
802.11n_2 = DIR655_N2_
802.11n_5 = DIR655_N5_
UserID = admin
Password = *****
GoRestore = /Tools/System.shtml
RestoreFolder = \DIR-655
Open = DIR-655_Open.gws.htm
802.1x=
WEP64 = DIR-655_WEP64.gws.htm
WEP128 = DIR-655_WEP128.gws.htm
WPA-PSK = DIR-655_WPA-PSK_mixed.gws.htm
WPA = DIR-655_WPA_mixed.gws.htm
WPA2-PSK = DIR-655_WPA2-PSK.gws.htm
WPA2 = DIR-655_WPA2.gws.htm
LEAP =

[Linksys WRT54GS]
PDU_Port = 9
Model = WRT54GS
Firmware = 4.71.1
IP = 10.10.32.155
SSH = no
802.11n_2 =
802.11n_5 =
UserID =
Password = *****
GoRestore = /Backup_Restore.asp
RestoreFolder = \wrt54gs
Open = WRT54GS_Open.cfg
802.1x=
WEP64 =
WEP128 = WRT54GS_WEP128.cfg
WPA-PSK = WRT54GS_WPA2-psk_mixed.cfg
WPA = WRT54GS_WPA2_mixed.cfg
WPA2-PSK = WRT54GS_WPA2-psk.cfg
WPA2 = WRT54GS_WPA2.cfg
LEAP =

[Linksys WRT350N]
PDU_Port = 8
Model = WRT350N

(Continues)

```
Firmware = 2.00.19
IP = 10.10.32.163
SSH = no
802.11n_2 = WRT350_N2_
802.11n_5 = WRT350_N5_
UserID = admin
Password = *****
GoRestore = /setup.cgi?next_file=Administration.htm
RestoreFolder = \WRT350Nv2
Open = WRT350v2_open.cfg
802.1x=
WEP64 =
WEP128 = WRT350v2_WEP128_key1.cfg
WPA-PSK = WRT350v2_wpa-psk_mixed.cfg
WPA = WRT350v2_wpa.cfg
WPA2-PSK = WRT350v2_wpa2-psk.cfg
WPA2 = WRT350v2_wpa2.cfg
LEAP =


[Linksys WRT610N]
PDU_Port = 7
Model = WRT610N
Firmware = 1.00.02.10
IP = 10.10.32.156
SSH = no
802.11n_2 = WRT610_N2_
802.11n_5 = WRT610_N5_
UserID = admin
Password = *****
GoRestore = /Restore.asp
RestoreFolder = \WRT610N
Open = WRT610NV1_open.cfg
802.1x=
WEP64 =
WEP128 = WRT610NV1_WEP128.cfg
WPA-PSK = WRT610NV1_WPA-psk_mixed.cfg
WPA = WRT610NV1_WPA_mixed.cfg
WPA2-PSK = WRT610NV1_WPA2-psk.cfg
WPA2 = WRT610NV1_WPA2.cfg
LEAP =


[Netwjork 54Mbps]
; Netwjork uses 3ComTFTP-server for setup backup/restore,
; which MUST be located in Script-dir

PDU_Port = 6
Model = 54Mbps
Firmware = default
IP = 10.10.32.157
SSH = no
802.11n_2 =
802.11n_5 =
UserID = admin
Password = *****
GoRestore = /system_backup.asp
RestoreFolder = \Netwjork
Open = Netwjork_open.bin
802.1x=
WEP64 =
WEP128 = Netwjork_WEP128.bin
WPA-PSK = Netwjork_wpapsk.bin
WPA =
WPA2-PSK = Netwjork_wpa2psk.bin
WPA2 =
LEAP =
```

(Continues)

[Telewell TW-EA515]
PDU_Port = 5
Model = TW-EA515
Firmware = 5.53.S3.ds36
IP = 10.10.32.160
SSH = no
802.11n_2 =
802.11n_5 =
UserID = admin
Password = *****
GoRestore = /config
RestoreFolder = \TelewellEA515
Open = TelewellEA515_open.icf
802.1x=
WEP64 =
WEP128 = TelewellEA515_WEP128.icf
WPA-PSK = TelewellEA515_wpa-psk.icf
WPA =
WPA2-PSK = TelewellEA515_wpa2-psk.icf
WPA2 =
LEAP =

[Thomson 585]
PDU_Port = 4
Model = ST780
Firmware = 6.2.16.3
IP = 10.10.32.158
SSH = no
802.11n_2 =
802.11n_5 =
UserID = Administrator
Password = *****
GoRestore = /cgi/b/bandr/?be=0&l0=0&l1=1&tid=BACKUP_RESTORE
RestoreFolder = \Thomson585
Open = Thomson_585_Open.ini
802.1x=
WEP64 =
WEP128 = Thomson_585_WEP128.ini
WPA-PSK = Thomson_585_wpa-psk_mixed.ini
WPA =
WPA2-PSK = Thomson_585_wpa2-psk.ini
WPA2 =
LEAP =

[ZyXEL NBG-415N]
PDU_Port = 2
Model = NBG-415N
Firmware = 3.60(ZP.2)C0
IP = 10.10.32.164
SSH = no
802.11n_2 = Zyxel_N2_
802.11n_5 = Zyxel_N5_
UserID =
Password = *****
GoRestore = /Tools_System.html
RestoreFolder = \ZyXel415N
Open = Zyxel415N_Open.gws
802.1x=
WEP64 =
WEP128 = Zyxel415N_WEP128.gws
WPA-PSK = Zyxel415N_wpa-psk_mixed.gws
WPA = Zyxel415N_wpa_mixed.gws
WPA2-PSK = Zyxel415N_wpa2-psk.gws
WPA2 = Zyxel415N_wpa2.gws
LEAP =

[ZyXel P-661HW-D1]
PDU_Port = 1

(Continues)

Model = P-661HW-D1 Firmware = 3.40(AHQ.0)
IP = 10.10.32.161
SSH = no
802.11n_2 =
802.11n_5 =
UserID =
Password = *****
GoRestore = /RestoreCfg.html
RestoreFolder = \ZyXel661
Open = P-661HW-D1_Open
802.1x=
WEP64 =
WEP128 = P-661HW-D1_WEP128
WPA-PSK = P-661HW-D1_WPA-PSK_mixed
WPA = P-661HW-D1_WPA_mixed
WPA2-PSK = P-661HW-D1_WPA2-PSK
WPA2 = P-661HW-D1_WPA2
LEAP =
;##################################AP SETUP ends ##

Appendix 7. RADIUSSetupInfo.ini -file

```
; RADIUS Setup Info -file
; Contains settings and variables
;
; Author: Jukka Issakainen
;
; NOTE! RADIUS' names in brackets '[]' MUST be same as in 'Servers' -line!!!
;
;
; Parameters used: (Check EAP-types, MUST be same as in VerificationWizard.ini -file)
; IP = server's IP-address
; Port = used RADIUS-port
; RestoreFile = Nestsh dumpfile name
; TLS/PEAPv0 = yes/no
; PEAPv1 = yes/no
; TTLS = yes/no
; PureTTLS = yes/no <- not currently used
; LEAP = yes/no <- not currently used
; SIM = yes/no
; AKA = yes/no
; KOE = yes/no <- for testing purposes


[RADIUS]
RestorePath = D:\wlan\ap_setups\radius
RadiusProxy = 10.10.32.10
Username = wizard
UserPwd = *****
; Proxy address is needed for psexec, which will run e.g. netsh exec ias.set on remote

Servers = Microsoft IAS, Juniper Odyssey, Cisco ACS, FreeRADIUS, Nokia Test Network

;##################################RADIUS SETUP starts ########################################;

; RADIUS *.set files are created with NETSH-command. It dumps current IAS-setting to a file, which can be re-played
; to instantly change authentication settings
;
; To record current settings enter to command prompt: netsh aaaa dump > filename.set

; To Replay saved settings enter to command prompt: netsh exec filename.set

;

[Microsoft IAS]
IP = 10.10.32.20
Port = 1812
RestoreFile = ias.set
TLS/PEAPv0 = yes
PEAPv1 = no
TTLS = no
PureTTLS = no
LEAP = no
SIM = no
AKA = no
KOE = no

[Juniper Odyssey]
IP = 10.10.32.50
Port = 1814
RestoreFile = juniper.set
TLS/PEAPv0 = yes
PEAPv1 = yes
TTLS                                                    =                                                    yes
```

(Continues)

PureTTLS = yes
LEAP = yes
SIM = no
AKA = no
KOE = no

[FreeRADIUS]
IP = 10.10.32.13
Port = 1814
RestoreFile = freeradius.set
TLS/PEAPv0 = no
PEAPv1 = yes
TTLS = yes
PureTTLS = yes
LEAP = no
SIM = yes
AKA = no
KOE = no

[Cisco ACS]
IP = 10.10.32.50
Port = 1812
RestoreFile = acs.set
TLS/PEAPv0 = yes
PEAPv1 = yes
TTLS = no
PureTTLS = no
LEAP = yes
SIM = no
AKA = no
KOE = no

[Nokia Test Network]
RestoreFile = NTN.set
TLS/PEAPv0 = no
PEAPv1 = no
TTLS = no
PureTTLS = no
LEAP = no
SIM = yes
AKA = yes
KOE = no

;################################RADIUS SETUP ends ##;