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SDR UAI, VIRTUAL MACHINE FOR A SOFTWARE DEFINED RADIO TOOLPACK

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The purpose of this paper is to present the implementation of a virtual system or virtual machine, named Software Defined Radio – University of Al Azhar Indonesia (SDR-UAI), that can encapsulate the GNU Radio installation process. GNU Radio is a development toolkit software used by electrical engineering students to learn and experience various radio systems without processing the hardware. GNU Radio and Universal Software Radio Peripheral (USRP) from Ettus Research is considerably a good combination of SDR system that can be used in a telecommunication lab. However, along with this preference, this combination poses the constraints in installation process due to its native operating system (OS) and growth characteristic. With conventional method, the process can be very complicated and painful, mostly ended with an unsuccessful installation. By using virtualization technology, the steps conducted in installation process can be reduced by 80% and it takes less than one hour compare with as much of 2 days in conventional method. A user interface analysis based on task network model used to measure the effectivity of this SDR-UAI.

Key words: VirtualBox, GNU Radio, USRP, SDR, task network analysis

1. Introduction

Virtualization is a framework of dividing the resources of a computer into multiple execution environments. More specific, it is a layer of software that provides the illusion of a real machine to multiple instances of virtual machines [1]. By using virtualization, we can run multiple operating system on one hardware that resource pooled by virtual machine manager. This allow to develop secured and portable pre made operating system that can be moved from one system to another. The virtual machine is increasingly utilized in engineering for system development in education [2-4].

Software Defined Radio (SDR) is a technology which basically transfer telecommunication processes usually done in hardware, to software. One of its lead benefit is, by using a single PC or embedded system, we do not have to replace the hardware to update the radio system, we just need to update the software.

One available SDR application on public is the open source GNU Radio that can run on POSIX system especially on Ubuntu and Fedora of GNU/Linux distribution. With regular PC, GNU Radio and hardware such as Universal Software Radio Peripheral (USRP) from Ettus Research, the student can learn and experience various radio system range from AM, GSM until Wifi within single environment. This could down cost the requirement for telecommunication system Lab and speed up the research [5-6].

One drawback of GNU Radio is that there are no “double click” solution where students or developer can grab installation file and run installation process in easy way. It requires knowledge to compile application from source code and a hard work to gather all necessary component. Its native build is to run in Ubuntu or Fedora Linux, which is not very common among some electrical engineering student. Moreover the software is not included in recent Ubuntu repository, making the installation process harder.

In this research, the author use VirtualBox to run Ubuntu Linux OS that configured for GNU Radio and USRP hardware. A pre made system can easily be plugged in any PC that can run VirtualBox or other virtualization software. This approach will reduce the needs to replace or dual booting Operating System, as well as to instal GNU Radio and its component on every machine. VirtualBox also have feature to halt or suspend the system, this will give the ability to halt the OS on any certain step, shutdown the computer without loss of work progress. By turn on the host and re run the VirtualBox, it will back to suspended state of guest OS. This feature will bring uninterrupted workspace. VirtualBox have ability to emulate the USB standard, so Guest OS can utilize the Host OS USB port. It is also support USB version 2 standard via Extension Pack.

To evaluate the virtual machine constructed, a utility analysis is conducted. The evaluation is done using simplified model based on task network analysis [7-13].

2. Implementation of SDR-UAI

Figure 1 shows the process of developing a virtual machine, SDR-UAI. The preparation research on GNU Radio, USRP and UHD has led into some methods available to install GNU Radio. A quick test into the methods available gave out some advantages and problems, i.e. that Ubuntu has outdated version of GNU Radio; Ettus Research has connection problems in using cellular network; and GNU Radio official manual create installation is not updated. A test methods for later should be decided. The criteria to be met are that the system build must be able to install GNU Radio within one hour; and that it can be upgraded easily. 5 tests were decided to determine the success of the virtual system created.

Next steps are are building the virtualization infrastructure. VirtualBox provides almost perfect solution for developing virtual machine to run Ubuntu and GNU Radio. A test has been done using 2GB disk space ended with OS that locked down due to run out of disk space. A 4GB space was then necessary during the development, although the resulting virtual system guest OS us2 disk space less than 2GB.

Afterward, the group steps are to test all possible methods to install GNU Radio and check whether it can run properly and connect USRP hadware. This is the most resource extensive task.

The resulting winner of the tests could not immediately be released into redistribution file without leaving some trash files. The guest OS for final distribution must be rebuilt from the scratch with small installation resource in mind. To do that, Ubuntu offers method to build a bare bone Linux installation that just install essential packages. After the rebuild and clean up, small modifications are necessary like creating application shortcut into desktop, allowing the guest OS to be ready for export and redistribute into another machine.

The five tests mentioned above to check whether the installation worked properly were: 1) *uhd_find_device*, a command line tool to check and find all UHD devices connected to computer; 2) *uhd_usrp_probe*, a command line to find USRP device and to read detailed information like hardware configuration and external connection to modify clock timer; 3) *uhd_fft*, to make sure that USRP device connects properly by grabbing signal from USRP, do Fast Fourier Transform (FFT) and draw the result; 4) Simple Signal FFT, a simple simulation using 3 blocks from GNU Radio Companion; and 5) AM Receiver, incorporating both GRC and USRP, based on [5] and [14].

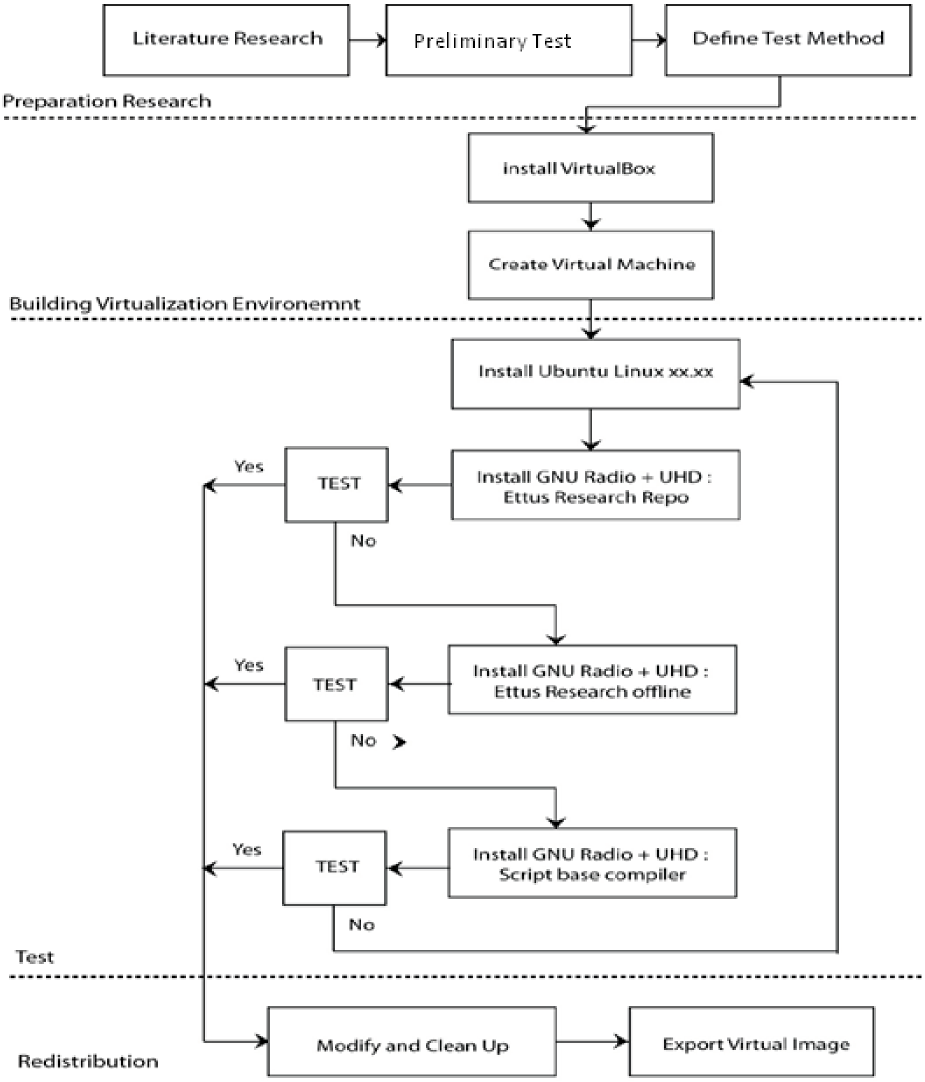
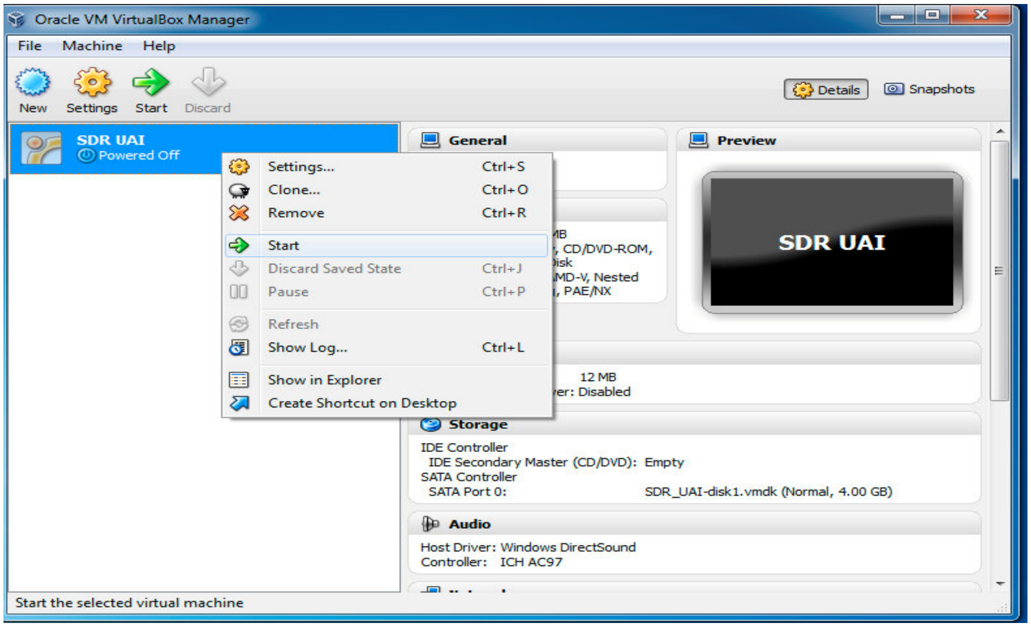

Literature Research
Preliminary Test
Define Test Method
Preparation Research
install VirtualBox
Create Virtual Machine
Building Virtualization Environemnt
Install Ubuntu Linux xx.xx
Install GNU Radio + UHD : Ettus Research Repo
TEST
Yes
No
Install GNU Radio + UHD : Ettus Research offline
TEST
Yes
No
Install GNU Radio + UHD : Script base compiler
TEST
Yes
No
Test
Modify and Clean Up
Export Virtual Image
Redistribution

Figure 1. Implementation Steps

3. Discussion

The implementation step resulted a pack of files containing guest OS on top of virtual box, ready to distribute. This files could be copied into USB Flashdisk, DVD, memory card or post it into cloud server for easy access.

To run a virtual system, the user can use one form the list on left column and then click “Start” icon on toolbox or right click and “Start” (see figure 2). This action will turn on the virtual system and activate that as guest OS. A window will pop up and show black screen like we usually found when starting a computer. There is almost no deference between virtual system and real machine after it had run. Clicking the guest OS window will force keyboard and mouse connects into that virtual machine. To back into host OS click right CTRL on keyboard.



MB
, CD/DVD-ROM,
isk
MD-V, Nested
, PAE/NX

12 MB
er: Disabled

IDE Controller
IDE Secondary Master (CD/DVD): Empty
SATA Controller
SATA Port 0: SDR_UAI-disk1.vmdk (Normal, 4.00 GB)

Host Driver: Windows DirectSound
Controller: ICH AC97

Figure 2. Activating the package

As the package is activated, the guest OS is launched, then within its desktop the GNU Radio Companion appears automatically, and can simply be clicked to launch.

User Interface Analysis

One of the objectives was to simplify the installation process of GNU Radio Companion and USRP. In this part, a model based evaluation is done as the system performance analysis.

Model-based evaluation is using a model to obtain usability measures of a system as it is approached by user. The method utilize a model of a human-computer interaction situation, representing the designed user interface, to calculate the usability prediction. This model is also called the engineering model or analytical model of usability. Models available are based on task analysis. The models explain how users finished certain tasks by interacting with the designed interface, employing psychological theories to calculate the usability value. Three methods of model-based evaluation are task network models, cognitive architecture models and GOMS model.

This research adapt the task network model, in which the tasks are represented as PERT-like process network. A single process can only begin if all conditions are fulfilled. Each process is assigned a completion time. A process or task may be done by human or machine.

Upon observation, the installation process packed within the virtual system is considered as a one-path sequential process network. Since the user interface designed within the reasearch is regarded to be linear, there is no need to execute a full Monte-Carlo simulation with random events, but simply as the task scenario required. The analysis is done by comparing the steps needed by using the developed virtual system. In order to obtain the performance value, the whole process are simple summed up as the total performance. The statistical result is displayed in table 1.

Counted for table 1 was every step must be taken to get the GNU Radio works. On the middle column, there is conventional steps where user install Ubuntu and GNU Radio on computer. On the right are the steps that required to get GNU Radio works on every computer using virtualization solution.

Table 1. Steps count with and without 'SDR UAI'

NO	Activity	Conventional	With Virtual System
1	Install VirtualBox		9
2	Install Extension Pack		7
3	Create and Prepare VM		-
4	Install Ubuntu	39	-
5	Install Lubuntu	19	-
6	Install GNU Radio + UHD Ettus	49	-
7	Install GNU Radio + UHD Ettus using dpkg	+18	-
8	Install GNU Radio + UHD Scripts		-
9	Install pre-made VM		5
10	Run GNU Radio	3	4
	Total steps	**128**	**25**

Table 2. Installing VirtualBox

Step	**Description**	**Cognitive distribution**
1	Open folder of SDR distribution	External
2	Think what should do	Internal
3	Double Click "README FIRST"	External
4	Recognize what step should take	Internal
5	Double click Installer	External
6	Read warning from UAC	External
7	Click "RUN" key	External
8	Read warning of driver installation	External
9	Click "Install"	External

Table 3. Installing Extension Pack

Step	**Description**	**Cognitive distribution**
1	Double click of file extension pack	External
2	Read explanation of Extention pack	External
3	Click "Run"	External
4	Read License	External
5	Placing cursor into scroll bar	External
6	Scroll down	External
7	Click "I Agree"	External

With straight analysis and evaluation by respondences, it could be concluded that virtualization method is :

(1) reduced the steps required by 5 times;

(2) reduced the time required by more than 10 times;

(3) much simpler because all steps are GUI like "clicked" or "double-clicked"

compare to conventional method.

Detail of steps for virtualization method described in the four tables – table 2 to table 5:

Table 4. Installing Virtual Machine

Step	Description	Cognitive distribution
1	Double Click “SDR_UAI.ova”	External
2	Read “License”	External
3	Click “I Agree”	External
4	Read Virtual Image descriptions	External
5	Click “Import”	External

Table 5. Running GNU Radio

Step	Description	Cognitive distribution
1	Look at VirtualBox window, think what should be clicked	Internal
2	Click on “SDR UAI”	External
3	Click on “Start”	External
4	Double Click on “GNU Radio Companion”	External

By contrast, the conventional method requires user to read carefully almost every step, typing and waiting. This conventional method also need proper internet connection. The worst in dual boot case installing second OS on same machine can disturb the first OS when the user pick wrong step on preparing the disk. From experience, creating working GNU Radio installation needs a half until 2 days, depends on the internet connection and user knowledge on Linux environment while with virtual system it takes less than one hour.

4. Conclusion

The paper has introduced a virtual system as a portable configuration of an OS Ubuntu Linux, packed with GNU Radio Companion from GNU Radio 3.6 and USRP 1. The guest OS also support the usage of USB for communication between computer and USRP.

Utilizing the virtual system has successfully minimize the steps needed to install and operate the GNU Radio Companion, from 128 reduced to 25 steps needed.

The GRC and GNU Radio 3.6 workswell on Ubuntu 12.04 and Ubuntu 11.10 , including the use of Ettus Research repository for the USRP. Installation of GRC and USRP with linux is then modified into a file form, easy to distribute and launch without the necessity of internet connection during the process.

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