INIPRO

Embedded Linux on Zynq

김현옥 (hokim1972@naver.com)

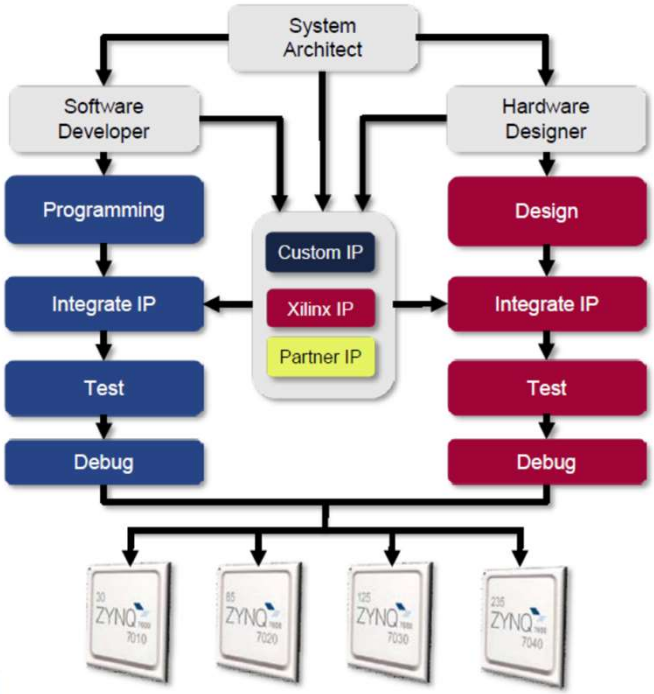
Overview of Zynq

- **Zynq = Dual core ARM (PS: Processing System) + FPGA (PL: Programmable Logic)**
- **Processor concentrated chip**

  Processor runs with minimal(?) PL programming.

  Less flexibility.

  More efficient parallel hardware and software development.



Overview of Zynq PS development

INIPRO

- **Bare-Metal** without OS

  Possible to write fast programs.

  Difficult to realize complex systems with components like webserver, FTP server, USB support and so on.

  SDK Provides ARM Toolchain.

- **Real-Time OS**

  For applications with strict time constraints.

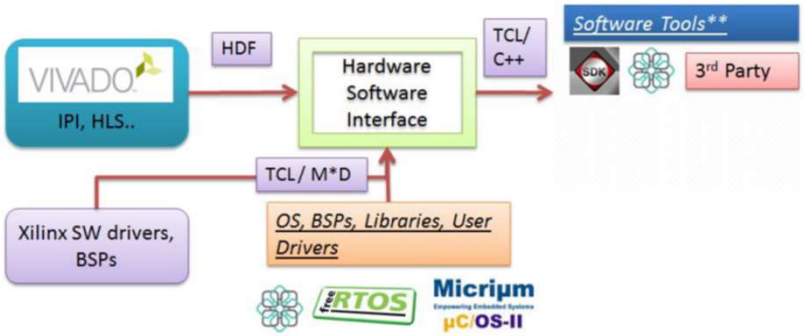
  Most are commercial.

- **Linux**

  Greatest flexibility.

  Many drivers, libraries and software package.

Development Tool



- **Vivado** GUI, CUI(2015.4)

  Design hardware

  Generate bit/hdf files

- **HSI** Hardware Software Interface

  Scalable framework enabled SW tool integration with Vivado

  Compile FSBL / Generate DT

- **Ubuntu** (16.04 LTS)

  (Host) Compile u-boot, kernel and DT

  (Target) Compile drivers / applications

Development Environment Set-up

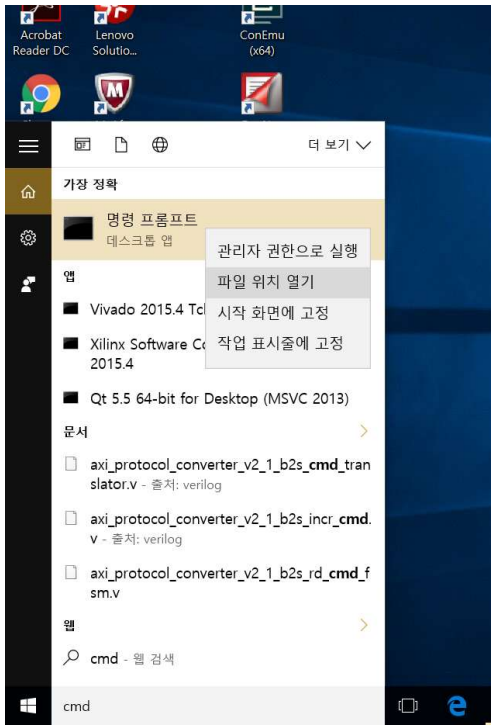
INIPRO

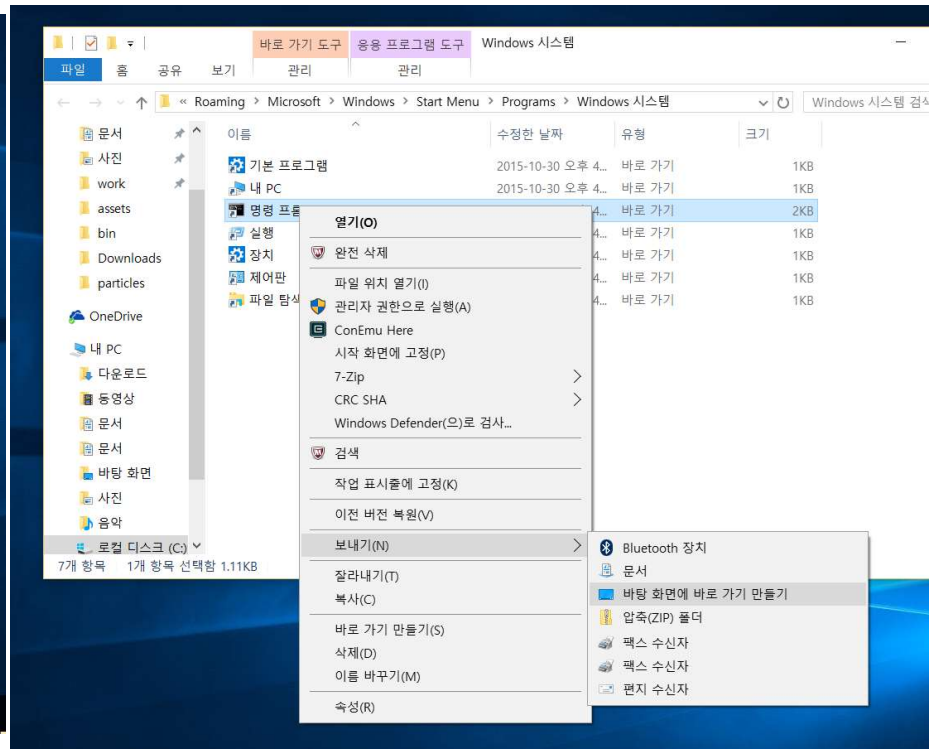
- **Windows** 10

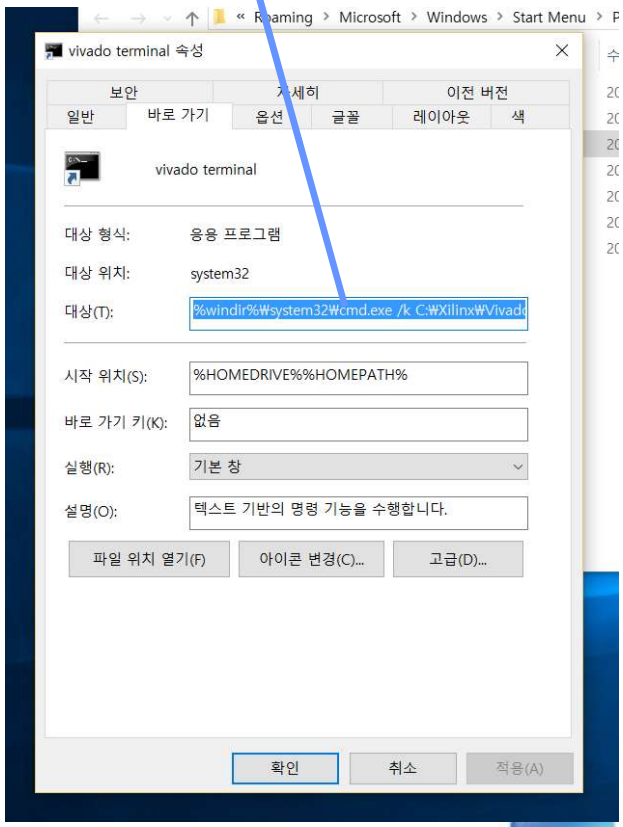
  Install Vivado 2015.4 w/ SDK.

  cmd terminal for Vivado.

  %windir%\system32\cmd.exe /k C:\Xilinx\Vivado\2015.4\settings64.bat



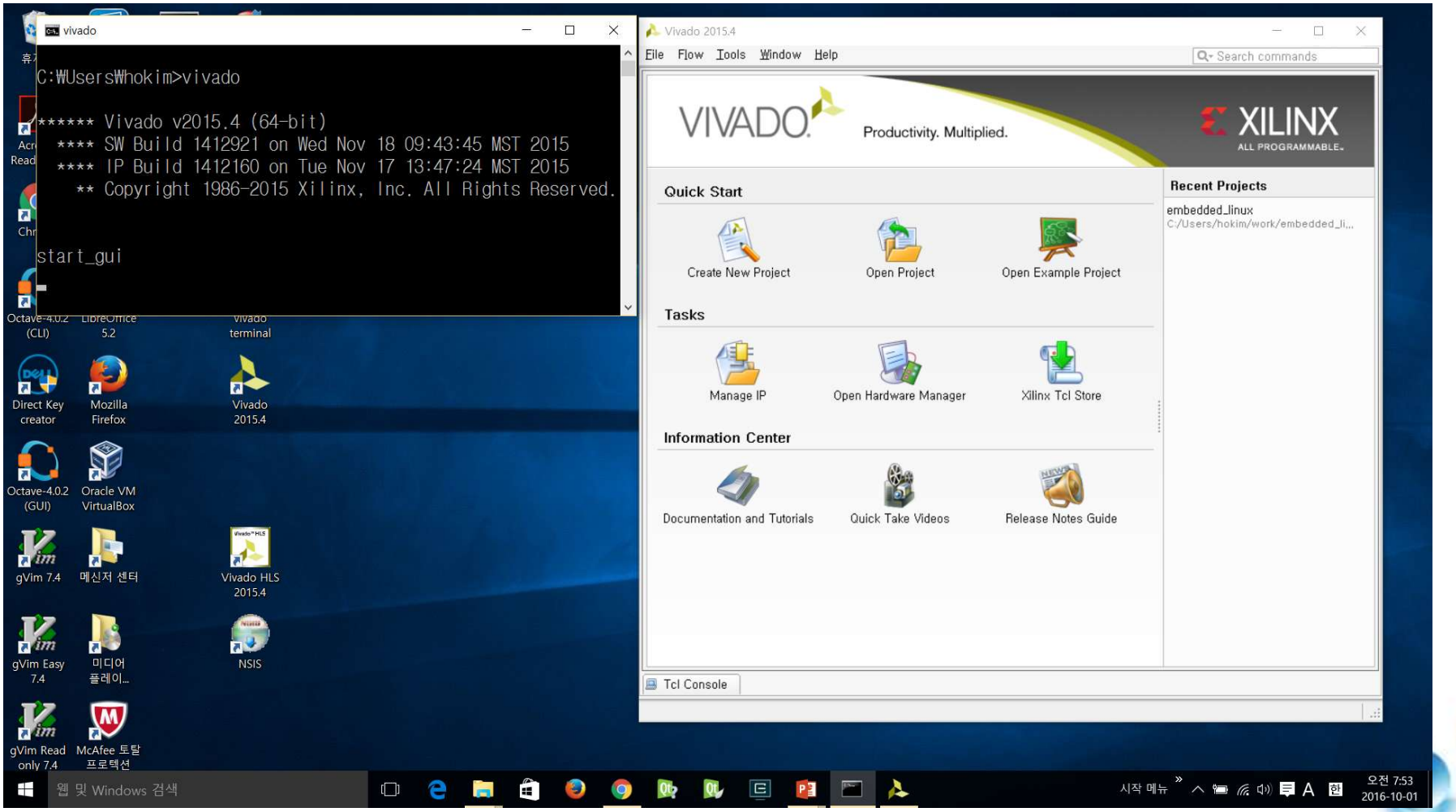




Development Environment Set-up

INIPRO

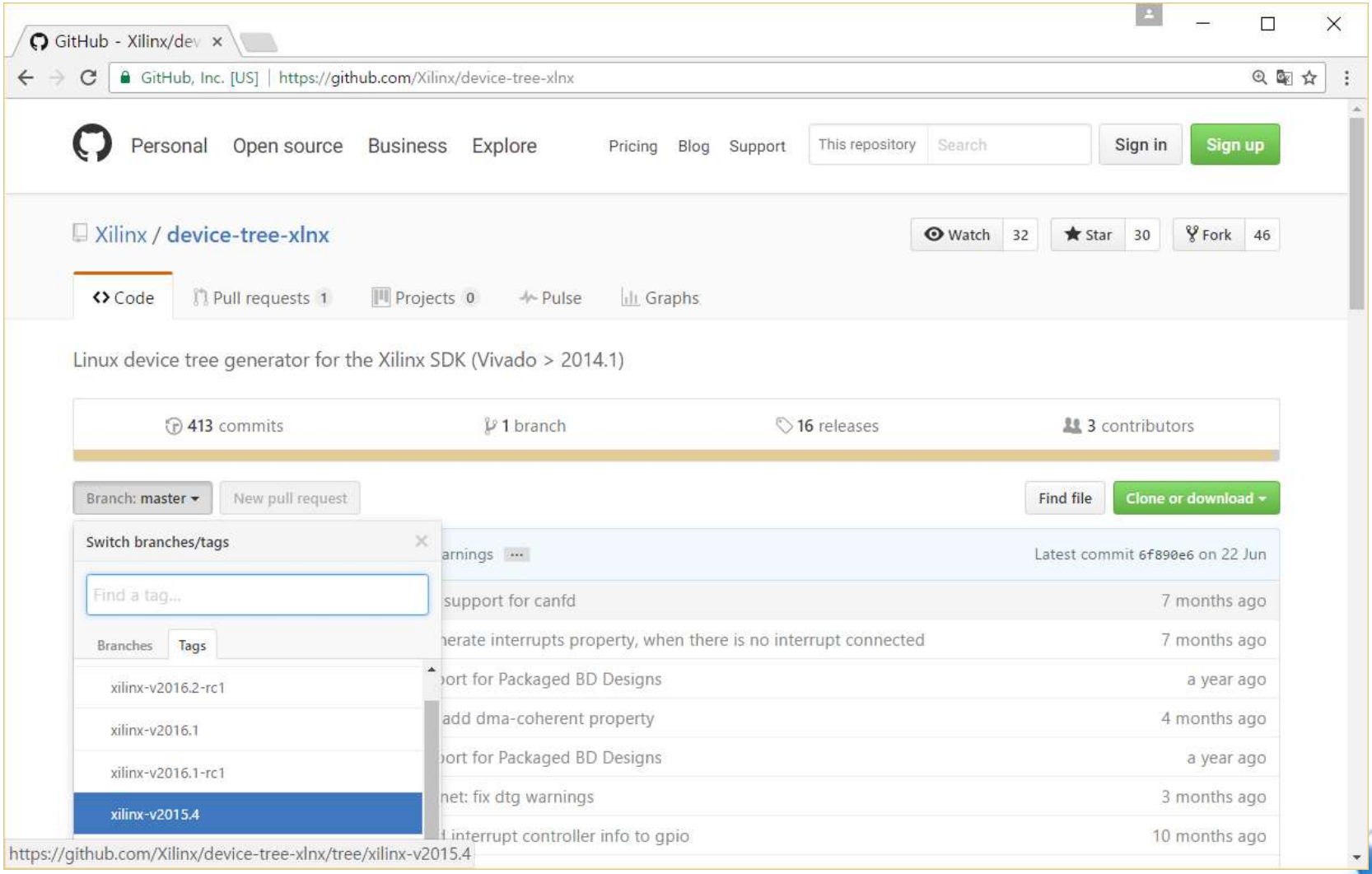
- **cmd terminal** for Vivado.



Development Environment Set-up

INIPRO

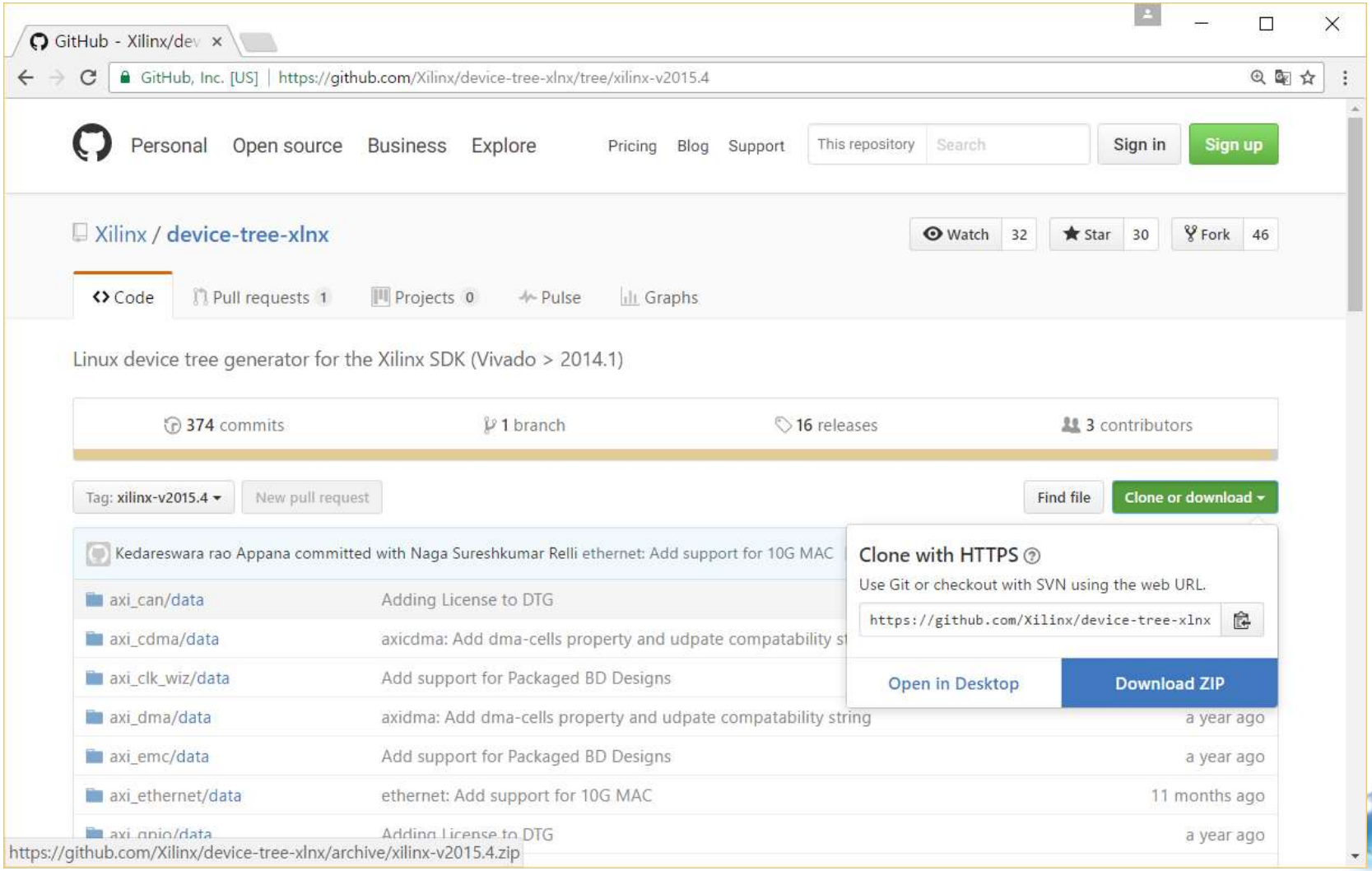
- **Device Tree Source**



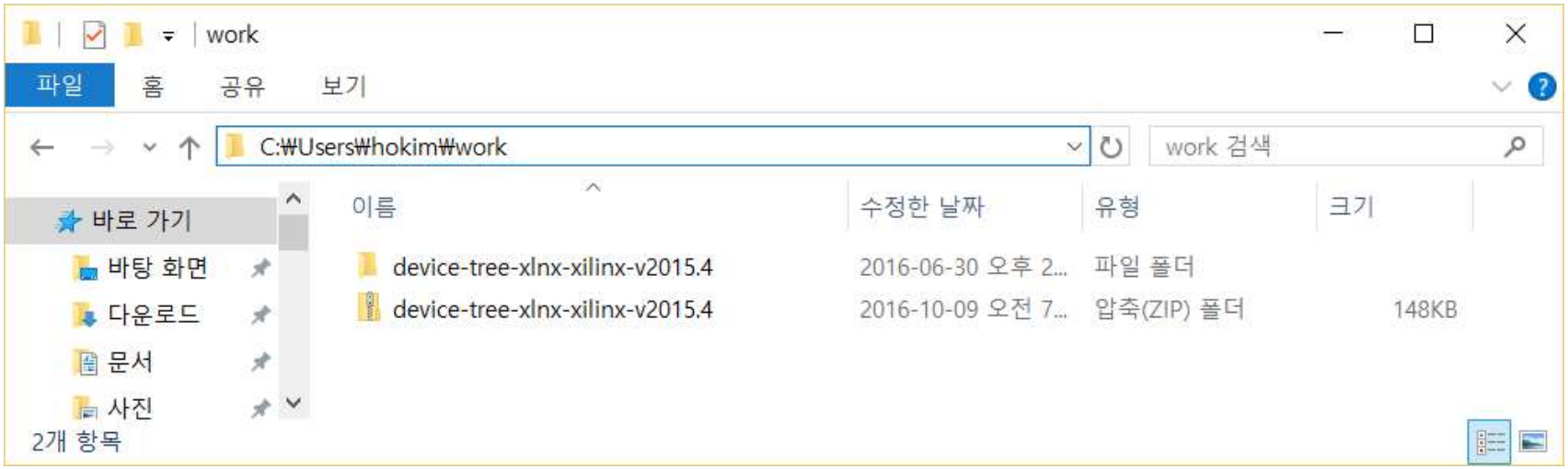
Development Environment Set-up

INIPRO

- **Device Tree Source**



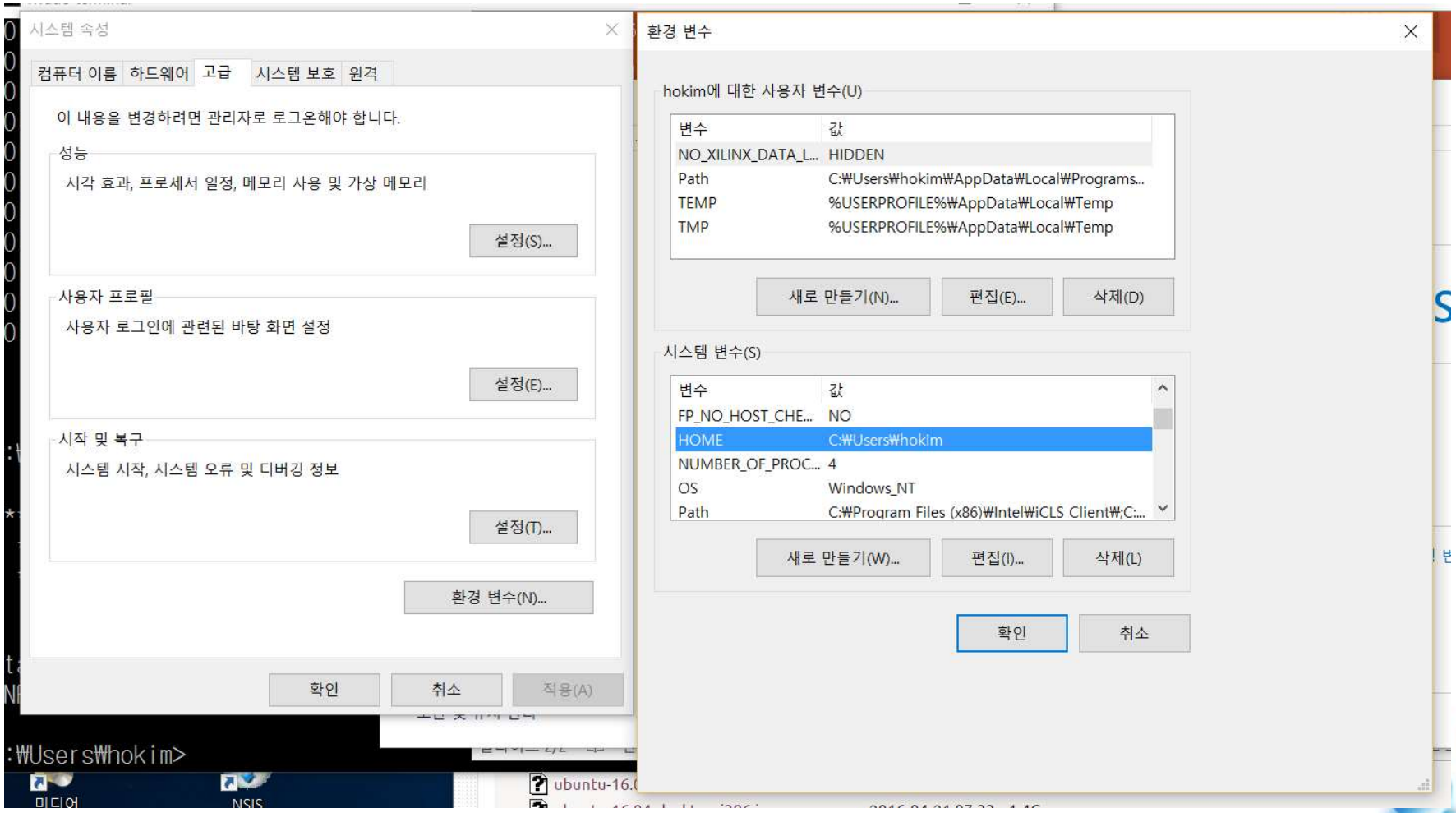
Device Tree Source



Development Environment Set-up

INIPRO

- **Environment Variable(HOME)**



Development Environment Set-up

INIPRO

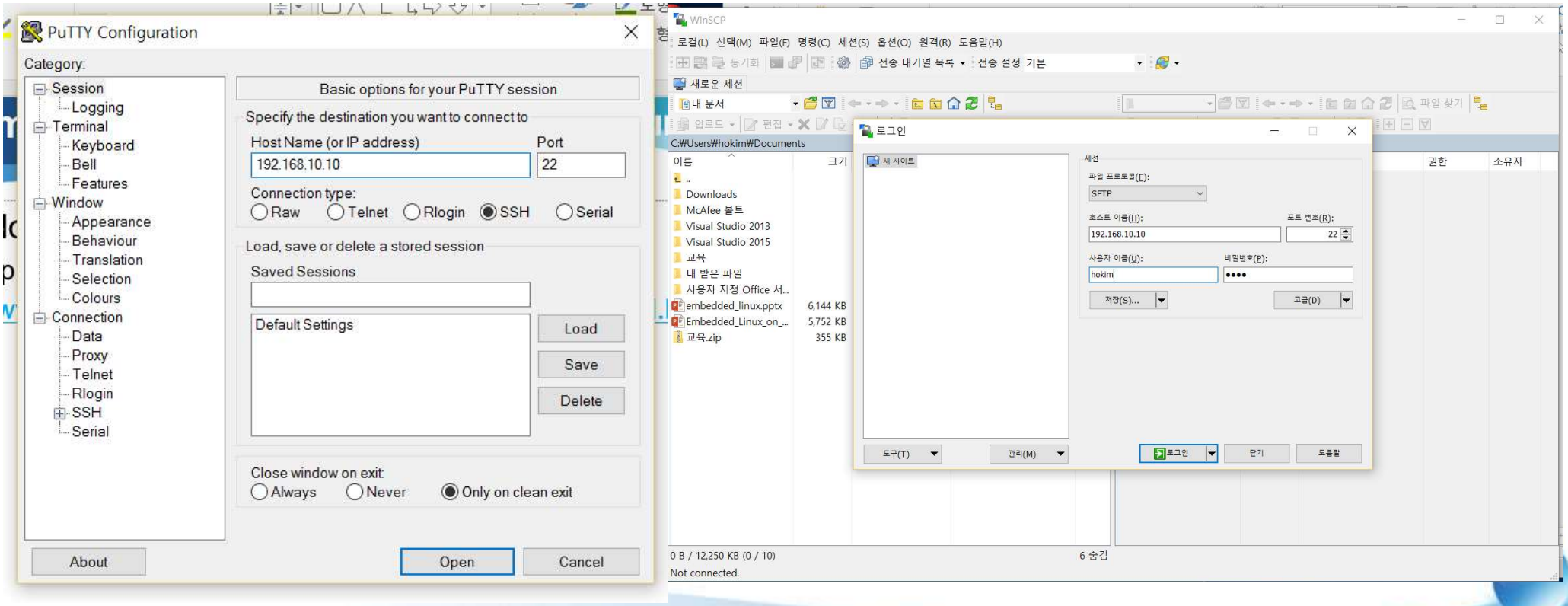
- **Windows ←→ Ubuntu**

Install putty.exe for remote login shell.

(http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html)

Install WinSCP for file transfer.

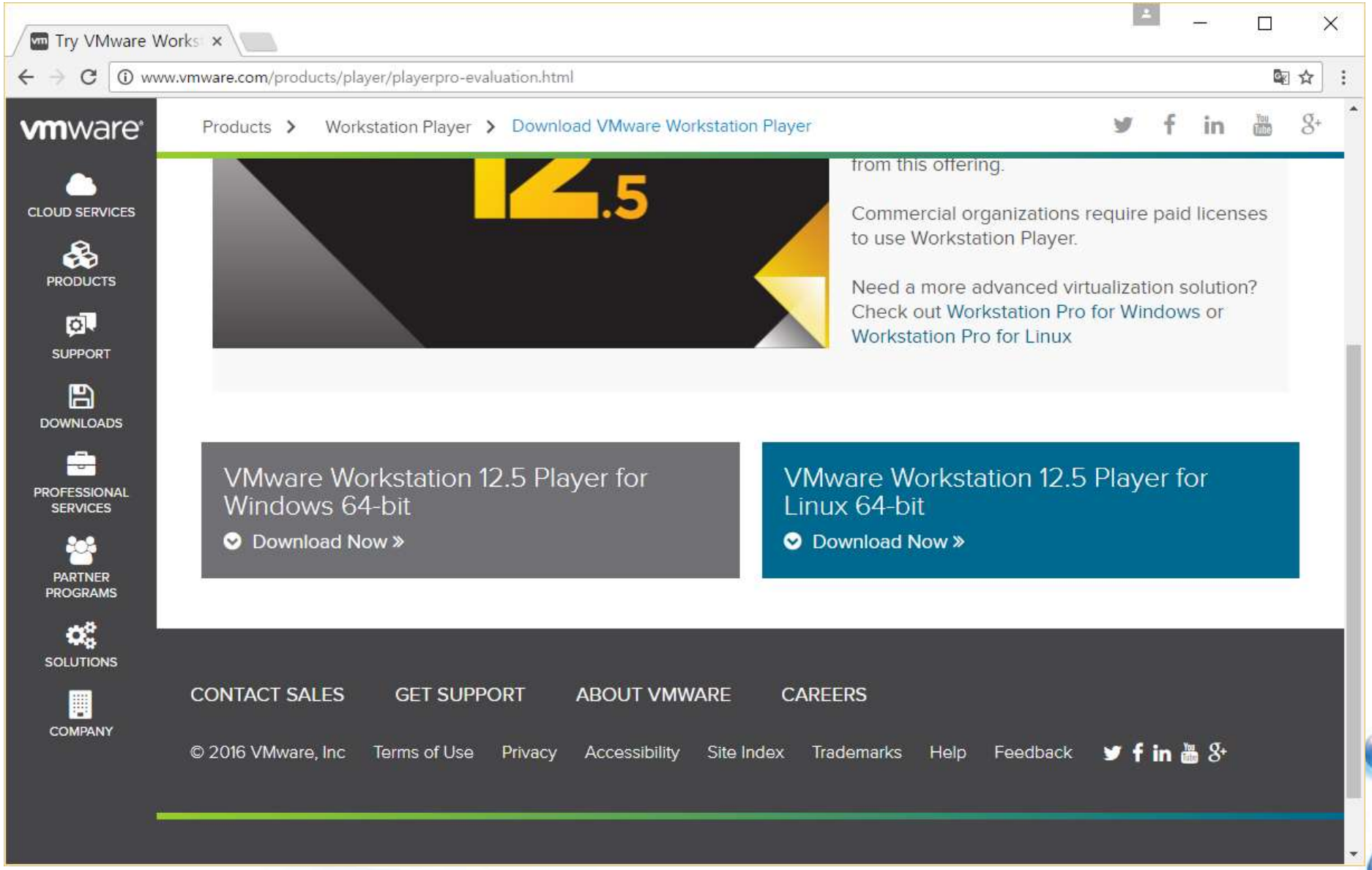
(https://winscp.net/eng/download.php)



Development Environment Set-up

INIPRO

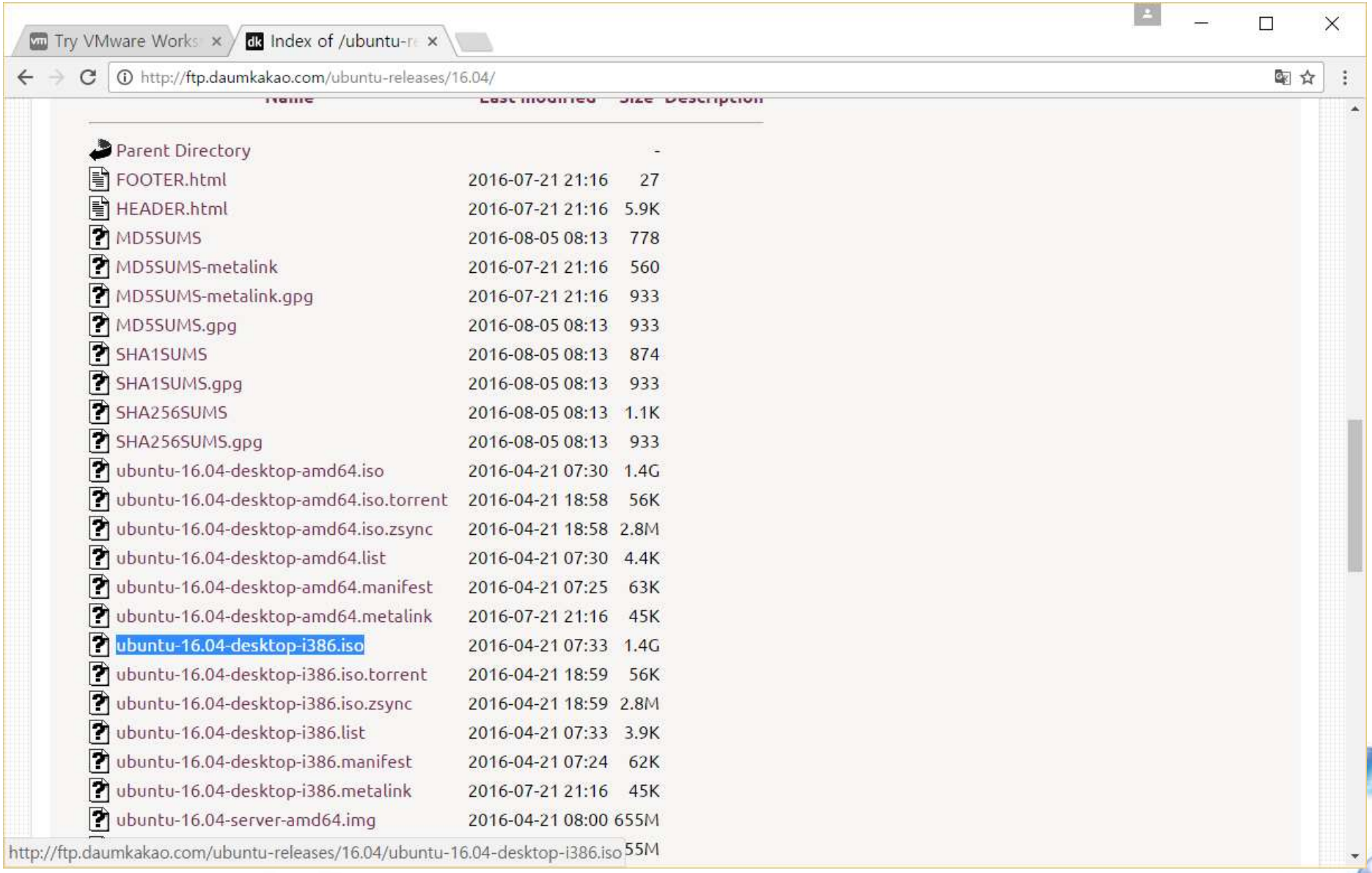
- **Ubuntu on VMware-player**



Development Environment Set-up

INIPRO

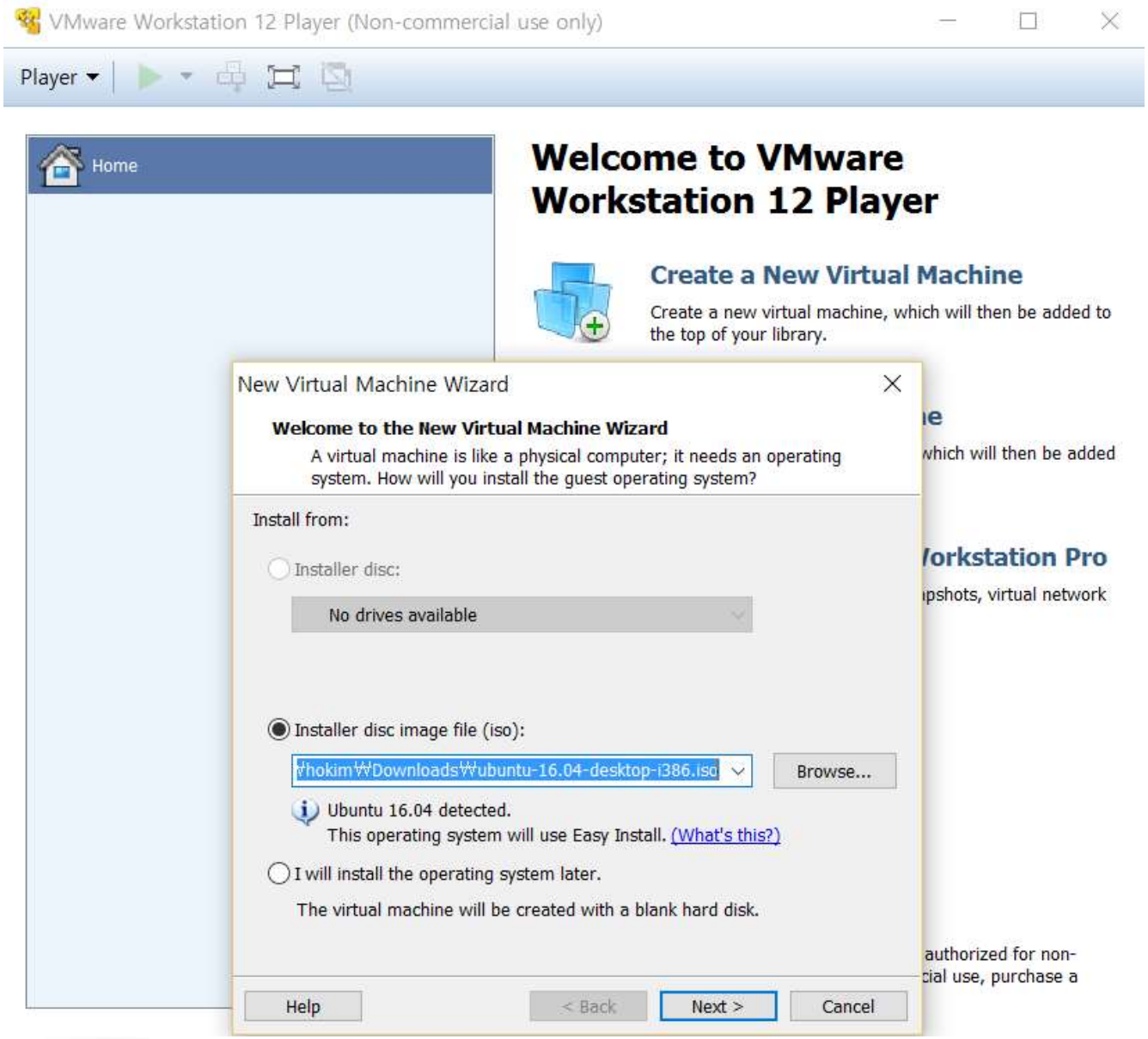
- **Ubuntu on VMware-player**



Development Environment Set-up

INIPRO

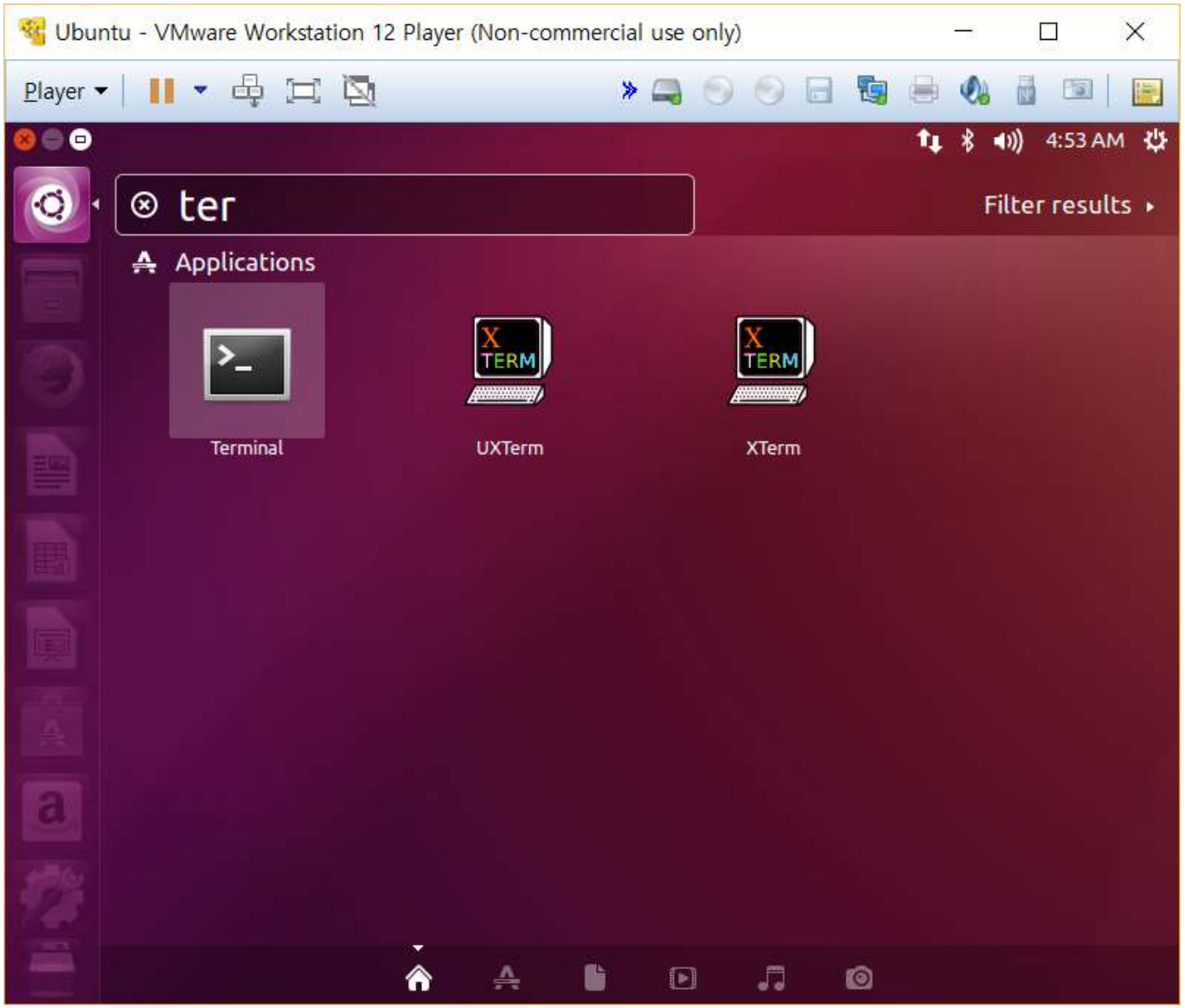
- Ubuntu on VMware-player



Development Environment Set-up

INIPRO

- **Ubuntu on VMware-player**

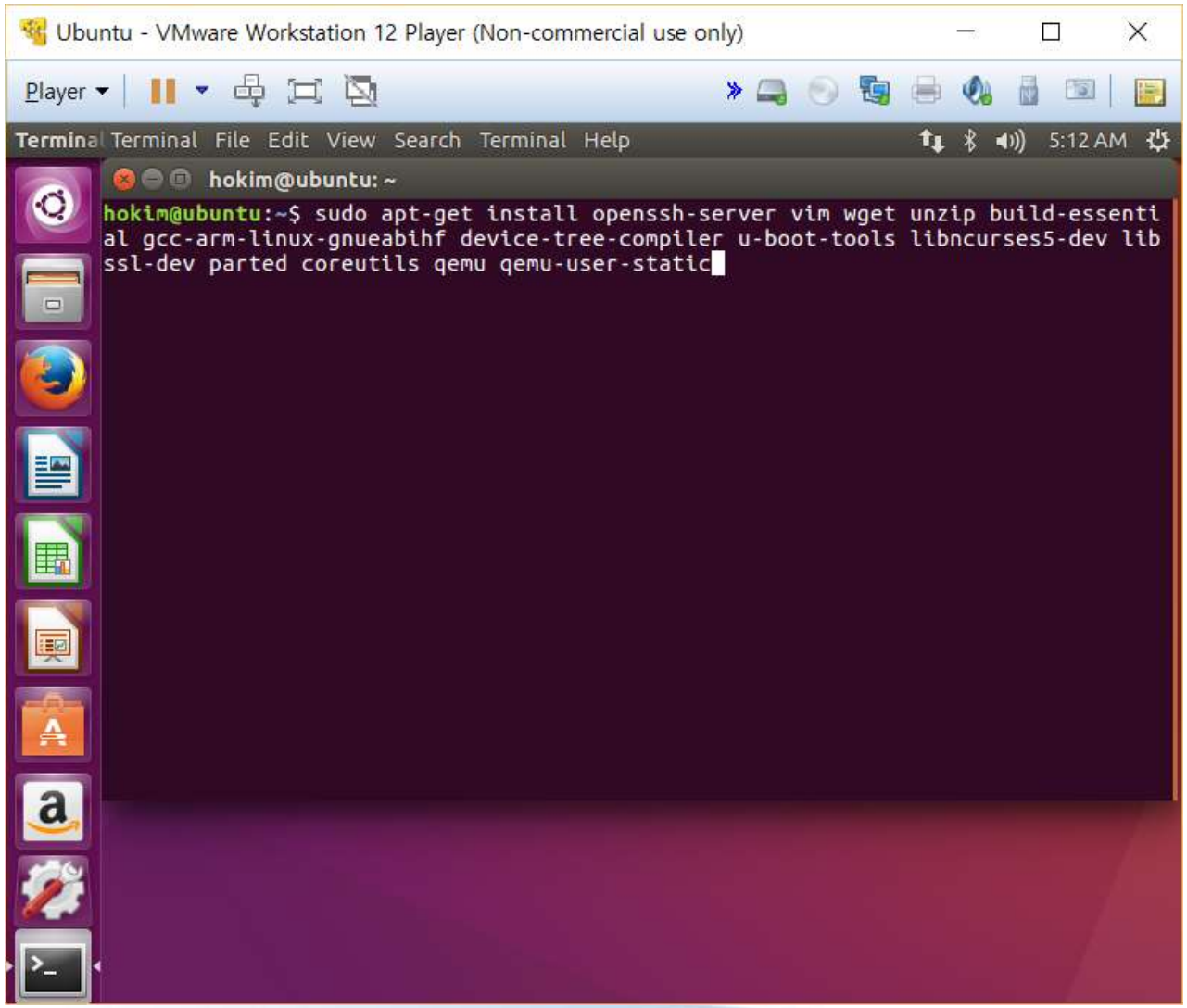


Development Environment Set-up

INIPRO

Ubuntu on VMware-player

$ sudo apt-get install openssh-server vim wget unzip build-essential gcc-arm-linux-gnueabihf device-tree-compiler u-boot-tools libncurses5-dev libssl-dev parted coreutils qemu qemu-user-static



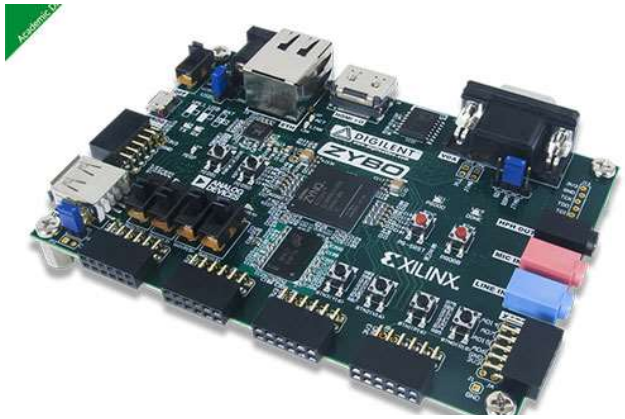
Development Process

INIPRO

- **Target Board** Zybo(Zynq-7010)

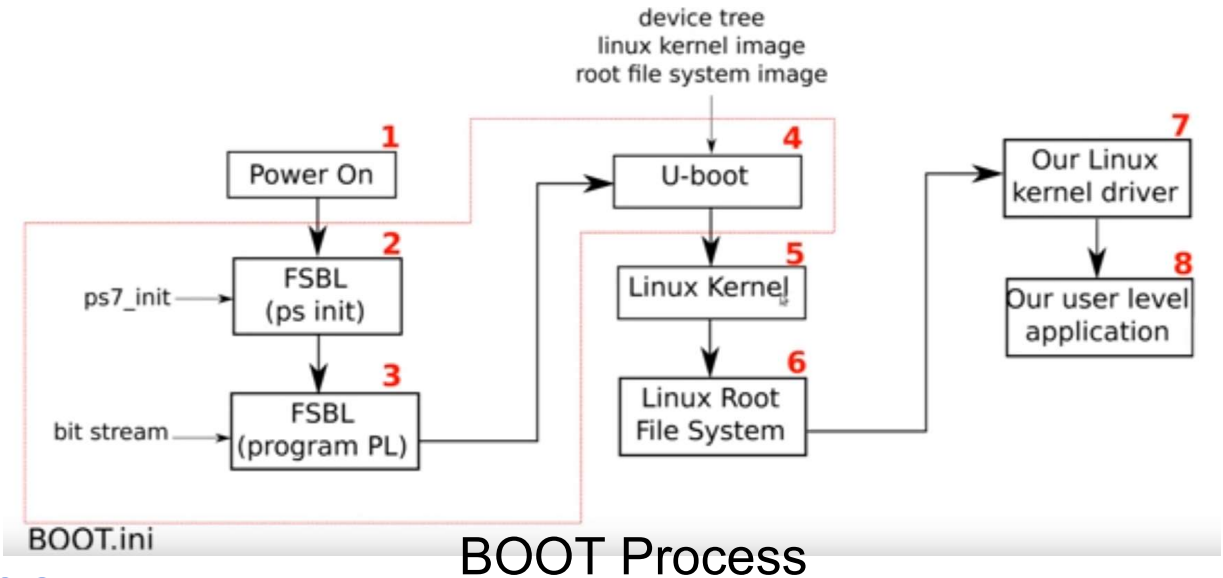
  Gigabit Ethernet, USB, SD, UART

  28,000 logic cells, 240 KB BRAM



- **Development Process**

1. bit stream
2. FSBL
3. DT Generation
4. u-boot
5. DT Compile
6. linux kernel image
7. root file system image
8. BOOT.bin(fsbl + bit + u-boot)
9. Update BOOT.bin / DT / kernel
10. (user kernel driver)/user application



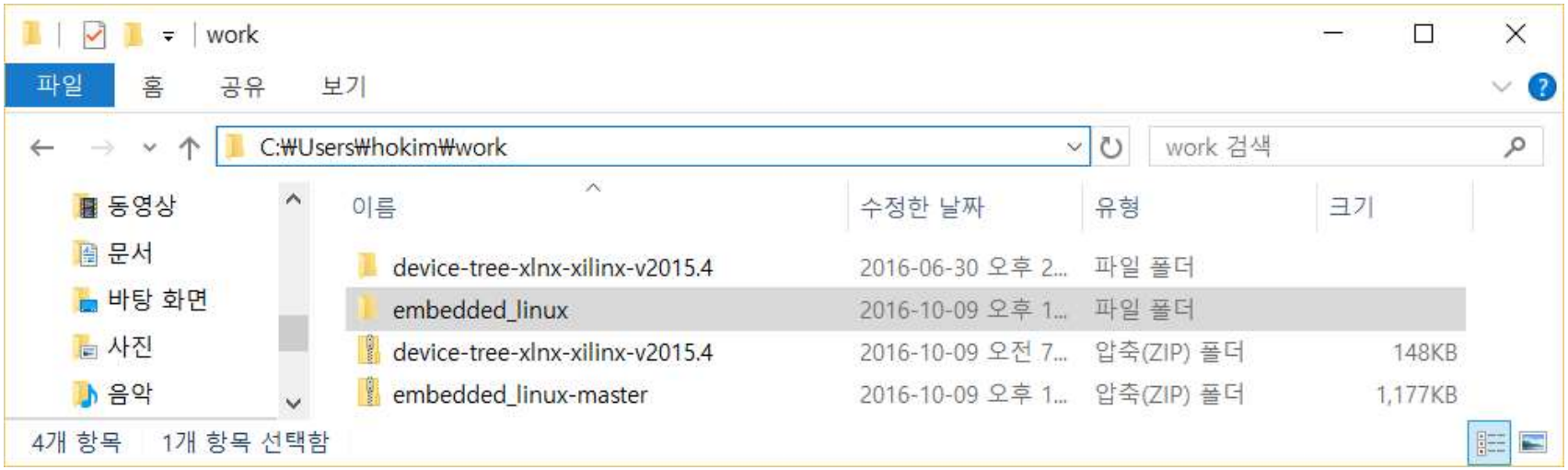
BOOT Process

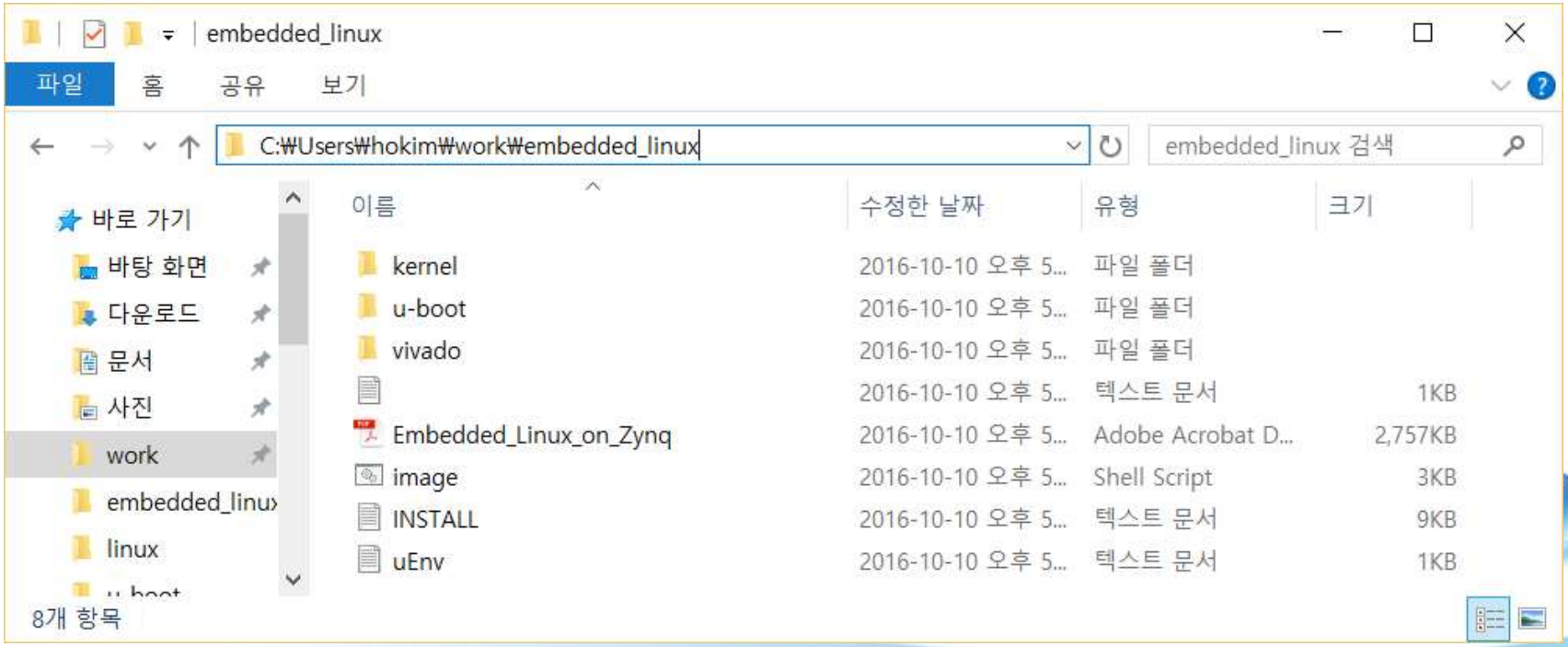
Development Process

INIPRO

- **Source code**

https://github.com/inipro/embedded_linux





Design of Zynq PS Hardware

INIPRO

- **Vivado Design**

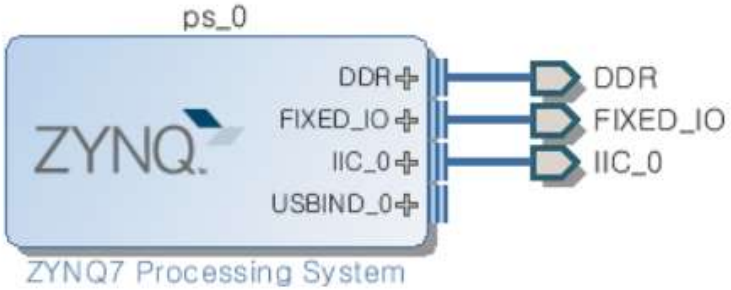
SD0 (boot files, root file system)

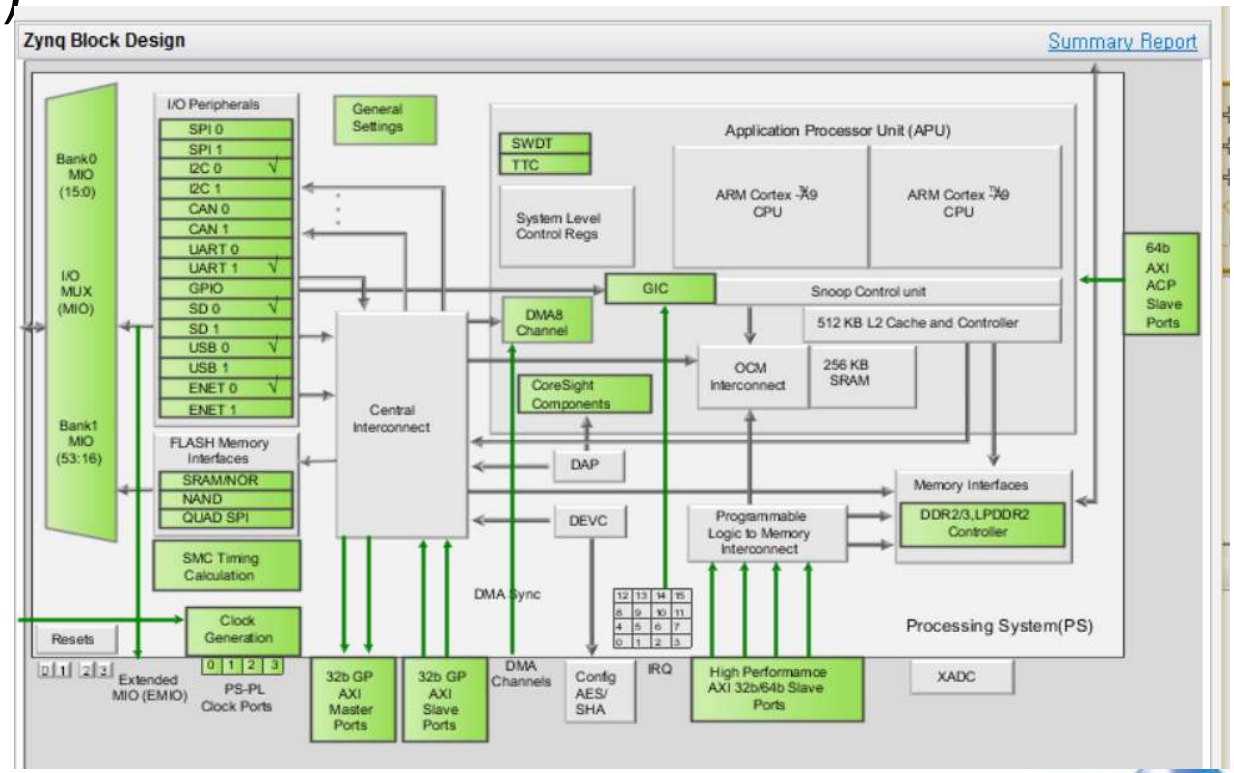
UART1 (console)

I2C0 (eeprom w/ Ethernet mac address; EMIO)

USB0 (usb host)

ENET0 (Gigabit Ethernet)





Vivado Project

INIPRO

embedded_linux.tcl

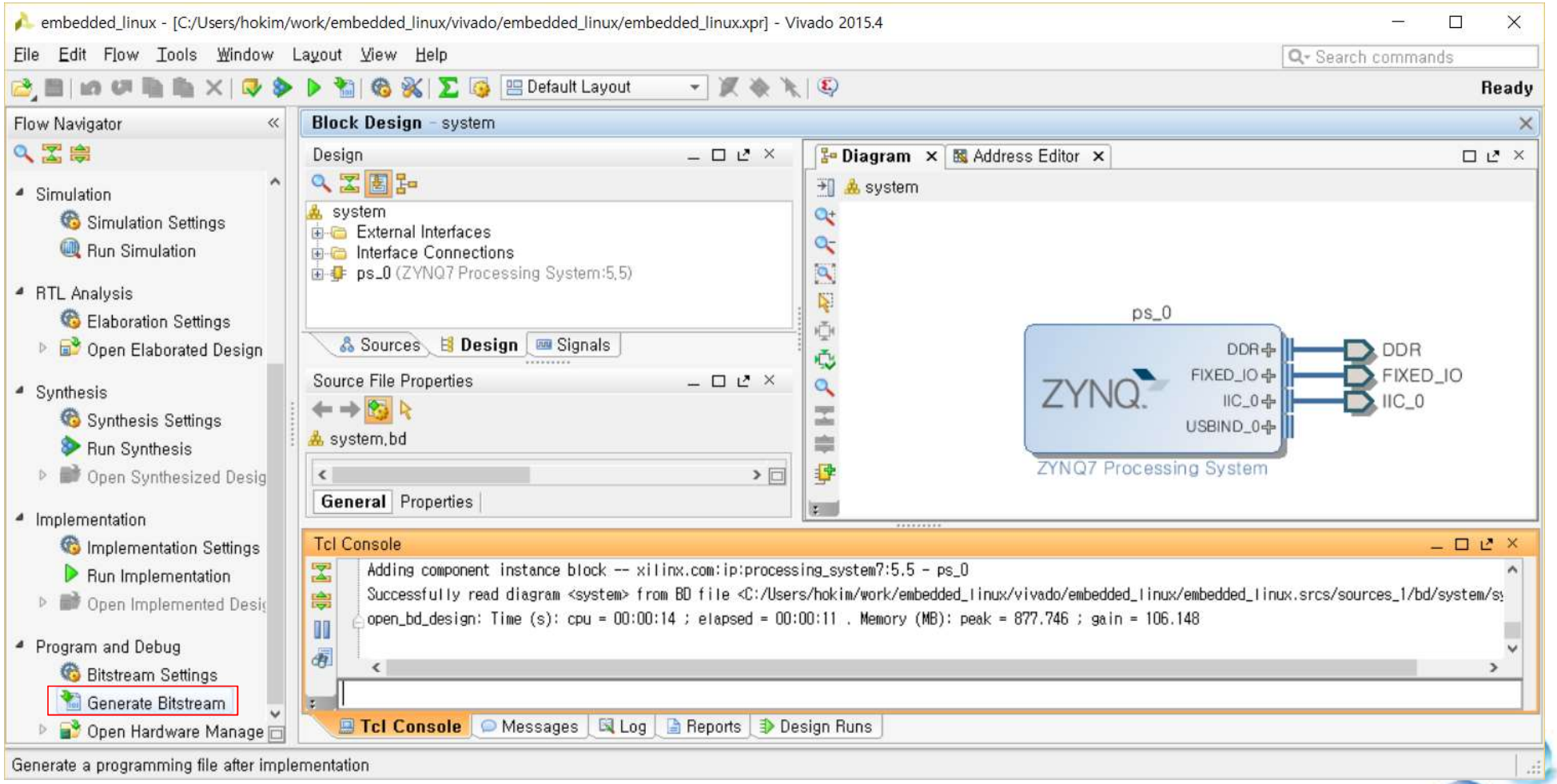
```
set project_name embedded_linux
set part_name xc7z010clg400-1
#set ip_dir ip
set bd_path $project_name/$project_name.srcs/sources_1/bd/system
file delete -force $project_name
create_project -part $part_name $project_name $project_name
#set_property ip_repo_paths $ip_dir [current_project]
#update_ip_catalog
create_bd_design system

create_bd_cell -type ip -vlnv xilinx.com:ip:processing_system7:5.5 ps_0
source embedded_linux_preset.tcl
set_property -dict [apply_preset IPINST] [get_bd_cells ps_0]
apply_bd_automation -rule xilinx.com:bd_rule:processing_system7 -config {
                make_external {FIXED_IO, DDR}
} [get_bd_cells ps_0]
create_bd_intf_port -mode Master -vlnv xilinx.com:interface:iic_rtl:1.0 IIC_0
connect_bd_intf_net [get_bd_intf_pins ps_0/IIC_0] [get_bd_intf_ports IIC_0]

generate_target all [get_files $bd_path/system.bd]
make_wrapper -files [get_files $bd_path/system.bd] -top
add_files -norecurse $bd_path/hdl/system_wrapper.v
add_files -norecurse -fileset constrs_1 zybo.xdc
set_property verilog_define {TOOL_VIVADO} [current_fileset]
close_project
```

In cmd window for Vivado

```
C:\ cd C:\Users\hokim\work\embedded_linux\vivado
C:\ vivado  -nolog -nojournal -mode batch -source embedded_linux.tcl
```

output : embedded_linux\embedded_linux.xpr…

Bit Generation



HDF Generation

INIPRO

hwdef.tcl

```
# vivado -nolog -nojournal -mode batch -source hwdef.tcl

set project_name embedded_linux

open_project $project_name/$project_name.xpr

if {[get_property PROGRESS [get_runs synth_1]] != "100%"} {
                launch_runs synth_1
                wait_on_run synth_1
}

file delete -force $project_name/$project_name.hwdef

write_hwdef -force -file $project_name/$project_name.hwdef

close_project
```

```
C:\ vivado  -nolog -nojournal -mode batch -source hwdef.tcl
```

output : embedded_linux\embedded_linux.hwdef

FSB Compile

INIPRO

fsbl.tcl

```
# hsi -nolog -nojournal -mode batch -source fsbl.tcl

set project_name embedded_linux

set hard_path $project_name/$project_name.hard
set fsbl_path $project_name/$project_name.fsbl

file delete -force $hard_path $fsbl_path

file mkdir $hard_path
file copy -force $project_name/$project_name.hwdef $hard_path/$project_name.hdf

open_hw_design $hard_path/$project_name.hdf
create_sw_design -proc ps7_cortexa9_0 -os standalone fsbl

add_library xilffs
add_library xilrsa

generate_app -proc ps7_cortexa9_0 -app zynq_fsbl -dir $fsbl_path -compile

close_hw_design [current_hw_design]
```

```
C:\ hsi  -nolog -nojournal -mode batch -source fsbl.tcl
```

output : embedded_linux\embedded_linux.fsbl/executable.elf

DT Generation

INIPRO

devicetree.tcl

```
# hsi -nolog -nojournal -mode batch -source devicetree.tcl

set project_name embedded_linux

set boot_args {console=ttyPS0,115200 root=/dev/mmcblk0p2 ro rootfstype=ext4 earlyprintk rootwait}

set hard_path $project_name/$project_name.hard
set tree_path $project_name/$project_name.tree

file delete -force $hard_path $tree_path

file mkdir $hard_path
file copy -force $project_name/$project_name.hwdef $hard_path/$project_name.hdf

set_repo_path $::env(HOME)/work/device-tree-xlnx-xilinx-v2015.4

open_hw_design $hard_path/$project_name.hdf
create_sw_design -proc ps7_cortexa9_0 -os device_tree devicetree

set_property CONFIG.kernel_version {2015.4} [get_os]
set_property CONFIG.bootargs $boot_args [get_os]

generate_bsp -dir $tree_path

close_sw_design [current_sw_design]
close_hw_design [current_hw_design]
```

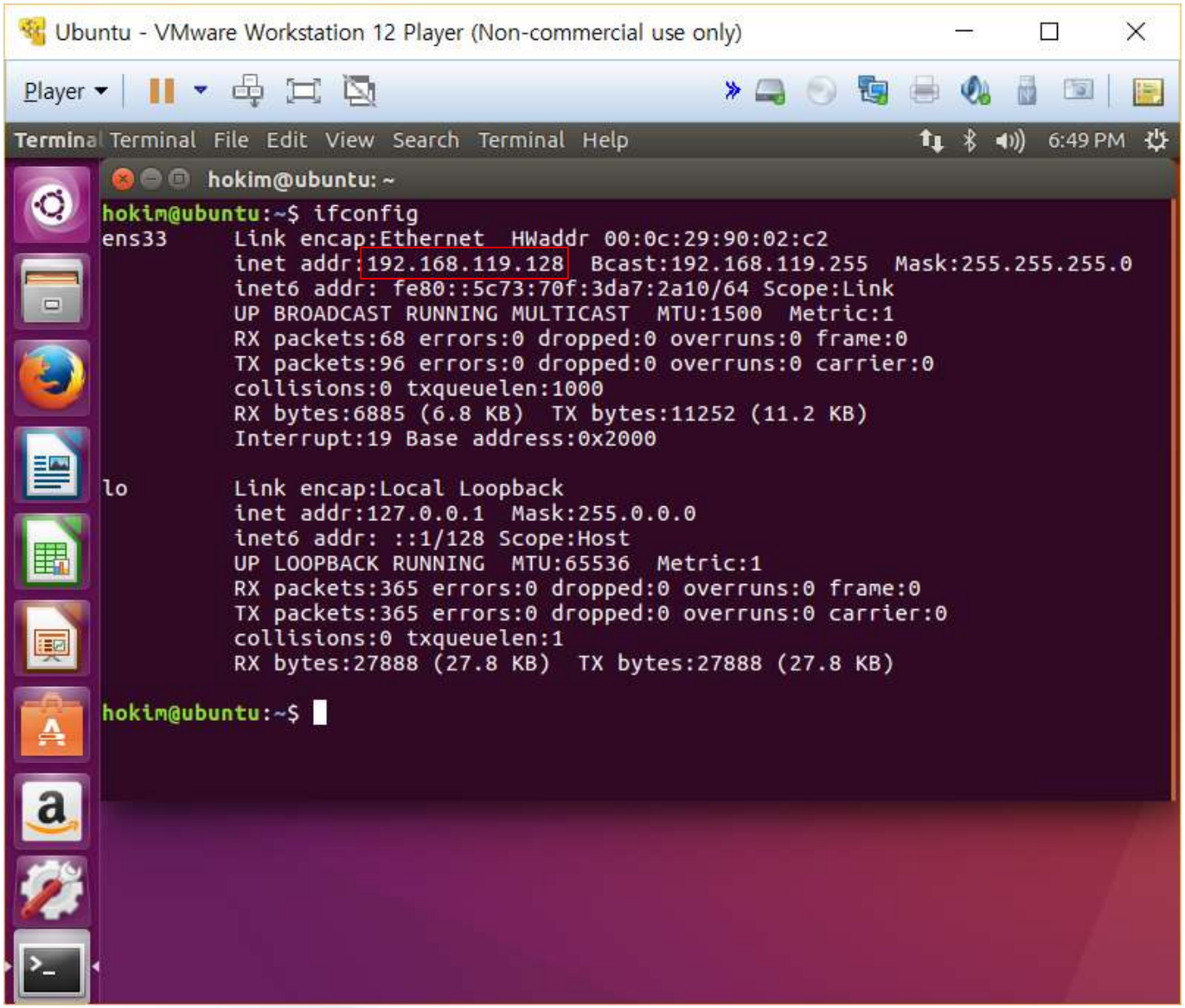
```
C:\ hsi  -nolog -nojournal -mode batch -source devicetree.tcl
```

output : embedded_linux\embedded_linux.tree/*

File Transfer (Windows → Ubuntu)

INIPRO

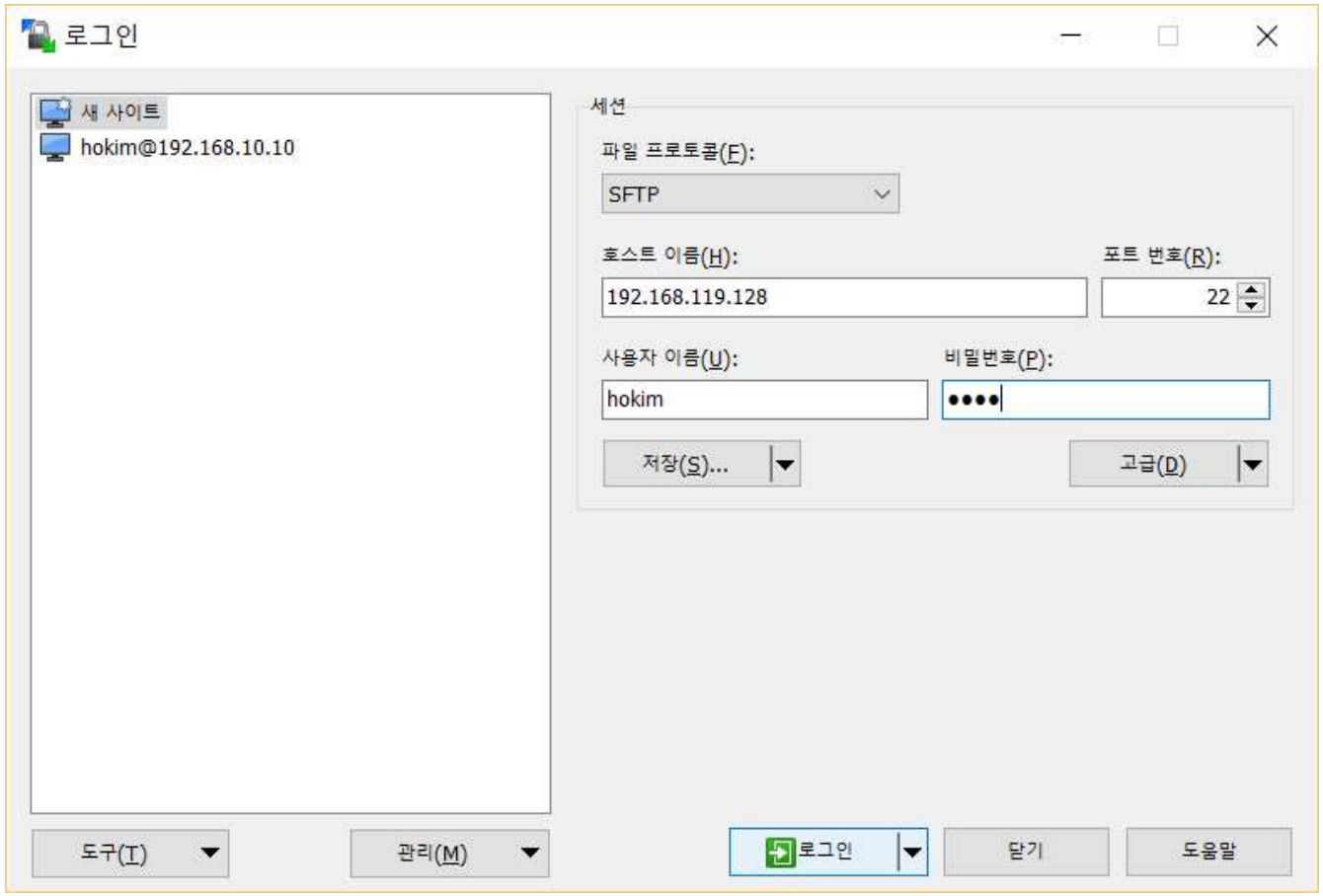
Ubuntu network IP



File Transfer (Windows → Ubuntu)

INIPRO

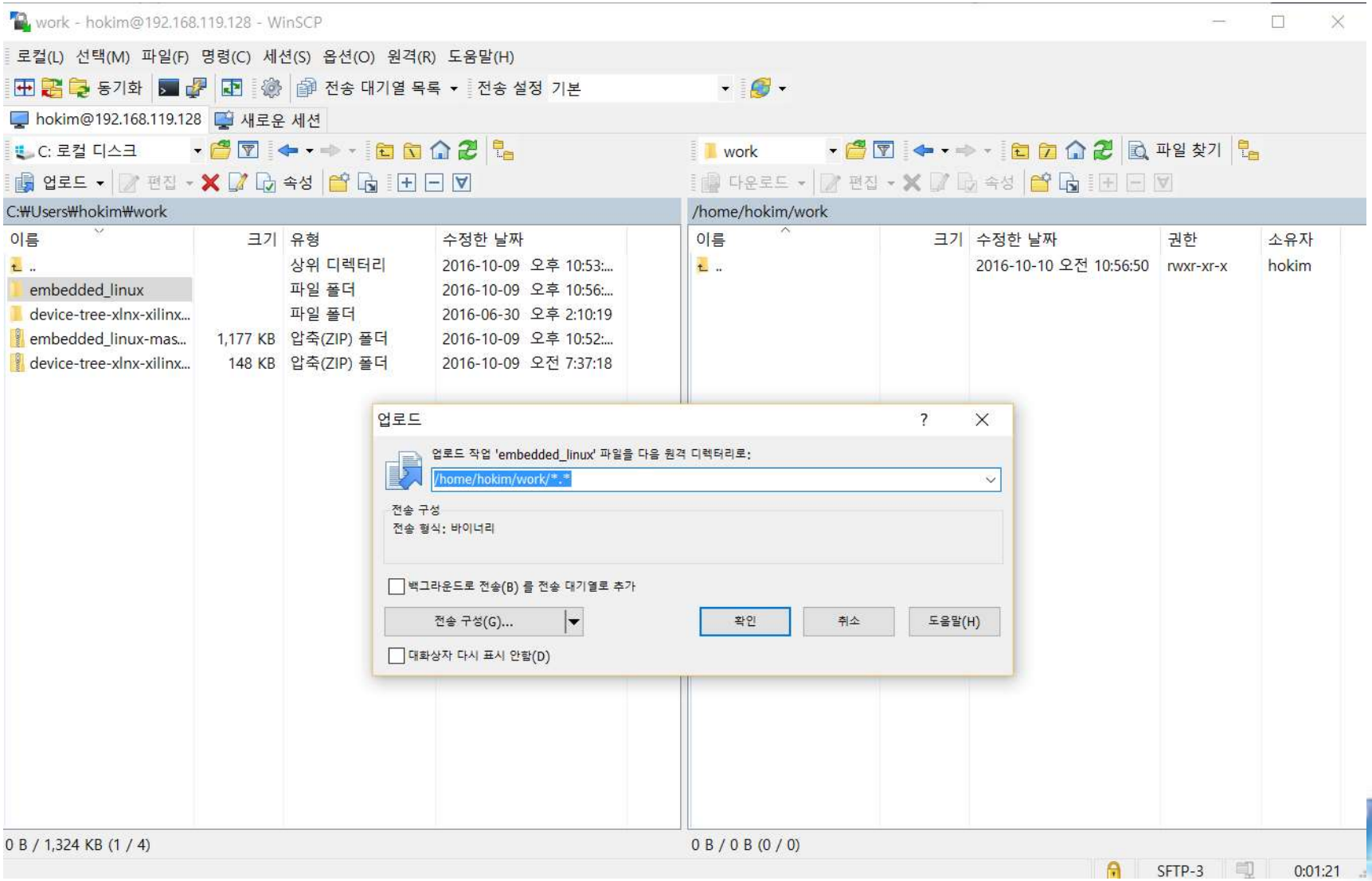
embedded_linux using WinSCP



File Transfer (Windows → Ubuntu)

INIPRO

embedded_linux using WinSCP



- **Boot loader** for linux

  Load linux kernel(uImage, devicetree.dtb) from SD to DRAM.

  Set ethernet using mac address from i2c eeprom.

  Boot uImage.

u-boot Compile

In Terminal of Ubuntu
Can use gedit instead of vi
- - : deletion
- + : insert

```
$ cd ~/work/embedded_linux
$ mkdir -p dl
$ wget https://github.com/Xilinx/u-boot-xlnx/archive/xilinx-
v2015.4.tar.gz -O dl/u-boot-xlnx-xilinx-v2015.4.tar.gz
$ cd u-boot
$ tar xvzf ../dl/u-boot-xlnx-xilinx-v2015.4.tar.gz
$ cd u-boot-xlnx-xilinx-v2015.4
$ nano board/xilinx/zynq/board.c
```

u-boot Compile

INIPRO

board/Xilinx/zynq/board.c

```
int board_late_init(void)
{
+   #if defined(CONFIG_ZYNQ_GEM_EEPROM_ADDR) && \
+       defined(CONFIG_ZYNQ_GEM_I2C_MAC_OFFSET)
+           unsigned char enetaddr[6];
+
+           if (eeprom_read(CONFIG_ZYNQ_GEM_EEPROM_ADDR,
+                           CONFIG_ZYNQ_GEM_I2C_MAC_OFFSET,
+                           enetaddr, ARRAY_SIZE(enetaddr)))
+                   printf("I2C EEPROM MAC address read failed\n");
+           else
+                   eth_setenv_enetaddr("ethaddr", enetaddr);
+   #endif
+
    switch ((zynq_slcr_get_boot_mode()) & ZYNQ_BM_MASK) {
    case ZYNQ_BM_QSPI:
```

$ nano common/main.c

common/main.c

```
 if (cli_process_fdt(&s))
        cli_secure_boot_cmd(s);

+               setenv("fdt_high", "0x1E000000");
+               setenv("sdboot", "echo Importing environment from SD... && mmcinfo && fatload mmc 0 0x2000000 uEnv.txt &&
env import -t 0x2000000 ${filesize} && boot");

    autoboot_command(s);
```

u-boot Compile

```
$ cp ../zynq-zyboc.dts arch/arm/dts
$ cp ../zynq_zyboc.h include/configs
$ cp ../zynq_zyboc_defconfig configs
```

arch/arm/dts/zynq-zyboc.dts

```
/dts-v1/;
#include "zynq-7000.dtsi"

/ {
        model = "Zynq ZYBOC Development Board";
        compatible = "inipro,zynq-zyboc", "xlnx,zynq-7000";

        aliases {
                ethernet0 = &gem0;
                serial0 = &uart1;
        };

        memory {
                device_type = "memory";
                reg = <0x0 0x20000000>;
        };

        chosen {
                bootargs = "earlyprintk";
                linux,stdout-path = &uart1;
                stdout-path = &uart1;
        };

};
```

```
&clkc {
        ps-clk-frequency = <50000000>;
};

&gem0 {
        status = "okay";
        phy-mode = "rgmii-id";
        phy-handle = <&ethernet_phy>;

        ethernet_phy: ethernet-phy@0 {
                reg = <0>;
        };
};

&sdhci0 {
        status = "okay";
};

&uart1 {
        status = "okay";
};
```

u-boot Compile

INIPRO

include/configs/zynq_zyboc.h

```
#ifndef __CONFIG_ZYNQ_ZYBOC_H
#define __CONFIG_ZYNQ_ZYBOC_H

#define CONFIG_SYS_SDRAM_SIZE (512 * 1024 * 1024)

#define CONFIG_ZYNQ_SERIAL_UART1
#define CONFIG_ZYNQ_GEM0
#define CONFIG_ZYNQ_GEM_PHY_ADDR0  0

#define CONFIG_SYS_NO_FLASH

#define CONFIG_ZYNQ_SDHCI0
#define CONFIG_ZYNQ_I2C0
#define CONFIG_SYS_I2C_EEPROM_ADDR_LEN 1
#define CONFIG_CMD_EEPROM
#define CONFIG_ZYNQ_GEM_EEPROM_ADDR    0x50
#define CONFIG_ZYNQ_GEM_I2C_MAC_OFFSET 0xFA
#define CONFIG_ZYNQ_BOOT_FREEBSD

/* Define ZYBO PS Clock Frequency to 50MHz */
#define CONFIG_ZYNQ_PS_CLK_FREQ       50000000UL

#include <configs/zynq-common.h>

#endif /* __CONFIG_ZYNQ_ZYBOC_H */
```

u-boot Compile

INIPRO

include/configs/zynq_zyboc.h

```
CONFIG_ARM=y
CONFIG_ARCH_ZYNQ=y
CONFIG_TARGET_ZYNQ_ZYBOC=y
CONFIG_DEFAULT_DEVICE_TREE="zynq-zyboc"
# CONFIG_SYS_MALLOC_F is not set
CONFIG_SPL=y
CONFIG_FIT=y
CONFIG_FIT_VERBOSE=y
CONFIG_FIT_SIGNATURE=y
# CONFIG_CMD_IMLS is not set
# CONFIG_CMD_FLASH is not set
# CONFIG_CMD_SETEXPR is not set
CONFIG_OF_EMBED=y
```

$ nano arch/arm/dts/Makefile

```
dtb-$(CONFIG_ARCH_ZYNQ) += zynq-zc702.dtb \
    zynq-zc706.dtb \
    zynq-zed.dtb \
    zynq-zybo.dtb \
    zynq-microzed.dtb \
    zynq-cc108.dtb \
    zynq-afx-nand.dtb \
    zynq-afx-nor.dtb \
    zynq-afx-qspi.dtb \
    zynq-cse-nand.dtb \
    zynq-cse-nor.dtb \
    zynq-cse-qspi.dtb \
    zynq-picozed.dtb \
    zynq-zc770-xm010.dtb \
    zynq-zc770-xm011.dtb \
    zynq-zc770-xm012.dtb \
-   zynq-zc770-xm013.dtb
+   zynq-zc770-xm013.dtb \
+   zynq-zyboc.dtb
```

u-boot Compile

INIPRO

$ nano arch/arm/mach-zynq/Kconfig

```
config TARGET_ZYNQ_ZYBO
    bool "Zynq Zybo Board"
    select ZYNQ_CUSTOM_INIT

config TARGET_ZYNQ_AFX
    bool "Zynq AFX Board"
    select ZYNQ_CUSTOM_INIT

config TARGET_ZYNQ_CSE
    bool "Zynq CSE Board"
    select ZYNQ_CUSTOM_INIT

config TARGET_ZYNQ_CC108
    bool "Zynq CC108 Board"
    select ZYNQ_CUSTOM_INIT

+config TARGET_ZYNQ_ZYBOC
+    bool "Zynq Zyboc Board"
+    select ZYNQ_CUSTOM_INIT
.....
.....
config SYS_CONFIG_NAME
    default "zynq_zed" if TARGET_ZYNQ_ZED
    default "zynq_microzed" if TARGET_ZYNQ_MICROZED
    default "zynq_picozed" if TARGET_ZYNQ_PICOZED
    default "zynq_zc70x" if TARGET_ZYNQ_ZC702 || TARGET_ZYNQ_ZC706 \
                || TARGET_ZYNQ_ZC70X
    default "zynq_zc770" if TARGET_ZYNQ_ZC770
    default "zynq_zybo" if TARGET_ZYNQ_ZYBO
    default "zynq_cse" if TARGET_ZYNQ_CSE
    default "zynq_afx" if TARGET_ZYNQ_AFX
    default "zynq_cc108" if TARGET_ZYNQ_CC108
+   default "zynq_zyboc" if TARGET_ZYNQ_ZYBOC

endif
```

u-boot Compile

INIPRO

```
$ make arch=ARM zynq_zyboc_defconfig
$ make arch=ARM CROSS_COMPILE=arm-linux-gnueabihf- CFLAGS="-O2
-mtune=cortex-a9 -mfpu=neon -mfloat-abi=hard" all
$ cp u-boot ~/work/embedded_linux/vivado/u-boot.elf
```

- **Kernel driver** for platform devices

  = Kernel source code + Device Tree

  Hierarchy of Devices

  Provide register address, irq number, so on as property of device.

- **Platform device**

  Instead of being dynamically detected, must be statically described in either:

  Kernel source code or Device Tree

  The devices on I2C buses or SPI buses, or the devices directly part of the system-on-chip.

Device Tree Compile

```
$ cd ~/work/embedded_linux
$ cp vivado/embedded_linux/embedded_linux.tree/system.dts .
$ nano system.dts
```

system.dts

```
&clkc {
    fclk-enable = <0x0>;
    ps-clk-frequency = <50000000>;
};

+&gem0 {
+    phy-handle = <&phy0>;
+    ps7_ethernet_0_mdio: mdio {
+        #address-cells = <0x1>;
+        #size-cells = <0x0>;
+        phy0: phy@0 {
+            compatible = "realtek,RTL8211E";
+            device_type = "ethernet-phy";
+            reg = <0>;
+        };
+    };
+};
```

```
+&i2c0 {
+    eeprom@50 {
+        /* Microchip 24AA02E48 */
+        compatible = "microchip,24c02";
+        reg = <0x50>;
+        pagesize = <8>;
+    };
+};
+/ {
+    usb_phy0: phy0 {
+        compatible = "ulpi-phy";
+        #phy-cells = <0>;
+        reg = <0xe0002000 0x1000>;
+        view-port = <0x0170>;
+        drv-vbus;
+    };
+};
+&usb0 {
+    usb-phy = <&usb_phy0>;
+};
```

```
$ dtc -O dtb -I dts -i vivado/embedded_linux/embedded_linux.tree/ -o
devicetree.dtb system.dts
```

Linux Kernel Compile

INIPRO

```
$ cd ~/work/embedded_linux
$ wget https://github.com/Xilinx/linux-xlnx/archive/xilinx-v2015.4.01.tar.gz -O
dl/linux-xlnx-xilinx-v2015.4.01.tar.gz
$ cd kernel
$ tar xvzf ../dl/linux-xlnx-xilinx-v2015.4.01.tar.gz
$ cd linux-xlnx-xilinx-v2015.4.01
$ cp -r ../drivers/rtl8192cu drivers/net/wireless/
$ nano drivers/net/wireless/Kconfig
```

drivers/net/wireless/Kconfig

```
source "drivers/net/wireless/mwifiex/Kconfig"
source "drivers/net/wireless/cw1200/Kconfig"
source "drivers/net/wireless/rsi/Kconfig"
+source "drivers/net/wireless/rtl8192cu/Kconfig"

endif # WLAN
```

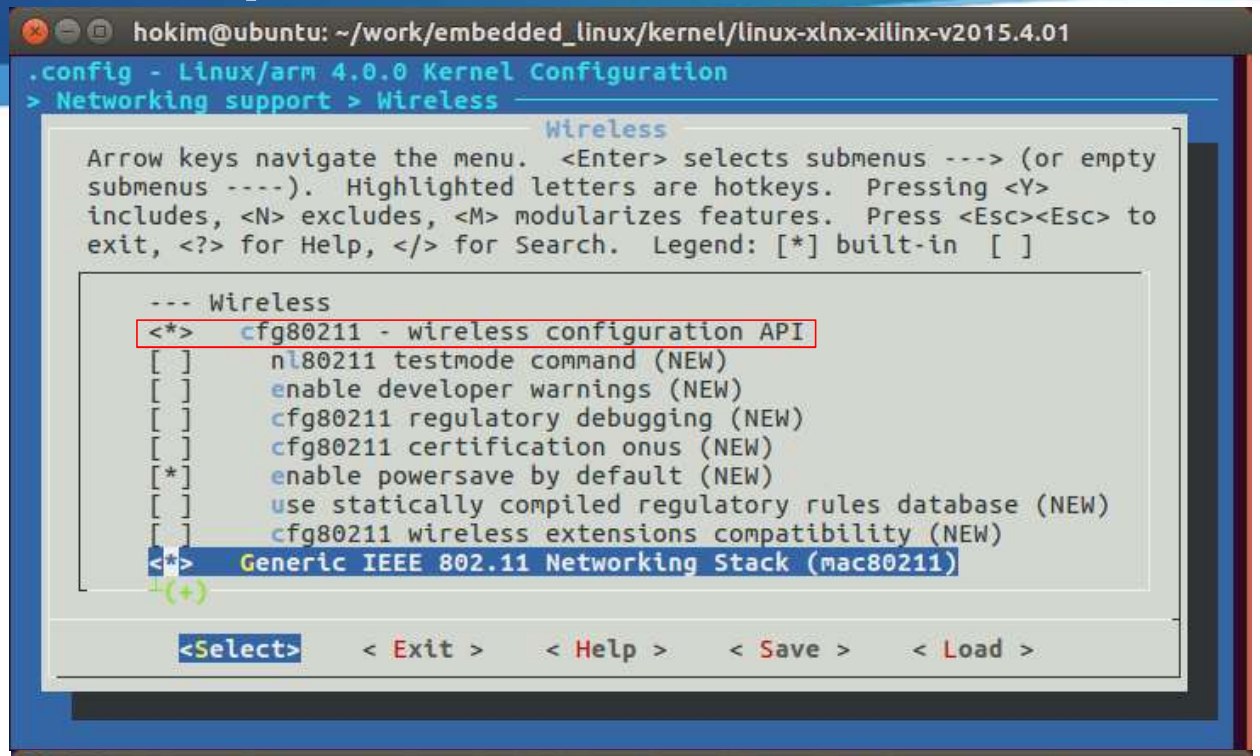
```
$ nano drivers/net/wireless/Makefile
```

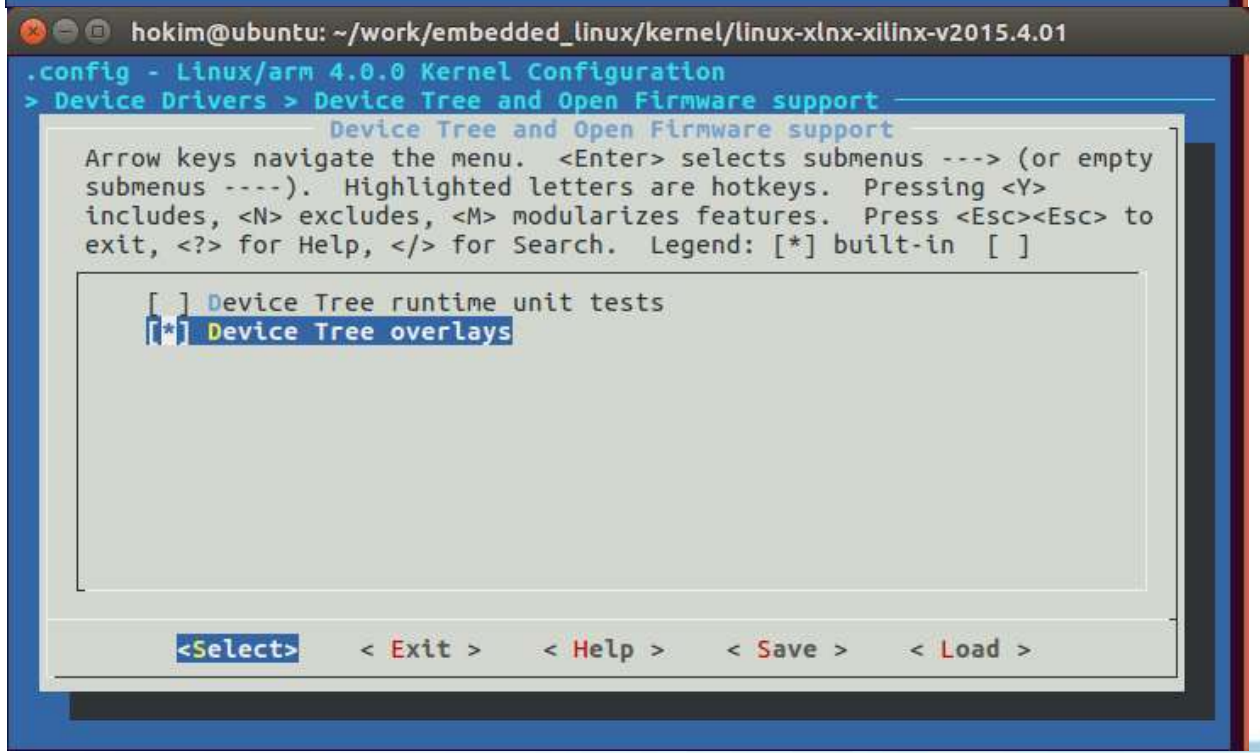
drivers/net/wireless/Makefile

```
obj-$(CONFIG_CW1200)    += cw1200/
obj-$(CONFIG_RSI_91X)   += rsi/
+obj-$(CONFIG_RTL8192CU)    += rtl8192cu/
```

```
$ make ARCH=arm xilinx_zynq_defconfig
$ make ARCH=arm menuconfig
```

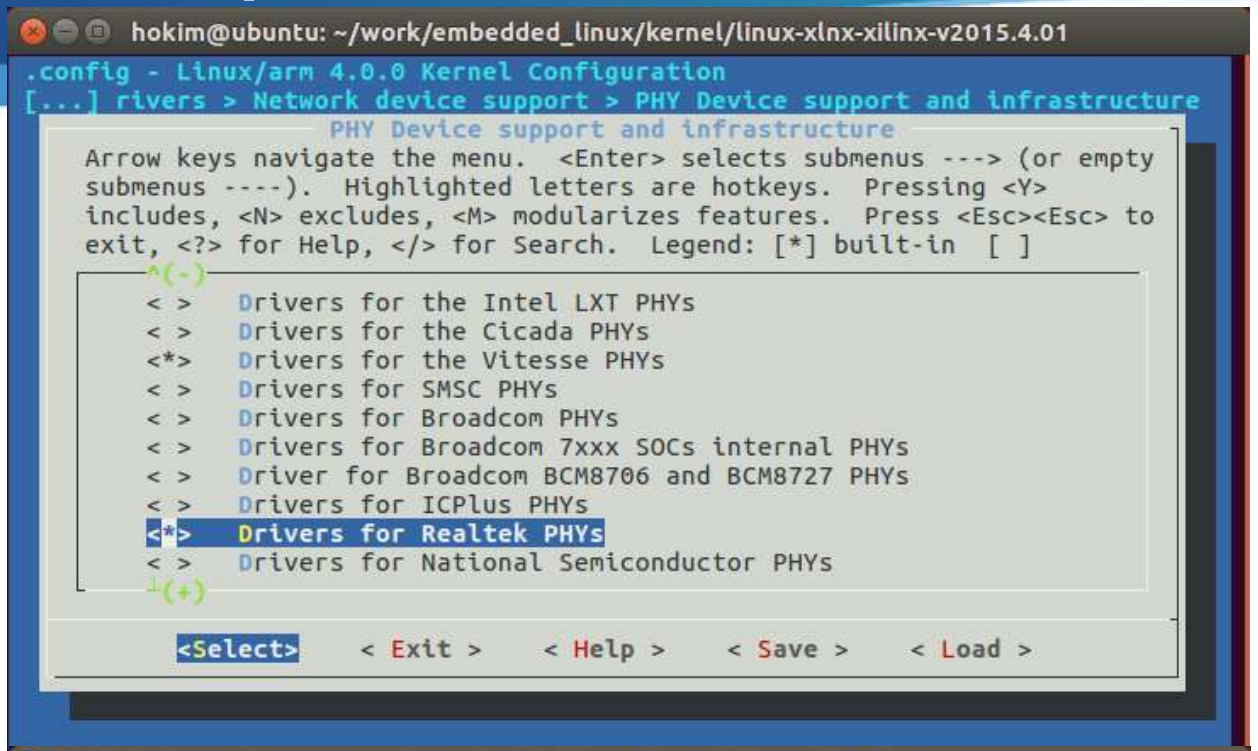
Linux Kernel Compile

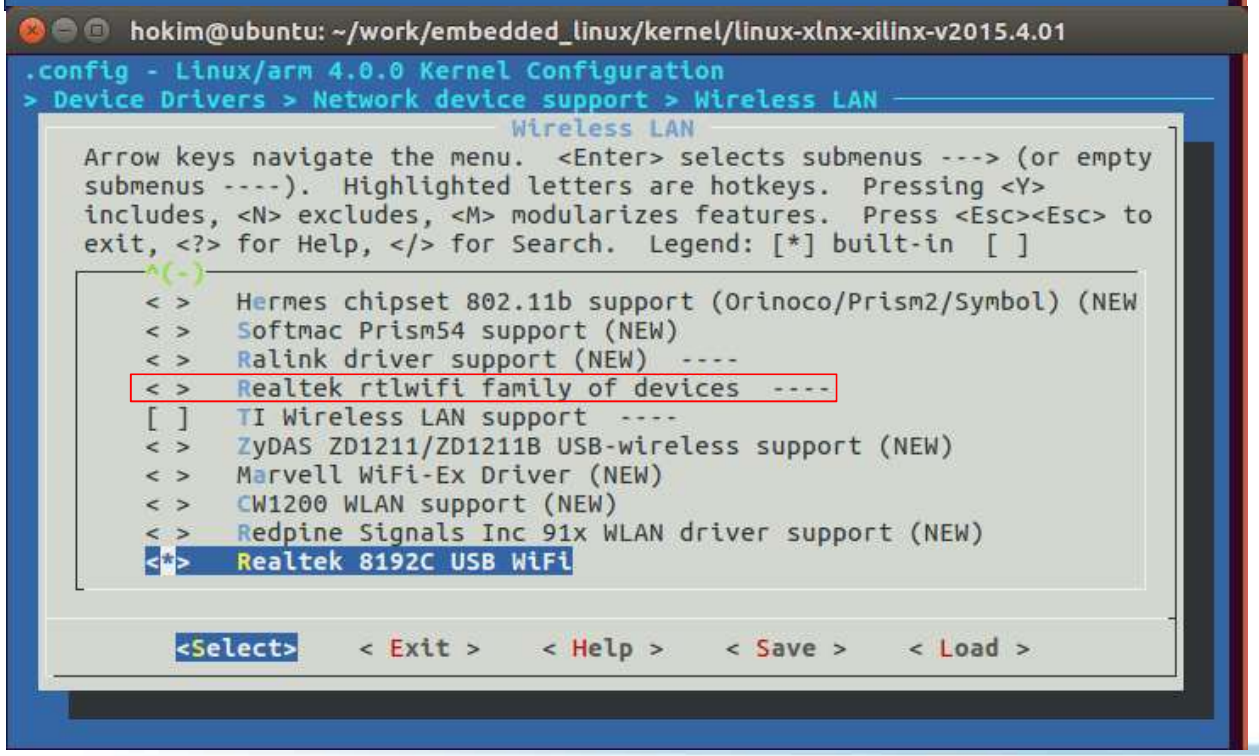




Linux Kernel Compile

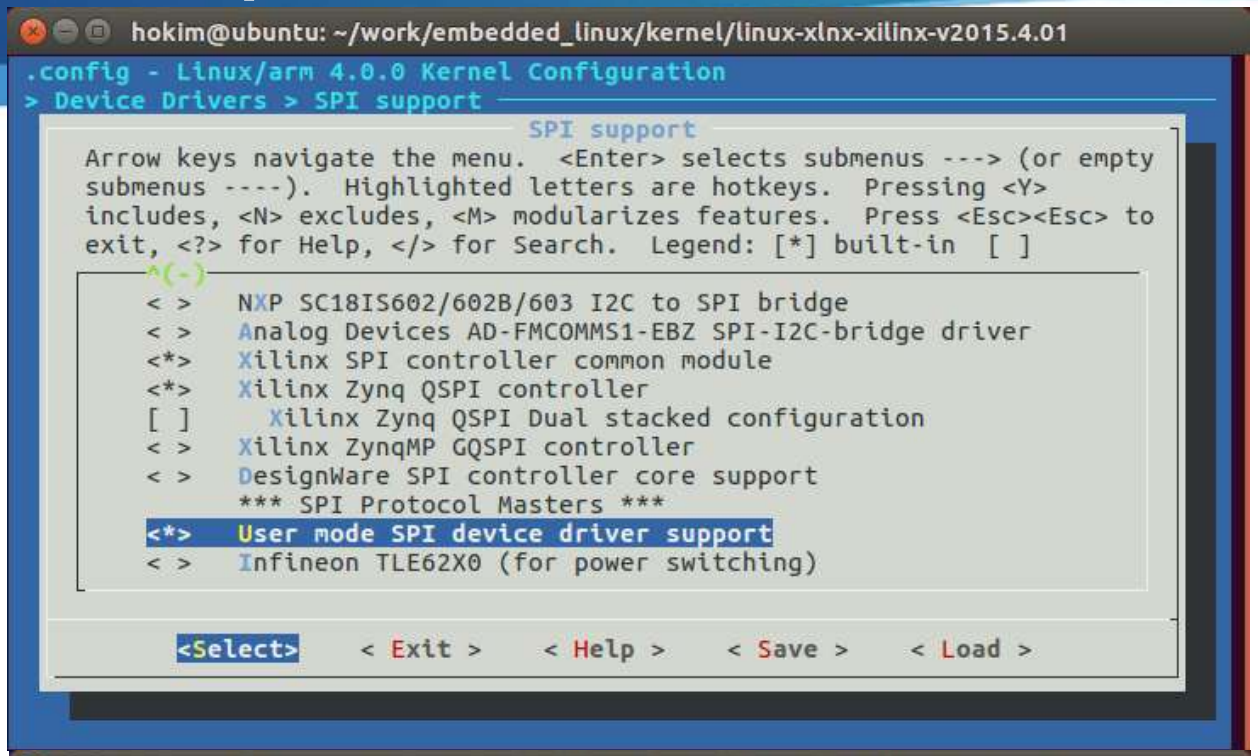
INIPRO

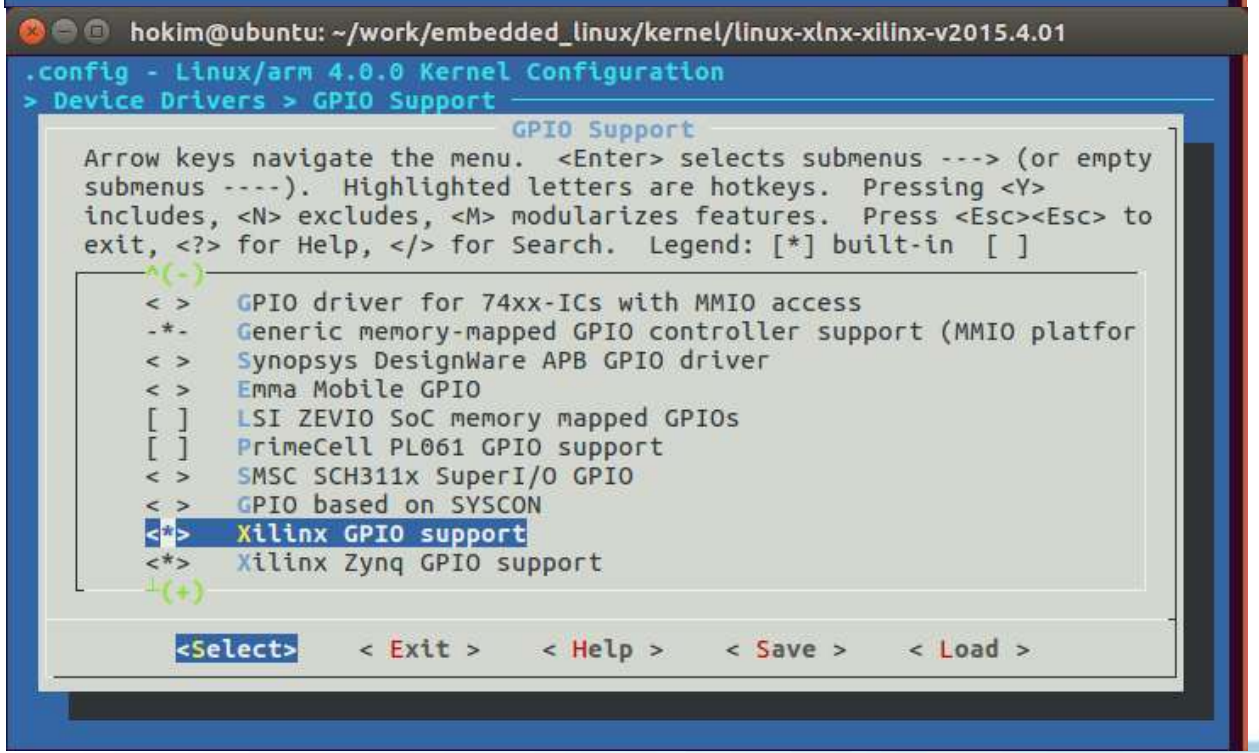




Linux Kernel Compile

INIPRO





Linux Kernel Compile

INIPRO

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabihf- CFLAGS="-O2
-mtune=cortex-a9 -mfpu=neon -mfloat-abi=hard" -j $(nproc)
UIMAGE_LOADADDR=0x8000 uImage
$ cp arch/arm/boot/uImage ../..
```

Root File System Build

INIPRO

```
$ cd ~/work/embedded_linux
$  sudo sh ./image.sh
```

image.sh

```
mkdir -p dl

UBUNTU_URL=http://cdimage.ubuntu.com/ubuntu-base/releases/16.04/release
UBUNTU=ubuntu-base-16.04-core-armhf.tar.gz
if [ ! -f dl/$UBUNTU ]; then
        wget $UBUNTU_URL/$UBUNTU -O dl/$UBUNTU
fi

ARCH=armhf
SIZE=3500
mkdir -p img
IMAGE=img/ubuntu-core_${ARCH}_16.04.img
dd if=/dev/zero of=$IMAGE bs=1M count=$SIZE
DEVICE=$(losetup -f)
losetup $DEVICE $IMAGE
parted -s $DEVICE mklabel msdos
parted -s $DEVICE mkpart primary fat16 4MB 128MB
parted -s $DEVICE mkpart primary ext4 128MB 100%
BOOT_DEV=/dev/$(lsblk -lno NAME $DEVICE | sed '2!d')
ROOT_DEV=/dev/$(lsblk -lno NAME $DEVICE | sed '3!d')
mkfs.vfat -v $BOOT_DEV
mkfs.ext4 -F -j $ROOT_DEV
ROOT_DIR=root
mkdir -p $ROOT_DIR
mount $ROOT_DEV $ROOT_DIR
cd $ROOT_DIR
tar xvf ../dl/$UBUNTU
rm -fr boot
cd ..
```

Root File System Build

INIPRO

image.sh

```
cat > $ROOT_DIR/etc/fstab << EOF_CAT
# /etc/fstab: static file system information.
# <file system> <mount point>   <type>  <options>             <dump>  <pass>
/dev/mmcblk0p1  /boot           vfat    errors=remount-ro      0       0
/dev/mmcblk0p2  /               ext4    errors=remount-ro      0       1
EOF_CAT

cp /etc/resolv.conf         $ROOT_DIR/etc/
cp /usr/bin/qemu-arm-static $ROOT_DIR/usr/bin/
chroot $ROOT_DIR << EOF_CHROOT
sed -i 's/^# deb http:\/\/ports\.ubuntu\.com\/ubuntu-ports\/ xenial universe.*/deb http:\/\/ports\.ubuntu\.com\/ubuntu-ports\/
xenial universe/' /etc/apt/sources.list
sed -i 's/^# deb http:\/\/ports\.ubuntu\.com\/ubuntu-ports\/ xenial-updates universe.*/deb http:\/\/ports\.ubuntu\.com\/ubuntu-
ports\/ xenial-updates universe/' /etc/apt/sources.list
apt-get update
apt-get -y upgrade
DEBIAN_FRONTEND=noninteractive apt-get -y install vim nano sudo openssh-server udev usbutils u-boot-tools device-tree-
compiler kmod net-tools wpasupplicant parted rfkill lshw wireless-tools gcc g++ cmake git i2c-tools iputils-ping
echo "Asia/Seoul" > /etc/timezone
ln -fs /usr/share/zoneinfo/Asia/Seoul /etc/localtime
locale-gen "en_US.UTF-8"
DEBIAN_FRONTEND=noninteractive dpkg-reconfigure locales
EOF_CHROOT
rm $ROOT_DIR/etc/resolv.conf
rm $ROOT_DIR/usr/bin/qemu-arm-static

mkdir -pv $ROOT_DIR/etc/systemd/system/serial-getty\@ttyPS0.service.d
cat > $ROOT_DIR/etc/systemd/system/serial-getty\@ttyPS0.service.d/autologin.conf << EOF_CAT
[Service]
ExecStart=
ExecStart=-/sbin/agetty --autologin root -s %I 115200,38400,9600 linux
EOF_CAT
umount -l $ROOT_DIR
rmdir $ROOT_DIR
losetup -d $DEVICE
```

File Transfer (Ubuntu → Windows)

INIPRO

using WinSCP

Ubuntu	Windows
~/work/embedded_linux/ devicetree.dtb, uImage	C:₩Users₩hokim₩work₩embedded_linux
~/work/embedded_linux/vivado/ u-boot.elf	C:₩Users₩hokim₩work₩embedded_linux₩vivado
~/work/embedded_linux/img/ ubuntu-core_armhf_16.04.img	C:₩Users₩hokim₩work

Boot.bin Build

INIPRO

bootbin.tcl

```
# tclsh bootbin.tcl

set project_name embedded_linux

set fileId [open $project_name/boot.bif "w"]
puts $fileId "img:{\[bootloader\] $project_name/$project_name.fsbl/executable.elf
$project_name/$project_name.runs/impl_1/system_wrapper.bit u-boot.elf}"
close $fileId

file delete -force boot.bin

exec bootgen -image $project_name/boot.bif -w -o i boot.bin >&@stdout
```

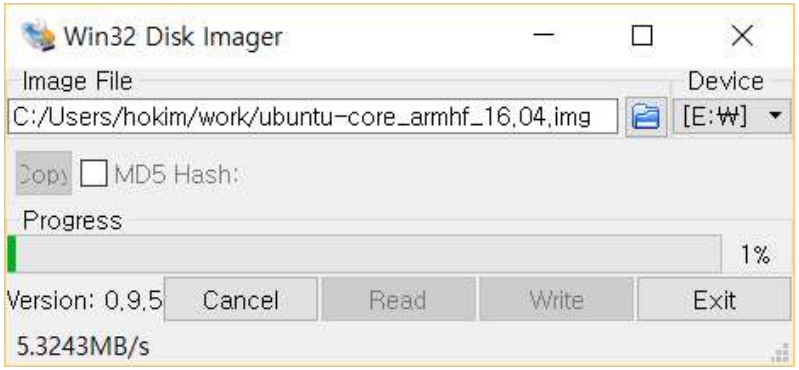
In cmd window for Vivado

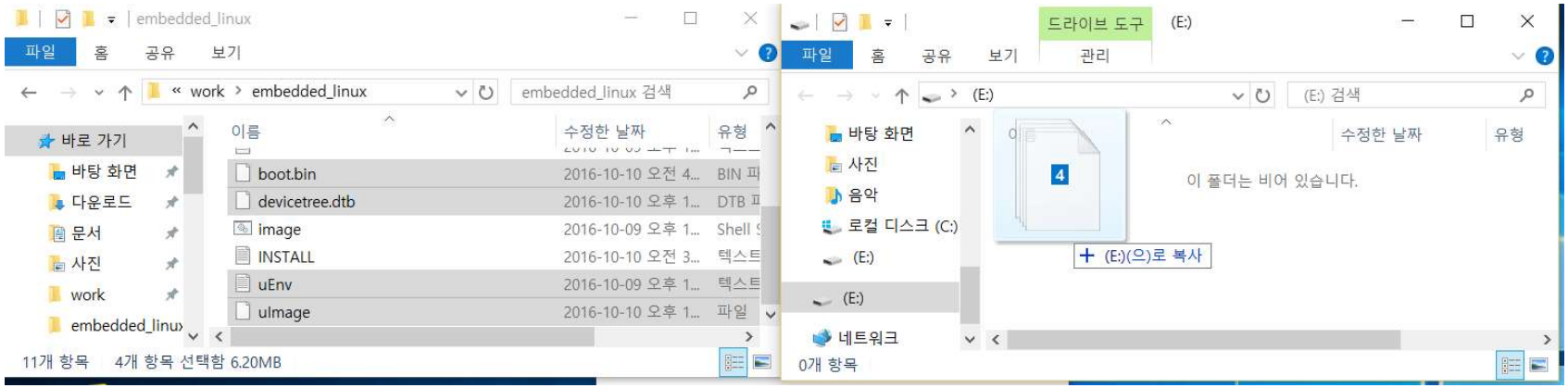
```
C:\  cd c:\Users\hokim\work\embedded_linux\vivado
C:\ tclsh bootbin.tcl
C:\ copy boot.bin ..
```

output : boot.bin

SD Card

https://sourceforge.net/projects/win32diskimager/

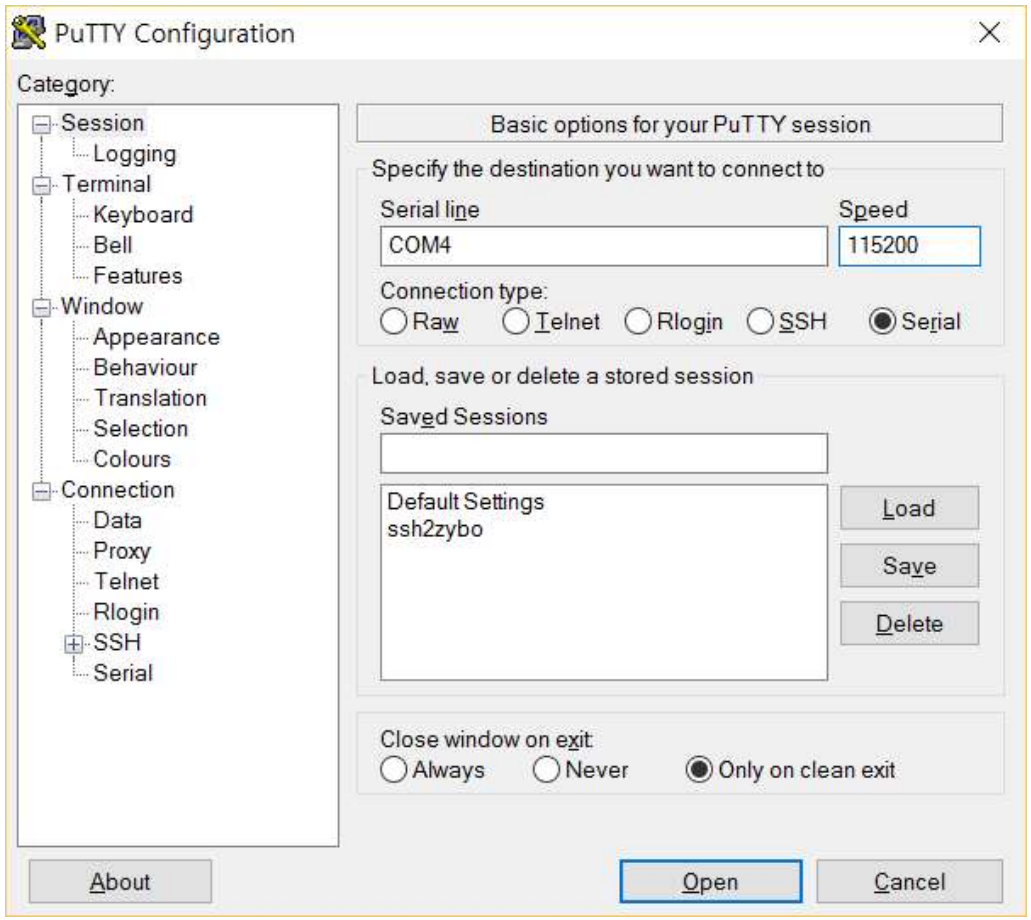


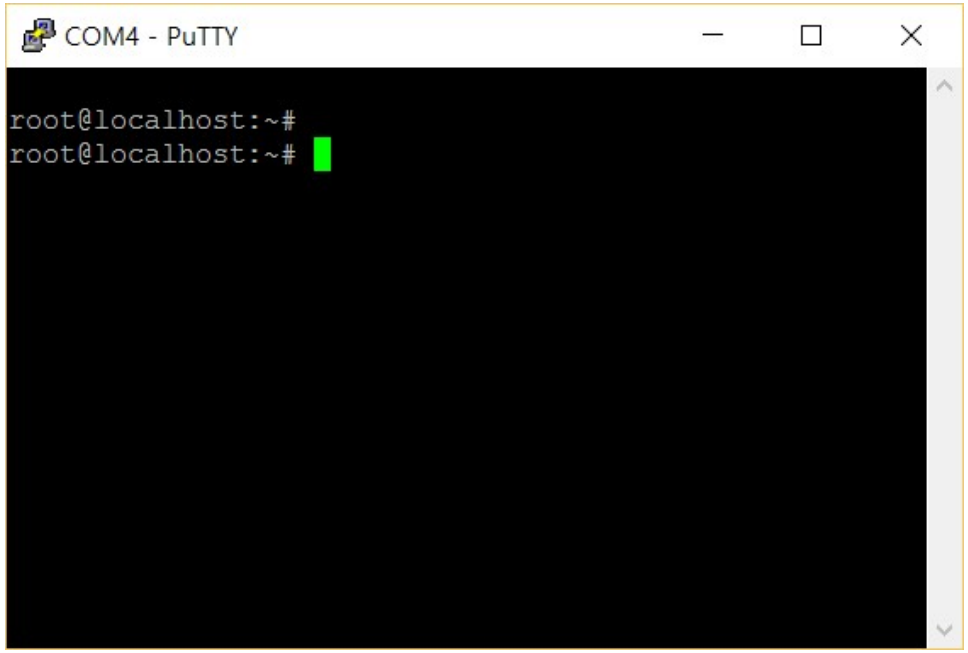


Boot zybo with SD card

Post install

Log in through UART console using putty





Post install

INIPRO

```
# groupadd -g 1000 hokim
# groupadd -g 1001 admin
# useradd -u 1000 -g 1000 -G adm,dialout,cdrom,audio,dip,video,plugdev,admin
-d /home/hokim -m -s /bin/bash hokim
# passwd hokim
# nano /etc/network/interfaces.d/eth0
```

/etc/network/interfaces.d/eth0

```
allow-hotplug eth0
iface eth0 inet static
address 192.168.10.10
netmask 255.255.255.0
```

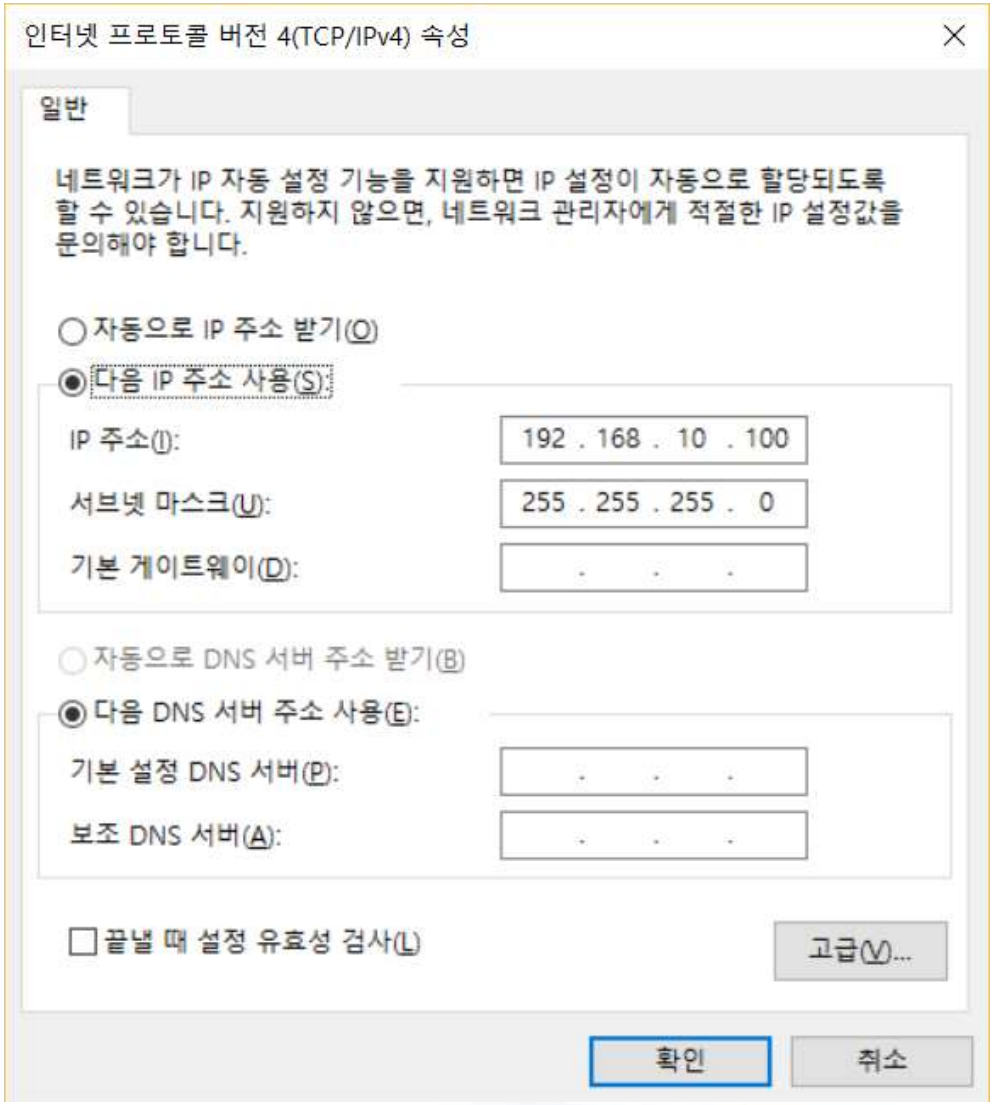
```
# halt
```

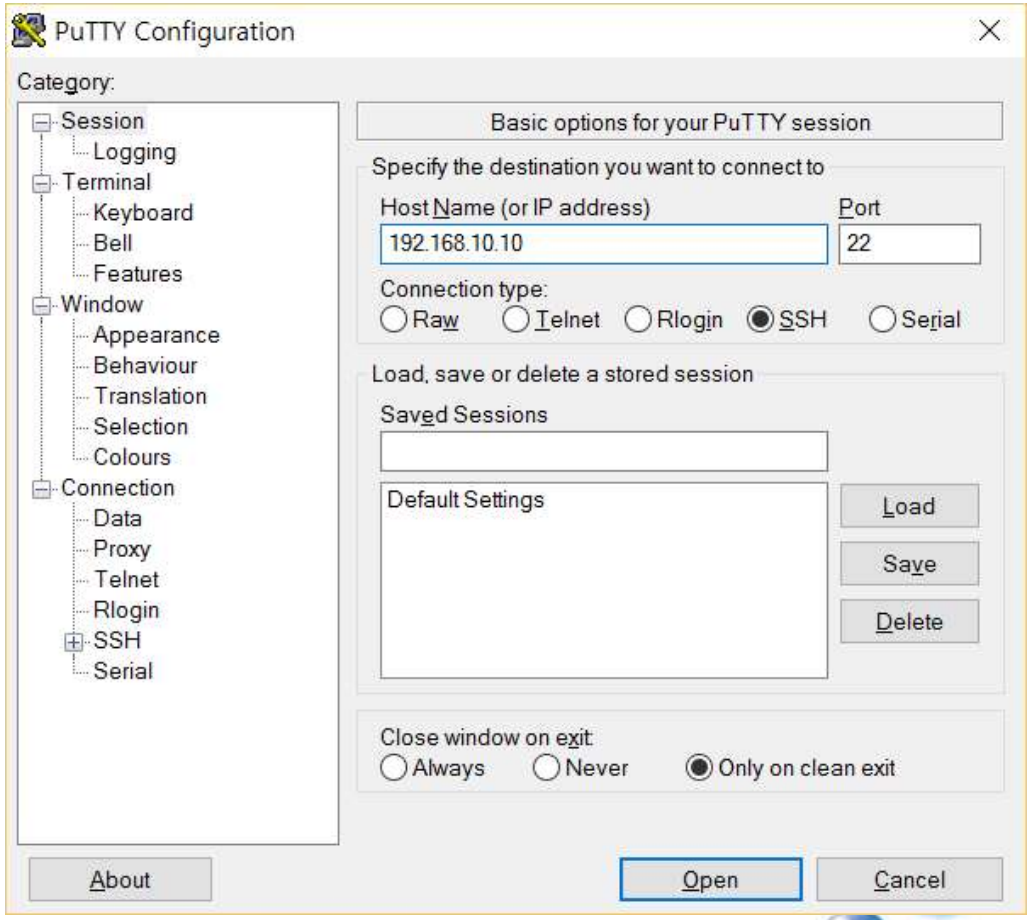
Turn off/on zybo

Post install

INIPRO

Log in through ethernet using putty





Post install

INIPRO

$ sudo nano /etc/hostname

/etc/hostname

```
-localhost.localdomain
+zybo
```

$ sudo nano /etc/hosts

/etc/hosts

```
127.0.0.1       localhost
127.0.1.1       zybo

# The following lines are desirable for IPv6 capable hosts
::1             ip6-localhost ip6-loopback
fe00::0         ip6-localnet
ff00::0         ip6-mcastprefix
ff02::1         ip6-allnodes
ff02::2         ip6-allrouters
```

$ ls /sys/class/net

output:

```
enx74da38422193 eth0  lo
```

Post install

INIPRO

```
$ sudo nano /etc/network/interfaces.d/enx74da38422193
```

/etc/network/interfaces.d/enx74da38422193

```
allow-hotplug enx74da38422193
iface enx74da38422193 inet dhcp
        pre-up wpa_supplicant -B -D wext -i enx74da38422193 -c /etc/wpa_supplicant.conf
        post-down killall -q wpa_supplicant
        udhcpc_opts -t7 -T3
```

```
$ sudo nano /etc/wpa_supplicant.conf
```

/etc/wpa_supplicant.conf

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

network={
                ssid="INIPRO"
                key_mgmt=WPA-PSK
                psk="20471047"
}
```

```
$ sudo halt
```

Turn off/on zybo

Post install

INIPRO

```
$ sudo nano /etc/network/interfaces.d/enx74da38422193
```

/etc/network/interfaces.d/enx74da38422193

```
allow-hotplug enx74da38422193
iface enx74da38422193 inet dhcp
        pre-up wpa_supplicant -B -D wext -i enx74da38422193 -c /etc/wpa_supplicant.conf
        post-down killall -q wpa_supplicant
        udhcpc_opts -t7 -T3
```

```
$ sudo nano /etc/wpa_supplicant.conf
```

/etc/wpa_supplicant.conf

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

network={
                ssid="INIPRO"
                key_mgmt=WPA-PSK
                psk="20471047"
}
```

```
$ sudo -s
# echo -e "d\n2\nw" | fdisk /dev/mmcblk0
# parted -s /dev/mmcblk0 mkpart primary ext4 128M 100%
# halt
```

Post install

INIPRO

Turn off / on zybo
Log in through ethernet using putty

```
$ sudo resize2fs /dev/mmcblk0p2
$ df -h
```

output:

```
Filesystem      Size  Used Avail Use% Mounted on
/dev/root       7.0G  632M  6.0G  10% /
devtmpfs        242M     0  242M   0% /dev
tmpfs           250M     0  250M   0% /dev/shm
tmpfs           250M  6.5M  244M   3% /run
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           250M     0  250M   0% /sys/fs/cgroup
/dev/mmcblk0p1  118M  6.3M  112M   6% /boot
```

Post install

INIPRO

$ ifconfig

output:

```
enx74da38422193 Link encap:Ethernet  HWaddr 74:da:38:42:21:93
          inet addr:192.168.0.148  Bcast:192.168.0.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:418 errors:0 dropped:3 overruns:0 frame:0
          TX packets:12 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:77995 (77.9 KB)  TX bytes:1772 (1.7 KB)

eth0      Link encap:Ethernet  HWaddr d8:80:39:5c:48:82
          inet addr:192.168.10.10  Bcast:192.168.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:437 errors:0 dropped:1 overruns:0 frame:0
          TX packets:448 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:33219 (33.2 KB)  TX bytes:57605 (57.6 KB)
          Interrupt:145 Base address:0xb000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:80 errors:0 dropped:0 overruns:0 frame:0
          TX packets:80 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:5920 (5.9 KB)  TX bytes:5920 (5.9 KB)
```