Tiny Core: Custom Kernel

Building a custom Tiny Core kernel

Introduction

There may come a time when you want to build your own custom kernel for a particular thin client. For example I needed to do this whilst sorting out a problem with a Wyse S10 where, amongst other things, the BIOS was disabling the IDE interface so preventing its use. My solution to this was to modify the pata_CS5536 driver so that it re-enabled the interface as part of its initialisation phase, and then recompile the kernel so that it used this modified driver. At the same time I took the opportunity to remove the embedded collection of SATA/IDE drivers that were not used by the Wyse S10. Also there is an earlier variant of the S10 that uses the pata_CS5535 driver which, for many years, has been marked 'experimental' and not included in the standard build.

In principle a kernel rebuild is not a simple process as the modules are also an integral part of the system. These also should be recompiled and then the associated ramdisk(s) (**core.gz** et al) remastered with the rebuilt modules. However, as in this case where the changes you've made to the kernel are minor, we can skip the modules/remastering stage which leaves us with the simple process of producing a new **vmlinuz** kernel file. This is the process described here.

This how-to describes how to set up an environment that will let you recompile the Linux kernel, and shows you how you can make minor changes to the kernel configuration to tailor it more to specific hardware.

If you are intending to be more adventurous I would note that if you are too aggressive at removing stuff from the kernel you may end up with a kernel that crashes on startup. The basic principle is to be patient and only make a small number of changes at a time. You should also keep a copy of the previous kernel **.config** file so that it is easy to revert to a previous (working) build in the event of such a thing happening.

At the time of writing Tiny Core is at revision 10.0 and uses kernel 4.19.10. If you're following this guide with a later build you will need to make minor adjustments to file names and paths to match the current release.

Prerequisites

You obviously need an environment to build the kernel in - a combination of hardware and software. Back in 2013 I used a Shuttle PC (spec lost in the mists of time) running Fedora.

These days I find the obvious candidate for the operating system to be Tiny Core itself. As to hardware you've got the option of using what ever you have to hand (old PC, thin client or whatever) or you can install Tiny Core in a Virtual Machine (such as Virtual Box) on your Windows(?) desktop computer. The choice is yours.

Modern thin clients are a lot more powerful than they used to be and I'm currently using a Wyse Dx0D fitted with a dual-core CPU, 2GB of RAM and an 4GB SSD for this task. This is running the same version of Tiny Core (10.0) that I want to build the new kernel for.

Installing Tiny Core is straight forward - use something like LiLi (Linux Live USB creator) to install Tiny Core onto a pen drive. Boot from that pen drive, download the **tc-install.tcz** app and then run it. Install Tiny Core to the hard disk and, when filling in the command line options, set /home and /opt to be persistent on the hard disk. If you don't they will be RAM based and so have to be saved/restored on shutdown/boot. (**tc**'s home directory with the kernel files comes in at 1GB).

In selecting your hardware base you don't actually need vast amounts of disk space - at least not 'vast' in today's terms. I found that the Tiny Core development installation described below along with the Linux kernel took up ~1.3GB of disk space.

When I went through this exercise back in February 2017 I tried out three thin clients:

1. A Dell FX160 fitted with 1GB of RAM and an 80GB laptop drive. The CPU in this is an Intel Atom 230 single core processor running at 1.6GHz.
2. A Dell Z90D7 fitted with 2GB of RAM and a SanDisk U100 8GB SSD. The CPU in this an AMD G-T56N. It's a dual core CPU running at 1.65GHz.
3. A Dell D10DP fitted with 2GB of RAM and a SanDisk U100 8GB SSD. The CPU in this an AMD G-T48E. It's a dual core CPU running at 1.4GHz.

Having set up each machine I did a **make clean** followed by **time make bzImage** to get the following results:

	Z90D	**D10DP**	**FX160**
real	43m 23.11s	49m 16.16s	1hr 8m 04s
user	41m 21.27s	46m 56.87s	1hr 5m 06s
sys	1m 46.47s	2m 03.65s	2m 59.61s

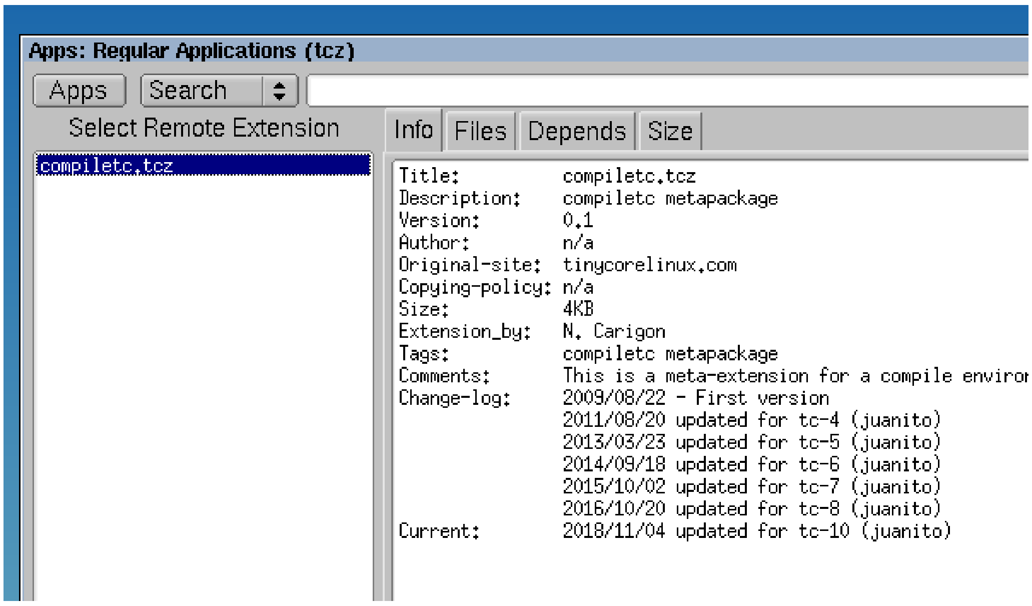
In January 2018, with kernel 4.8.17, the initial build time was 1 hour 12 minutes on the Wyse D10DP. I guess this reflects the drivers and features that have been added to the kernel since release 4.2.9.

Note: The timings are for the first pass when *everything* is compiled. Thereafter, after I edited the kernel **.config file** to remove the unwanted drivers the build time was around 1 minute 20 seconds. It took a similar time to rebuild the kernel after I had edited the **pata_cs5536.c** driver file.

With the latest iteration (kernel 4.19.10) the initial build comes in at just under 1hr 20 minutes.

Configuring Tiny Core

Having put together a basic Tiny Core platform the next step is to fire up the App Browser and download and install the various extensions you'll need.



```
Title:          compiletc.tcz
Description:    compiletc metapackage
Version:        0.1
Author:         n/a
Original-site:  tinycorelinux.com
Copying-policy: n/a
Size:           4KB
Extension_by:   N. Carigon
Tags:           compiletc metapackage
Comments:       This is a meta-extension for a compile enviror
Change-log:     2009/08/22 - First version
                2011/08/20 updated for tc-4 (juanito)
                2013/03/23 updated for tc-5 (juanito)
                2014/09/18 updated for tc-6 (juanito)
                2015/10/02 updated for tc-7 (juanito)
                2016/10/20 updated for tc-8 (juanito)
Current:        2018/11/04 updated for tc-10 (juanito)
```

We need to install:

- kmaps.tcz
- compiletc.tcz
- perl5.tcz
- ncurses-dev.tcz
- seamonkey.tcz or chromium-browser.tcz
- bash.tcz
- bc.tcz

The first is to set things up for your keyboard (if non-US) - don't forget to add **kmap=qwerty/uk** or the equivalent to the syslinux/extlinux boot menu if you haven't already.

The next two items install the tools required to compile the kernel.

The **ncurses** library is used by **menuconfig** (see on).

Finally you'll need the browser to get hold of the kernel sources.

Now decide where you're going to do the work. In this case I'm happy to do this as the standard user (**tc**). To keep track of things I'll create a subdirectory **wyseSX0** to remind me in a few months time what machine this kernel build was targeted at. Also, in case I'm going to do this for another thin client, I'll create another directory **kernel** to keep a local copy of the original files to save me having to download them again.

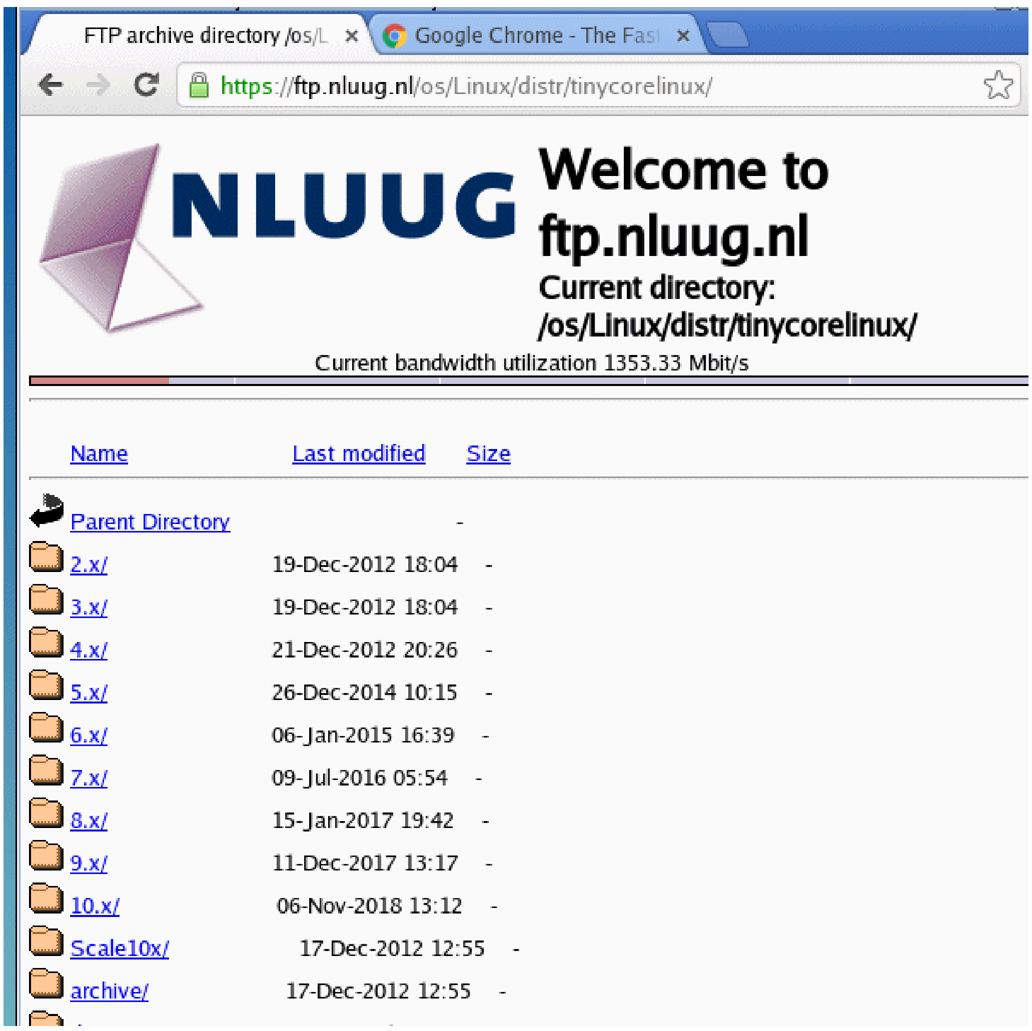
```
tc@box:~ mkdir wyseSX0 kernel
tc@box:~
```

If you've a non-us keyboard and downloaded **kmaps.tcz** it's worth rebooting at this point to check that you've got everything set correctly so that your keyboard works as it should.

Install Source Tree

The next step is to get hold of the kernel sources. Luckily for us these are already packaged up and available from the Tiny Core site or one of its mirrors. The wiki has a list of mirrors. Pick a suitable one to suit your location. **https://ftp.nluug.nl/os/Linux/distr/tinycorelinux/** works nicely for me here in the UK.

On firing up a browser and heading to the chosen mirror we find:



FTP archive directory /os/L × Google Chrome - The Fast ×

https://ftp.nluug.nl/os/Linux/distr/tinycorelinux/

Welcome to ftp.nluug.nl
Current directory: /os/Linux/distr/tinycorelinux/

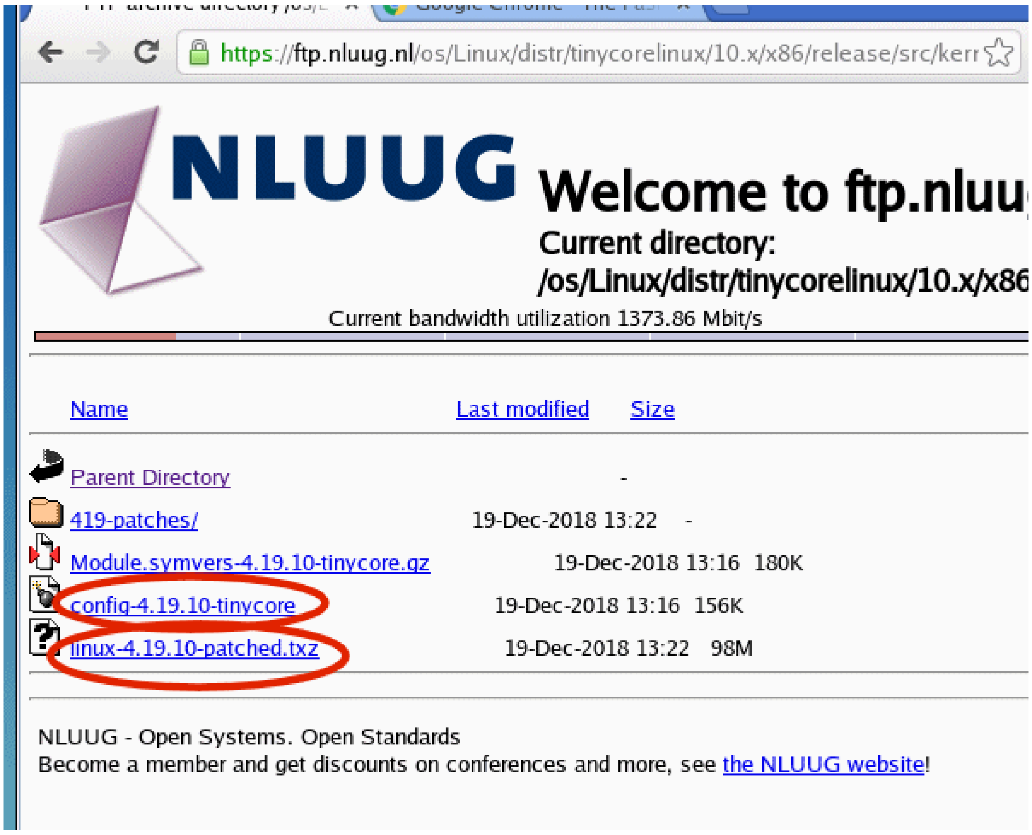
Current bandwidth utilization 1353.33 Mbit/s

Name	Last modified	Size
Parent Directory		-
2.x/	19-Dec-2012 18:04	-
3.x/	19-Dec-2012 18:04	-
4.x/	21-Dec-2012 20:26	-
5.x/	26-Dec-2014 10:15	-
6.x/	06-Jan-2015 16:39	-
7.x/	09-Jul-2016 05:54	-
8.x/	15-Jan-2017 19:42	-
9.x/	11-Dec-2017 13:17	-
10.x/	06-Nov-2018 13:12	-
Scale10x/	17-Dec-2012 12:55	-
archive/	17-Dec-2012 12:55	-

Next we have to drill down through several screens to reach the sources....

- **10.x/** we're using 10.0...
- **x86/** ...it's the 32-bit x86 version...
- **release/** ...the released version...
- **src/** ...we're after the sources...
- **kernel/** ...for the kernel

This should bring you to the following screen:



https://ftp.nluug.nl/os/Linux/distr/tinycorelinux/10.x/x86/release/src/kerr

NLUUG Welcome to ftp.nluu

Current directory:
/os/Linux/distr/tinycorelinux/10.x/x86

Current bandwidth utilization 1373.86 Mbit/s

Name	Last modified	Size
Parent Directory		-
419-patches/	19-Dec-2018 13:22	-
Module.symvers-4.19.10-tinycore.gz	19-Dec-2018 13:16	180K
config-4.19.10-tinycore	19-Dec-2018 13:16	156K
linux-4.19.10-patched.txz	19-Dec-2018 13:22	98M

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10.0 uses kernel 4.19.10 so we now need to download the two circled files. One is the kernel source tree which already has all Tiny Core specific patches applied to it. The other is the config file that determines exactly how it is built. Click on each in turn and download them into the **kernel** subdirectory.

Next we need to extract the files. This is easily done with a couple of commands from a terminal window:

```
$ cd ~/wyseSX0
tc@box:~/wyseSX0$ tar xvf ~/kernel/linux-4.19.10-patched.txz
tc@box:~/wyseSX0$ cp ~/kernel/config-4.19.10-tinycore linux-4.19.10/.config
```

The **tar** command extracts the kernel source to the directory **~/wyseSX0/linux-4.19.10/** and the **cp** command puts the Tiny Core specific configuration file in the right place.

Initial Build

We now have everything set up to build the kernel. It's worth having a quick go at this stage to confirm that everything works. I also like to benchmark things using the **time** to get an idea of how long this takes.

Whilst the kernel compiles you'll see odd warning messages, but you don't have to worry unless things halt with a specific error message.

```
tc@box:~/wyseSX0$ cd linux-4.19.10
tc@box:~/wyseSX0/linux-4.19.10$ make clean
tc@box:~/wyseSX0/linux-4.19.10$ time make bzImage
```

Our new kernel is sitting in the directory **arch/x86/boot/bzImage**

In my particular case with the Wyse D10DP it took about 1 hour and 18 minutes to build the kernel.

Customising

There are a variety of ways in which you can edit the kernel configuration settings. I use **menuconfig** as that's what I've done for years.... [Known as the 'Mother Duck' syndrome]

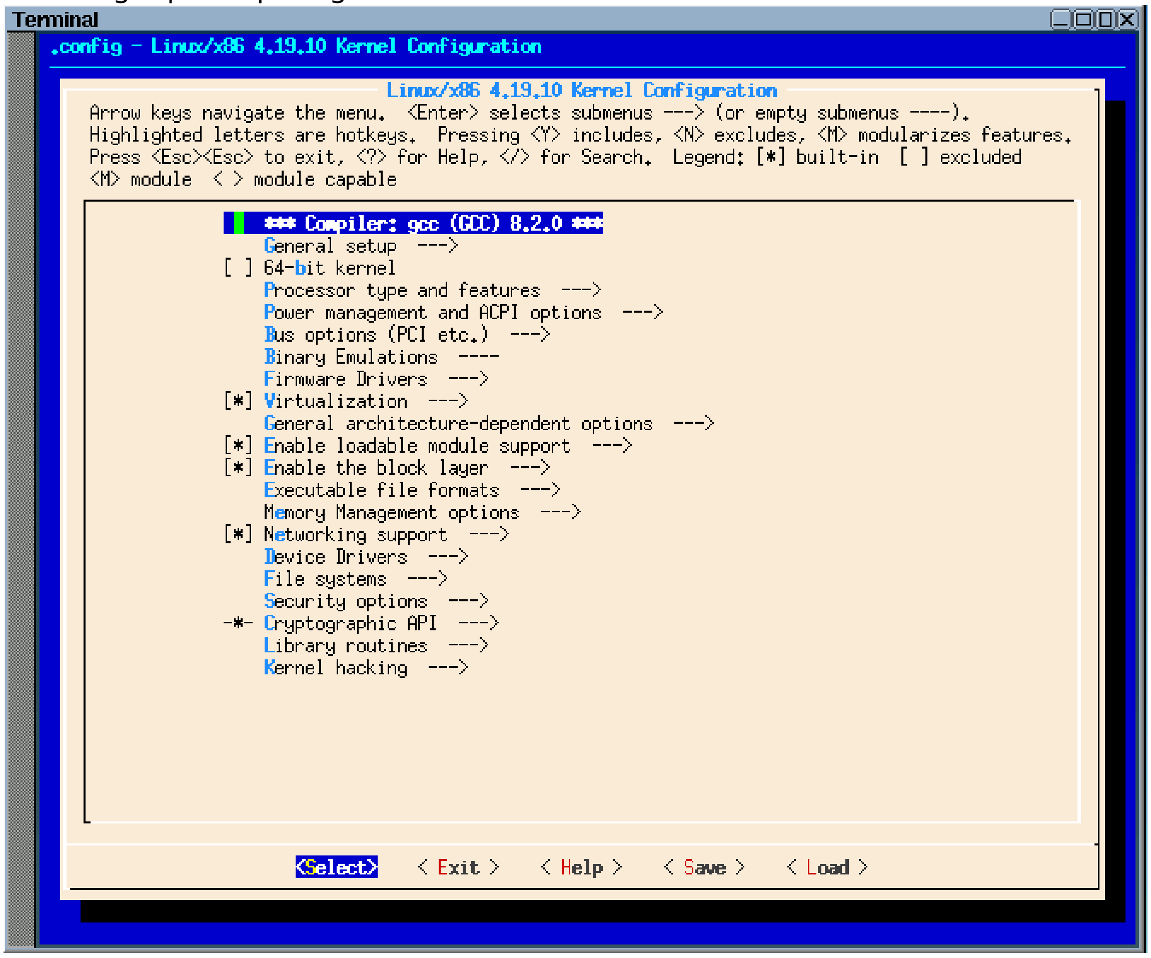
First step is make any changes we want to make to the source files. In this case I've edited the file **drivers/ata/pata_cs5536.c**. There is also the alternative more generic driver **drivers/ata/pata_amd.c**, but I initially picked on the explicit cs5336 one as it was more obvious what was going on.

Next, for the Wyse SX0, we need the (modified) CS5536 driver and also the CS5535 driver. The later is for the earlier version of the SX0 and is not actually included in the standard Tiny Core build. These are the only two drivers we are interested in so we might as well dump the others from our custom build.

To edit the kernel **.config** file we use the command....

```
tc@box:~/wyseSX0/linux-4.19.10$ make menuconfig
```

This brings up the opening screen:



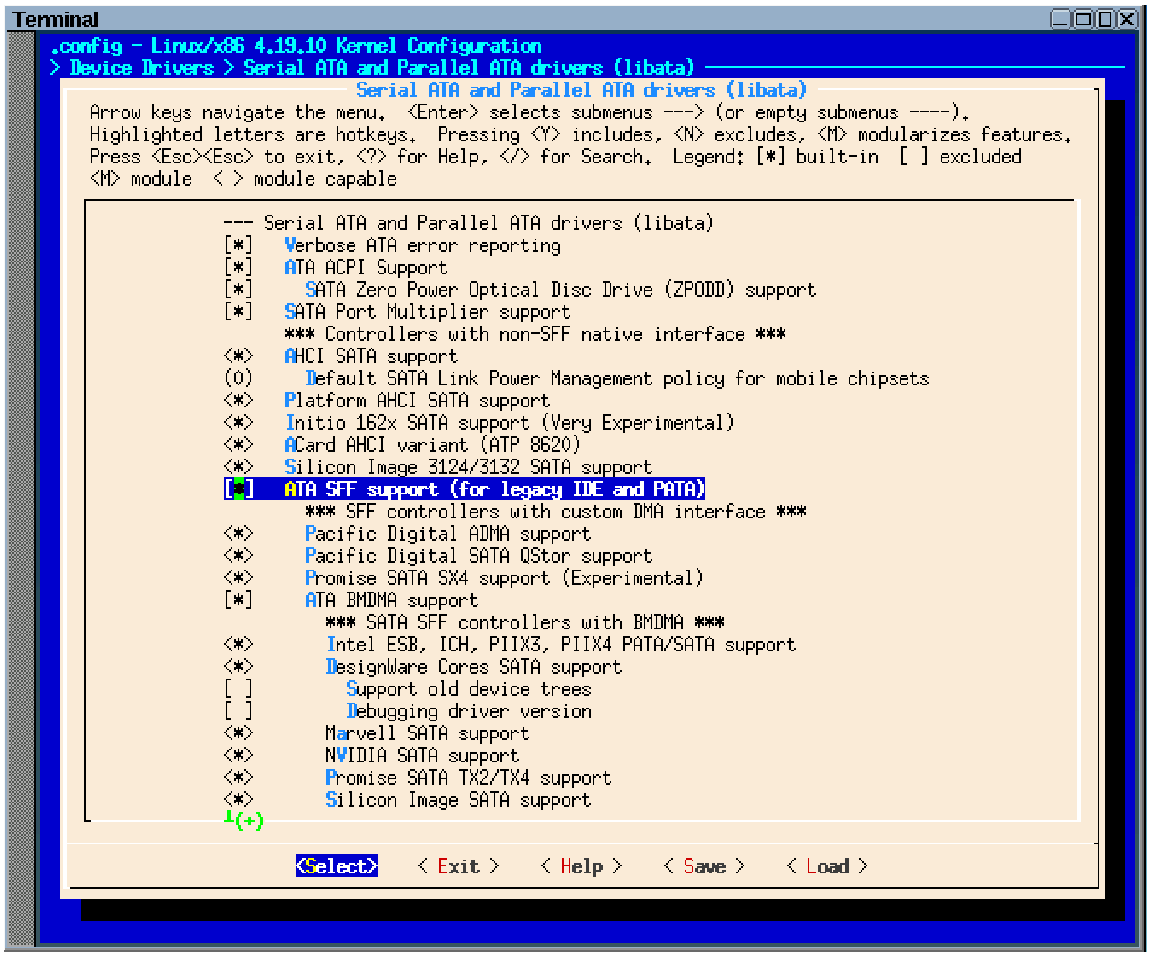
```
Terminal
.config - Linux/x86 4.19.10 Kernel Configuration
                    Linux/x86 4.19.10 Kernel Configuration
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).
  Highlighted letters are hotkeys.  Pressing <Y> includes, <N> excludes, <M> modularizes features.
  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ] excluded
  <M> module  < > module capable

                *** Compiler: gcc (GCC) 8.2.0 ***
                General setup  --->
            [ ] 64-bit kernel
                Processor type and features  --->
                Power management and ACPI options  --->
                Bus options (PCI etc.)  --->
                Binary Emulations  ----
                Firmware Drivers  --->
            [*] Virtualization  --->
                General architecture-dependent options  --->
            [*] Enable loadable module support  --->
            [*] Enable the block layer  --->
                Executable file formats  --->
                Memory Management options  --->
            [*] Networking support  --->
                Device Drivers  --->
                File systems  --->
                Security options  --->
            -*- Cryptographic API  --->
                Library routines  --->
                Kernel hacking  --->

            <Select>    < Exit >    < Help >    < Save >    < Load >
```

On these screens you use the cursor up/down keys to get you from line to line, the spacebar to change the configuration of the current selection between built-in/excluded/Module, and the cursor left/right keys to switch between **Select/Exit/Help** at the bottom of the screen. A **v(+)** at the bottom the screen indicates that there are further items off the bottom of the screen.

Use the cursor down key to select **Device Drivers -->** (hit enter) and then **Serial ATA and Parallel ATA drivers (libata) -->** on the next screen. This then brings up the following screen:



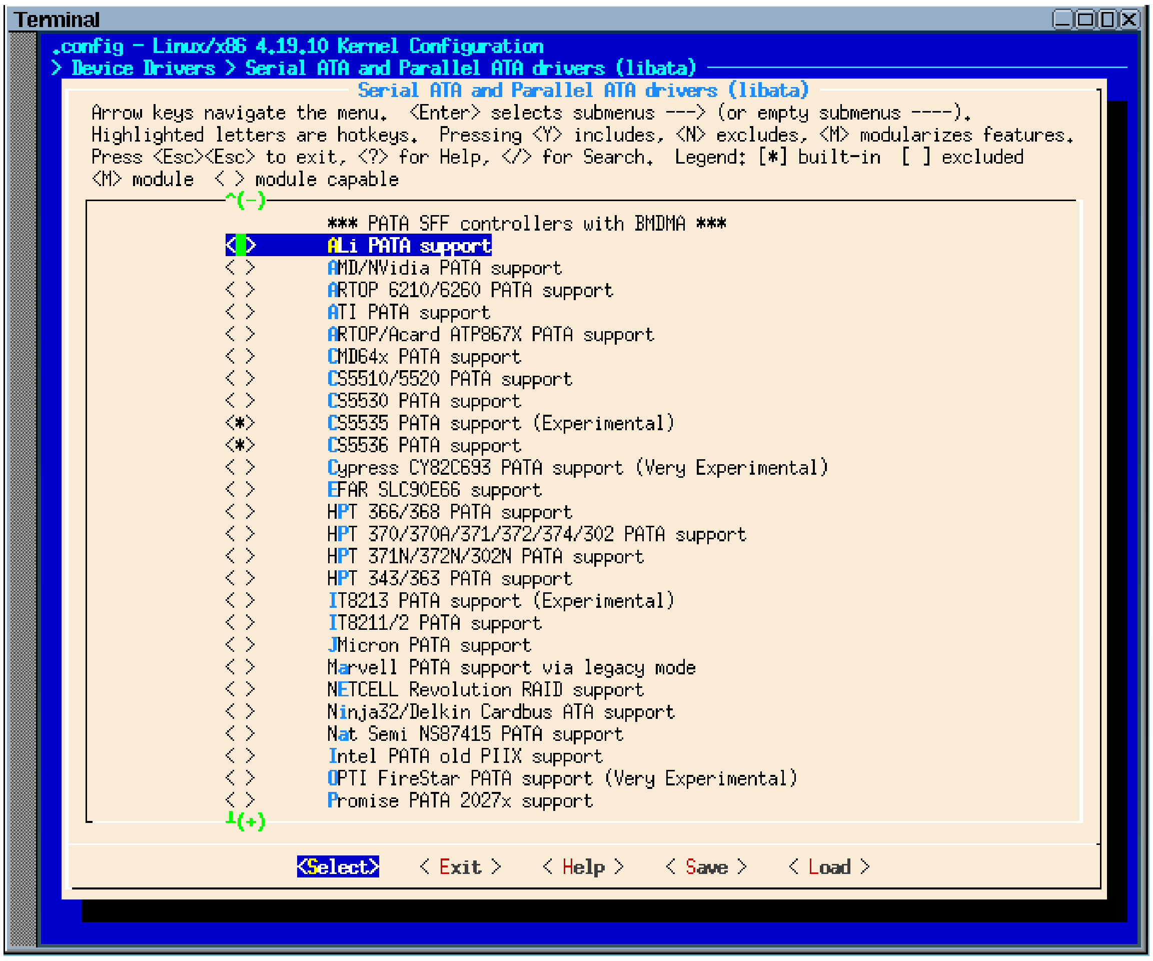
```
Terminal
.config - Linux/x86 4.19.10 Kernel Configuration
> Device Drivers > Serial ATA and Parallel ATA drivers (libata) ─────────────────
                    Serial ATA and Parallel ATA drivers (libata)
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).
  Highlighted letters are hotkeys.  Pressing <Y> includes, <N> excludes, <M> modularizes features.
  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ] excluded
  <M> module  < > module capable

          --- Serial ATA and Parallel ATA drivers (libata)
          [*]   Verbose ATA error reporting
          [*]   ATA ACPI Support
          [*]     SATA Zero Power Optical Disc Drive (ZPODD) support
          [*]   SATA Port Multiplier support
                *** Controllers with non-SFF native interface ***
          <*>   AHCI SATA support
          (0)     Default SATA Link Power Management policy for mobile chipsets
          <*>   Platform AHCI SATA support
          <*>   Initio 162x SATA support (Very Experimental)
          <*>   ACard AHCI variant (ATP 8620)
          <*>   Silicon Image 3124/3132 SATA support
          [*]   ATA SFF support (for legacy IDE and PATA)
                  *** SFF controllers with custom DMA interface ***
          <*>     Pacific Digital ADMA support
          <*>     Pacific Digital SATA QStor support
          <*>     Promise SATA SX4 support (Experimental)
          [*]     ATA BMDMA support
                    *** SATA SFF controllers with BMDMA ***
          <*>       Intel ESB, ICH, PIIX3, PIIX4 PATA/SATA support
          <*>       DesignWare Cores SATA support
          [ ]         Support old device trees
          [ ]         Debugging driver version
          <*>       Marvell SATA support
          <*>       NVIDIA SATA support
          <*>       Promise SATA TX2/TX4 support
          <*>       Silicon Image SATA support
          ┴(+)

          <Select>    < Exit >    < Help >    < Save >    < Load >
```

Our wanted drivers are sitting under **ATA SFF support** and then **ATA BMDA support**. It is worth initially deselecting **ATA BMDA support** to collapse the tree so we can then easily deselect all the other entries under **ATA SFF support**.

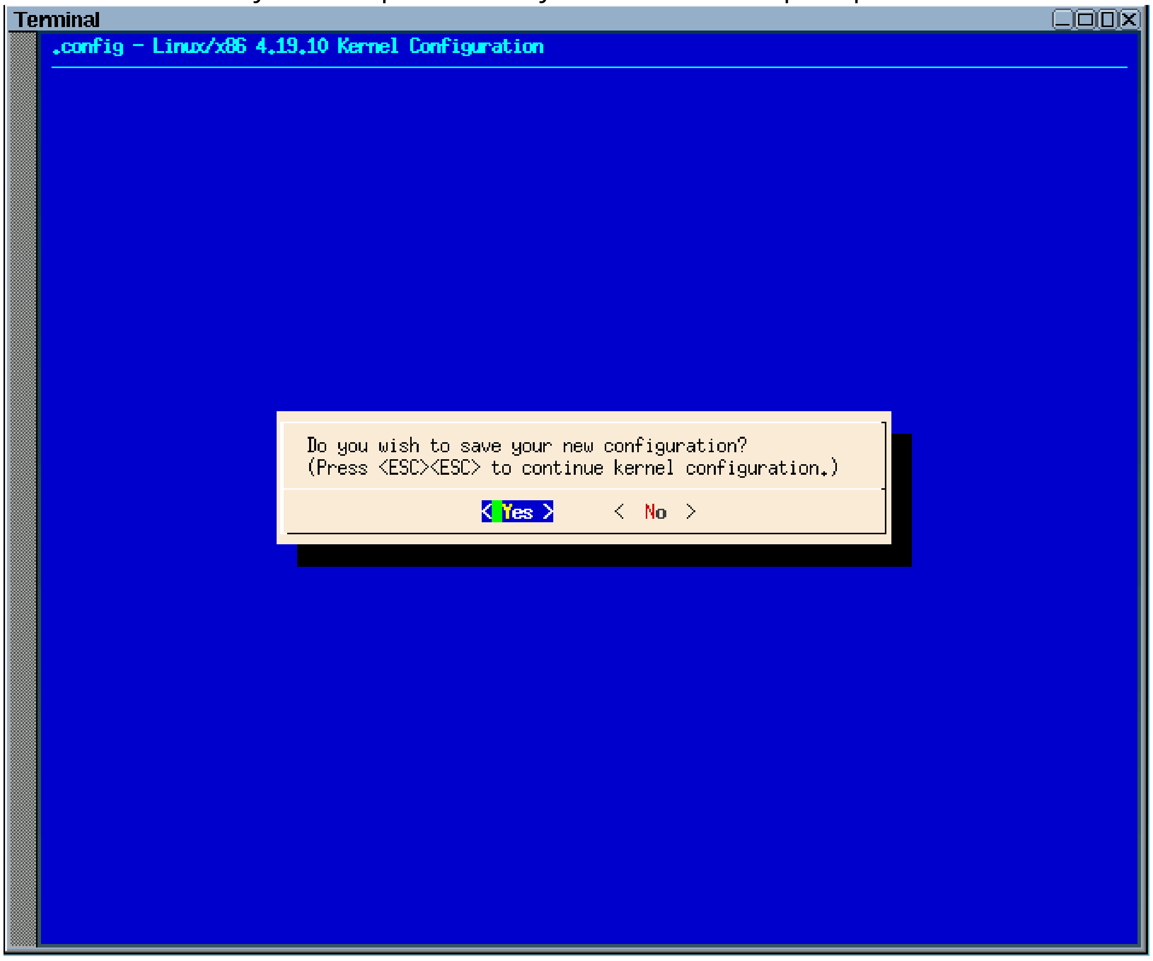
Next change **ATA BMDA support** to be built-in, and then work through the list excluding everything except for our wanted drivers. There are a fair number of drivers so remember to keep on scrolling down the screen until you've done the lot. What you should end up with is:



```
Terminal
.config - Linux/x86 4.19.10 Kernel Configuration
> Device Drivers > Serial ATA and Parallel ATA drivers (libata) ──────────────
                   Serial ATA and Parallel ATA drivers (libata)
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).
  Highlighted letters are hotkeys.  Pressing <Y> includes, <N> excludes, <M> modularizes features.
  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ] excluded
  <M> module  < > module capable
              ^(-)
                        *** PATA SFF controllers with BMDMA ***
              < >       ALi PATA support
              < >       AMD/NVidia PATA support
              < >       ARTOP 6210/6260 PATA support
              < >       ATI PATA support
              < >       ARTOP/Acard ATP867X PATA support
              < >       CMD64x PATA support
              < >       CS5510/5520 PATA support
              < >       CS5530 PATA support
              <*>       CS5535 PATA support (Experimental)
              <*>       CS5536 PATA support
              < >       Cypress CY82C693 PATA support (Very Experimental)
              < >       EFAR SLC90E66 support
              < >       HPT 366/368 PATA support
              < >       HPT 370/370A/371/372/374/302 PATA support
              < >       HPT 371N/372N/302N PATA support
              < >       HPT 343/363 PATA support
              < >       IT8213 PATA support (Experimental)
              < >       IT8211/2 PATA support
              < >       JMicron PATA support
              < >       Marvell PATA support via legacy mode
              < >       NETCELL Revolution RAID support
              < >       Ninja32/Delkin Cardbus ATA support
              < >       Nat Semi NS87415 PATA support
              < >       Intel PATA old PIIX support
              < >       OPTI FireStar PATA support (Very Experimental)
              < >       Promise PATA 2027x support
              ↓(+)

            <Select>    < Exit >    < Help >    < Save >    < Load >
```

Now select **exit** at the bottom the screen and work your way back through the previous menu screens until you end up with a 'Do you want to save..' prompt.



```
Terminal
.config - Linux/x86 4.19.10 Kernel Configuration

        Do you wish to save your new configuration?
        (Press <ESC><ESC> to continue kernel configuration.)

                  < Yes >      <  No  >
```

Select **Yes** and exit.

We now recompile the kernel image (**make bzImage**).

make should only rebuild those parts of the kernel that are affected by the changes we've made. In this example it took about 1 minute 20 seconds to build a new version of the kernel.

Testing

At this point it's worth spending a few minutes working out how you want to proceed. To a degree this is dependent on whether you are just making a few simple changes to the kernel or whether it is something more extensive that may result in a lot of edit/compile/test cycles. Two options are:

1. Copy the new kernel to a USB stick and boot that on the target machine.
2. Use the PXE capability of the thin client (if supported) to load the new kernel over the network.

Option [2] does make the testing cycle easier/quicker but takes more effort to set up. A way of doing this is described here.

It is also worth spending a small amount of time to create some scripts to automate the process of getting the new kernel image to where you want it, and, while you're at it, having a way to back track should you make a mistake and things stop working.

As mentioned above I wrote up how to set up PXE back in 2013. I suggest you read that article if you're headed down that route. Below is a simple approach and script that I've used for an option 1 approach.

In this example we need to get the new kernel onto the pen drive and also backup any files we are changing - **.config**, **bzImage** and **pata_cs5336.c**. To make life easy we'll backup all three of these every time into a directory inventively named **backup**. To keep track of what's what we'll add a time stamp to the file names so we don't accidently overwrite previous entries. As the compile/test cycle takes a few minutes we can use a YYMMDDHHMM style of time stamp without bothering about the seconds.

Starting with a standard installation of Tiny Core on a pen drive I edited the **syslinux.cfg** file on the pen drive to add a 'testing' menu entry that used the kernel file **vmlinuzSX0**.

```
LABEL tcsx
MENU LABEL Boot TinyCore SX0 (on slow devices, waitusb=5)
KERNEL /boot/vmlinuzSX0
INITRD /boot/core.gz
APPEND loglevel=7  kmap=qwerty/uk waitusb=5 tce=UUID="A677-5512"
```

What the script does is:

1. Mount the pen drive.
2. Copy **arch/x86/boot/bzImage** to **/boot/vmlinuzSX0**
3. Unmount the pen drive.
4. Backup the key files adding a time stamp to their file names.

My simple script (which lacks a full set of bomb-proof error checks) looks like this:

```
#!/bin/sh
#
# Ensure PENDRIVE is set to match your system!

PENDRIVE="sdb1"
STAMP=`date +%y%m%d%H%M`

echo using pendrive $PENDRIVE
echo timestamp is $STAMP
```

```
# Mount the pendrive and copy over the new system.
#  - check it is inserted
#  - mount it
#  - check we can see the boot directory
#  - copy the file over
#  - umount it

if ! [ -d "/mnt/$PENDRIVE" ] ; then
  echo "Pendrive is not present"
  exit
fi
sudo mount /dev/$PENDRIVE /mnt/$PENDRIVE
if [ $? -ne 0 ] ; then
  echo "[$?] failed to mount the pen drive"
  exit
fi

if ! [ -d "/mnt/$PENDRIVE/boot" ] ; then
  echo "Can't see the boot directory on $PENDRIVE"
  exit
fi
sudo cp -f arch/x86/boot/bzImage /mnt/$PENDRIVE/boot/vmlinuzSX0
sudo umount /dev/$PENDRIVE
echo "kernel copied over"

# Backup our working files
cp arch/x86/boot/bzImage backup/$STAMP_bzImage
cp .config backup/$STAMP_config
cp drivers/ata/pata_cs5536.c backup/$STAMP_pata_cs5536.c
echo "Files backed up"
```

This obviously assumes that the pen drive you insert appears to the system as /dev/sdb1. You will need to set the variable **PENDRIVE** to suit your setup. Also it expects to be run from the 'root' directory of the kernel build (where you type **make**).

[Back]

Any comments? email me. Added pre March 2014 Last update June 2019