Experiences with OpenEmbedded and the OMAP5912 Starter Kit

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Overview

• OMAP5912 Starter Kit
• OpenEmbedded
• Problems and solutions
• Evaluation
• Resources
• Conclusions
Disclaimer

- I am not an expert.
- Nothing is claimed to be optimal.
- This talk is a chronicle of what I did to get OpenEmbedded running on an OSK with a LCD module.
OMAP 5912 Starter Kit (OSK)
OSK – Back Side
OSK Hardware Features

- Texas Instruments TMS320C55xx core operating at 192 Mhz
- ARM9 core operating at 192 Mhz
- TLV320AIC23 codec
- 32 Mbyte DDR RAM
- 32 Mbyte on board Flash ROM
- 4 Expansion connectors (bottom side)
- RS-232 serial port
- 10 MBPS Ethernet port
- USB port
OSK Hardware Features (cont’d)

• On board IEEE 1149.1 JTAG connector for optional emulation
• +5 Volt operation only, power supply included
• Size: 5.55" x 3.54" (141 x 90 mm), 0.062 thick, 8 layers
• Compatible with Spectrum Digital's OSK wire Wrap Prototype Card
Software Features

• Compatible with MontaVista's Linux for OSK5912
• Compatible with OMAP Code Composer Studio from Texas Instruments
What’s Included

- OMAP5912 OSK board
- MontaVista Linux for OMAP5912 OSK
- Null modem RS-232 cable
- Ethernet cable
- AC Power cord and Power supply
- Quick Start Guide
- The flash is preloaded
Q-VGA LCD Module
Q-VGA LCD Module – Back Side
Description

- A plug-in for the OMAP5912 OSK
- NEC QVGA 3.5” LCD display and touch screen
- 4 user defined buttons
- 5 position joystick button
- Dual function camera port
What’s Included

- QVLM module
- Stylus
- Drivers
- Documentation
OpenEmbedded Overview

• Tools to generate
  – Tool chain
  – Different distributions
  – Different user level GUIs for different boards

• Everything is controlled by a “package”
OpenEmbedded Packages

• Package is described by a meta file
  – Dependencies between packages
  – Required patches
  – URLs for source and patches
  – How to build and install the package
  – ...

• Build packages with “bitbake”
  – Written in python
Distributions

• Familiar
• OpenZaurus
• OpenOmap
• Openslug, nylon, …
• Look in openembedded/conf/distros for others
User Level GUIs

• Opie (Open Palmtop Integrated Environment)
  – Based on qt libraries
  – www.trolltech.com

• Gpe
  – Based on X11 libraries
  – GTK+ widgets
  – http://www.gtk.org/
OpenEmbedded Directory Structure

- **Main ones you’ll use (under build/tmp)**
  - work - where all the work is done, sources
  - stamps - time stamps for the operations
  - rootfs - root file system, suitable for NFS mounting
  - deploy - images and package files (ipk format)
  - temp - in package subdirectory under work directory is where the log files are

- **Others**
  - cache
  - cross
  - staging
Boot OSK

- Connect ethernet and serial cables
- On Linux host
  
  ```
  $ minicom -w
  ```
- Power up OSK
- Hit a key in minicom to stop booting process
- Oh no, prompt: OMAP1610 Innovator #
First Problem

- Need to get new version of u-boot
- Not really difficult to fix – just do normal Opie build
- Builds new u-boot and we will then update the flash
- More on this later
Set Up U-Boot

- Change IP info in u-boot

```
OMAP1610 Innovator # printenv
baudrate=115200
ipaddr=156.117.97.156
serverip=156.117.97.139
netmask=255.255.254.0
bootargs=console=ttyS0,115200n8 noinitrd ...
bootcmd=bootm 0x100000
bootfile=uImage
bootdelay=10
stdin=serial
stdout=serial
stderr=serial
```
Set Up U-Boot (cont’d)

- Linux host IP address: 192.168.1.10
- MAC address on OSK: 00:0e:99:02:07:a4
- Desired OSK IP address: 192.168.1.102
- More details at
Set Up U-Boot (cont’d)

OMAP1610 Innovator # setenv ethaddr 00:0e:99:02:07:a4
OMAP1610 Innovator # setenv ipaddr 192.168.1.102
OMAP1610 Innovator # setenv serverip 192.168.1.10
OMAP1610 Innovator # setenv netmask 255.255.255.0
OMAP1610 Innovator # printenv
  baudrate=115200
  bootargs=console=ttyS0,115200n8 noinitrd rw ip=off ...
...
  ipaddr=192.168.1.102
  serverip=192.168.1.10
  netmask=255.255.255.0
  ethaddr=00:0e:99:02:07:a4

Environment size: 279/131068 bytes

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Set Up U-Boot (cont’d)

• Save changes

OMAP1610 Innovator # saveenv
Saving Environment to Flash...
Un-Protected 1 sectors
Erasing Flash...
Erasing sector 1 ... done
Erased 1 sectors
Writing to Flash...
U-Boot Problem Is Waiting

- There is a bug in the pre-installed version of u-boot
  - OSK may hang after decompressing the kernel
- Two solutions
  - Upgrade u-boot
  - Modify and recompile the kernel
Get Started with OpenEmbedded

- Check/install required software on GettingStarted wiki page
  - [http://www.openembedded.org](http://www.openembedded.org)
- Download svn
  - [http://subversion.tigris.org/](http://subversion.tigris.org/)
- Create a directory for bitbake and install it
  - mkdir $HOME/src/bitbake
  - cd $HOME/src/bitbake
  - svn co svn://svn.berlios.de/bitbake/trunk/bitbake
- Potential problem
  - svn.berlios.de doesn’t allow http access
Getting Started (cont’d)

- Download OpenEmbedded
  
  ```
  $ cd $HOME/src/oe
  $ mkdir build
  $ bk clone \ http://openembedded.bkbits.net/openembedded
  $ cd openembedded
  $ bk -r co -q
  ```

- Size ~ 235MB
Configuration

• Make config file
  $ cd $HOME/src/oe/build
  $ mkdir conf
  $ cp ../openembedded/conf/local.conf.sample \ conf/local.conf

• Edit build/conf/local.conf – read the file as you edit it (there will be a test!)
  – DL_DIR – download directory
  – BB_FILES – where the bitbake “meta” files are
  – TMPDIR – where all the work goes
  – MACHINE – omap5912osk
  – DISTRO – openomap
Machines

akita.conf  mtx-1.conf  tosa-2.6.conf
beagle.conf  native.conf  tosa.conf
boxer.conf  netvista.conf  tune-arm920t.conf
c7x0.conf  nslu2.conf  tune-arm926ejs.conf
colinux.conf  omap1510inn.conf  tune-c3.conf
collie.conf  omap1610h2.conf  tune-ppc603e.conf
corgi.conf  omap1710h3.conf  tune-ppce500.conf
epia.conf  omap2420h4.conf  tune-sh3.conf
geodegx.conf  omap5912osk.conf  tune-sh4.conf
h3600.conf  poodle-2.4.conf  tune-strongarm.conf
h3900.conf  poodle-2.6.conf  tune-xscale.conf
handheld-common.conf  poodle.conf  vibren-pxa255idp.conf
husky.conf  ramses.conf  w1500g.conf
ipaq-common.conf  SCCS  wrt54.conf
ipaq-pxa-2.6.conf  shepherd.conf  x86.conf
jornada56x.conf  simpad.conf  x86-uml.conf
jornada6xx.conf  spitz.conf  xxs1500.conf
jornada7xx.conf  sun4cdm.conf  zaurus-clamshell-2.4.conf
lite5200.conf  thinclient-common.conf  zaurus-clamshell-2.6.conf
mainstone.conf  tosa-2.4.conf  zaurus-clamshell.conf
## Distributions

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>asusoe.conf</td>
<td>openslug.conf</td>
</tr>
<tr>
<td>colinuxoe.conf</td>
<td>openzaurus-3.5.2.conf</td>
</tr>
<tr>
<td>familiar-0.8.0.conf</td>
<td>openzaurus-3.5.3.conf</td>
</tr>
<tr>
<td>familiar-0.8.1.conf</td>
<td>openzaurus-3.5.4.conf</td>
</tr>
<tr>
<td>familiar-0.8.2.conf</td>
<td>openzaurus.conf</td>
</tr>
<tr>
<td>familiar-0.9.0.conf</td>
<td>preferred-e-versions.inc</td>
</tr>
<tr>
<td>familiar.conf</td>
<td>preferred-gpe-versions-2.6.inc</td>
</tr>
<tr>
<td>generic.conf</td>
<td>preferred-gpe-versions.inc</td>
</tr>
<tr>
<td>jlime.conf</td>
<td>preferred-opie-versions.inc</td>
</tr>
<tr>
<td>nylon.conf</td>
<td>sharprom-compatible.conf</td>
</tr>
<tr>
<td>openmnci.conf</td>
<td>switchbox.conf</td>
</tr>
<tr>
<td>openomap.conf</td>
<td>unslung.conf</td>
</tr>
<tr>
<td>opensimpad-0.9.0.conf</td>
<td>wrt54oe.conf</td>
</tr>
</tbody>
</table>

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Build OpenEmbedded

$ cd $HOME/src/oe/build
$ bitbake opie-image

NOTE: Using cache in '/h.../build/tmp-omap5912osk/cache'
NOTE: Parsing finished. 2316 cached, 0 par ... 0 masked.
NOTE: Building provider hash: [###############...##] (100%)
NOTE: build 200506031402: started

OE Build Configuration:
TARGET_ARCH    = "arm"
TARGET_OS      = "linux"
MACHINE        = "omap5912osk"
DISTRO         = "openomap"
TARGET_FPU     = "soft"
...

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The Problems Start

NOTE: package uboot-0.0cvs20050... do_compile: started
ERROR: function do_compile failed
ERROR: log data follows (/home/pesos/src/oe/build/tmp\-omap5912osk/work/uboot-0.0cvs20050520-r2/temp/log.do_
compile.31040)
| NOTE: make CROSS_COMPILE=arm-linux- omap5912osk
| make: *** No rule to make target `omap5912osk'. ...
| FATAL: oe_runmake failed
NOTE: Task failed:
NOTE: package uboot-0.0cvs20...task do_compile: failed
ERROR: TaskFailed event exception, aborting
NOTE: package uboot-0.0cvs20050520: failed
ERROR: Build of opie-image failed
U-Boot Solution

- In openembedded/packages/uboot/uboot_cvs.bb change
  
  UBOOT_MACHINE ?= "${MACHINE}" 

  to 

  UBOOT_MACHINE ?= "${MACHINE}_config"

- In work/uboot-0.0cvs20050520-r2/u-boot/include/configs/omap5912osk.h add (by
  
  #define for CFG_MALLOC_LEN) 

  - #define CFG_GBL_DATA_SIZE 128
U-Boot Solution (cont’d)

- Edit …/work/uboot-0.0cvs20050520-r2/u-boot/cpu/arm926ejs/config.mk
  - Delete short-load-bytes
  - Delete apcs-32
  - -m parameters for arm processor
  - This solution depends on the gcc version
Example of Finding Solution

netconsole.c ns16550.c ... ks8695eth.c > .depend
  | ks8695eth.c:27:31: asm/arch/platform.h: No such file or directory
  | make[1]: *** [.depend] Error 1
  | make[1]: Leaving directory `/home/pesos/src/oe/build/tmp-omap5912osk/work/uboot-0.0cvs20050523-r2/u-boot/drivers'
  | make: *** [drivers/libdrivers.a] Error 2
  | FATAL: oe_runmake failed
NOTE: Task failed:
NOTE: package uboot-0.0cvs20050523-r2: task do_compile:
  failed
ERROR: TaskFailed event exception, aborting
NOTE: package uboot-0.0cvs20050523: failed
ERROR: Build of opie-image failed
Solution Example (cont’d)

$ cd ../work/uboot-0.0cvs20050523-r2/u-boot
$ find . -name platform.h
./include/asm-microblaze/platform.h
./include/asm-arm/arch-ks8695/platform.h

Error message was from
ks8695eth.c:27:31: asm/arch/platform.h

Edit u-boot/drivers/ks8695.c:
    change
    #include <asm/arch/platform.h>
    to
    #include <asm-arm/arch-ks8695/platform.h>

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Kernel Build Error

NOTE: package linux-omap1-2.6.12-... do_package: completed
NOTE: package linux-omap1-2.6.12-... task do_deploy: started
ERROR: function do_deploy failed
ERRO...work/linux-omap1-2.6.12-rc2/temp/log.do_deploy.14073)
  Image Name: OE
  Created: Mon May 23 09:48:27 2005
  Image Type: ARM Linux Kernel Image (gzip compressed)
  Data Size: 996832 Bytes = 973.47 kB = 0.95 MB
  Load Address: 0x10C08000
  Entry Point: 0x10C08000
  cp: cannot create regular file `/tftpboot/uImage_bb.cc': Permission denied
NOTE: Task failed:
NOTE: package linux-omap1-2.6.12-rc2: task do_deploy: failed
ERROR: TaskFailed event exception, aborting
NOTE: package linux-omap1-2.6.12: failed

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Kernel Solution

• Compile has completed
• Looks like it’s trying to write kernel image to /tftpboot
• That’s not the place I put my images!
• deploy is a meta operation (in a .bb file)
  – Kernel packages are in openembedded/packages/linux
  – There is a linux-omap1_2.6.12-rc2.bb
  – Aside: there are 68 different kernel entries in directory
Kernel Solution (cont’d)

• A “grep tftpboot *.bb” verifies that linux-omap1_2.6.12-rc2.bb is the only file

• During the edit to fix /tftpboot, it seems that things are being put in ${DEPLOY_DIR} instead of ${DEPLOY_DIR}/images where they belong. So
  – Change ${DEPLOY_DIR} to ${DEPLOY_DIR}/images (if appropriate)
  – Change /tftpboot to wherever you keep kernel images to boot
Bad Value for -mtune

- At some point (this one happened during build of udev) you might get the following error during a compile:

```c
udev.c:1: error: bad value (arm926ejs) for -mtune= switch
```
-mtune Solution

• In openembedded/conf/machine/tune-arm926ejs.conf change
  
  TARGET_CC_ARCH = "-march=armv5te -mtune=arm926ejs"
  
  to
  
  TARGET_CC_ARCH = "-march=armv5te -mtune=arm926ej-s"

• Note: this is dependent on compiler version

• Can be found by doing a “man gcc” and looking at the “Arm Options” under “Hardware Models and Configurations” (it’s way, way down the man page)

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What Next?

- Eventually, it finishes
- In the process the following have been built:
  - u-boot image
  - kernel image
  - root file system image (jffs2)
  - root file system suitable for NFS mounting
Updating U-Boot

• Before we can update u-boot, we need to copy the new u-boot image from build/tmp/deploy/images to our “tftpboot” directory

    cp build/tmp-omap5912osk/deploy/images/u-boot-omap5912osk-20050511192010.bin /home/pesos/images/
Updating U-Boot (cont’d)

OMAP1610 OSK # tftpboot 10000000
/home/pesos/images/u-boot-omap5912osk-20050511192010.bin
Using MAC Address 00:0E:99:02:07:A4
TFTP from server 192.168.1.10; our IP address is 192.168.1.102
Filename '/home/pesos/images/u-boot-omap5912osk-20050511192010.bin'.
Load address: 0x10000000
Loading: ################################
done
Bytes transferred = 87424 (15580 hex)
OMAP1610 OSK #

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Updating U-Boot (cont’d)

OMAP1610 Innovator # protect off 0 1FFFF
.

Un-Protected 1 sectors
OMAP1610 Innovator # erase 0 1FFFF
.

done

Erased 1 sectors
OMAP1610 Innovator # cp.b 10000000 0 15580

Copy to Flash... done

OMAP1610 Innovator #
Let’s Try to Boot

• Copy kernel image to OSK at 0x10000000

OMAP5912 OSK # tftpboot 10000000
/home/pesos/images/uImage_bb.cc
Using MAC Address 00:0E:99:02:07:A4
TFTP from server 192.168.1.10; our IP address is 192.168.1.102
Filename '/home/pesos/images/uImage_bb.cc'.
Load address: 0x10000000
Loading:
###################################################
.... done
Bytes transferred = 940954 (e5b9a hex)
Booting (cont’d)

• Boot the kernel image from 0x10000000

OMAP5912 OSK # bootm 10000000
#
# Booting image at 10000000 ... 
  Image Name: OE
  Image Type: ARM Linux Kernel Image (gzip compressed)
  Data Size: 940890 Bytes = 918.8 kB
  Load Address: 10c08000
  Entry Point: 10c08000
  Verifying Checksum ... OK
  Uncompressing Kernel Image ... OK
...

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Booting (cont’d)

... Copying default qpe.conf into /home/root/Settings/
Starting Opie in 5 seconds... press key to interrupt.
Starting Opie....
ODEvice() - found 'Hardware : TI-OSK'
...
<unknown>: setting QWS_DISPLAY to 'Transformed:Rot0:0'
qt_init() - starting in daemon mode...

OpenEmbedded Linux omap5912osk ttyS0

omap5912osk login:

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Booting (cont’d)
Booting (cont’d)

• But

omap5912osk login: root
login: cannot set groups: Operation not permitted

OpenEmbedded Linux omap5912osk ttyS0

omap5912osk login:
Booting (cont’d)

• Try again, but simpler
  
  $ bitbake bootstrap-image

• Only build pieces necessary to boot
  – Command line operations
  – Root file system for NFS mount
  – busybox
  – no GUI
Login Solution

• Tinylogin is being used
  – Tinylogin web site and the Makefile have suggestions
  – They don’t make a difference

• Put in lots of debug writes in Tinylogin

• The cause of the problem:

  In file `kernel/sys.c` function `sys_setgroups()`

```c
if (!capable(CAP_SETGID))
    return -EPERM;
```

• `capable()` is in include/linux/sched.h
Login Solution (cont’d)

• Put debug writes in kernel
• The problem is in sys_setgid (obviously!)
• Aside: how to compile only a kernel
Compiling New Kernel

$ cd build/tmp-5912osk/stamps/
$ rm linux-omap1-2.6.12-rc2.do_compile
$ rm linux-omap1-2.6.12-rc2.do_populate_staging
$ rm linux-omap1-2.6.12-rc2.do_package
$ rm linux-omap1-2.6.12-rc2.do_deploy
$ bitbake linux-omap1

• Removing do_configure may cause a problem
Login Solution (cont’d)

$ ls -l tmp-omap5912osk/rootfs/bin/tinylogin
-rwsr-xr-x 1 pesos pesos 39328 Jun 2 08:26 tinylogin
$

- It’s suid and owner/group are pesos
- Solution
$ chmod 755 tinylogin

- It doesn’t need to be suid
- Now we can log in!
Touch Screen Problem

• “Tap anywhere” doesn’t do anything
• Login problem and touch screen problem are unrelated
• Now we have a console window where we can diagnose the problem better
Touch Screen Solution

- [http://oskfordummies.hp.infoseek.co.jp/](http://oskfordummies.hp.infoseek.co.jp/) has information on setting up touch screen
- It uses tslib
- tslib is in OpenEmbedded, but not linked into qte
- Recompile qte with QT_QWS_TSLIB defined
Touch Screen Solution (cont’d)

• Edit packages/qte/qte_2.3.10.bb to include tslib as part of qte configuration

• Change

EXTRA_OECONF = "-system-jpeg -system-libpng ..." to

EXTRA_OECONF = "-tslib -system-jpeg ..."

• Rebuild qte
  – Remove relevant qte* files from build/tmp/stamps
  – bitbake opie-image
rootfs Problem and Solution

• First login initialized many files
• They are owned by root
• Can’t make new rootfs as a “normal” user
• A (simple) solution
  – Remove rootfs directory before running bitbake
Touch Screen Problem Continues

- Still no touch screen
- "od -vx /dev/input/event1" prints out things – that’s good
- In file `qte-2.3.10-r16/qt-2.3.10/src/kernel/qwsmouse_qws.cpp`

```c
if((tsdevice = getenv("TSLIB_TSDEVICE")) != NULL) {
    m_ts = ts_open( tsdevice, 1 );
} else {
    m_ts = ts_open( "./dev/ts", 1 );
}
```
- So define TSLIB_TSDEVICE
Still Doesn’t Work

- Lots of debug prints in qte startup
- daemon mode isn’t starting correctly
- There’s a command line –nodaemon option
- In rootfs/etc/init.d/opie

- Change appropriate line to

  $SSHAGENT $OPIEDIR/bin/qpe -nodaemon -terminal 2 &
One Step Closer – Calibration
Finished – sort of
OpenEmbedded Size

• Initial download: 235 MB
• tmp directory: 4.4 GB
  – work: 3.8 GB
  – rootfs: 36 MB
• Be careful – it grows, especially CVS packages
CVS Packages

$ du -sh work/tmp-omap5912osk/libopie2*
21M    libopie2-1.2.0+cvs-20050520-r0
21M    libopie2-1.2.0+cvs-20050523-r0
21M    libopie2-1.2.0+cvs-20050601-r0

$ ls ~/downloads/opie.libopie2*
opie.libopie2_cvs.handhelds.org__20050329.tar.gz
opie.libopie2_cvs.handhelds.org__20050330.tar.gz
opie.libopie2_cvs.handhelds.org__20050331.tar.gz
...
opie.libopie2_cvs.handhelds.org__20050520.tar.gz
opie.libopie2_cvs.handhelds.org__20050523.tar.gz
opie.libopie2_cvs.handhelds.org__20050601.tar.gz

18 of them!

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Disadvantages

• Can be difficult to use automatically generated tool chain for external project

• Two sources for bugs
  – Meta files
  – Code bugs

• Frequently, waiting a day can fix a problem
  – Just do “bk pull” and try again
  – If not, post to appropriate mailing list
  – Not everyone is using your configuration
Disadvantages (cont’d)

• Just before major release, files undergoing tremendous changes
• If a version works, keep it for a while (or save it)
• The size of the sources can sneak up on you
Advantages

• Easy to use
• Tool chain built automatically
• Gets and merges appropriate patches
• Multiple distributions and boards and kernels
  – 49 boards (openembedded/conf/machine)
  – 25 distributions (openembedded/conf/distros)
  – Various 2.4 and 2.6 kernels
  – User level GUIs
OpenEmbedded URLs

- OpenEmbedded home page
  - http://openembedded.org/
- OpenEmbedded mailing lists
  - http://www.oesf.org/forums/
- OpenEmbedded wiki front page
  - http://openembedded.org/cgi-bin/moin.cgi/FrontPage
- How to build OpenEmbedded
  - http://openembedded.org/cgi-bin/moin.cgi/GettingStarted
OSK URLs

• OMAP kernel code
  – http://linux.omap.com/pub/

• OMAP mailing list

• OMAP patches for various Linux kernel versions

• A main site for Linux OMAP
  – http://www.muru.com/linux/omap/
OSK URLs (cont’d)

- OSK for dummies
- Description of OSK board with some links
  - http://tree.celinuxforum.org/CelfPubWiki/OSK
- Spectrum Digital OSK catalog page
  - http://www.spectrumdigital.com/cgi/catalog.cgi?show_product=701875
- Mistral Software OSK LCD catalog page
OSK URLs (cont’d)

• TI page for Linux OMAP downloads
  – http://focus.ti.com/docs/general/splashdsp.jhtml?&path=templatedata/cm/splashdsp/data/linux_com_downloads

• TI page for OSK
  – http://focus.ti.com/docs/toolsw/folders/print/tm dxosk5912.html
Conclusions

• OSK
  – Designed with CE in mind
  – Full featured development system
  – Inexpensive
  – Lots of support from community

• OpenEmbedded
  – Easy to use
  – Community support
  – Not difficult to add/modify simple packages
  – Overall, well done and worth serious consideration