Timesys University

Track One

Building a connected home automation device with the Digi ConnectCore™ Wi-i.MX51 using LinuxLink

Session 4

How to optimize, test and integrate the solution for quick deployment

Audio streaming is available for this event.
Turn on your speakers to listen.

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Tools You Can Use

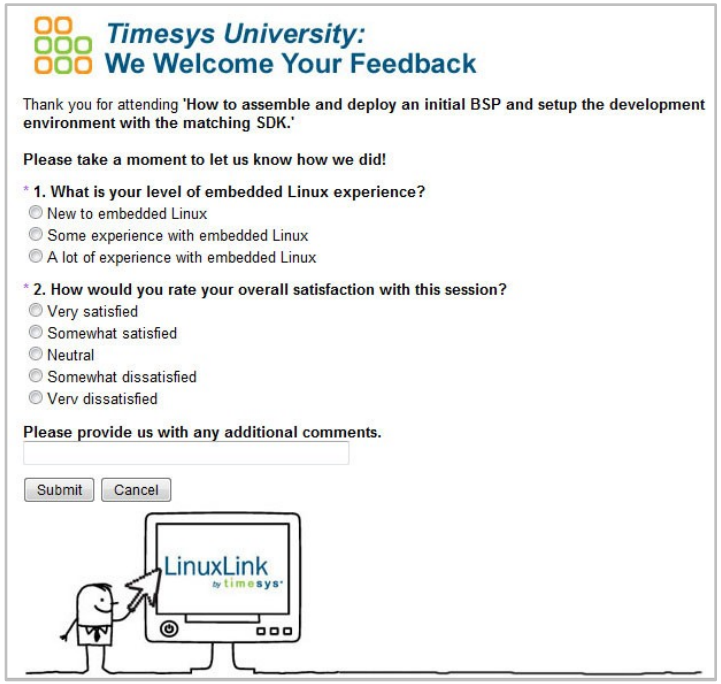
Q&A

- Click on Q&A panel (?) or chat icon in the bottom right corner
- Type in your question in the space provided
- Click on “Submit”

Tools You Can Use

Polling

- The poll will appear on your screen
- Select your answer for each question
- Click on “Submit”



Session Information

- **You can download the slides for today's session at** http://www.timesys.com/embedded-linux/training/timesys-university/digi_wi-imx51

- **You can view a recording of today's session at** http://www.timesys.com/embedded-linux/training/timesys-university/digi_wi-imx51

- **Today's speakers:**

Maciej Halasz
Director, Product Management
Timesys

Building a Connected Home Automation Device

- **Session 1 – Recording available**
  How to assemble and deploy an initial BSP and setup development environment with the matching SDK

http://www.timesys.com/embedded-linux/training/timesys-university/digi_wi-imx51

- **Session 2 – Recording available**
  How to build a control application using Qt Embedded for Linux to design a UI experience
- **Session 3 – Recording available**
  How to integrate a WIFI and Bluetooth functionality with the control application
- **Session 4 – today**
  How to optimize, test and integrate the solution for quick deployment

Today's Agenda

- **Recap of what we have done so far**
- **Measure the boot-time in our dev environment**
- **Integrate all developed software pieces**
  - Overlay concept
- **Fast boot optimizations**
  - Boot process overview
  - Bootloader optimizations
  - Kernel level optimizations
  - Filesystem optimizations
  - Other options
- **Deployment**
  - SD card preparations

Past Sessions Recap

What We Have Accomplished So Far

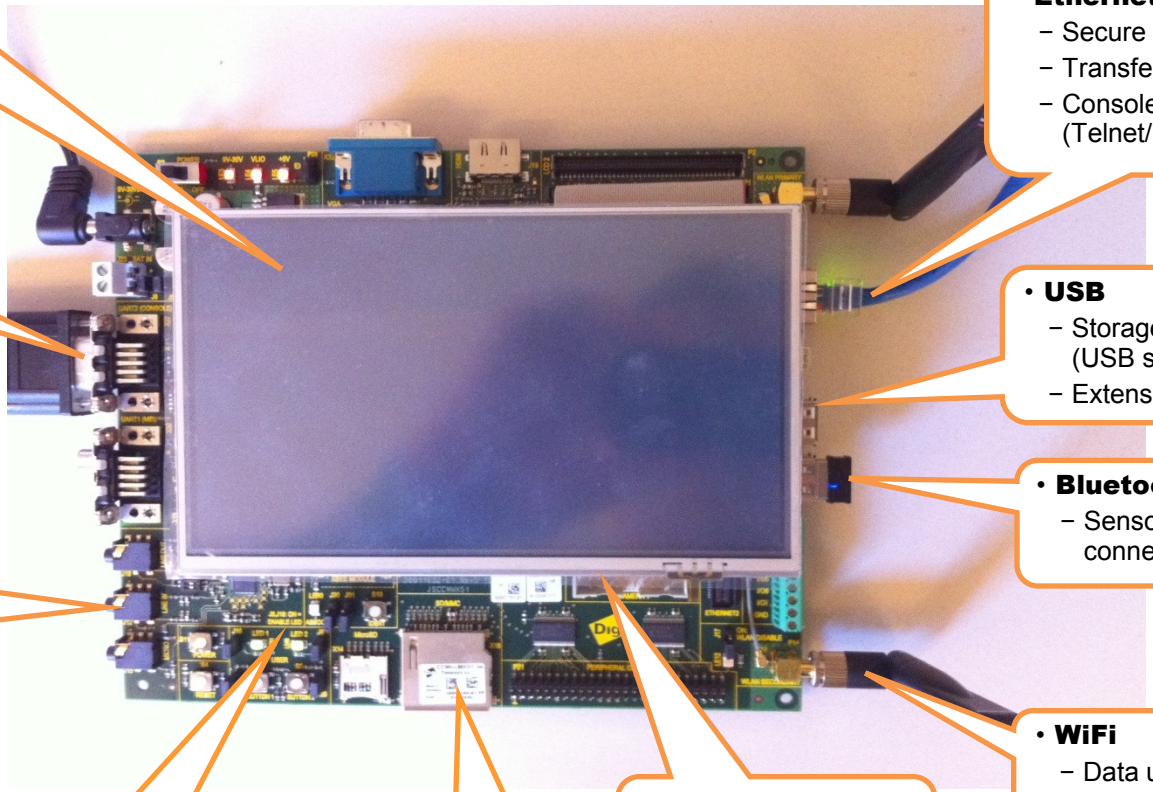
- **Learned about ConnectCore Wi-i.MX51 LinuxLink – needed for all exercises**
- **Built a custom BSP with LinuxLink Web Edition based on product requirements**
- **Built a control application with TimeStorm and Qt**
  - Added custom Widget
  - Compiled for local host and cross-compiled for the target
- **Added GPIO control for two devices — LEDs**
  - Used SYSFS
- **Added WiFi and Bluetooth connectivity**
- **Develop code for**
  - Remote accelerometers
  - Data upload to an ftp server

Project Requirements (Digi CC Wi-i.MX51)

- **Graphics**
- **Touchscreen**
- **Applications**
  - Screen calibration
  - Home automation application

- **Serial port communication**

- **Audio (optional)**
  - Alsa Mixer
  - Sound playback



- **Ethernet**
  - Secure Connection
  - Transfer (FTP/SCP)
  - Console (Telnet/SSH)

- **USB**
  - Storage (USB stick)
  - Extensions

- **Bluetooth**
  - Sensor connections

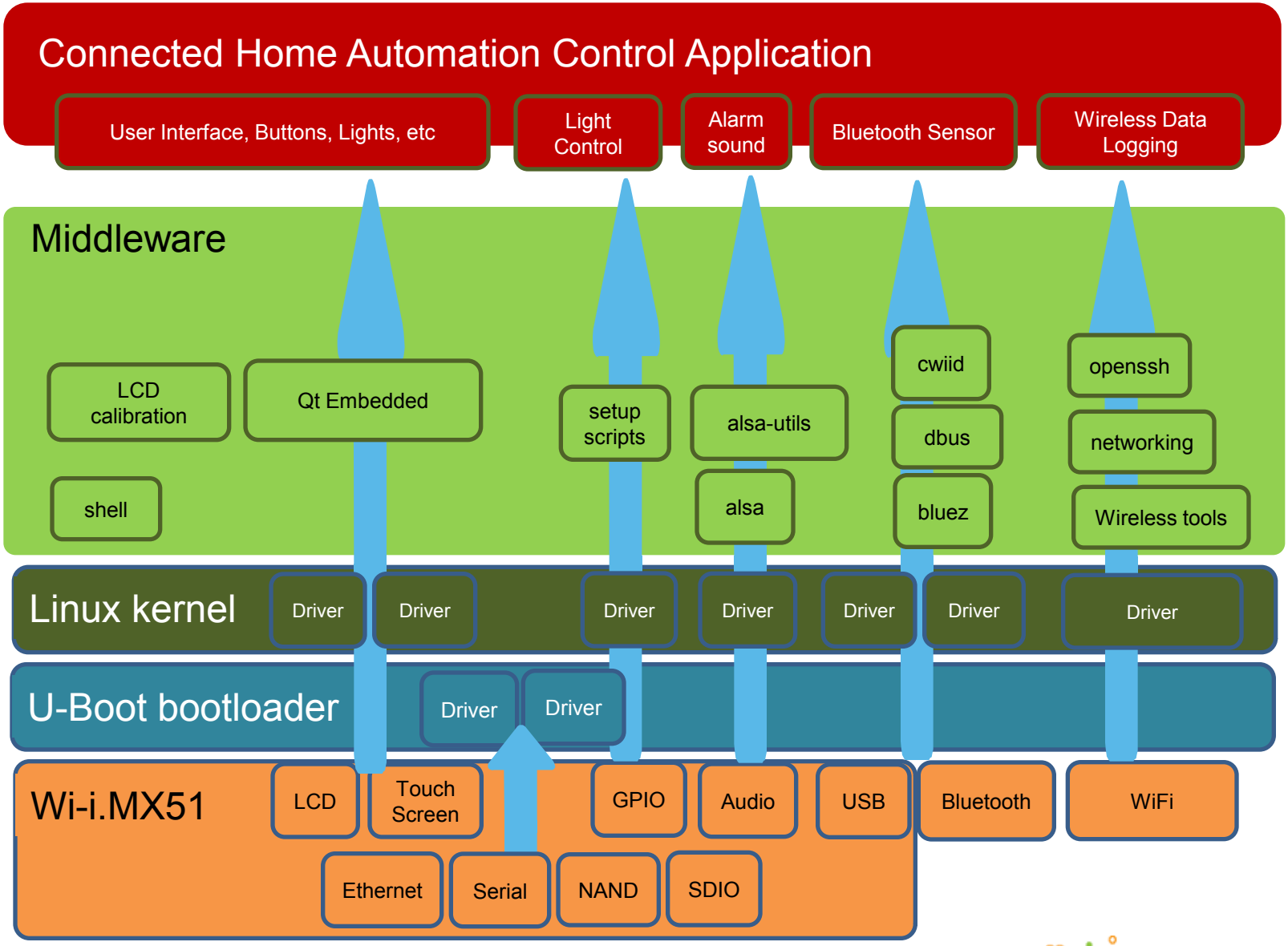
- **WiFi**
  - Data upload to a server

- **GPIO controlled LEDs**

- **SD/MMC Card**
  - Filesystem

- **NAND Flash**
  - Boot from
  - Additional storage

Home Automation Device (Blueprint)



Digi ConnectCore™ Wi-i.MX51 Giveaway Reminder

Giveaway

- **If you attend at least 3 out of 4 sessions in our Track 1, we will automatically enter you into a drawing for a prize.**
- **The results of the drawing of the complete ConnectCore Wi-i.MX51 Development Kit will be announced via e-mail, Twitter and on our site this Tuesday at 4pm EST**
- **Together with Digi International, we also offer the above mentioned kit at a discount price of $249+S&H**
- **If interested in buying a kit, send an email to sales@timesys.com with "CC-Wi-i.MX51 Kit SPECIAL OFFER" in subject line.**

Boot-time Measurement

Software Integration

Developed Components

- **U-Boot**
- **Linux Kernel**
  - Modules for WiFi and Bluetooth
- **Filesystem**
  - BlueZ, WiFi utilities, Qt for Embedded, etc.
- **Home Automation Application**
- **Setup scripts**
  - Wifi, GPIO, Application startup

Overlay

- **Way to integrate custom Linux components with the underlying Linux system**
  - Structured development
  - Simplified maintenance
- **Create an overlay**
  - Create a set of subfolders
  - Copy custom content to appropriate places
- **Define appropriate entries using Factory's Desktop interface**

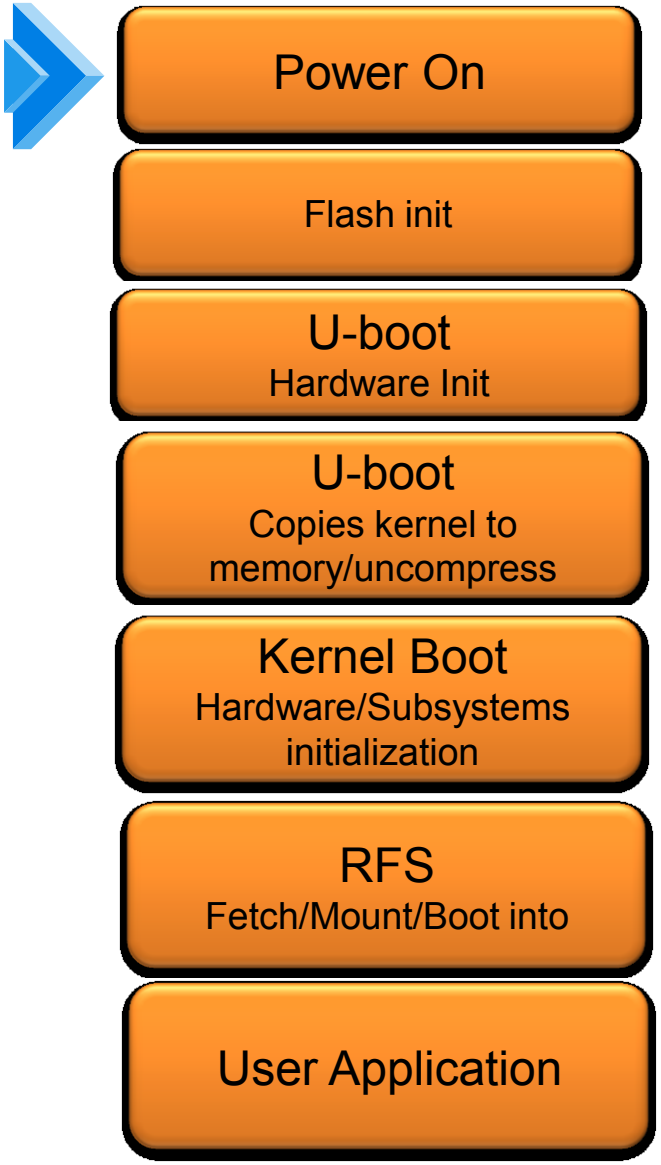
  file:///<fully qualified path to overlay's tar file>

Fast-boot Optimizations

Boot Process Overview

- **U-Boot**
  - Reset, copy U-Boot to SDRAM and jump to start address
  - Basic System Init. (IMPORTANT)
  - Copy Linux kernel Image to SDRAM from SD
  - Decompress the kernel if needed
  - Jump to upload address and start the kernel
- **Kernel**
  - Run Kernel Init code
  - Init kernel subsystems (device drivers)
  - Init SD card
  - Mount SD card partition with RFS
  - Execute init script
- **Application**
  - Depends on your specific requirements

Boot Process Sequence



Bootloader Optimizations

- **Low hanging fruit**
  - Set the bootdelay variable to 0 (time savings 4s)
  - Preset the bootcmd; do not use setenv (time savings 0.5s)
  - Disable console (time savings 2s)
    - CFG_CONSOLE_INFO_QUIET
    - CONFIG_SILENT_CONSOLE
    - In our case- silent=yes
  - Disable other tests (time savings 2-6s)
- **Additional modification/enhancements**
  - If possible, use uncompressed Linux kernel
  - Optimize the NAND read operation, to shorten image copy time
  - Rewrite/disable CRC32 checksum code
  - Load the image directly to Entry point
    - Set CONFIG_LOADADDR
  - If NOR Flash is used, leverage XIP
  - For large kernel image use different compression algorithms

Linux Kernel Optimizations

- **Low hanging fruit (time savings: 2-15+s)**
  - Use uncompressed kernel
    - Uncompressing takes time
  - Remove unused kernel options
    - Not used networking i.e. IPV6, multiple file systems
    - Debug features and symbols (for final deployment)
  - Build all possible device drivers as Loadable Kernel Modules
    - Keep the features needed at boot time built into the kernel
    - Remaining drivers built as LKMs will make kernel smaller
  - Consider various approaches for your RFS deployment
    - JFFS2 with appended journal summary (skip flash scan)
    - CRAMFS, UBIFS
  - Suppress the console output
    - Use “quiet” with your kernel command line
- **Additional modifications/enhancements**
  - Staged booting
  - Code level modifications
  - Add a splash screen

Making Linux Kernel Small and Fast

Linux kernel options we will look at today

Kernel Option	Comment
CONFIG_EMBEDDED	Disables or tweaks a number of kernel options and settings. Think uClinux
CONFIG_IKCONFIG	Saves complete kernel configuration in the kernel
CONFIG_KALLSYMS	Prints our symbolic crash information and backtraces
CONFIG_BUG	Disables BUG and WARN functions
CONFIG_HOTPLUG	Can be disabled if no external devices will be attached and if you use static device files
CONFIG_DNOTIFY	File change notification to user space
CONFIG_EXT2	Disable if using jffs2 file system
CONFIG_PRINTK	Makes kernel silent when disabled
CONFIG_PRINTK_TIME	A way to track where time is spent at boot time
CONFIG_CC_OPTIMIZE_FOR_SIZE	Will select –Os instead of –O2 resulting in a smaller kernel

Fast Boot Offering from Timesys

- **If your requirements include fast booting, Timesys can help you save time**
- **Implement added levels of optimizations with open source techniques**
  - Some of the deep level techniques, described earlier
- **Use non open source technologies available to Timesys to further speed up the boot-time**
  - Typically needed when many services have to be up and running asap
- **This engineering experience is available as a service**

Deployment
SD Card

SD Card Deployment

- **Card Preparations**
  - Use a card of appropriate size
  - Format the card as follows:
    - Partition 1: VFAT – size: 16MB
    - Partition 2: ext2 – size: 48MB+
  - Copy the images
    - Partition 1: uImage kernel
    - Partition 2: uncompress the file system created with the factory Desktop interface
  - Insert the card in the target's SD Card slot
  - Change the bootcmd variable to boot from SD Card

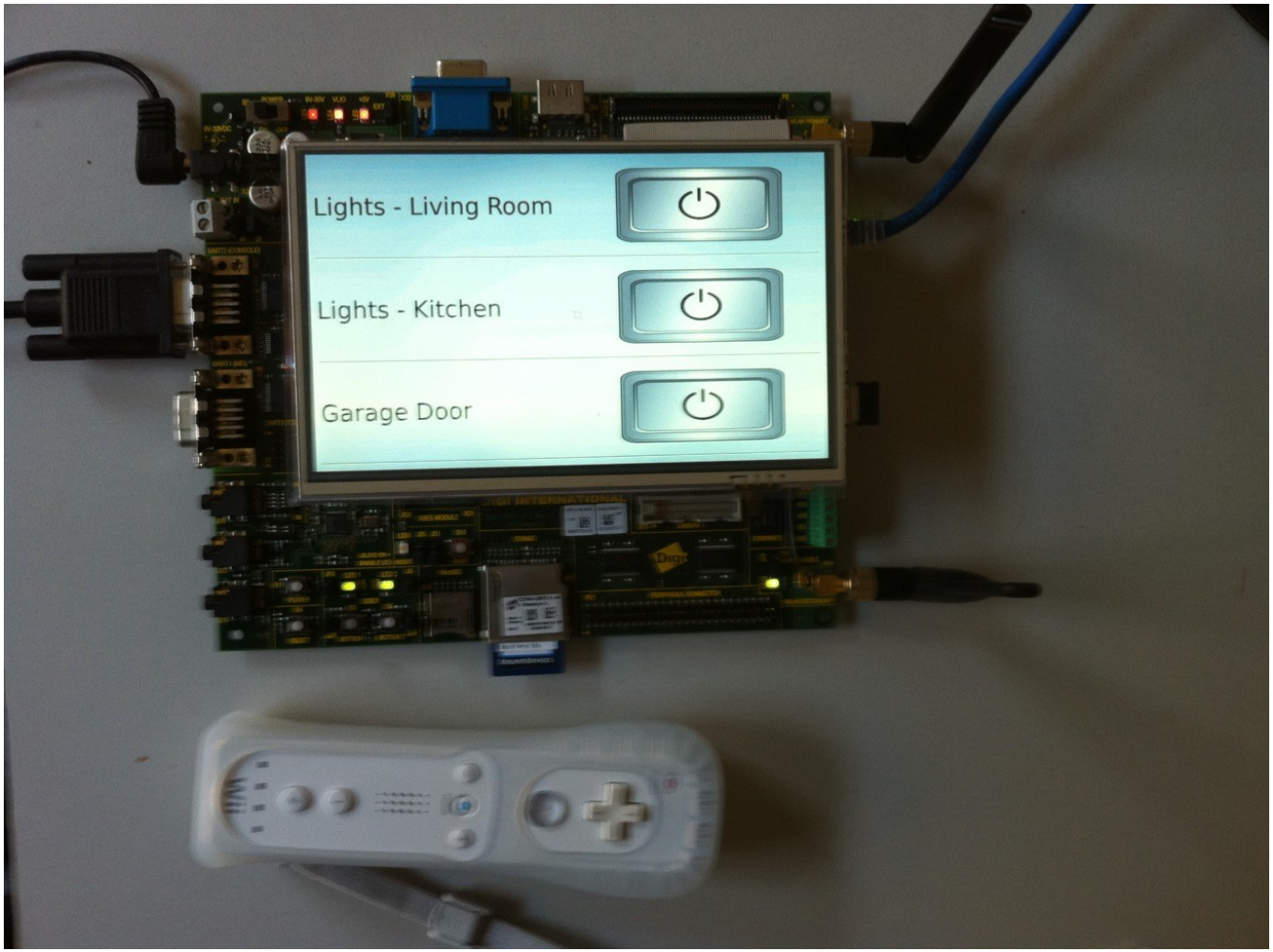
    setenv bootcmd 'mmc-info; fatload mmc 1 uImage 90800000; bootm 90800000'
  - Reset the system

What We Have Accomplished

- **Created an overlay – integrated custom code**
- **Learned about boot-time optimizations**
  - Concepts
  - Linux component specific
- **Deployed Linux on SD Card**
- **Measured boot-time**

This is it!!!

Hope you enjoyed this Timesys University Track



Last Week's Homework – Share Your Experience

1. **Setup a generic Bluetooth network**
2. **Pair your system with a BT device of choice**
3. **Look at available Bluetooth profiles**
4. **Setup a wifi network using the reference board you work with**

- Did you setup your Bluetooth network?
- What Bluetooth device(s) did you pair with?
- What WiFi chip/driver did you use in your wireless network setups?

Glossary

LinuxLink (Web Edition) – Web-based version of LinuxLink

LinuxLink (Desktop Edition) – Local version with full customization and third-party tools integration

Workorder – Stores definition of your software – filenames, versions

Bootloader – Runs first, initializes necessary hardware, loads Linux

Linux kernel – Operating system that manages hardware access and other features for higher level software

Device Driver – Code that's part of a Linux kernel, defines how software accesses specific hardware

File System – All files (libraries/utilities/scripts/etc.) combined on a single storage, e.g. NAND flash

Middleware – Complete frameworks including APIs, utilities that provide specific functionality, e.g. QT

API (library) – Used by applications, provide functionality, abstract hardware access

Toolchain (cross) – The most important part of the development environment. Used to compile source code into binaries.

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Stay Online for Q&A!