Assignment #3 - Building a Linux Device Driver

Grade Weight: 100pts

Drivers provide a software interface that allows the OS to communicate and control hardware devices. In this assignment, you will learn the fundamentals of building a device driver by implementing a driver that controls the input and output of some physical hardware. More specifically, your driver will control some lights (LEDs) and a button. A user space program will initiate a system call to the driver implemented in the kernel. Based on the input provided by user space process, the driver will turn will control four lights. The driver will also handle hardware signals, but turning off all the lights whenever a physical button is pressed.

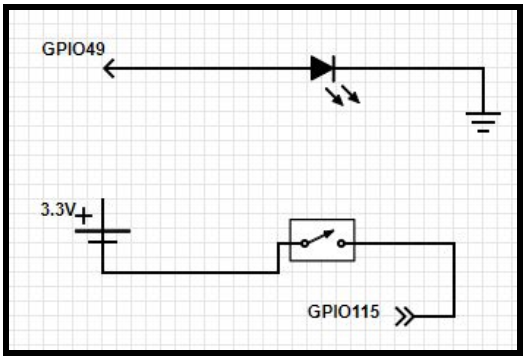
Hardware Required: In addition to the Beagle Bone Black, you will also need breadboard to build your circuit. The instructor / TAs will provide you with LEDS, a button and wires to complete this assignment. You are responsible for acquiring your own breadboard, as indicated in the course syllabus.

Sample Code: The sample code is a Loadable Kernel Module (LKM) driver. The sample code illustrates a number of critical parts of the assignment. When the button and LED are connected properly to the board, button presses will cause the LED to turn on and off.

- **Sample code is available here:** Sample Code

When testing the sample code, you will need to connect the button and LED properly to your board, for this to work properly. The LEDs and buttons will be connected to GPIO pins (General Purpose Input/Output pins) on your Beagle Board. You must have your LED connected to GPIO1_17 and the button connected to GPIO3_19. Instructions and significant help will also be provided in class and during lab sessions to assist you in learning how to connect the circuit properly. ***Please make sure you take proper notes during these class sessions. Class instruction will likely be critical in assisting you in completing this assignment.*** You will need to use the Pinout diagram below to determine how to connect your circuit to the appropriate pins.

Step #1: Connect a LED to GPIO49 and ground. Connect the Button to +3.3V and GPIO115.



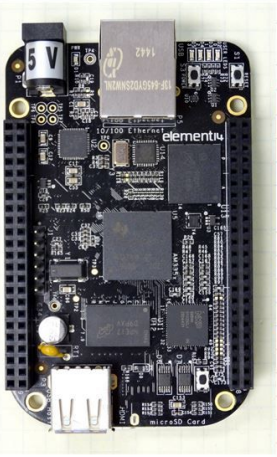
Schematic for Sample Program

Notice that GPIO49 connects to pin 23 and GPIO115 conects to pin 27, as indicated in the pinout diagram below.

Beaglebone Black Pinout Diagram

P9

Function	Physical Pins		Function
DGND	1	2	DGND
VDD 3.3 V	3	4	VDD 3.3 V
VDD 5V	5	6	VDD 5V
SYS 5V	7	8	SYS 5V
PWR_BUT	9	10	SYS_RESET
UART4_RXD	11	12	GPIO_60
UART4_TXD	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
SPIO_CSO	17	18	SPIO_D1
I2C2_SCL	19	20	I2C_SDA
SPIO_DO	21	22	SPIO_SLCK
GPIO_49	23	24	UART1_TXD
GPIO_117	25	26	UART1_RXD
GPIO_115	27	28	SP11_CSO
SP11_DO	29	30	GPIO_112
SP11_SCLK	31	32	VDD_ADC
AIN4	33	34	GND_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPWMO
DGND	43	44	DGND
DGND	45	46	DGND



LEGEND
Power, Ground, Reset
Digital Pins
PWM Output
1.8 Volt Analog Inputs
Shared I2C Bus
Reconfigurable Digital

P8

Function	Physical Pins		Function
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
GPIO_66	7	8	GPIO_67
GPIO_69	9	10	GPIO_68
GPIO_45	11	12	GPIO_44
EHRPWM2B	13	14	GPIO_26
GPIO_47	15	16	GPIO_46
GPIO_27	17	18	GPIO_65
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT4	23	24	MMC1_DAT1
MMC1_DATO	25	26	GPIO_61
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_AC_BIAS
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

Your Tasks: Extending the sample code above, complete the following:

1. Connect an additional three LEDs to your BBB (for a total of four LEDs and one button). Help will provided during class and lab session to assist you in connecting your circuit properly. You will need to acquire the LEDs, button and wires from the instructor or course TA.
2. Create a user-level program passes a string containing 4 bits of information (for example “1001” or “0111”. The user-level program should continue to prompt the user until -1 is entered.
3. The driver should display the binary number on the four LEDs. For example, if the number “1111” is sent, all four LEDs should be turned ON. If the number “0111” is transmitted, only three LEDs should be turned ON.
4. When the button is pressed, it should act as a reset. In other words, when the button is pressed, all the LEDs should be turned OFF until another number is transmitted from the user space program.
5. Avoid race conditions. Two user space programs should never be able to have the driver open at the same time.
6. Make sure to edit the Makefile to build your userspace program.

HINTS:

- Look at the user-level code from assignment #2. This should help you in constructing the user space program that sends data to the driver.
- Make sure to control the LEDs and button to a GPIO (General Purpose Input/Output) pin based on the pinout diagram.

Submission Instructions:

- Demonstrate that your code and circuit work to the TA or instructor during a lab session BEFORE the due date.
- Submit your code on Blackboard as a single tar file that contains (1) your driver code, (2) your user space code, and (3) a Makefile that compiles both programs.
- ***Both the assignment demonstration and Blackboard code submission are required to receive credit for this assignment.***

Grading Rubric

Code submitted correctly. Contains Makefile, driver and user space program contained in a single .tar file on Blackboard.	**10 points**
Code is well organized, contains reasonable error checking and contains useful comments	**10 points**
User space code sends four bits of information to the driver and continues to prompt user for additional information until -1 is entered. Displays helpful and meaningful messages to the user.	**10 points**
When button is pressed, all LEDs are turned off by the driver	**20 points**
Driver turns LEDs on/off correctly as indicated by the user / user space program	**30 points**
Race conditions avoided. Driver does not allow two or more user space processes to access the driver at the same time.	**20 points**
TOTAL	**100 Points**

**Code that does not compile will not receive any credit*

***Your assignment must be demonstrated to a TA and submitted on Blackboard to receive credit*

WARNING! You may help each other, but your code submitted should not be copying significant portions of code. Submitted work needs to be your own. All programs will be screened for similarities using MOSS software.