Agenda

- Project Overview
- Parts
- Power Distribution
- Schematic and Bill of Materials
- Questions and Comments
Product Description

- InfiniTable is a fully interactive, multifunctional table made up of individual tiles that can be connected in any configuration desired by the user.

- There will be intelligence on each tile supporting a multi-functional sensor array working in tandem with a programmable LED array to provide a fully interactive and responsive experience.

- The system is controlled by an LCD touchscreen, and also features Bluetooth capabilities so the user can remotely control the table, or stream music from a personal smartphone.
Product Development Team

- **Will Miller**: Processor, PCB Power Requirements, WiFi Module
- **Charles Crain**: Bluetooth Module, MP3 Converter, Software development
- **Isaac Flores**: Tile Interfacing, LED and Sensor Addressing
- **Brian Phan**: Android Application, Force Sensors and Tile layout
- **Sarah Pilkington**: LCD Touchscreen, LED design/layout, User Interface
Applications

○ Current application: Platform for popular party games, but there are many more practical applications
  • Games
    ○ Board Games, Table-top Games
  • Flooring
    ○ Light-Up/Force-sensitive tiling for homes and businesses
  • Security
    ○ Alerts to a change in force if something is moved or removed
Block Diagram

MP3 Decoder/Speakers

Wife Module

SD Card Reader

Bluetooth Module

Processor
NXP LPC 4088

LCD Display/Touchscreen

App Control

Tiles

Sensors:
Force/Optical

LEDs

4 pin JST SM

UART

SPI

SPI/4-bit SD Card Interface

UART

UART

SPI

4C

PC

RGB

Analog

SPI/4-bit SD Card Interface

Analog
Subsystem Definitions

- **Tiles (Isaac & Brian)**
  - Can be connected in any configuration desired by the user

- **Sensors (Isaac & Brian)**
  - **Force sensors:** measure the force from the die when it hits the table

- **LEDs (Sarah)**
  - Visual representation of the information gathered by sensors
  - Pulse/change color to the beat of the music
Subsystem Definitions (II)

- LCD Touchscreen (Sarah)
  - User interface used to control the system
- Android Application (Brian & Charlie)
  - Redundant path for the LCD user interface
- Bluetooth Module (Brian)
  - Connect cellular device through Bluetooth in order to play music and to use the Android Application
- WiFi Module (Will)
  - Redundant path for the Bluetooth Module
Subsystem Definitions (III)

- MP3 Decoder (Charlie)
  - Enable system to play music through a Bluetooth connected cellular device
- SD Card Reader (Charlie)
  - Storage for pre-recorded game sounds and music, and pre-configured game designs
Parts – Processor

- NXP LPC4088
  - 512kB Flash
  - 96kB RAM
  - 120MHz Clock Speed
  - Supply Voltage: 2.4-3.6 V
  - UART, I²C, SPI, I2S, USB Interfaces
  - 109 GPIO pins
Parts – Processor (II)
Parts – **Tiles**: Block Diagram
Parts – Tiles: Components

- **Tile Components:**
  - Wire-to-board connector
  - CPLD Breakout board
  - Breadboard
  - USB Connector
  - LEDs
  - Force Sensors

- **Software Structure**
  - Verilog
  - C/C++
Parts – **Tiles**: Connector

- **Wire-to-board connector**
  - Molex Pico-Lock
  - 10 pins
  - Wires add flexibility for connections to tile
- **Female Contacts**
  - 24-28 AWG
- **10 wire ribbon cable**
  - 28 AWG
Parts – **Tiles: Breakout Board**

- ispMACH 4256ZE Breakout Board
  - USB mini-B connector for power and programming
  - 4x15 prototype area
  - Four 2x20 expansion board
  - Power Supply
    - 5V USB
    - Board regulates to 1.8V and 3.3V
  - Operating Power Supply Current
    - CPLD Typical: 372 µA
    - Rest of board: not specified
Parts – **Tiles**: CPLD

- ispMACH 4256ZE CPLD
  - Power Supply
    - 1.8V
  - Operating Power Supply Current
    - Typical: 372 µA
  - 144 TQFP, 20x20 mm
  - Supported on ispLever Classic 3.1
  - Number of Macro Cells: 256
  - Max Delay time: 7.5 ns
- LED and Sensor interface
- I²C Slave
Parts – Tiles: $I^2C$ Slave Module

- Lattice Semiconductors $I^2C$ Slave Module
  - Reference Design 1054 based on $I^2C$ Bus Specification version 2.1
  - Verilog
  - Software programmable slave address
  - Supports clock stretching as handshake
  - Supported on ispMACH 4256ZE
    - Utilizes 48 Macrocells and 26 I/O pins
    - Max frequency: >15MHz
    - Parallel I/O
Parts – **Tiles**: I²C Slave Module (II)

- Parallel Data Interface
  - Module performs parallel to serial conversion
- Clock Stretching
  - Low ready signal keeps SCL low
Parts – Tiles: I²C Slave Module (I)

- 10 wire bus
  - SDA
  - SCL Power
  - Ground
  - Interrupt
  - Reset
  - GPIO_0
  - GPIO_1
  - GPIO_2
Parts – **Tiles**: Breadboard

- **Breadboard**
  - 3.2 L x 2.08 W inches
  - Provides greater flexibility
- **USB Connector**
- **Force Sensor Circuitry**
- **Additional parts**
Parts – **Tiles: USB Connector**

- USB Connector
  - Power Supply to Breakout board from 5V power line
  - Ground serial data lines
  - Through hole mount
Parts – Tiles: Interface Structure

- Hardware Structure
  - CPLD
  - 10 wire bus
  - USB Connector

- Software Structure
  - Verilog/C instruction
  - Event Handler
Parts – Tiles: LED/Sensor interface
Parts – **Tiles**: Hardware Structure

- **CPLD**
  - Verilog HDL
    - I²C Slave RD
    - LED/Sensor interface
    - Bus routing
    - Registers

- **USB Connector**
  - Power Supply
  - No serial data communication
Parts – Tiles: Software Structure

- Verilog (Tiles)
- C (Processor)
- Instruction Framework
  - Read
  - Write
  - Configure
  - Poll
- Event Handler
  - Interrupt and Poll driven
Power Distribution – Tiles

- +5.0V DC Power Supply through the connector from the PCB
- Two Voltage Regulators to provide isolation
  - +5.0V to +5.0V
    - Used to power the LM358 op-amp, CMOS inverter, and ADC
    - Also powers the CPLD through the USB connection that internally regulates the voltage to 1.8V
  - +5.0V to -5.0V
    - Done by switching the power and ground outputs
    - Used as the Vref for the force sensor current-to-voltage converter circuit.
Parts – Force Sensors

- Interlink Electronics FSR® 400 series
  - Part of the single zone Force Sensing Resistor® family
  - Actuation Force as low as 0.2N and sensitivity range to 20N
  - Robust: up to 10M actuations
  - LM358 Dual Op-amp to drive the sensor output
Parts – Force Sensors (II)

- Used to determine intensity and location of impact on the tile
- Each tile will have a 2x2 array of sensors to allow for four quadrants of location accuracy
- Sensor circuit will provide a 0 to +5V range of analog output that will be input into a CMOS inverter that will be set to switch at a predetermined threshold.
  - CMOS inverter used to:
    - Drive an interrupt line to the processor
    - Signal the ADC to start a conversion
- ADC will have an 8-bit parallel latched output to the CPLD
Parts – Force Sensors (III)

Force Sensor Layout

Op-Amp Circuit
Parts – Android Application

- Android-based user interface that provides a redundancy check for the LCD Touchscreen
- Does not require any additional hardware other than an Android phone
- Will use either Bluetooth or WiFi to communicate with InfiniTable
  - Possibly used to stream music
Parts – Android Application (II)

- Using either the RN171XVW-I/R WiFi Module or the RN41XVC-I/RM Bluetooth Module
- Android API level 21 (Lollipop)
- Client server model with the WiFi/Bluetooth module as the server and the Android App as the client.
- Two states:
  - “Setup state” to establish a TCP/UDP connection, ideally with passcode authorization
    - Only allow for one client connection at a time
  - “Data transfer state” to allow for:
    - Mode selection
    - Music streaming
Parts – LCD Touchscreen

- **Capacitive Touchscreen:**
  - 800 x 480 Pixels
  - 3.3V Liquid Crystal Display
  - 24-bit Parallel RGB Interface
  - White LED Backlight
  - Capacitive Touch Panel with $I^2C$ Interface

- **Software description:**
  - Capacitive touch screen is interrupt driven, and will send a signal to the processor when the user touches it
  - Will contain menus and options for game-play and general system control
Parts – LCD Touchscreen (II)

Diagram showing connections and components related to LCD Touchscreen.
Parts – LED Strip

- 16.5mm wide, 4mm thick
- 32 LEDs per meter
  - Can be cut down to 2 LEDs (2.45” long per segment)
  - 5V at 120mA per segment
- Weatherproof casing
- Each LED is individually controllable
- Connector: 4-pin JST SM
  - Data, Clock, Power, and Ground
Parts – LED Strip (II)

- Possible layouts
  - Option 1:
    - Cross
  - Option 2:
    - 6 pointed star
  - Option 3:
    - Tic-Tac-Toe
  - Option 4:
    - Columns
Parts – LED Strip (III)

- Power analysis
  - Layout Option 1:
    - 18 inches of LEDs – 6 segments
    - Maximum Power Consumption: 5V at 720mA per tile
  - Layout Option 2:
    - 44 inches of LEDs – 16 segments (1 meter)
    - Maximum Power Consumption: 5V at 1.92A per tile
  - Layout Option 3:
    - 36 inches of LEDs – 12 segments
    - Maximum Power Consumption: 5V at 1.44A per tile
  - Layout Option 4:
    - 36 inches of LEDs – 12 segments
    - Maximum Power Consumption: 5V at 1.44A per tile

- If some LEDs are kept off or dimmed, power consumption can be **a third or less of the maximum**
Parts – LED Strip (IV)

- LEDs will flash in different colors, frequencies, and patterns depending on the mode
  - **Game-Play**
    - Depending on the game being played, LEDs will change for that format
    - LEDs will also receive force and location data from the force sensors, and display this data visually on the tile
  - **Music**
    - LEDs will pulse and change color in response to music being played through the system
  - **Idle**
    - LEDs will change color and flash arbitrarily

- Software heavily based on provided sample code for the Arduino family of microcontrollers
Parts – WiFi Module

- **RN171XVW-I/RM**
  - Ultra-low power
    - 4 uA sleep, 35 mA Rx, 185 mA Tx at 12 dBm
    - Tx power configurable from -2 to 12 dBm
  - 2.4GHz IEEE 802.11 b/g transceiver
  - Configuration over UART interface using ASCII commands
  - Features Infrastructure, AdHoc, and AP modes
  - Secure WiFi authentication via WEP, WPA, and WPA2
  - Built-in networking applications
Parts – WiFi Module (II)
Parts – Bluetooth Module

- Microchip Technology RN41-XVC
  - Wireless communication with InfiniTable via Bluetooth on an Android phone
  - Variety of game settings can be selected through Android application
  - Backwards-compatible with Bluetooth version 2.0, 1.2, and 1.1
  - Secure communication, 128-bit encryption
  - UART Data Connection
  - Requires 3.3V power supply
Parts – Bluetooth Module (II)
Parts – MP3 Decoder

VS1011 Module
• Decodes MPEG 1.0 & 2.0 audio layer III; layers I & II optional
• 320 kbit/s MP3 with 12.0 MHz external clock
• High-quality stereo DAC for optimal sound quality.
• Data Connection: SPI
• Single-Supply Operation: 2.5 to 3.6 V
• 5.5 KiB On-chip RAM for user code or data
• 3.5 mm jack to connect to connect external speakers
Parts – MP3 Decoder (II)
Parts – SD Card Reader

- Kyocera 5738 Series
  - Surface mounted, works with generic SD Card
  - Stores game data and audio data for points scored and fouls
  - Use of both SPI bus and 4-bit SD bus
Printed Circuit Board
Power Distribution – PCB

- Two barrel jacks:
  - 5V input for most of the PCB
  - 19.2V Input for the LCD display
- The 5V input will be regulated down to 3.3V to supply every IC on the PCB
- The MP3, Bluetooth and WiFi module all handle analog power independently given a 3.3V digital input.
Critical Elements

- Accurate location and force measurements from the force sensors
- Capability for any tile configuration
  - Tile addressing
- Working user interface
  - LCD touchscreen or Android Application
Schematic and Bill of Materials

- The full schematic and bill of materials can be found in the attached PDFs
Questions? Comments?

Thank you!