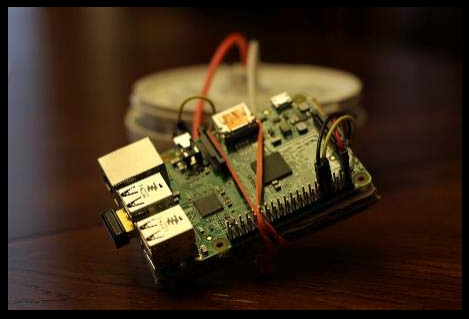
Raspberry Pi Smoke Detector



Jordan Ehrman

Senior Design Project

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Outline

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Problem Topic

- Standard smoke detectors work only if you hear them. If the homeowner is not home, they will not notify them.
- If there is a fire and no one is home, the fire will continue to burn until it is seen from the outside of the house by someone.
- This typically means that the fire would likely go from being a room and contents fire, to a fully evolved structure fire.

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Problem Topic

- It is my goal to design and create a system that would warn a homeowner of a smoke detector trip by email in case the resident isn't home.
- When smoke is detected, the system will use a standard smoke detector to sound an audible alarm for people in the structure but will also send a MMS message to pre specified numbers.

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Background

- As a firefighter, I know how much more devastating it is for the family if the fire is a fully involved house fire as opposed to a room and contents fire.
- Training has taught me that early detection is key.

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Background

- Most of the materials we use today for making furniture and carpet and other products are mostly synthetic with means that they burn hotter and faster than ever before. The video that follows is a clip from UL about how fast and how h

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Criteria

Requirement Data			Verification Planning		
ID	Requirement Type	Requirement (Shall or Should statements)	Verification Method	Date Verified	Verification Report
1	Operational	The system shall detect smoke	Demonstration	30-Mar-15	Pass
2	Operational	The system shall provide an audible alarm	Demonstration	30-Mar-15	Pass
3	Operational	The system shall send an emal to designated addresses upon detecting smoke	Demonstration	10-Mar-15	Pass
4	Functional	The system shall detect smoke with ionization sensors	Analysis	30-Mar-15	Pass
5	Functional	The system shall use Raspberry Pi to send email	Test	10-Mar-15	Pass
6	Performance	The system shall send email within 25 seconds of audible alarm sounding	Test	15-Apr-15	Pass
7	Performance	The system shall sound audible alarm within 15 seconds of smoke in chamber	Test	15-Apr-15	Pass
8	Physical	The system shall be smaller than 6" by 6" by 4"	Inspection	15-Apr-15	Pass
9	Physical	The system shall take less storage than 32GB	Analysis	10-Mar-15	Pass
10	Environmental	The system shall work in smoke filled environment	Test	15-Apr-15	Pass
11	Environmental	The system shall work in temperatures of 100 °F	Test	15-Apr-15	Pass

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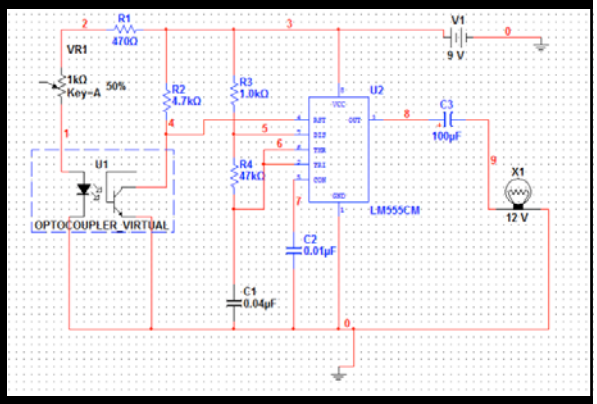
Feasibility

- Original Design
  - 555 Timer
  - No smoke, Reset high
  - Smoke, Reset low
- Problems
  - Inconsistent
  - Not long enough alarm



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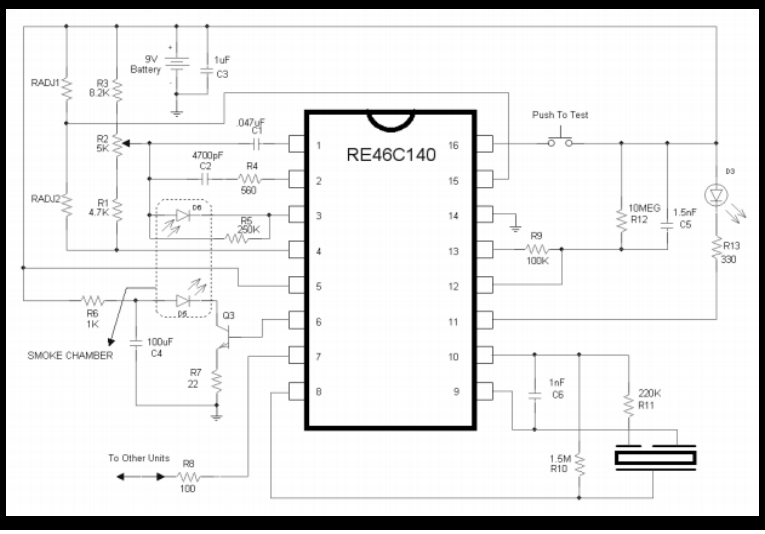
Feasibility

- Second design



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Feasibility

- Problems
  - Photoelectric sensor not seeing objects
  - Alarm opposite
  - Could switch Pi input but would not be able to easily change Smoke detector
  - Would not meet UL standards

Feasibility

- Change to commercial (store bought smoke detector) and use the signal that comes off of that.
- Benefits
  - Easily be added to a home interconnect system already in place
  - Meets standards

Legal

- High legal standards
- UL Standard 217
- No standard about tapping into residential interconnect
- Smoke alarms are only required to be stand alone devices
- NFPA has standards too but they are more for where the smoke alarm should be located in the home, not how they are supposed to operate.
- Correct standards meet since I am using a store bought smoke detector

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Scope

- Smoke Detector
  - Purchase Commercial Detector
  - Test Detector output
- Signal Switcher and Input Regulator
  - Design in Multisim
  - Test in Multisim
  - Test with Breadboard
  - Buy components
  - Layout Board
  - Assemble Board
  - Test
- Raspberry Pi
  - Buy Raspberry Pi
  - Set up Raspberry Pi
  - Program Raspberry Pi
  - Test Raspberry Pi Programing
- Functional Prototype
  - Connect all components
  - Test Complete Prototype
- Final Report
  - Write Draft Report
  - Write Report
- Presentation
  - Write Presentation
  - Practice Presentation

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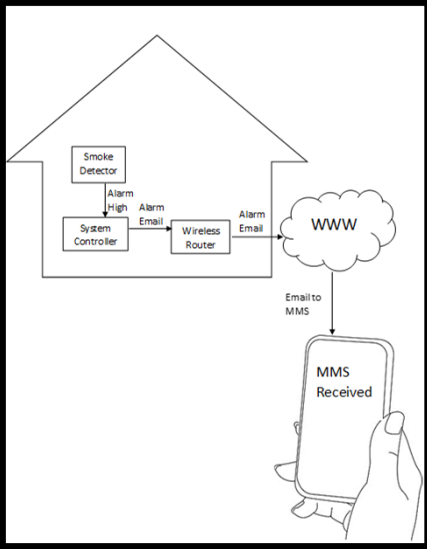
Hardware Design



Top-Level Diagram

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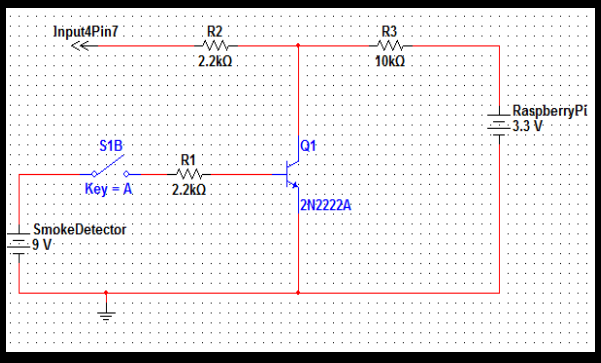
Hardware Design

- 9 volt out of interconnecting smoke detector
- 3.3 volt input for Raspberry Pi
- Transistor as a switch



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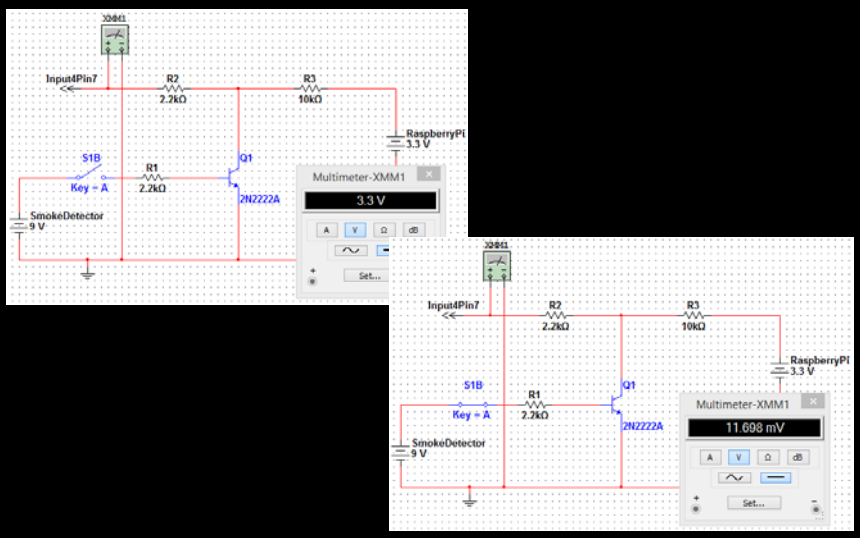
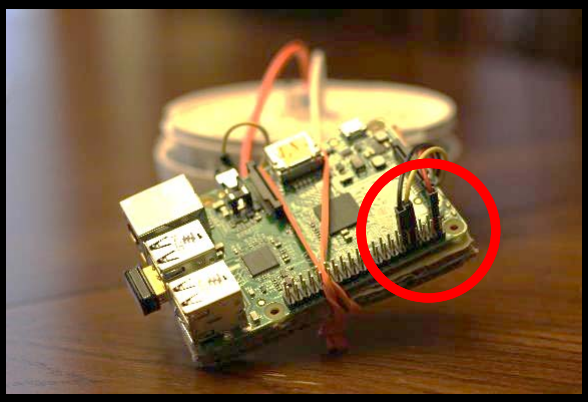
Hardware Design

Simulation Results



Hardware Design

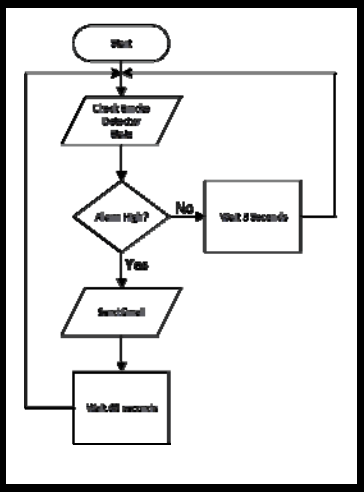
- Pin 1 – 3.3 V
- Pin 9 – GND
- Pin 7 – Input 4



Raspberry Pi B+
B+ J8 GPIO Header

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7
DNC	27	28	DNC
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

Software Design



Raspberry Pi Flow Chart

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Software Design

- Main operation needed to accomplish was send out an email when certain pin is changed from high to low.
- Reasons I chose Raspberry Pi over other microcontrollers
  - Lots of I/O pins
  - Low cost
  - Ease of use
  - Online documentation
  - I have friends that know it well

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Software Design

- What I needed to accomplish
  - Send email
  - Automatically start program on boot
- Automatically starting program
  - Crontab
    - sudo crontab –e
    - @reboot sh /home/pi/launch.sh >/home/pi/cronlog 2>&1
  - Shell Script
    - Launch.sh

```
#! /bin/sh
cd /
sudo python Email.py
```

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Software Design

- Sending Email

```
#import libraries
import smtplib from email.mime.text
import MIMEText
import RPi.GPIO as GPIO
import time
import datetime
#Setup input and output pins
GPIO.setmode(GPIO.BCM)
GPIO.setup(4, GPIO.IN)
#Start Program
print ("Activate to Prococeed")
time.sleep(3)
#start loop
loop="1"
while loop =="1":
        #Check to see if input pin is high
        if GPIO.input(4)==1:
                time.sleep(5)
                print("not active")
        #Check to see if input pin is low
```

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Software Design

```
        if not GPIO.input(4):
                text="""Smoke Detector Activation"""
                timestamp=
                datetime.datetime.now().strftime("%B %d, %Y %I:%M%p")
                message = text + " - " +timestamp
                msg = MIMEText(message)
                msg['subject']='1560 Wheatfield Ct'
                msg['from'] = 'ehrmansmokedetect@gmail.com'
                msg['to'] = '2602735307@mms-tf.net'
                s = smtplib.SMTP('smtp.gmail.com', 587)
                s.ehlo()
                s.starttls()
                s.login('ehrmansmokedetect@gmail.com' , '*********')
                s.sendmail(msg['From'], msg['To'], msg.as_string())
                s.quit
                print("Message sent")
                time.sleep(60)
                while not GPIO.input(4):
        pass
GPIO.cleanup()
```

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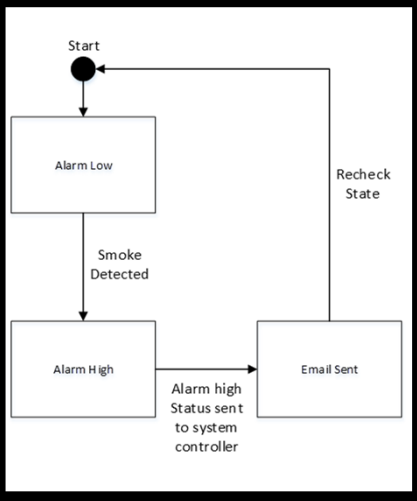
Software Design



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Problems in Testing

- Email
  - Was not getting messages to phone
    - Sending Emails but was not receiving
    - Sent email from my phone MMS to email
    - Found out that email address had changed since I last used it
- Hard to tell when messages were actually being sent
  - Put a time stamp in the message
- I wasn't getting the correct values off the smoke detector
  - Was using the wrong two cables from the interconnect

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Verification

- Requirement 1: The system shall detect smoke
  - Striking match blowing it out
- Requirement 2: The system shall provide an audible alarm
- Requirement 3: The system shall send an email to designated addresses upon detecting smoke
- Requirement 4: The system shall detect smoke with Ionization sensors.
  - Appendix A
- Requirement 5: The system shall use Raspberry Pi to send email

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Verification

- Requirement 6: The System shall send email within 25 seconds of audible alarm

Test Number	Seconds to Receive Message
1	19.1s
2	13.0s
3	16.4s
4	14.2s
5	14.8s
6	13.1s
7	11.3s
8	14.4s
9	13.2s
10	11.1s

Average: 14.1s

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Verification

- Requirement 7: The system shall sound audible alarm within 15 seconds of smoke in chamber

Test Number	Seconds to Alarm
1	1.1s
2	2.1s
3	2.4s
4	1.6s
5	1.3s
6	2.3s
7	1.9s
8	1.2s
9	1.6s
10	2.1s

Average: 1.8s

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Verification

- Requirement 8: The system shall be smaller than 6” x 6” x 4”
  - 4” x 2” x 2”
- Requirement 9: The system shall take less storage than 32GB
  - 16GB SD card
- Requirement 10: The system shall work in a smoke filled environment
  - In the toaster oven with some food sprinkled on the bottom to produce smoke for 10 minutes
- Requirement 11: The system shall work in temperatures of 100°F
  - In the toaster oven set to 100°F

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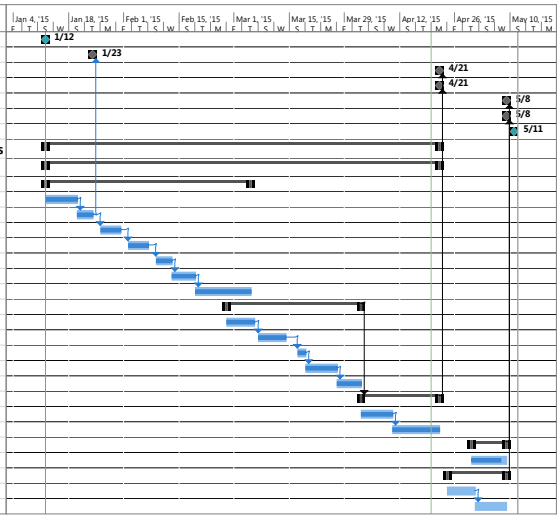
Schedule

ID	Task Mode	Task Name	Duration
1		Project Start	0 days
2		Design Complete	0 days
3		Functional Prototype	0 days
4		Verified Prototype	0 days
5		Final Report Complete	0 days
6		Presentation Complete	0 days
7		End Of Semester	0 days
8		**Prototype**	**72 days**
9		**Development**	**72 days**
10		**Signal Switcher and Input Regulator**	**38 days**
11		Design in MultiSim	6 days
12		Test in MultiSim	4 days
13		Test with Breadboard	5 days
14		Buy components	5 days
15		Layout Board	4 days
16		Assemble board	4 days
17		Test	10 days
18		**Raspberry Pi**	**24 days**
19		Buy Raspberry Pi	5 days
20		Buy Wi-Fi Adapter	5 days
21		Set Up Rasberry Pi	2 days
22		Program Pi	6 days
23		Test Pi Programing	4 days
24		**Functional Prototype**	**14 days**
25		Connect all Components	6 days
26		Test complete Prototype	8 days
27		**Final Report**	**7 days**
28		Write Report	7 days
29		**Presentation**	**11 days**
30		Write Presentation	5 days
31		Practice Presentation	6 days



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Resource Management

Material/Tool Cost

Item	Qty	Cost Each	Total Cost	Comments
Raspberry Pi	2	$ 39.95	$ 79.90	
Resistors	10	$ 0.20	$ 2.00	
Capacitors	10	$ 0.25	$ 2.50	
Transistors	5	$ 0.25	$ 1.25	
IC chip	5	$ 0.40	$ 2.00	
LED	10	$ 0.40	$ 4.00	
LDR	10	$ 0.50	$ 5.00	
WiFi Adapter	2	$ 8.99	$ 17.98	
		Material Total	**$ 114.63**	

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Resource Management

Labor Cost (Hrs)

Task / Activity	Jordan Ehrman	Project
Purcahse Comercial Detector	1	1
Test Detector output	1	1
Design Input Regulator in Multisim	5	5
Test in Multisim	2	2
Test with breadboard	5	5
buy components	2	2
Layout Board	3	3
Assemble Board	6	6
Test	10	10
Buy Raspberry Pi	1	1
Set up Raspberry Pi	15	15
Program Raspberry Pi	10	10
Test Raspberry Pi Programing	10	10
Connect all components	2	2
Write Report	30	30
Write Presentation	15	15
Practice Presentation	2	2
Labor Hr Totals	**120**	**120**

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Quality Management

- Testing
- Research before buying
- Buying quality parts

Risk Management

ID	Entry Date	Type		Risk Description: 'IF statement'		Consequence of Risk: 'THEN statement'	Status	Likelihood (1-5)	Severity (1-5)	Score	Rank*	Response	Description of Response
1	15-Nov-14	Technical	IF	System cannot interface to the smoke detector	THEN	The project will not fulfill critcal operational need	Closed	3	5	15	High	Mitigate	Making several different plans to detect smoke. Possibly Use commercial smoke detector
2	15-Nov-14	Technical	IF	the system does not sound alarm	THEN	the project will not fulfill operational need	Closed	1	5	5	Medium	Mitigate	determine root cause of failure and correct problem
3	15-Nov-14	Technical	IF	the system does not send email	THEN	the project will not fulfill critical operational need	Closed	2	5	10	Medium	Mitigate	Research email support algorithanms on Raspberry Pi
4	15-Nov-14	Cost	IF	I am unable to program the Raspberry Pi	THEN	I will have to expend more time than budgeted on programming	Closed	1	4	4	Low	Mitigate	Seek help from friend that has Raspberry Pi prorgraming knoledge.
5	15-Nov-14	Cost	IF	The Raspberry Pi gets permanently damaged during the project	THEN	I will have to replace the Raspberry Pi	Closed	1	3	3	Low	Avoid	By purchasing 2 Raspberry Pi
6	15-Nov-14	Schedule	IF	Personal emergency happens during semester	THEN	the remaing project schedule will need to be compressed to finish in time	Closed	3	2	6	Low	Avoid	By putting as much time as possible into as early as possible
7	15-Nov-14	Schedule	IF	Parts get backordered	THEN	I won't be able to start integration and test activities as early as planned	Closed	2	2	4	Low	Avoid	by ordering parts early

Procurement

Item	Vendor	Price
Raspberry Pi (2)	Adafuit.com	$79.95
Resistors (5)	Radio Shack	$2.95
Resistors (5)	Radio Shack	$2.95
Transistor(3)	Mouser	$5.73
Solder Bread Board	Radio Shack	$9.95
Solder	Radio Shack	$8.99
Smoke Detector	Lowe's	$16.02
	Total	$126.54

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Lessons Learned

- Programing Raspberry Pi
  - I have programed microcontrollers for labs but there we just followed a set of instructions.
- The manufactures recommended design is not going to work.
  - It might get you close but don't expect it to work out the gate.

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Conclusion

- The project was a success
- I plan on implementing this design in my own home
- It was not too expensive to make and if I want to build another or expand the one that I already made, I have no doubt I would be able to accomplish this with all the things I learned about the Raspberry Pi

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Questions?

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Works Cited

[1] "Smoke Detectors and Americium," July 2014. [Online]. Available: http://www.world-nuclear.org/info/Non-Power-Nuclear-Applications/Radioisotopes/Smoke-Detectors-and-Americium/.

[2] "Photoelectric Smoke Detector," 2014. [Online]. Available: http://www.electroniq.net/555-timer-circuits/photoelectric-smoke-detector.html.

[3] electronic-circuits-diagrams.com, "electronic-circuits-diagrams.com," 2011. [Online]. Available: http://www.electronic-circuits-diagrams.com/alarmsimages/alarmsckt11.shtml. [Accessed 14 January 2014].

[4] "RE46C141E16F Microchip Technology," 2015. [Online]. Available: http://www.mouser.com/Search/ProductDetail.aspx?R=RE46C141E16Fvirtualkey57941000virtualkey579-RE46C141E16F.

[5] "New vs Old Room Fire Final UL," YouTube, 2010.

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Demo

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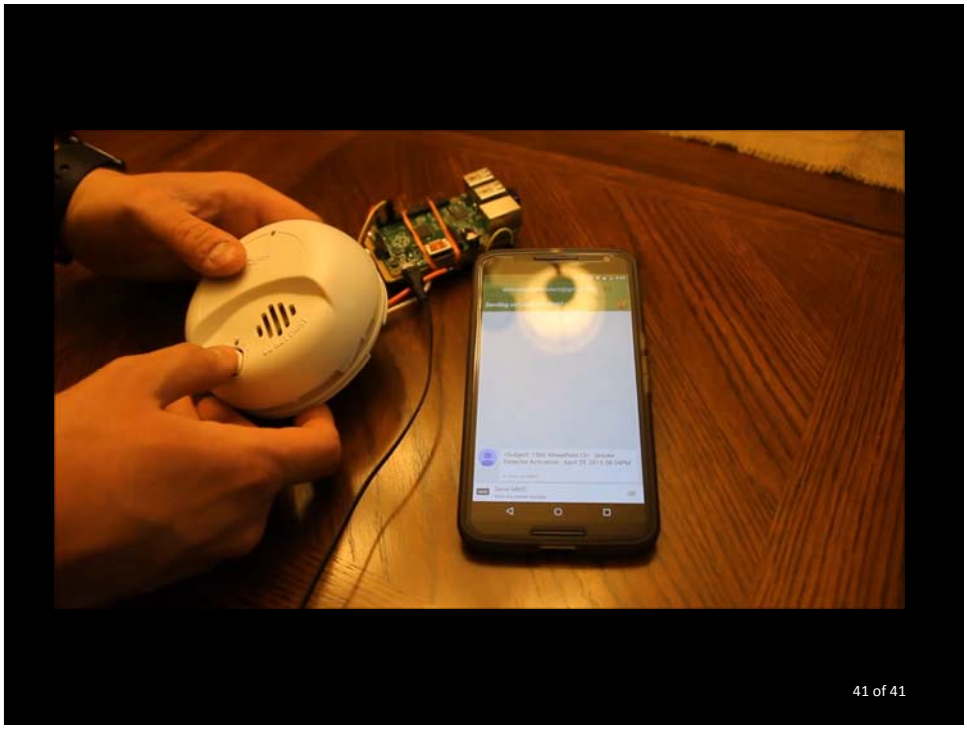
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