UMassAmherst

Equipack

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The Problem

- Backpacks are frequently misused
  - Most people don't know how to use the current features
  - Many people overload their bags to an unhealthy weight
- How familiar does this look?

http://www.newvision.co.ug/mobile/Detail.aspx?NewsID=635397&CatID=6

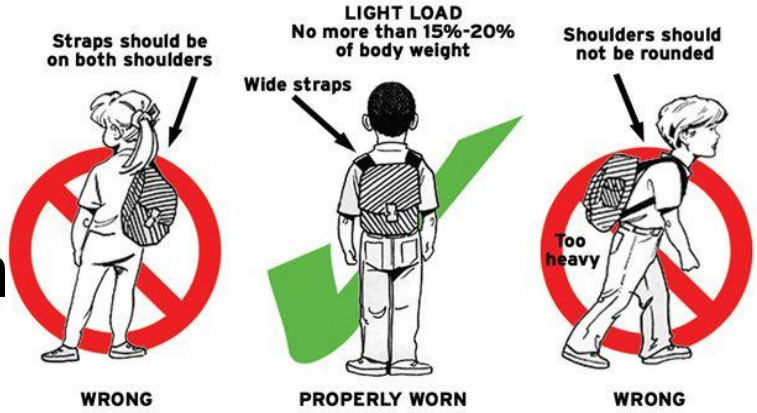
http://www.euclidchiropracticinc.com/causes-of-forward-head-posture-fhp-124

Significance

- Over/Improper loading of packs is shown to lead to:
  - 7,277 emergency room visits (annually), up 330% since 1996
  - ⅓ of 6th graders carry >30% of body weight

    Causing: Knee hyperextension, lower back overcompensation,

    back strain, shoulders stress
- 2011: backpack industry retail sales over $1.75 billion
  - Over 100 million units



Source: Pintrest, TheCarry. Improper backpack use.

Existing Solutions

- Carry less weight
  - Wasted potential!
- Empty roller bags can weigh +80%
  - Tendency to add more item
  - 50 lbs or more!
  - Not viable for all terrains
- More straps?
  - Not always clear how to use
  - Can cause more harm than good

Source: Overstock.com. HIgh Sierra Wheeled Backpack

Our Solution

- A Smart Backpack that:
  - Senses content weight
  - Senses load/stress distribution on wearer
- A Mobile App that:
  - Records data trends
  - Visually assists user with proper wear

Positive Change for Users

- Backpack will give the user new insight on backpack pressure allowing them to correctly fit the pack
- Backpack will notify user of excessive weight, helping them prevent harm
- Groups of people would be able to distribute weight fairly

Source: Advantage Physical Therapy. Improper vs. Proper wear

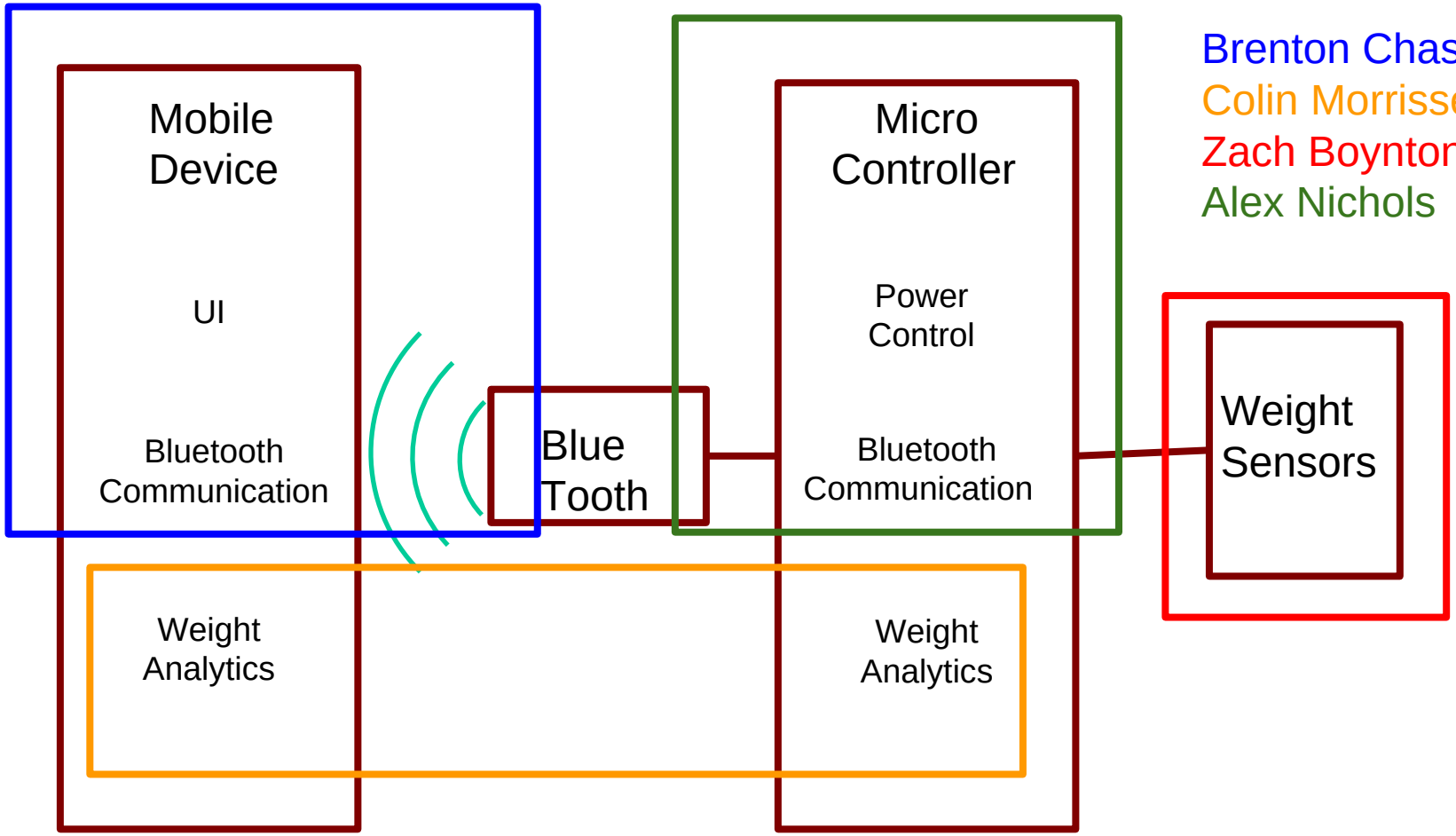
Specifications for Our Solutions

- Solution would need to be:
  - Low cost (< $25 mass production)
  - Passive or low power (< 20mW)
  - Light-weight (under 12oz additional weight)
  - Applicable to both frameless and framed packs with our solution
  - Provide user with feedback

Inputs and Outputs

- Inputs
  - Content weight sensor data
  - Shoulder strap sensor data
  - Lower back sensor data
- Outputs
  - Feedback on shoulder strap position
  - Feedback on content weight
  - Suggestions for improved strap configuration
  - Text alerts to subscribers when pack is overweight

Solution Breakdown



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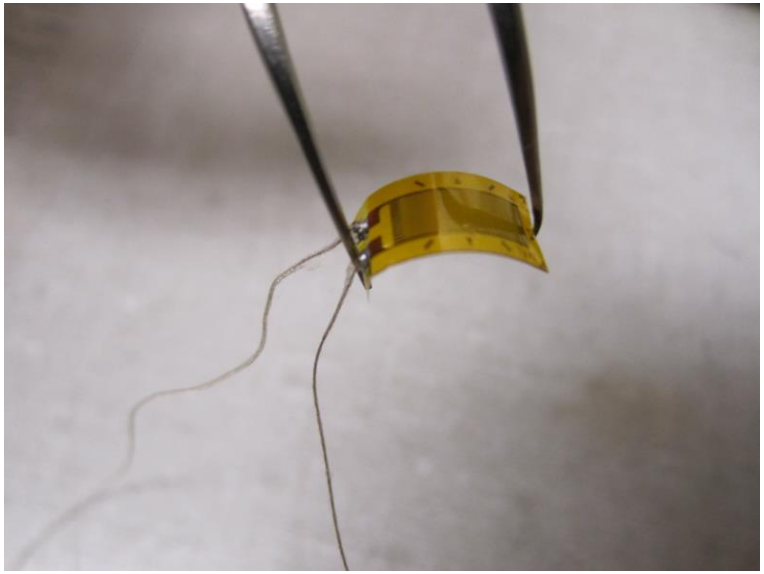
System Block: Weight Sensor

- System Requirements
  - Weight range of 0-100lbs
  - precise, within 1lb
  - insensitive to temperature
  - repeatable measurements
  - low power consumption
  - low cost
  - compact

Source: http://www.karlssonrobotics.com/cart/prodimages/10245-01.jpg

System Block: Weight Sensor

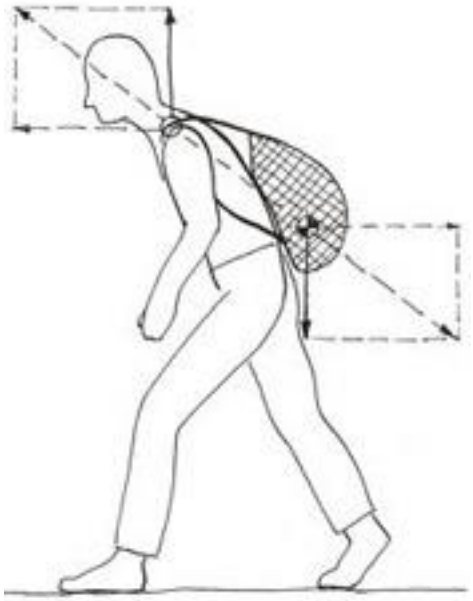
- System Implementation
  - Force sensors will be selected from broad sampling of devices
  - Circuitry will need to be placed around the sensor to amplify and filter the signal
  - Circuity will communicate with the microcontroller



Source: http://www.ndsu.edu/pubweb/~braaten/research.html

System Block: Weight Analytics

- System Requirements
  - Maximize weight on back and minimize shoulder weight
  - Recognise left/right load symmetry
  - approximately determine center of mass for the load



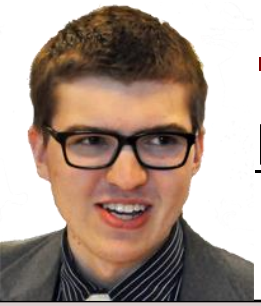
System Block: Weight Analytics

- System Implementation
  - Place sensors on lower, upper back and shoulders
  - Propose additional sensor locations if necessary, such as a spring sensor on the lower strap
  - Tests will be a combination of real world tests and physics modeling software).

Proposed Sensor locations for both left and right

System Block: µController and Broadcast

- µController Requirements
  - Low Power (10mA draw)
  - More than 8 ADC's
  - Interfaces with external broadcast tech
- External Broadcast Options
  - Need some way to communicate with phone/computer, which can provide GUI
  - Options: Bluetooth Classic, WiFi, Bluetooth Low Energy



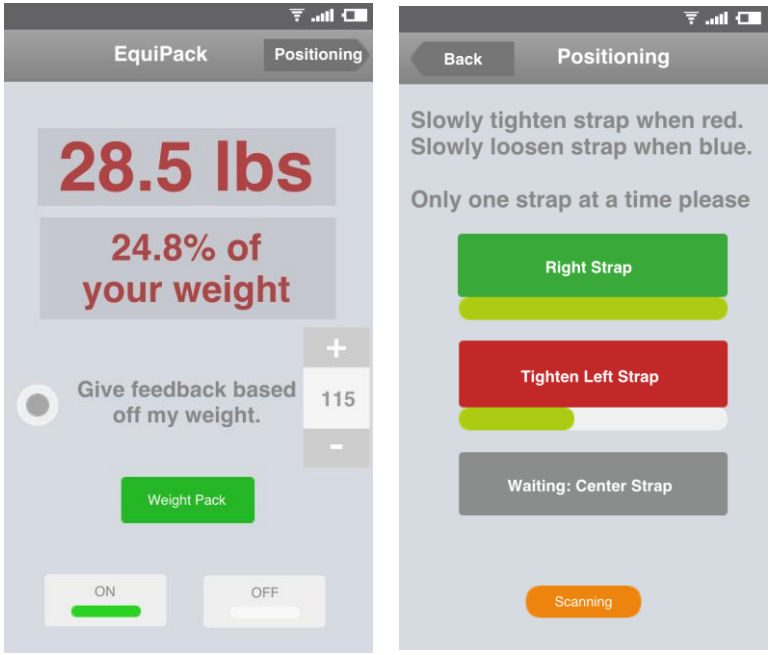
System Block: µController and Broadcast

- µController Implementation
  - LPC824M from NXP Semiconductors (µController)
    - 12 discrete ADC ports
    - 8.1mW power consumption
    - USART for BLE interface
    - Digital I/O for Power Management
  - NRF8001 from Nordic Semiconductor (BLE Module)
    - Simple Serial Interface with µController
    - 30mW power consumption when on
    - Supports Peripheral Mode

System Block: Mobile Application

- Mobile Requirements
  - Wellness apps and data collection practices
  - Secure data storage
  - Secure data transfer
  - Intuitive user interface
  - Children and Adults
  - Bluetooth Low Energy (BLE)

*Design not final



Source: Brenton Chasse's design on FluidUI.com

System Block: Mobile Application

- Market Availability
- System Implementation
  - Android 4.4 (API level 19)
    - Text alerts
  - Application takes BLE central role

Version	Codename	API	Distribution
2.2	Froyo	8	0.7%
2.3.3 - 2.3.7	Gingerbread	10	11.4%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	9.6%
4.1.x	Jelly Bean	16	25.1%
4.2.x		17	20.7%
4.3		18	8.0%
4.4	KitKat	19	24.5%

Source: Android Developer Dashboard. User API distribution

Source: Brenton Chasse's Powerpoint

MDR Deliverables

- Weight sensor network converting physical force to a measurable signal
- Functional software Weight Distribution Model
- App UI interface w/ BLE sending and retrieving “data”
- First pass PCB design
- µController interfaced with:
  - Bluetooth transceiver module
  - Power systems

Sources

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Comparison of Broadcast Systems

- Bluetooth Classic
  - Supported by almost all phones
  - But...power inefficient
- Bluetooth Low Energy
  - Power efficient (depending on the use case)
  - But...not supported by all phones
  - BUT...is the trending embedded communication protocol
- WiFi
  - Ubiquitous in homes, and will always be on
  - But...not necessarily portable
  - And...won't have a simple receiver API

Pricing:

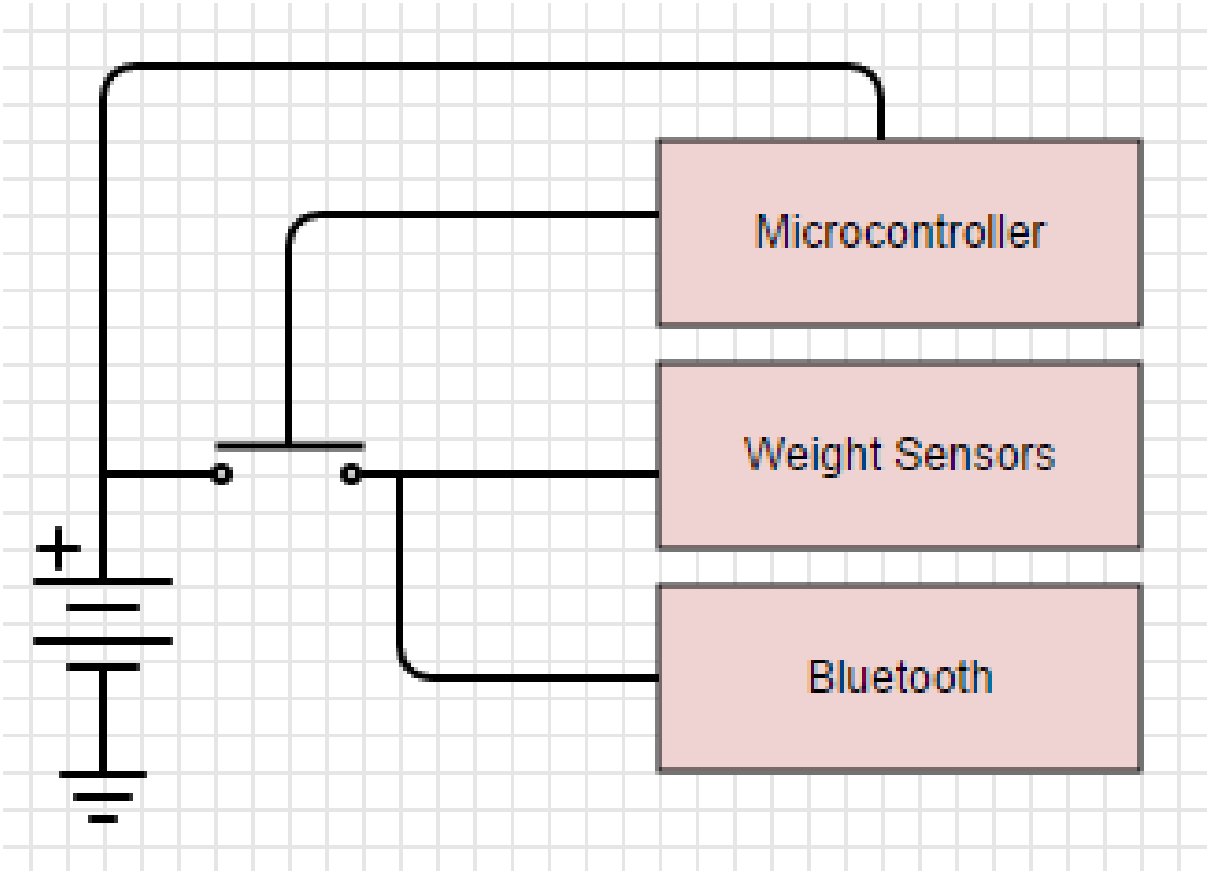
Top selling Jansport: $20.00 - 25.00
Top selling The North Face: $90.00

Margin: (90*.8) - 25 = $47.00

Prior to production, we can use $47.00 for embedding hardware in the backpack while still making a 20% profit.

Predict that we can do this in under $25.00, using some of the more expensive sensors (post manufacturing)

Power System



Advisor: Prof. Salthouse

Why weight

- Total weight of items in pack
- Weight per shoulder strap (proper wear)
- Expandability:
  - Items have specific weight (tracking)

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Applications

- Military
  - Pack weight relation to mobility
  - Inventory tracking is already an issue
    - (Universal inventories)
  - Distribution of weights between multiple bags
- College
- Children
  - Safety

Advisor: Prof. Salthouse

Weight Sensor design alternatives

Capacitive sensors
Cons
- very small changes in capacitance
- capacitance is harder to read/ more prone to parasitics

Pros
- Very cheap/easy to make

Strain Gauges
- Cons
  - temperature dependent, limited operating range
- Pros
  - Cheap, very compact, accurate

Piezieo Electric sensors
- Cons
  - More costly, produce high voltage swings

Pros
- accurate, compact

Possible topologies for weight circuits