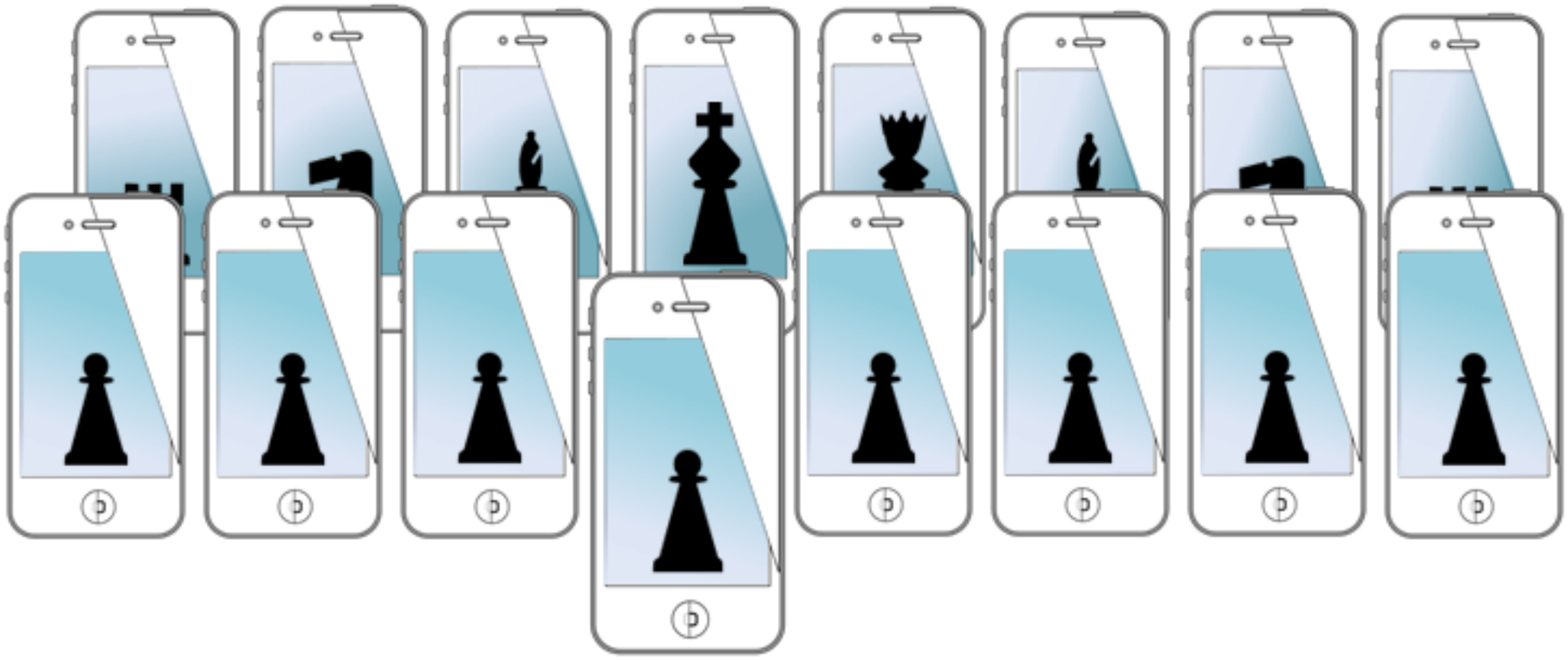
MOBILE SENSING LEARNING



CSE5323 & 7323

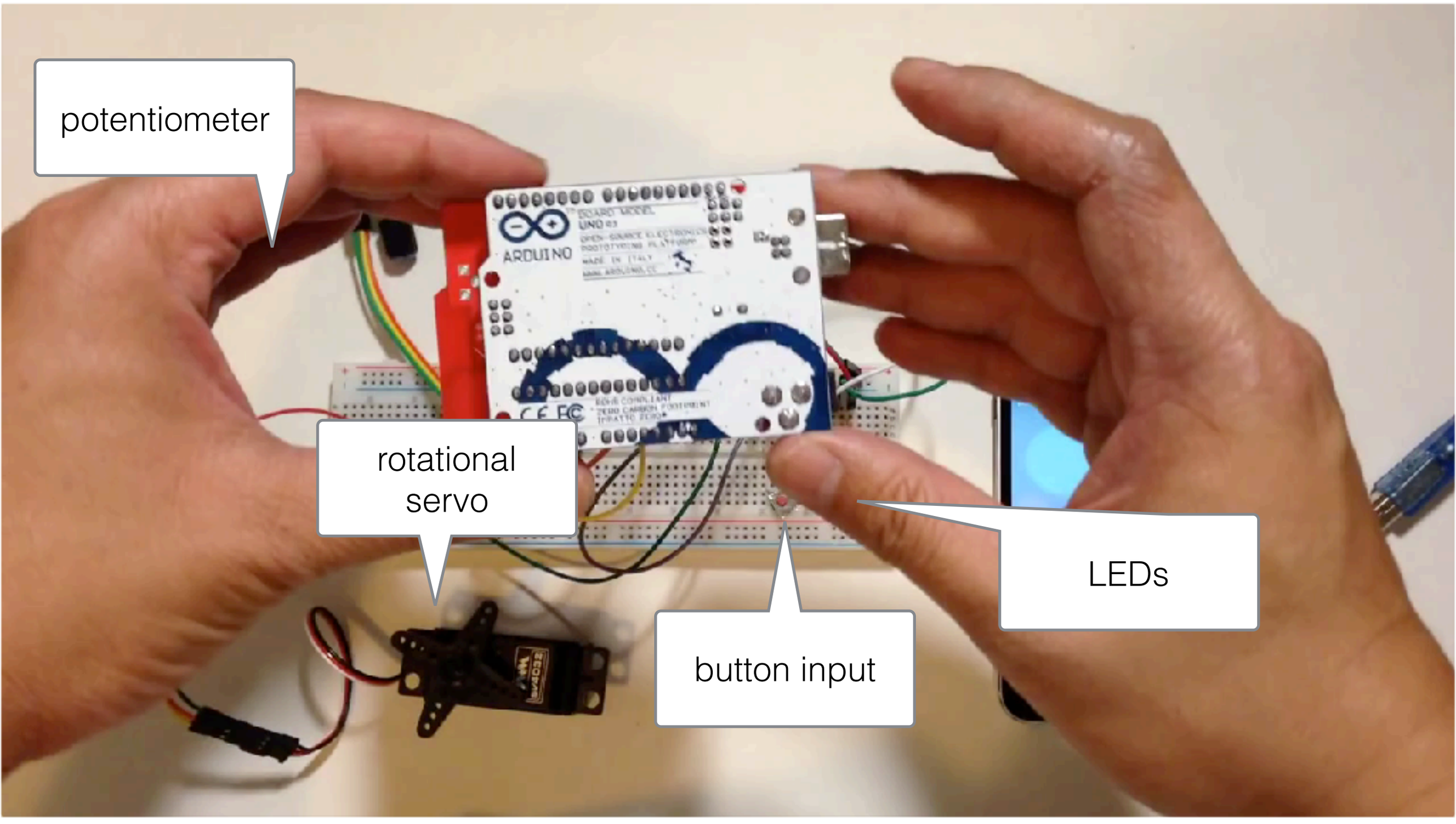
Mobile Sensing and Learning

Video Lecture: control and bluetooth

Eric C. Larson, Lyle School of Engineering,
Computer Science and Engineering, Southern Methodist University

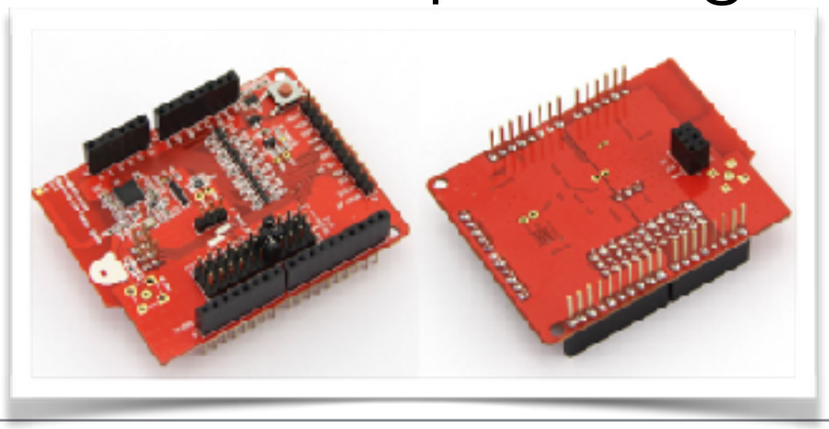
agenda

- bluetooth communication
  - microcontrollers
  - iOS


potentiometer
rotational servo
button input
LEDs

BLE shield

- BLE made really easy
- takes care of all the protocol of BLE
- uses pins 8-13 of the arduino (SPI)
  - 10 (SS), 11 (MOSI), 12 (MISO), and 13 (SCK)
  - 8 and 9 are RDYN and REQN for handshaking
  - remaining pins are **A0-A5** and **0-7**
- all communication is setup through `<ble_shield.h>`



BLE shield

setup

```
// Init. and start BLE library.
ble_begin();

// Enable serial debug
Serial.begin(57600);
```

setup SPI &
BLE shield controls

read from BLE, write to serial port

```
while ( ble_available() )
  Serial.write(ble_read());
```

if data available on SPI

read the byte

Serial is the USB port, not SPI

BLE shield

send text that we read from the serial port

```
while ( Serial.available() )
{
  unsigned char c = Serial.read();
  if (c != 0x0A)
  {
    if (len < 16)
      buf[len++] = c;
  }
  else
  {
    buf[len++] = 0x0A;

    for (int i = 0; i < len; i++)
      ble_write(buf[i]);
    len = 0;
  }
}

ble_do_events();
```

read from debug computer

pack in up to 16 bytes

add to transmit buffer

perform transmits
and acks

BLE firmata

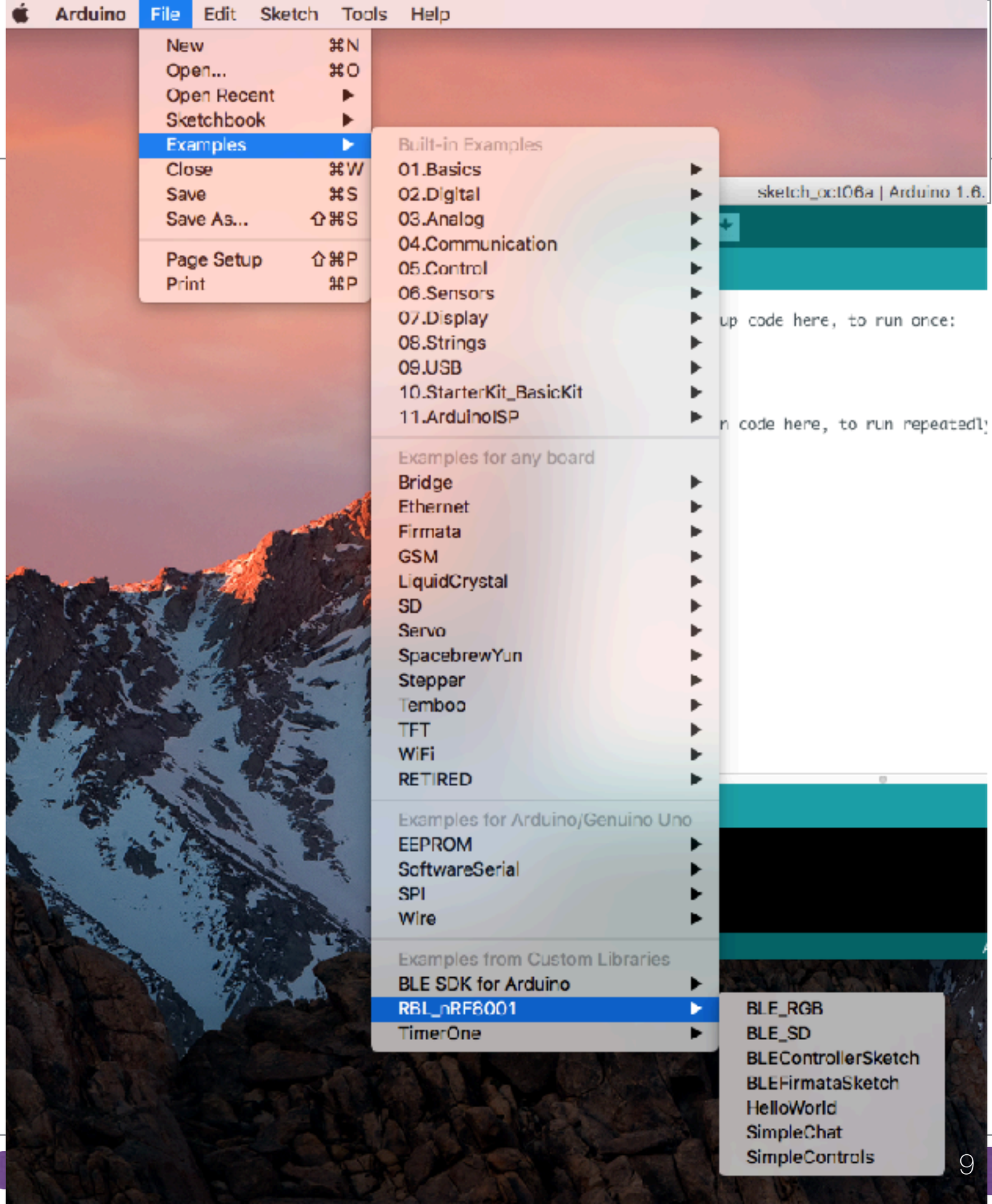
- enables custom firmware
  - set pins' output (analog or digital)
  - read input (analog or digital)
  - and essentially tell the arduino to do anything
- an adopted protocol
  - the BLE shield has already implemented this
  - the code can perform almost any operation that includes
    - reads, writes, ADC sampling, PWM, timers, serial comm, dedicated servo control
- http://redbearlab.com/bleshield/

installing library

- instructions available at:
- https://github.com/RedBearLab/BLEShield/blob/master/Docs/LibraryManager.pdf

BLE library

- plenty of examples and firmata included



bluetooth primer

- traditional bluetooth
  - short range wireless
  - low-medium latency
  - good for data like voice and audio
  - fairly power hungry
    - connection oriented
    - connection is maintained even when no data
- one million symbols per second
- but… cannot run from **coin cell battery** and limited to **seven** concurrent connections

bluetooth low-energy BLE

- designed for the internet-of-things
- asynchronous client / server model
- low latency
  - ~3 ms start to finish
- optimized for short bursts of information
  - so not really audio, but that gets abused
- number of connections
  - greater than two billion

theoretically

bluetooth low-energy BLE

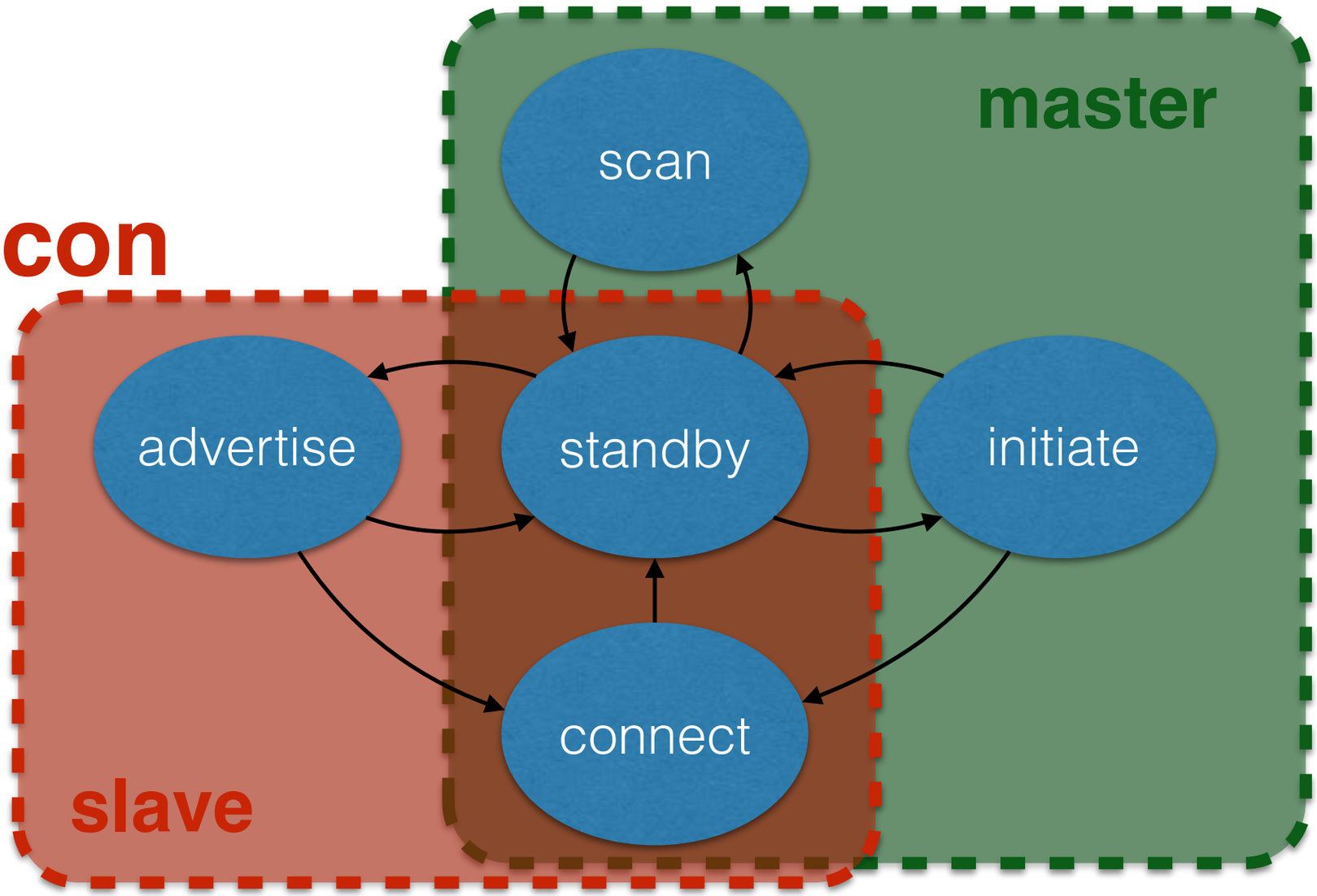
- data transfer can be triggered by events
- read at any time by a client
- interface protocol is Generic Attribute Protocol (GATT)
- client, server
  - characteristic (data)
  - service (collection of characteristics)
    - model name and serial number are part of GATT
  - descriptors
    - more information about a characteristic

GATT protocol

- everything has a universally unique ID (UUID, 128 bit)
- operations:
  - discover UUIDs
  - find service with UUID (or secondary service)
  - discover characteristics for a service
  - find characteristics for a given UUID
  - and get descriptors for characteristic

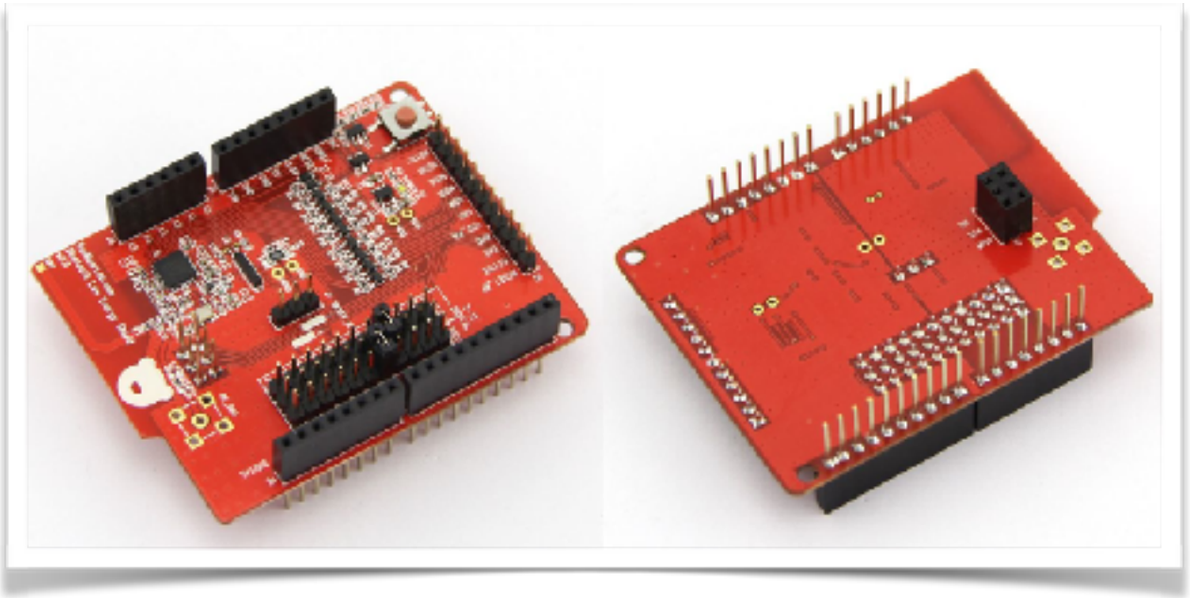
BLE connections

- 3 bands for advertising
- 37 bands for data transmission



who's who?

peripheral



slave

advertise

central

master

initiate

BLE in iOS

- we will use the red bear API
- instantiate BLE object
- connect to advertisers
- use delegation for responding to incoming data
- add as framework to project and that's it
- download from their github page

public API (.h)

```
@protocol BLEDelegate
@optional
-(void) bleDidConnect;
-(void) bleDidDisconnect;
-(void) bleDidUpdateRSSI:(NSNumber *) rssi;
-(void) bleDidReceiveData:(unsigned char *) data length:(int) length;
@required
@end

@property (strong, nonatomic) NSMutableArray *peripherals;
@property (strong, nonatomic) CBCentralManager *CM;
@property (strong, nonatomic) CBPeripheral *activePeripheral;

-(void) enableReadNotification:(CBPeripheral *)p;
-(void) read;
-(void) writeValue:(CBUUID *)serviceUUID
        characteristicUUID:(CBUUID *)characteristicUUID
        p:(CBPeripheral *)p data:(NSData *)data;

-(BOOL) isConnected;
-(void) write:(NSData *)d;
-(void) readRSSI;

-(void) controlSetup;
-(int) findBLEPeripherals:(int) timeout;
-(void) connectPeripheral:(CBPeripheral *)peripheral;
```

peripheral initiation

```
@interface ViewController : UIViewController <BLEDelegate> {
    BLE *bleShield;
}

//start search for peripherals with a timeout of 3 seconds
 // this is an asynchronous call and will return before search is complete
 [bleShield findBLEPeripherals:3];

 // after three seconds, try to connect to first peripheral
 [NSTimer scheduledTimerWithTimeInterval:(float)3.0
                                  target:self
                                selector:@selector(connectionTimer:)
                                userInfo:nil
                                 repeats:NO];

// Called when scan period is over to connect to the first found peripheral
-(void) connectionTimer:(NSTimer *)timer
{
    if(bleShield.peripherals.count > 0)
    {
        // connect the first found peripheral
        [bleShield connectPeripheral:[bleShield.peripherals objectAtIndex:0]];
    }
}

-(void) bleDidConnect
{
    // Schedule to read RSSI every 1 sec.
    rssiTimer = [NSTimer scheduledTimerWithTimeInterval:(float)1.0 target:self
                                selector:@selector(readRSSITimer:) userInfo:nil repeats:YES];
}
```

is this the proper way to connect?

async reading

```
-(void) bleDidReceiveData:(unsigned char *)data length:(int)length
{
    NSData *d = [NSData dataWithBytes:data length:length];
    NSString *s = [[NSString alloc] initWithData:d encoding:NSUTF8StringEncoding];
    self.label.text = s;
}
```

this won't cut it for A5!

you need to send data of different types — how?

SOP: define your own protocol

write data

```
NSString *s;
NSData *d;

if (self.textField.text.length > 16)
    s = [self.textField.text substringToIndex:16];
else
    s = self.textField.text;

s = [NSString stringWithFormat:@"%@\r\n", s];
d = [s dataUsingEncoding:NSUTF8StringEncoding];

[bleShield write:d];
```

SOP: define your own protocol

Demo time

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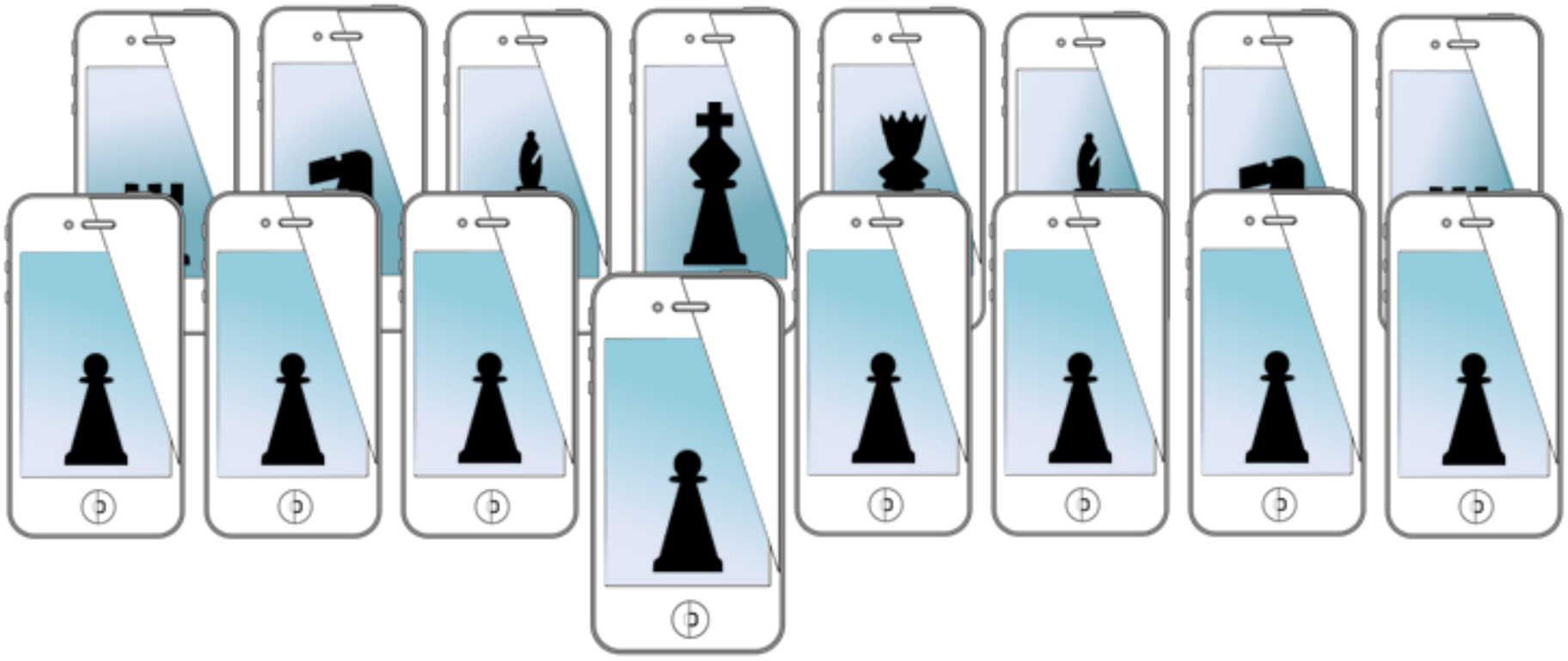

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