

Reducing Power Consumption and Cost of Remote Learning Technology

Researcher: Luke Charlesworth

Advisor: Professor Oliveira



Sierra Leone



Sierra Leone is located in West Africa, bordering Liberia and Guinea. It is a beautiful nation rich in culture and natural resources.



A legacy of conflict, public health crises, and colonialism has stunted the growth of education, leaving much of the nation in poverty.



Personal Involvement



World Possible
Sierra Leone

The RACHEL



- RACHEL stands for Remote Area Community Hotspot for Education and Learning.
- Creates a wireless network and access point for client devices to view digital education content in off-grid areas.
- Contains offline modules from Khan Academy, Kolibri, and Wikipedia.
- Developed by Jeremy Schwartz in 2009, now deployed in over 50 countries, primarily serving rural villages and prisons.

Current System

- WPSL has implemented a preliminary solar system (50 watt panel) and one RACHEL in the primary school's of Kabala, Fadugu, Senekedugu.
- Twice a week after school, trained teachers run an afterschool program for students looking to practice their math skills.
- Many challenges in scaling this system into classrooms.



Financial Problem

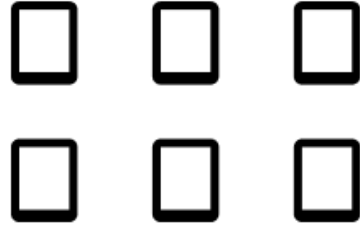
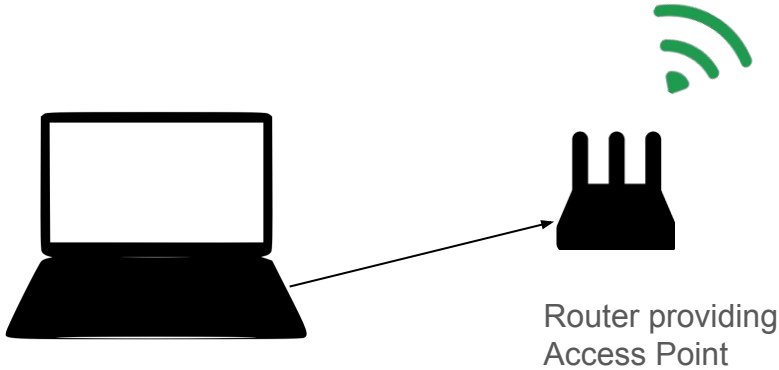


- The RACHEL 4.0 costs \$500 USD, it also requires client devices (laptops or tablets) and power to work in an off-grid environment.
- GDP Per Capita is ~\$480 USD in SL.
- 1 USD = 19,750 Leones
- DEC Kabala's 2022 School Budget was \$1500 USD.



Potential Solution

What if we can deploy RACHEL software on donated hardware?



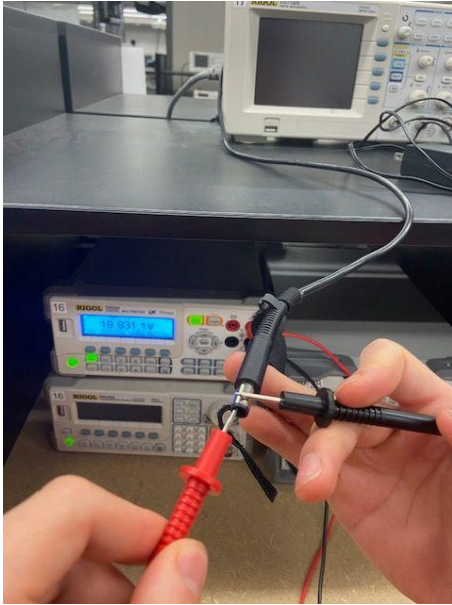
Student Client devices



Additional Constraints

- Laptops must be running an OS that supports a RACHEL installation (custom Linux Installer).
- If this new system consumes way more energy than the original RACHEL, cost benefits may be offset by increased power expenses.
- Network signal would need the range and strength to support a large classroom size for curriculum integration.
- **Can we reduce laptop power consumption without destroying usability?**

Watts and Volts: A CS Student's Worst Nightmare



A New Method...



<xpath>

```
def signupRandom():

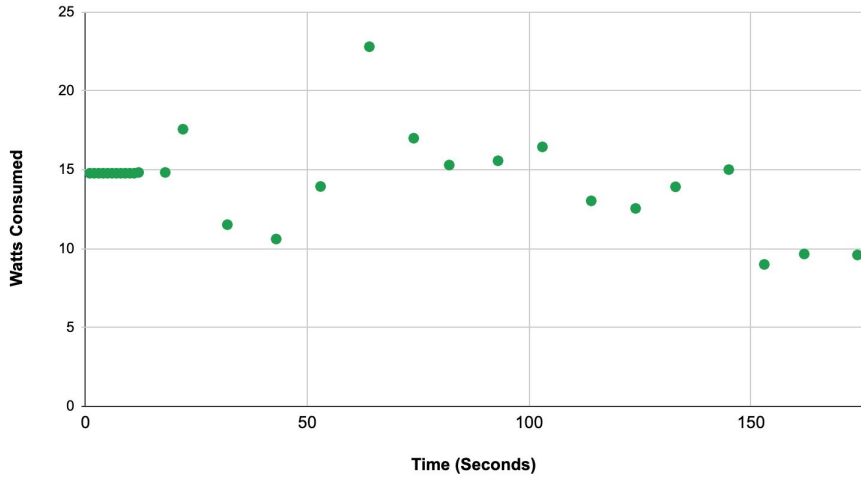
    service = Service(executable_path= "./chromedriver_mac64/chromedriver")
    driver = webdriver.Chrome(service = service);
    driver.get('http://192.168.88.240/index.php')

    # Click kolibri button
    window_before = driver.window_handles[0]
    kolibriButton = driver.find_element(By.XPATH, "//img[@src='modules/en-kolibri-
index/kolibri-logo.svg']")
    kolibriButton.click()
    window_after = driver.window_handles[1]
    driver.switch_to.window(window_after)
    # wait till the other window is loaded,
    # Let the user actually see something!
    elem = WebDriverWait(driver, 120).until(
        EC.presence_of_element_located((By.XPATH, "//p[@class='create']")))
    createAccountButton = driver.find_element(By.XPATH, "//p[@class='create']")
    createAccountButton.click()
```

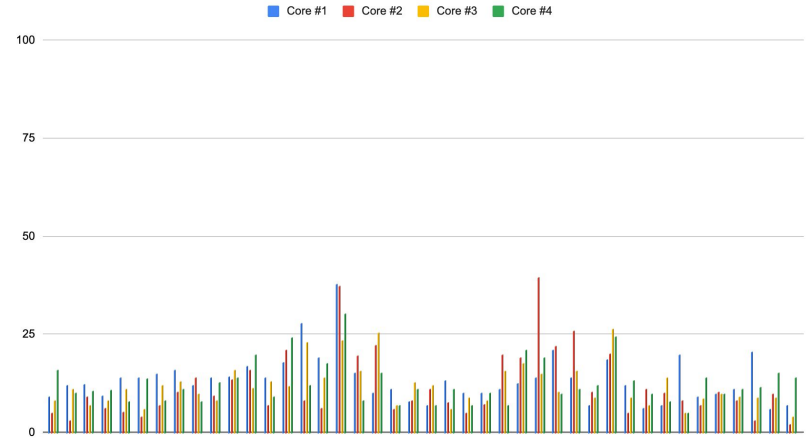


Characterizing the System

Watts Consumed over Time (Seconds)



CPU Utilization (20 Accts Onboarded and Play Video)



Turning Off Cores... Responsibly

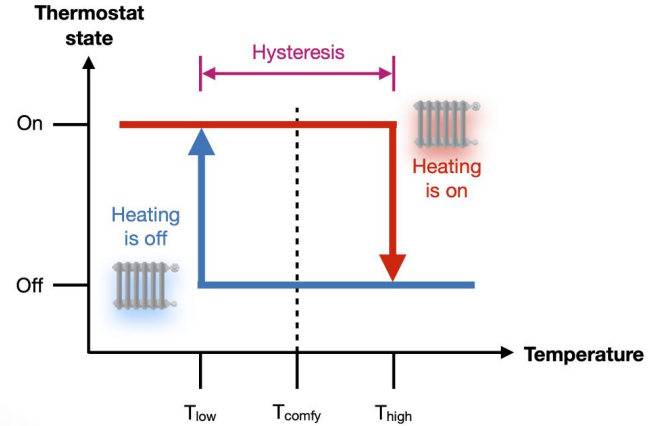
- Even with 50 users (the maximum classroom size) all watching Kolibri videos simultaneously, RACHEL PC's CPUs are not near full utilization.
- Idle Processor's still consume power...
- What if we can turn them off?

```
if [[ "$utilState" == "ONE" ]];
then
echo 0 > /sys/devices/system/cpu/cpu3/online
echo 0 > /sys/devices/system/cpu/cpu2/online
echo 0 > /sys/devices/system/cpu/cpu1/online
elif [[ "$utilState" == "TWO" ]];
then
echo 0 > /sys/devices/system/cpu/cpu3/online
echo 0 > /sys/devices/system/cpu/cpu2/online
echo 1 > /sys/devices/system/cpu/cpu1/online

elif [[ "$utilState" == "THREE" ]];
then
echo 0 > /sys/devices/system/cpu/cpu3/online
echo 1 > /sys/devices/system/cpu/cpu2/online
echo 1 > /sys/devices/system/cpu/cpu1/online
elif [[ "$utilState" == "FOUR" ]];
then
echo 1 > /sys/devices/system/cpu/cpu3/online
echo 1 > /sys/devices/system/cpu/cpu2/online
echo 1 > /sys/devices/system/cpu/cpu1/online
fi
```

Hysteresis

- A phenomenon in which the change in the system's response occurs with a time delay to the change of the driving force causing it.
- Usually in physics to describe delay between magnetic signal and resulting magnetism.
- Can't turn on and off Cores at the same utilization benchmark or we risk the flip-flop.
- Solved by adding moving average variable and changing benchmarks.





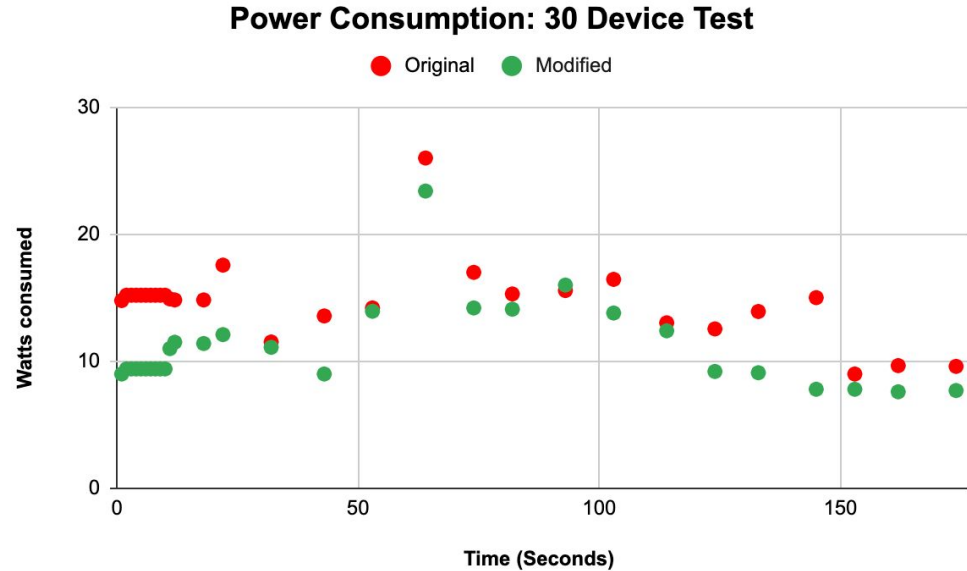
Smaller Power Improvements



```
#Default: <none>  
CPU_SCALING_MIN_FREQ_ON_AC=0  
CPU_SCALING_MAX_FREQ_ON_AC=2800000  
CPU_SCALING_MIN_FREQ_ON_AC=0  
CPU_SCALING_MAX_FREQ_ON_BAT=2800000
```

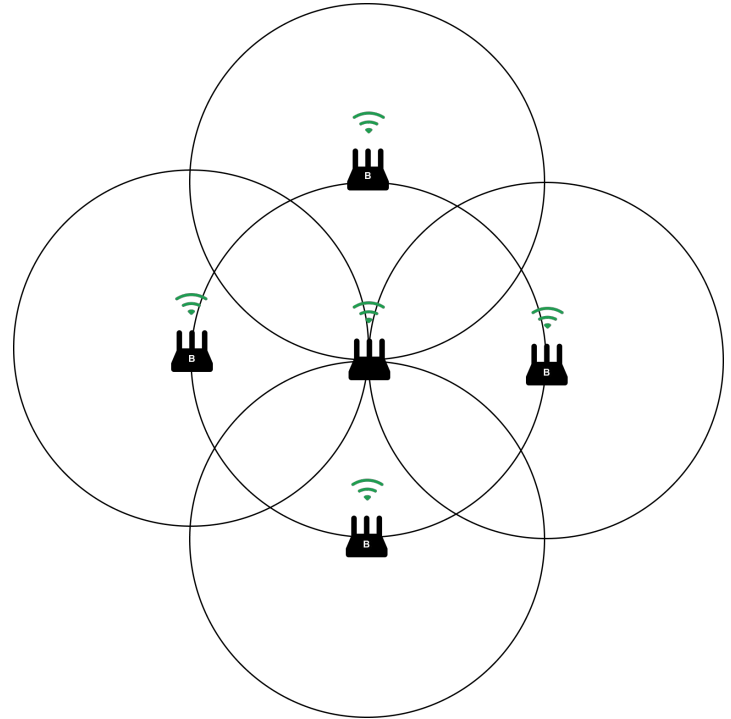
Did It Work ?

- Battery life extended by up to **21%** with 30 client devices continuously using network.
- Further real client testing will occur in village to confirm power reduction.



System Redesign

- Already have a bundle of AC1800 Routers from 2022 Summer Scholar Award...
- Will need a custom 12V battery to power router in classrooms regardless
- What if we had one central router located at the power supply unit and we put every other one in bridge mode?



Takeaways

- Organization is key when carting around a ton of technology in Pittsburgh
- Progress on a research project is never linear, so do not expect it to be (stress = enemy of success)
- Multicultural projects that span across continents introduce some communication challenges...
- Use Pitt's Resources!

