

Vehicle-to-Vehicle Update Delivery System

Created by Austin Gilbert, Aashima Mehta & Cameron Ufland

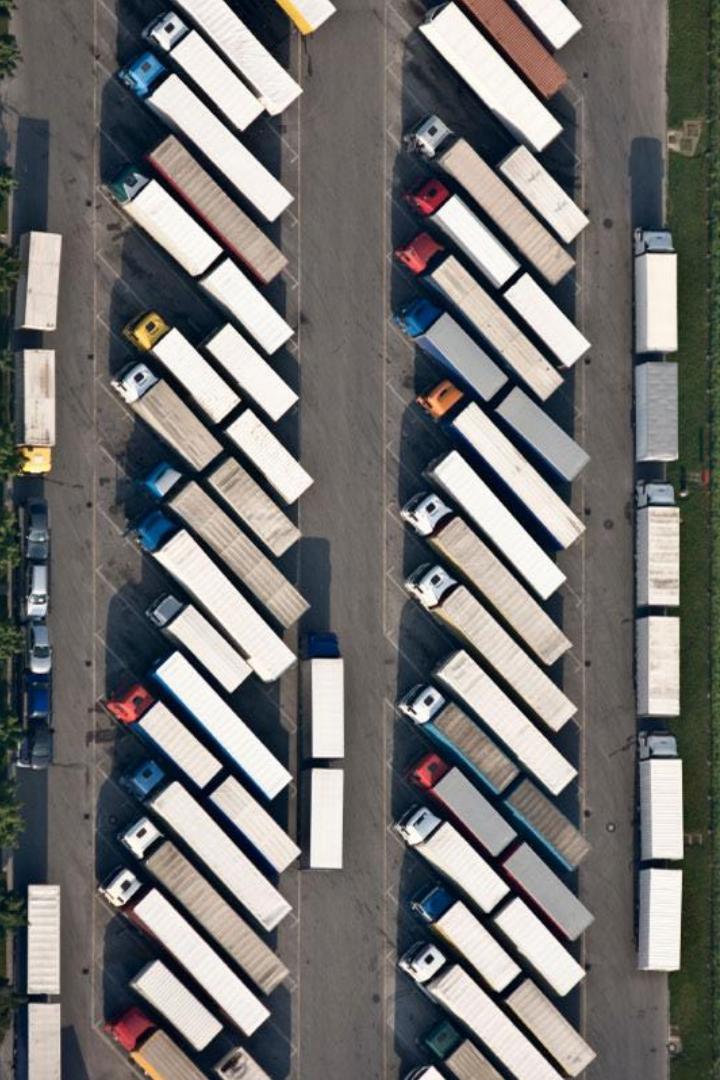
Designed for **PACCAR** Inc
Industry Advisor: David Sasaki

In affiliation with the UNIVERSITY *of* WASHINGTON | BOTHELL
Academic Advisor: Elaine Reeves

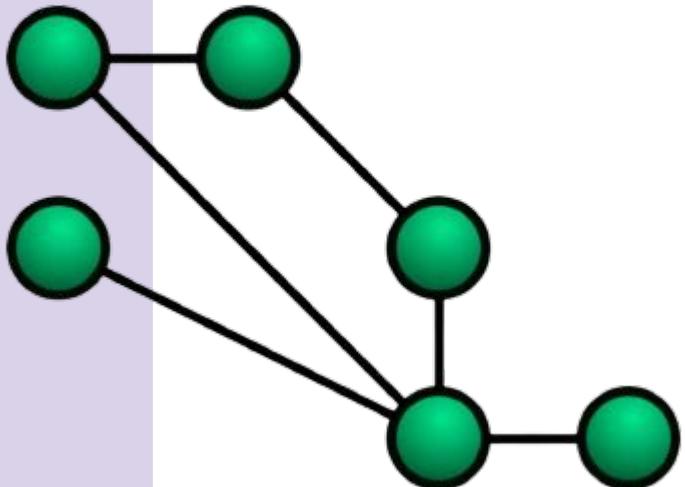


The Problem

- Trucks operate in remote areas
- Internet may not be a viable option for update delivery
- Vehicle software depreciates over time
- Critical safety and security updates do not become widespread



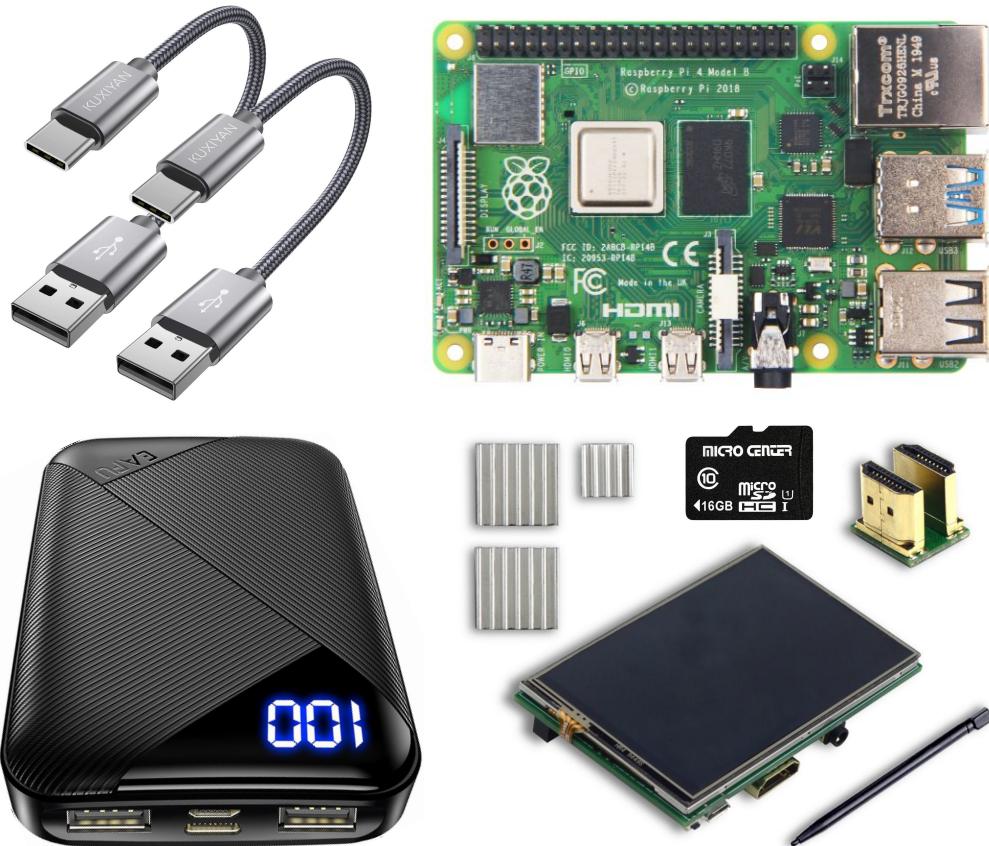
Our Solution



- Automatic delivery of updates from truck-to-truck
- Direction of update transfer determined via version number
- Proof of concept for technology using multiple Raspberry Pis

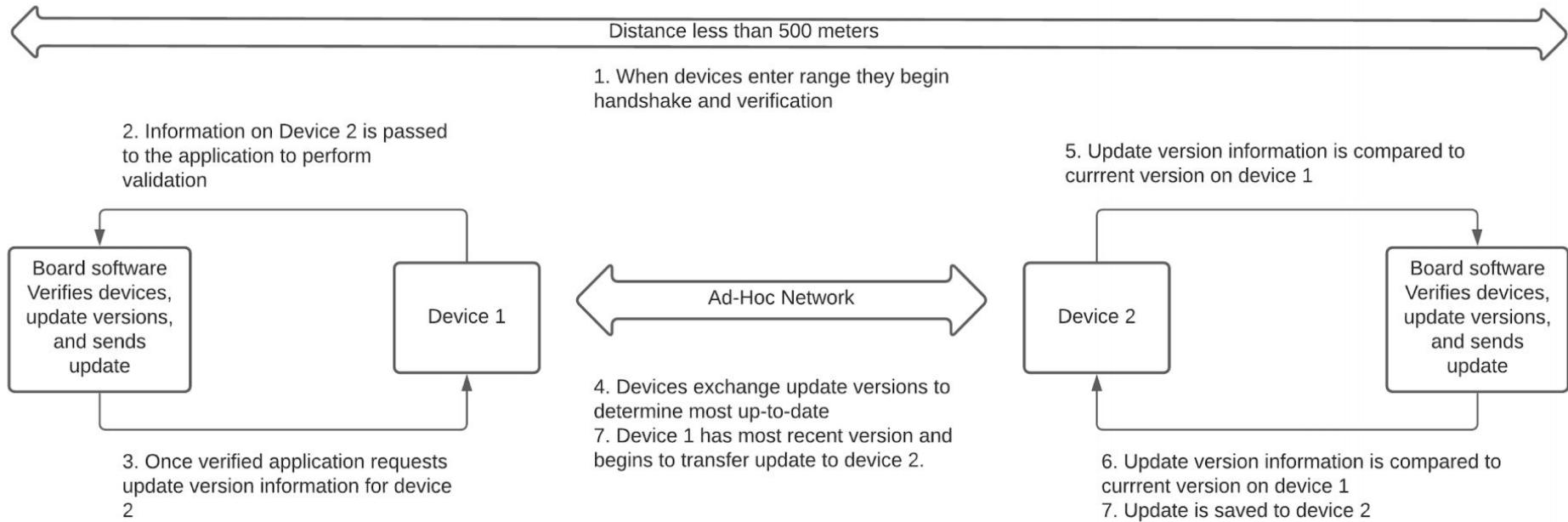
Hardware Design

- Raspberry Pi 4 Model B
- 3.5" Touchscreen
- Portable Power Bank
- USB-C to USB-A Cable
- SD Card



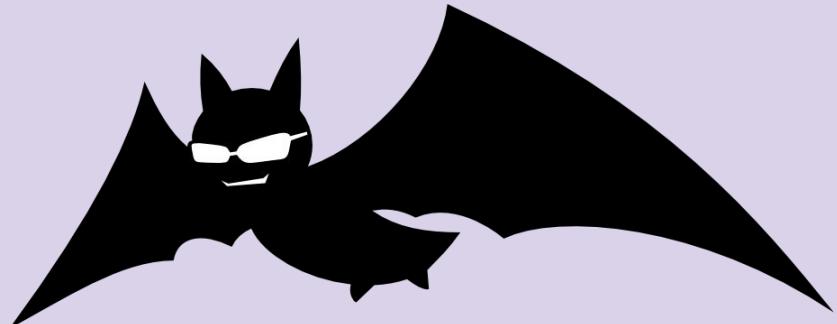


Overall Program Design

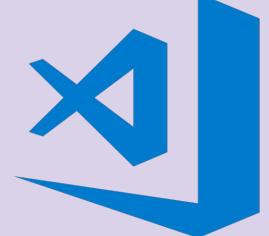
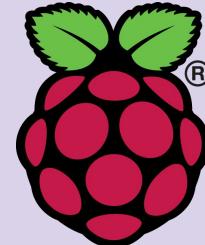
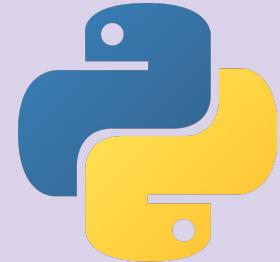


Software & Firmware Tools

- Raspberry Pi OS (32-bit)
- Python
- Visual Studio Code
- GitHub
- B.A.T.M.A.N. Advanced
- PyQt5 & Qt Designer

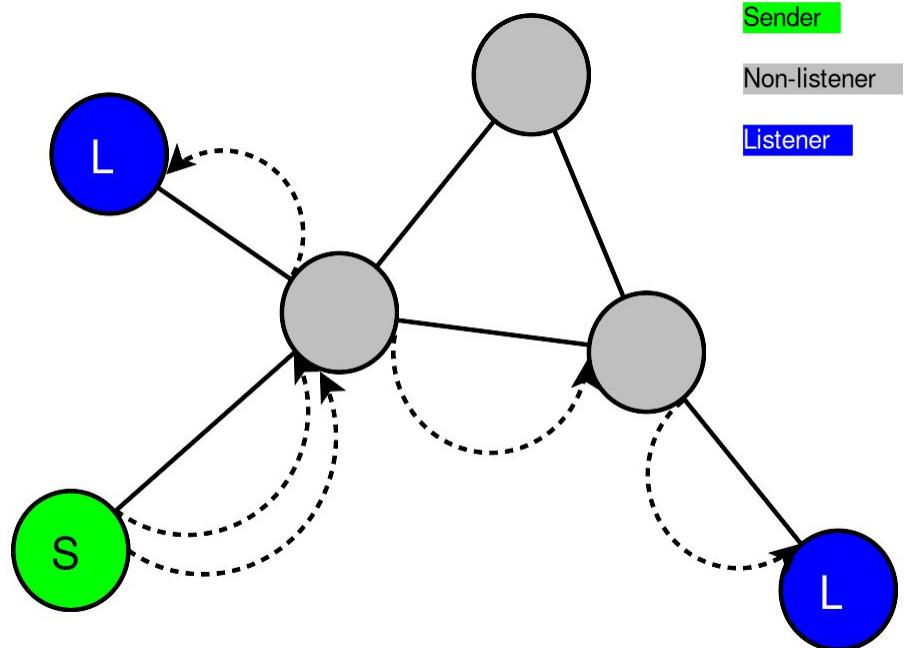


GitHub



Mesh Networks & B.A.T.M.A.N. Advanced

- “Better Approach to Mobile Ad-Hoc Networking”
- Ad-Hoc mesh network routing protocol
- Devices deploy networks, which connect with proximity and combine into bigger mesh networks



Software Design

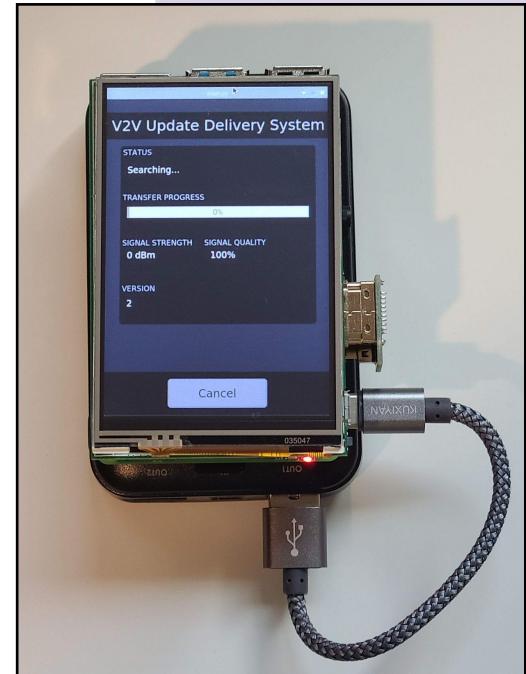
Raspberry Pi

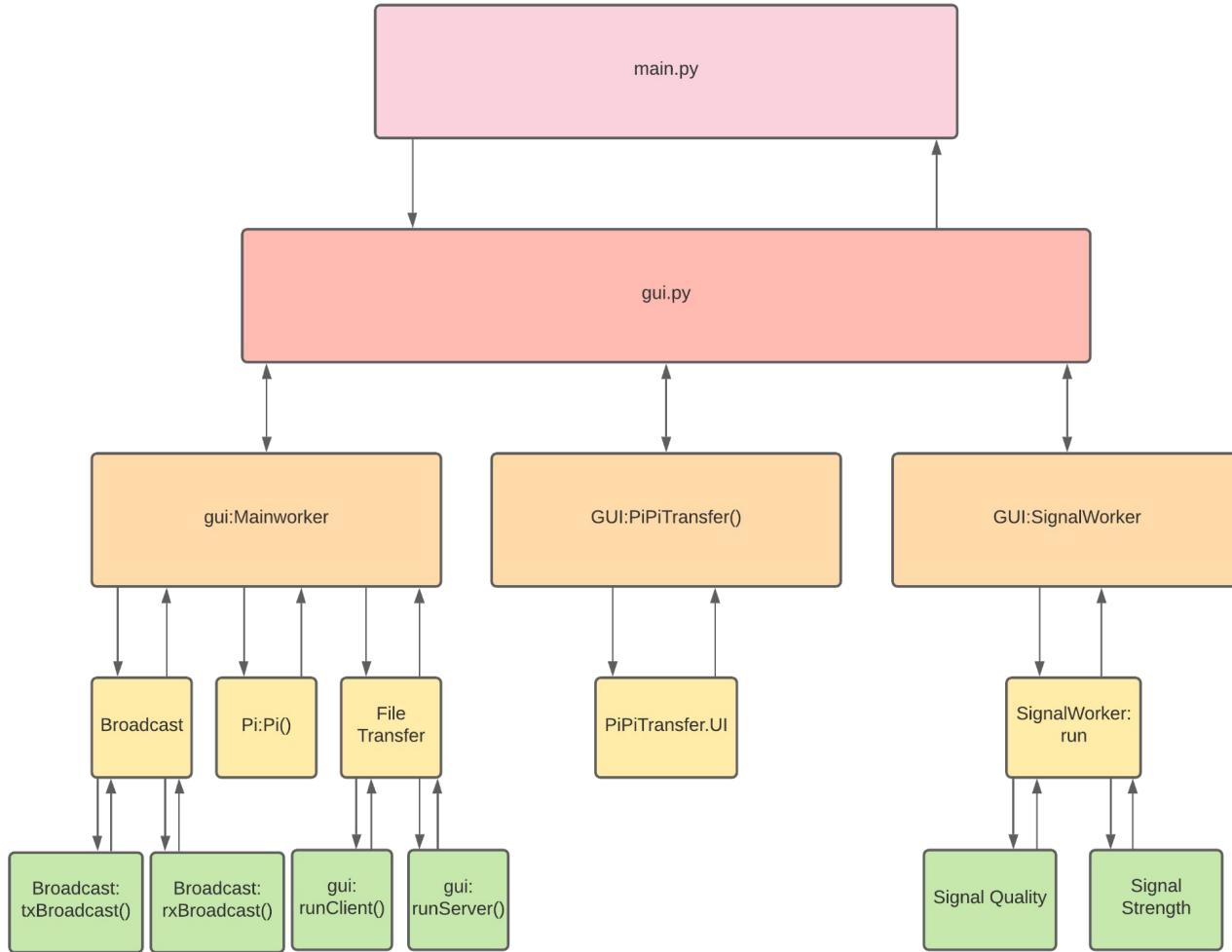
Vehicle-to-Vehicle Update Delivery System

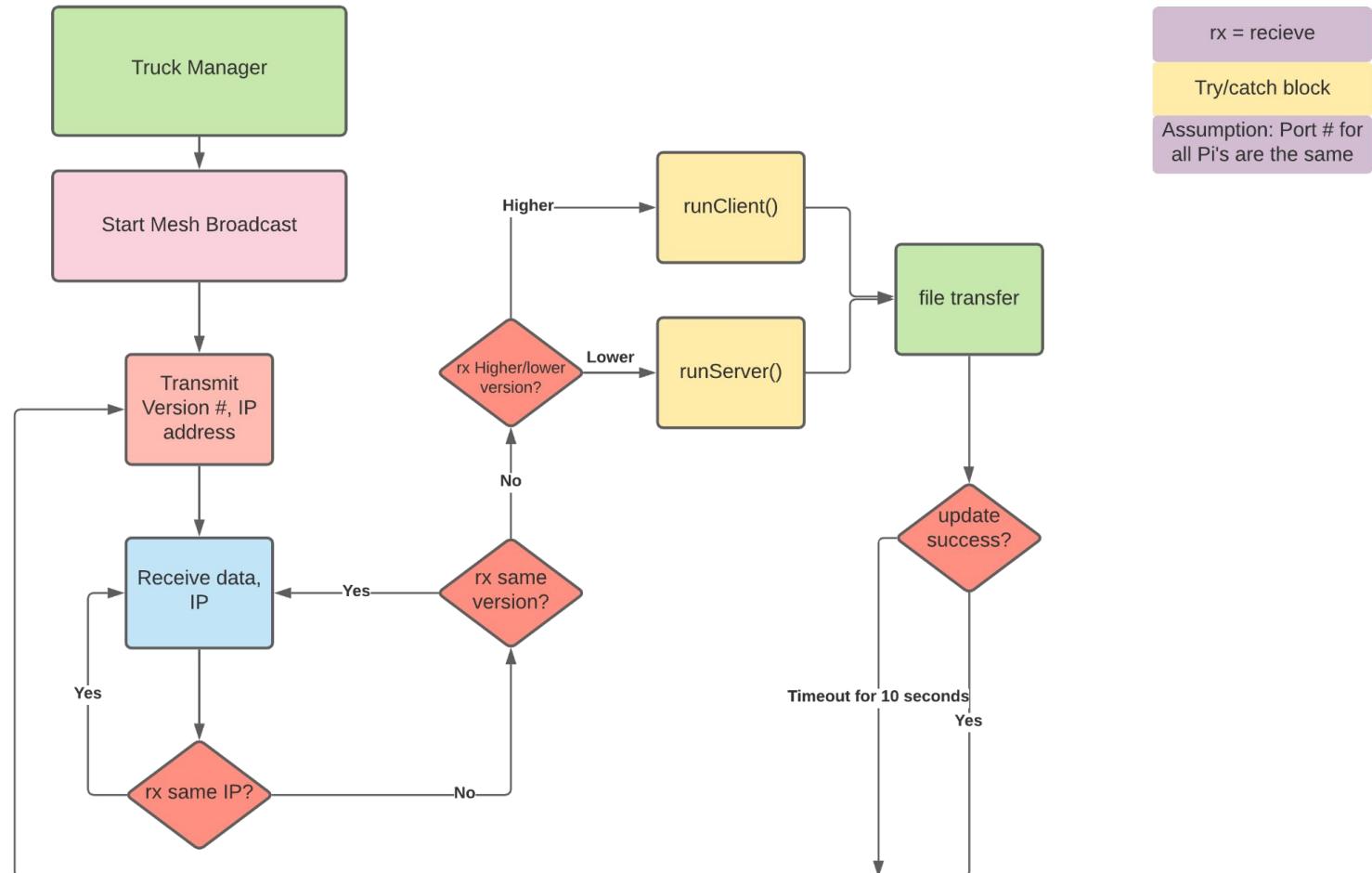
Batman Advanced

Screen Drivers

Raspberry Pi OS

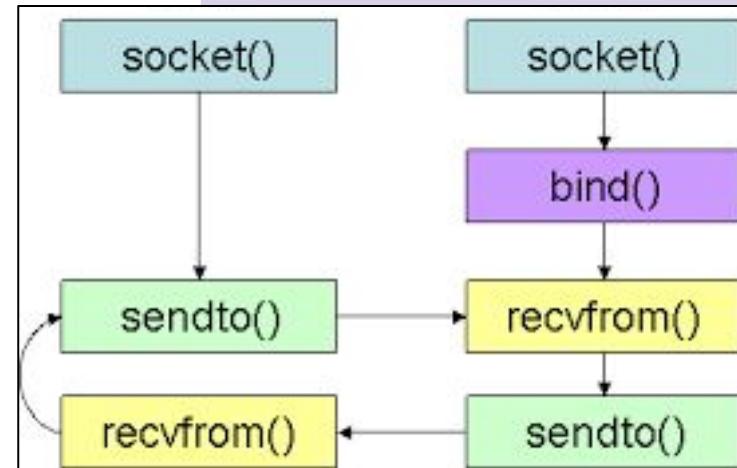


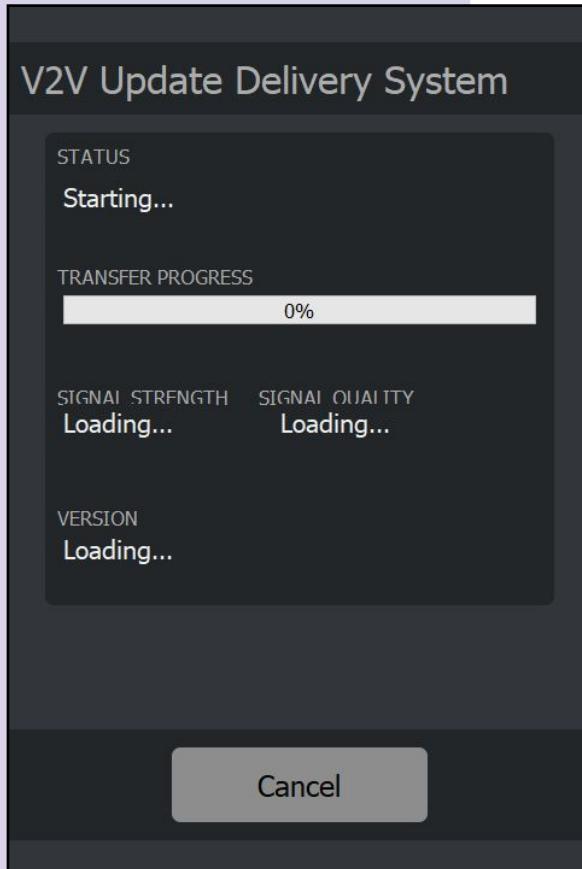




Sockets and TCP Packets

- Python class for sending messages using a server program
 - Sockets act as endpoint to a network node
 - UDP is used for broadcasting
 - TCP is used for transmitting update files



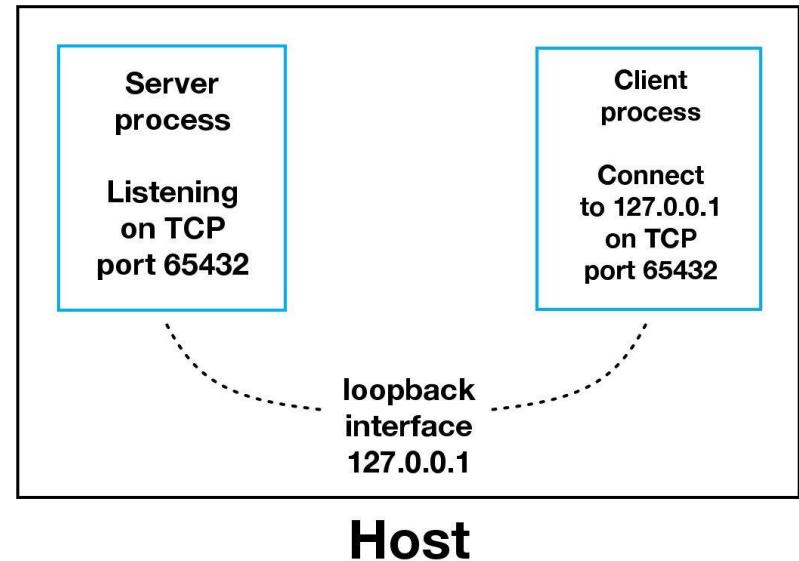


Graphical User Interface

- Uses multithreading
- Designed with PyQt5 & Qt Designer
- Logs current task on status logger
- Transfer Progress updated as update transfers
- Updates signal strength and quality
- Updates version number
- Cancel button refreshes program

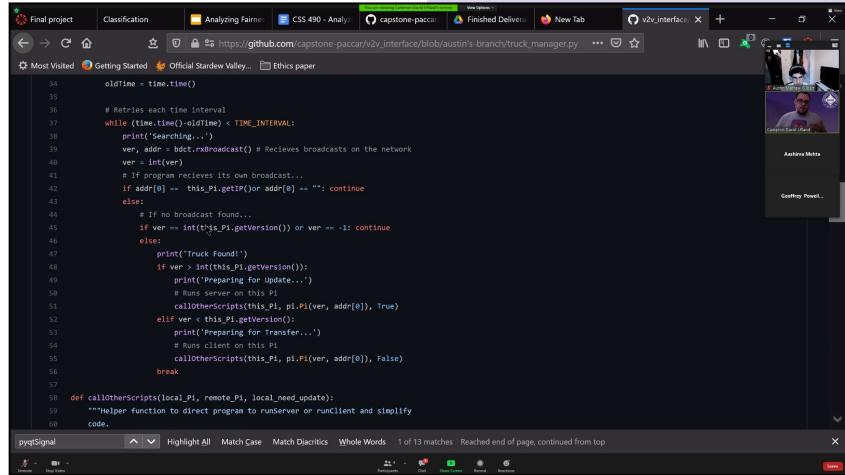
Road Blocks

- Outdated B.A.T.M.A.N. package
- Unstable images of Raspberry Pi OS
- Researching network design and implementation
- Raspberry Pi attempted to communicate over local IP address



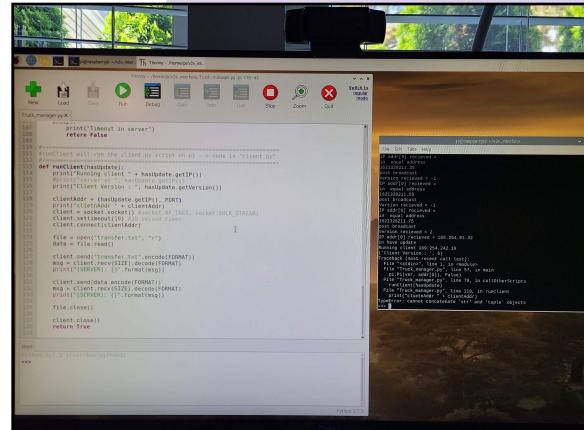
Software Integration Testing

- Debugging our program in real-time
- Testing our software throughout the quarter
- Design Review with fellow CE student Geoffrey Powell-Isom



```
oldtime = time.time()
...
# Retries each time interval
while (time.time() - oldtime) < TIME_INTERVAL:
    print("Searching...")
    ver, addr = bdct.recvBroadcast() # Receives broadcasts on the network
    ver = int(ver)
    # If program receives its own broadcast...
    if addr[0] == this_Pl.getIP() or addr[0] == "": continue
    else:
        # If no broadcast found,
        if ver == int(this_Pl.getVersion()) or ver == -1: continue
        else:
            print("Truck Found!")
            if ver > int(this_Pl.getVersion()):
                print("Preparing for Update...")
                # Runs server on this PI
                callOtherScripts(this_Pl, pi.PI(ver, addr[0]), True)
            elif ver < this_Pl.getVersion():
                print("Preparing for Transfer...")
                # Runs client on this PI
                callOtherScripts(this_Pl, pi.PI(ver, addr[0]), False)
            break
    ...
def callOtherScripts(local_Pl, remote_Pl, local_need_update):
    """Helper Function to direct program to runServer or runClient and simplify
    code.
    """
    ...

```

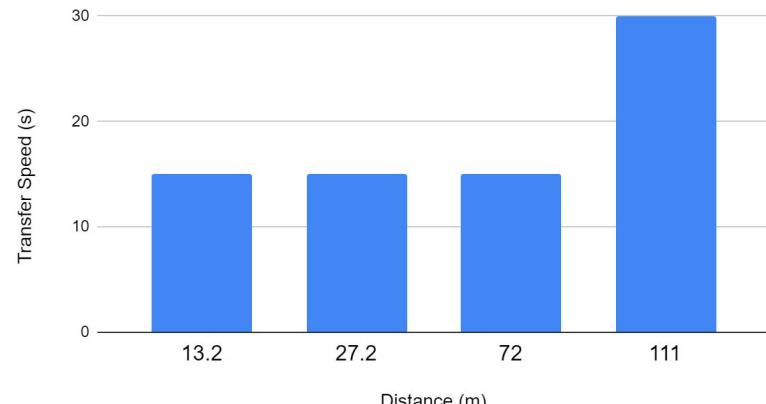


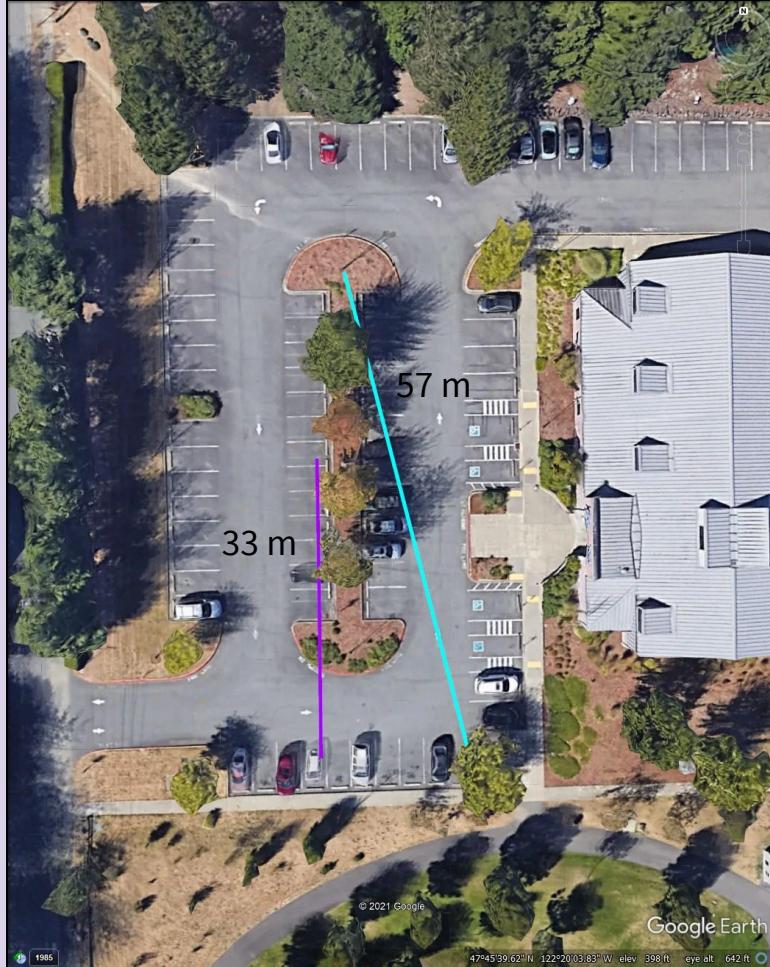
Field Testing



- Tests at Shoreline's Cromwell Park
- Trucks used earlier Truck Manager Program
- Tested File Transfer Distance on a big, open field
- Tested File Transfer Distance in a parking lot with obstructions

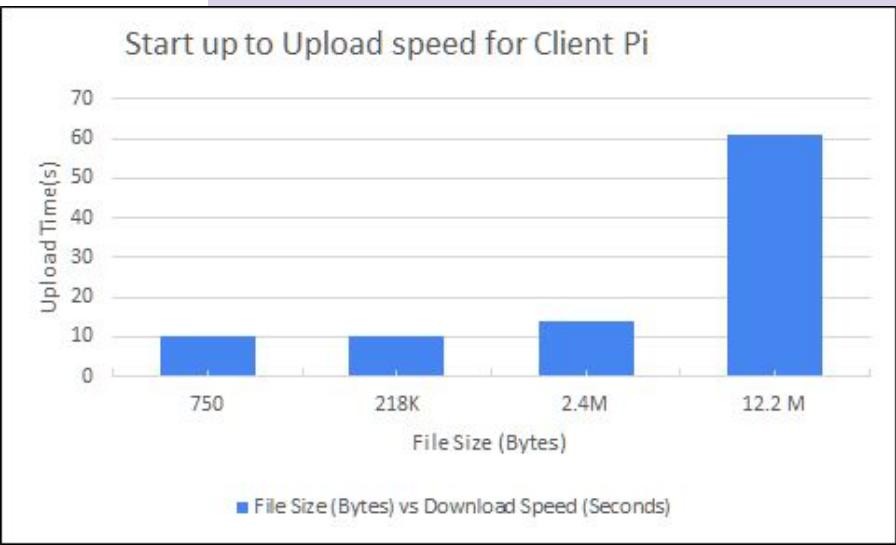
Distance Testing Results





File Transfer Speed Testing

- Distance of 50 cm
- Maximum file size of 12.2 MB
- Minimum file size of 750 Bytes
- Maximum time of 64.8 s
- Minimum time of 10.1s



Startup to Upload speed for varying file sizes

filesize (bytes)	Trial Times(s)					Average (s)
	1	2	3	4	5	
750	10.1	10.1	10.1	10.1	10.1	10.1
218K	10.2	10.1	10.2	10.2	10.1	10.16
2.4M	12	22	11	12	12	13.8
12.2 M	57.1	56.9	60.7	64.8	64.4	60.78

PSSUQ User Testing

Overall Score	1.75
System Usefulness (SYSUSE)	1.93
Information Quality (INFOQUAL)	1.60
Interface Quality (INTERQUAL)	1.56

Note: User Testing is scored on a scale where 1 is the best and 7 is the worst. The scores are the results of three people answering the survey about our product

Demonstration

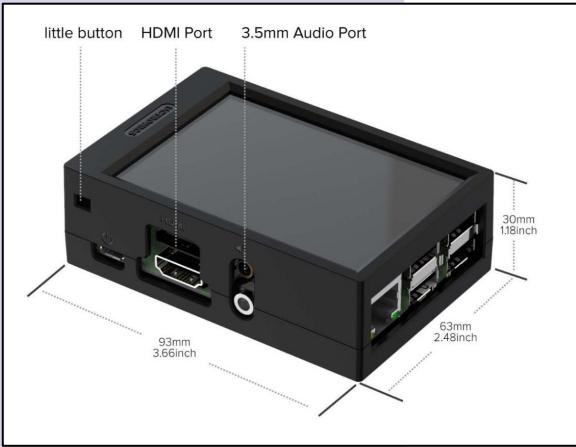
Program Boot Up (sped up 1.5x)



Conclusion

- Successful creation of a proof of concept for automatic delivery of updates between multiple devices in proximity
- Completion of 7/10 requirements, including all high-priority requirements and 3 lower priority requirements





Future Work

- Testing with more devices
- Large file transfer handling
- Implementation of security
- Long-range antenna
- Phone-to-Pi update delivery



References

- "B.A.T.M.A.N." *Wikipedia*, Wikimedia Foundation, 25 Apr. 2021, en.wikipedia.org/wiki/B.A.T.M.A.N.
- "PyQt5 FULL Modern Gui Tutorial #2 - Login Form: GUI & Database [for Beginners]." *YouTube*, Uploaded by Code First, 5 May 2021,youtu.be/pleHwE1swbY.
- "Dark Theme." *Material Design*, Google, 25 June 2014, material.io/design/color/dark-theme.html#usage.
- "PyQt5 FULL Modern Gui Tutorial #3 - Create Account Form: GUI & Database [for Beginners]." *YouTube*, Uploaded by Code First, 9 May 2021,youtu.be/kplbcFeNKCw.
- Doll, Tyler. "How to Setup a Raspberry Pi Ad-Hoc Network Using BATMAN-ADV on Raspbian Stretch." *Tyler Doll - Medium*, Medium, 18 Apr. 2019,
- Quintero, Jörg. "Re: Official 7' Touchscreen, Rotate Touch." *Raspberry Pi Forums*, Raspberry Pi Foundation, Broadcom, 30 June 2015, 1:35 pm, www.raspberrypi.org/forums/viewtopic.php?f=108&t=219333&p=1358066#p1348198. medium.com/@tdoll/how-to-setup-a-raspberry-pi-ad-hoc-network-using-batman-adv-on-raspbian-stretch-lite-dce6eb896687.
- Ramos, Leodanis Pozo. "Use PyQt's QThread to Prevent Freezing GUIs." *Real Python*, Real Python, 21 Dec. 2020, realpython.com/python-pyqt-qthread/.
- Dul, Michal. "File Transfer over Sockets without User-Space Memory in Python 3.5." *Notes on Data Processing*, Jeykll, Minimal Mistakes, 4 Feb. 2018, michaeldul.com/python/sendfile/.
- Reddy, Vivek. "TCP 3-Way Handshake Process." *GeeksforGeeks*, 6 Sept. 2019, www.geeksforgeeks.org/tcp-3-way-handshake-process/.
- Innes, Brian. "Part 1 - Mesh Networks." *Github*, GitHub, Inc., 21 Jan. 2020, github.com/binnes/WiFiMeshRaspberryPi/blob/master/part1/PIMESH.md.
- "Requirements Specification Template." 17 Apr. 2013.
- JamesH65. "BCM2711 - Raspberry Pi Documentation." *Raspberry Pi*, Raspberry Pi Foundation, 23 June 2019, www.raspberrypi.org/documentation/hardware/raspberrypi/bcm2711/README.md.
- Rockikz, Abdou. "How to Transfer Files in the Network Using Sockets in Python." *Python Code*, Feb. 2021, www.thepythoncode.com/article/send-receive-files-using-sockets-python.
- JamesH65. "FAQs - Raspberry Pi Documentation." *Raspberry Pi*, Raspberry Pi Foundation, 23 June 2019, www.raspberrypi.org/documentation/faqs/#:~:text=It%20uses%20a%201.2GHz,wireless%20LAN%2C%20and%20Bluetooth%204.2.
- "RPi USB Wi-Fi Adapters." *ELinux.org*, Wikimedia Foundation, 10 Mar. 2021, 15:18, elinux.org/RPi_USB_Wi-Fi_Adapters.
- Jin, Chuan. "Transfer File over TCP/UDP." *DevNotes*, Hexo, Next.Muse, 3 Aug. 2016, chuanjin.me/2016/08/03/transfer-file/.
- Schoch, Elmar, et al. "Communication Patterns in VENETs." *IEEE Communications Magazine*, vol. 46, no. 11, 25 Nov. 2008, pp. 119–125., doi:10.1109/mcom.2008.4689254.
- "KuWiFi High Gain 13 DBi Dipole Antenna: Product Description." *Amazon*, www.amazon.com/KuWiFi-Distance-Waterproof-Improving-Reception/dp/B00L8PZ8DA.
- "Send UDP Broadcast Packets." *Svn Python*, Apache Subversion, svn.python.org/projects/python/trunk/Demo/sockets/broadcast.py.
- Linder, Marek, and Simon Wunderlich. "B.A.T.M.A.N. Advanced." *Open-Mesh*, Redmine, www.open-mesh.org/projects/batman-adv/wiki/Wiki.
- Tomar, Nikhil. "File-Transfer-Using-TCP-Socket-in-Python3." *Github*, GitHub, Inc., 5 Jan. 2020, github.com/nikhilroxtormar/File-Transfer-using-TCP-Socket-in-Python3.
- Lindner, Marek, and Simon Wunderlich. "Debian Batman-Adv AutoStartup." *Open-Mesh*, Redmine, www.open-mesh.org/projects/batman-adv/wiki/Debian_batman-adv_AutoStartup.
- usabilityTEST. "Usability Testing & Information Architecture." *UsabilityTEST*, 2011, www.usabilitytest.com/.
- "Network Socket." *Wikipedia*, Wikimedia Foundation, 27 May 2021, en.wikipedia.org/wiki/Network_socket.
- "Usability Evaluation Basics." *Usability.gov*, Department of Health and Human Services, 8 Oct. 2013, www.usability.gov/what-and-why/usability-evaluation.html.
- newsordice. "Re: Rotate to 90 or 270 Degrees." *Raspberry Pi Forums*, Raspberry Pi Foundation, Broadcom, 17 Dec. 2016, 7:24 pm, www.raspberrypi.org/forums/viewtopic.php?t=166959#p1083497.
- Walicki, John, and Brian Innes. "Configuring Mesh Networking for the IoT Edge." *IBM Developer*, IBM, 6 Mar. 2019, developer.ibm.com/technologies/iot/tutorials/create-iot-mesh-network#1-set-up-the-mesh-network.
- ninedraft. "Python Udp Broadcast Client Server Example." *Github Gist*, GitHub, Inc., 25 Nov. 2020, gist.github.com/ninedraft/7c47282f8b53ac015c1e326fffb664b5.
- Whitehorn, Jack. "Sudo Batctl If Command on Gateway Node Results in <wlan0: <error reading="" status="">." <>GitHub</>, GitHub, Inc., 28 Feb. 2021, github.com/binnes/WiFiMeshRaspberryPi/issues/6#issuecomment-787487859.
- "PyQt5 FULL Modern Gui Tutorial #1 - Welcome Screen [for Beginners]." *YouTube*, Uploaded by Code First, 3 May 2021,youtu.be/RxGIB9U64fg.
<div></div></error>
- "Antenna Basics." *SimpleWiFi*, www.simplewifi.com/pages/antenna-basics.
- "WiFi Transmit Power Calculations Made Simples." *DigitalAir Wireless*, www.digitalairwireless.com/articles/blog/wifi-transmit-power-calculations-made-simples.
- "Antenna Gain." *Wikipedia*, Wikimedia Foundation, 26 Dec. 2020, en.wikipedia.org/wiki/Antenna_gain.
- Zeadally, Sherall, et al. "Vehicular Ad Hoc Networks (VANETS): Status, Results, and Challenges." *Telecommunication Systems*, vol. 50, no. 4, 9 Dec. 2010, pp. 217–241., doi:10.1007/s11235-010-9400-5.
- "Antenna Patterns and Their Meaning." *Cisco*, 7 Aug. 2007, www.cisco.com/c/en/us/products/collateral/wireless/aironet-antennas-accessories/prod_white_paper0900aecd806a1a3e.html.

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UWB Faculty

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Thank You!

```
def runClient(hasUpdate):
    print("Running client " + hasUpdate.getIP())
    print("Client Version : ", hasUpdate.getVersion())
    clientAddr = (hasUpdate.getIP(), PORT)
    client = socket.socket()
    #client.settimeout(10)

    client.connect(clientAddr)

    file = open("transfer.txt", "r")
    data = file.read()

    client.send("transfer.txt".encode(FORMAT))
    msg = client.recv(SIZE).decode(FORMAT)
    print("[SERVER]: {}".format(msg))

    client.send(data.encode(FORMAT))
    msg = client.recv(SIZE).decode(FORMAT)
    print("[SERVER]: {}".format(msg))

    file.close()

    client.close()
    return True
#except:
#    print("Timeout in client")
#    return False
```

Any Questions?