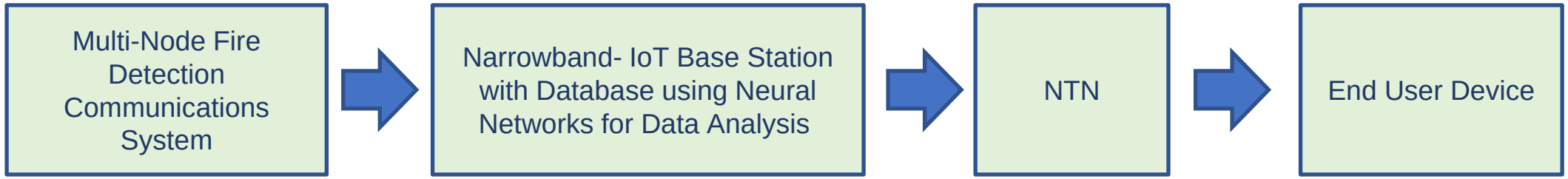
# Multi-Node Fire Detection Communications System and Non-Terrestrial Network

# 1. Multi-Node Fire Detection Communications System and Non-Terrestrial Network

- Our team has developed a concept to use multiple nodes to provide an early warning and continuous monitoring system for wildfires in rural areas paired with an emergency deployment of a non-terrestrial network (NTN) to establish a robust and stable wireless network
- The node system will communicate with a Narrowband IoT Base station, where a database will use neural networks to analyze data
- Multiple networks, in which Long short-term memory neural network (LSTM NN), Convolutional neural network (CNN) and fully connected neural network, are utilized to detect wildfires, predict the course of the current wildfire as well as build better predictions for future fires, as well as data denoising.
- The NTN would deliver the information from the nodes. It will also bring the ability to share massive amounts of data in rural and disaster areas that lack the necessary infrastructure or have had such infrastructure destroyed



# 2. Solution Details

- Multi-node Fire Detection Communications System
  - Nodes placed throughout forests will track local temperature, humidity, wind direction and speed, changes in gas composition, presence of smoke, and monitor infrared and visible light in order to detect and therefore prevent the spread of large-scale fires.
  - Nodes will be fire resistant and utilize solar or wind energy. The energy sources themselves will have methods of preventing explosive battery failures due to fire.
  - These nodes communicate with one another to send information to a central base station using a Narrowband Internet-of-Things (NB IoT) communication protocol
    - NB IoT has a 10km coverage radius and uses a bandwidth compatible with existing LTE base stations, cost is comparable to LTE base stations as well
  - At the base station, a database collecting information from the collected environmental data will attempt to detect, predict and give advanced warnings of wildfires using multiple neural networks
    - Combining LSTM NN and CNN works for time series prediction and image classification. A simple fully connected neural network works as a joint demodulator and decoder to guarantee accuracy of transmitted data. Since it is trained through a wide range of signal to noise ratios, it works in harsh conditions
    - System will prioritize the different pre-detection results found from the data, and can analyze the potential area threatened by the wildfire
- Non-Terrestrial Network (NTN)
  - Emergency deployment of Unmanned Ariel Vehicles (UAV) that act as a mesh network to relay data locally in areas with poor or damaged existing networks in rural disaster areas
  - UAV are being researched for use in future 6G applications, and could handle massive streams of data, including images and video
  - Power is largest challenge
    - Power source could potentially be tether-based, using the battery of the monitor nodes, and could detach and return to a centralized location as fire progresses
    - Drones could potentially take “shifts” in order to recharge power between shifts
  - A High-Altitude Platform System could be used to relay messages from a satellite to the UAVs, but is less cost-effective

# 3. Solution Origins

- The Multi-Node Fire Detection Communications System came from research conducted by team member Sam Hedrick.
- The machine learning tool utilized in the database came from research conducted by team member Wenjie Xu.
- Further study of machine learning was conducted by Samuel Temesgen.
- The use of NB IoT and NTN came from a discussion with Dr. Imtiaz Ahmed of Howard University, and the research was conducted by team member Derek Chandler.
- The team spoke with the mentor Eric Aselin about our project plans during the 4/6/2021 Mentor Session.

# 4. Our Team

- Students:
  - Samuel Hedrick (@GZ_Apex33 on Discord) – Graduate Electrical Engineering Student at Marshall University with Focus in Power Generation/Distribution
  - Wenjie Xu (@Wenjie on Discord) – Graduate Electrical Engineering Student at Marshall University with Focus in Wireless Communication
  - Derek Chandler (@chandler39 on Discord) – Undergraduate Computer Science Student at Marshall University. Registered Nurse for 10 years, currently an Acute Inpatient Dialysis RN
  - Samuel Temesgen (@semawiw21 on Discord) - Undergraduate Computer Science student at West Virginia State University, solution focus on deep learning with attack and defense approach
- Supporting Faculty:
  - Dr. Cong Pu (puc@marshall.edu, Marshall University)
  - Dr. Imtiaz Ahmed (imtiaz.ahmed@howard.edu, Howard University)
  - Dr. Heng Wu (heng.wu@wvstateu.edu, West Virginia State University)
  - Dr. Wook-Sung Yoo (yoow@marshall.edu, Marshall University)

# INSTRUCTIONS

- Each slide in this template covers an element the evaluators will be looking for in this hackathon. For further details, look at the evaluation requirements. The 4 slides you have is the limit, do not add more slides
- Replace the title text in the parenthesis and bullets with details on your submission. Pictures and graphics also will work
- Once you're done with the slide-deck, upload it to the Beat The Blaze website and @each member of your team in submission card. Finally, add in the "Hacks 21-2" tag to make sure we can track it
- If you have any other material you'd like to show off (pieces of code, prototypes of existing technology, videos, etc.), attach them to the submission card on the website
- The deadline for submissions is **April 9th** at **5 PM PDT**