FLASH POINT

A proposed node-based fire mapping and measurement system using remotely operated probes.

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RÆLLIC SYSTEMS

EXECUTIVE SUMMARY

Flash Point is a system for the scientific analysis and modeling of wildfires, and is also intended to improve fire fighting through the return of “live” data. The system relies on the Internet of Things to connect a network of sensors that are air-dropped into fire areas and also carried by fire fighters. The end goal is to offer a measurement platform based on scientifically valid mathematical proofs so that the end user--a fire fighting agency of the government--can study and model fires with big data instead of relying primarily on aerial imagery, guesswork, and estimates. Data collected include temperature, air quality, wind speed and direction, GPS position, and similar measurements. The devices communicate with each other via LTE mesh networking, and with the control center/servers using commercially available satcom modules.

BIG PICTURE DESIGN

The nodes are essentially small boxes packed with sensors and a long-life battery, that are delivered by parachute into fire areas. In the planned system, hundreds of these devices would be dropped at one time around the borders of active fires. When the devices in the path of the fire melt, that is a valid data point and more devices can be dropped in the path of the fire.

SENSORS

Temperature is measured in order to determine the direction in which the fire is moving. The range of a wildfire is from room temperature to approximately 1,500 degrees Fahrenheit. Sensors that measure from room temperature to 500 degrees should be sufficient because the nodes will melt and stop functioning at that point. The loss of multiple nodes simultaneously will show that the fire became overwhelming at those points, permitting the rapid mapping of the danger zone.

Air quality is measured with a sensor that determines parts per million of particulates such as soot and dust. Air quality is relevant because particulate matter provides a preview of fire activity in the area where particle concentrations rise compared to baseline.

Wind Speed and direction are measured to predict the direction a fire will move at a highly granular level. The system is intended to collect data for statistical analysis and measurement, and wind speed/direction are two important data points.

GPS is essential for measurement and modeling so that the measurements are placed at a particular point in space and time and remain valid.

Other sensors may be added if space remains and surplus battery power is available.

COMMUNICATIONS

LTE is the primary communications link and is accomplished with commercially available LTE modems from Sierra Wireless. The Sierra Wireless platform offers an open development environment and a number of other benefits. The nodes would be connected to each other in a mesh network and would share each other’s data and satcom status. For devices with an obstructed view of the satellite network, the LTE network would permit relays of data so that all nodes would be in contact even if a satellite connection were not possible for some nodes due to heavy foliage

or unusually mountainous terrain.

Satcom is the secondary communications link and is accomplished with commercially available Iridium short burst data modems. These devices permit the transmission of short messages of up to a certain number of bytes (currently 1,960 bytes) from each individual node to a server on the internet. This is ample space in which to send the data points contemplated for the system. In the Flash Point embodiment, a message would look something like this:

Device ID|Temp|Air quality (PPM)|Wind speed|Wind direction|GPS data
98234752937|254.5|46|10.0|NW|$GPGGA,114956.441,4054.929,N,07702.495,W,0,00,,,M,,M,,*53

The given message is 87 bytes long, primarily consisting of GPS data in the form of a NMEA sentence. If the devices measure every ten seconds and transmit 100 bytes of data for each measurement, the satcom data rate for a 200 node network would be approximately 2 KB/s or 7.2 MB per hour (172.8 MB/day). This would get expensive quickly due to the premium-level pricing of satellite data plans. With a public safety backer and emergency funding, this is not anticipated to be a large barrier because the cost of the data is vastly lower than the cost of fire fighting efforts. Also, the system could use Bayesian probability determinations to shut off portions of the network that were producing redundant data or were not near the fire anymore (the nodes will receive remote commands via the same satcom system). Finally, with LTE as the primary link, satcom is more of a backup to ensure that communications are always available.

POWER

The power supply is a long-life, compact battery with specifications to be determined. Although there is no inherent size limit on the nodes, the smaller the nodes are, the more nodes can be air-dropped at once and the easier they can be collected at the conclusion of the effort, if desired.

CONTROL CENTER/SERVERS

Due to the requirement of a hard-coded IP address and port in the satcom modules, Flash Point is contemplated to require a command and control server or servers on the internet. All that is required is a server listening on a particular port for messages from the nodes, which go through Iridium gateways rather than directly to the server. Messages are automatically queued for delivery by the Iridium network, so no queuing or pre-processing is required. At the low data rates anticipated for Flash Point, no particular or specialized hardware is required. The server also transmits messages via the Iridium network in order to reach the individual nodes with commands.

OTHER

The cost of each individual unit is unknown and depends on the cost for sensors and communications modules. If they end up costing $600 to $900 each, that is still within reason. There is no specific budget because the damage caused by wildfires is drastically out of proportion to the cost of Flash Point nodes. In any case, the fire fighting agency can collect intact nodes upon fire containment to reduce its costs. An individual deployment of hundreds of nodes, including satcom data, would probably cost in the low hundreds of thousands of dollars. At that point, building the nodes becomes the primary expense. In that connection, we plan to apply for a grant from the National Institute of Standards and Technology fire division.