A Game of Telephone:

Voice Multicast in Low-Power, Low-Bandwidth Mobile Wireless Networks

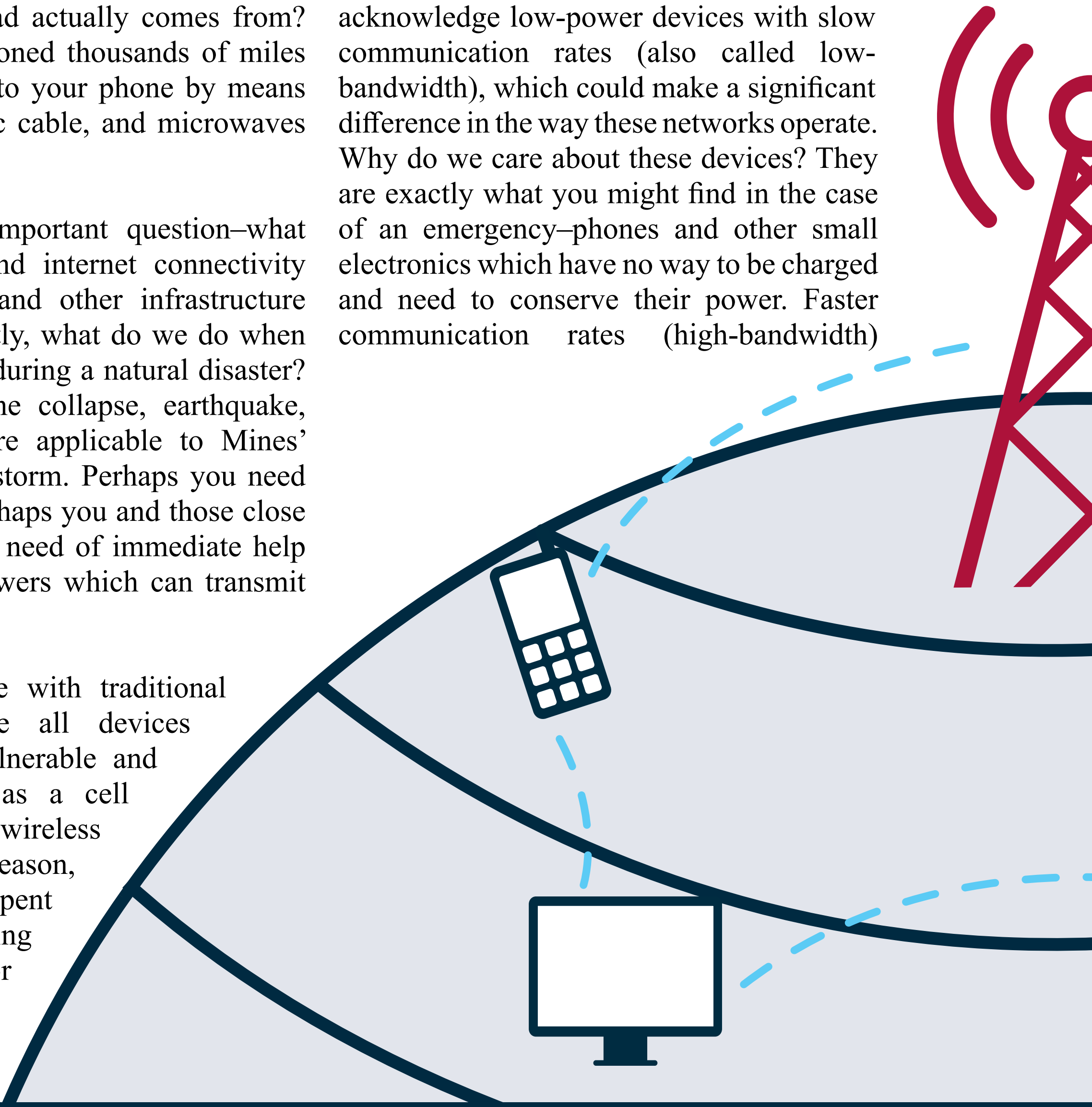
by Ethan Perry

We don't always realize it, but the devices in our pockets carry much more significance than we often give them credit. Yes, I am talking about cell phones and their flashy graphics, impressive processing power, and stunning cameras. But these features are not the only thing that make cell phones special. Have you ever wondered where all of the information you surf, stream, and download actually comes from? Much of this data is stationed thousands of miles away and makes its way to your phone by means of copper wire, fiber optic cable, and microwaves emitted by cell towers.

But that also begs an important question–what happens to our phone and internet connectivity when these cell towers and other infrastructure go down? More importantly, what do we do when the cell towers go offline during a natural disaster? Imagine a hurricane, mine collapse, earthquake, or maybe a disaster more applicable to Mines' students: a massive snowstorm. Perhaps you need emergency support, or perhaps you and those close to you are trapped and in need of immediate help without functional cell towers which can transmit your calls.

This is one drastic issue with traditional mobile networks, where all devices are connected to one vulnerable and stationary source, such as a cell tower, ethernet cable, or wireless router. For this precise reason, our research team has spent much time on understanding opportunistic networks, or networks which do not depend on the stationary sources that could be knocked out in the situation of an emergency.

More specifically, our team has identified a gap in the field of opportunistic networks. Research involving opportunistic networks typically doesn't acknowledge low-power devices with slow communication rates (also called low-bandwidth), which could make a significant difference in the way these networks operate. Why do we care about these devices? They are exactly what you might find in the case of an emergency–phones and other small electronics which have no way to be charged and need to conserve their power. Faster communication rates (high-bandwidth)

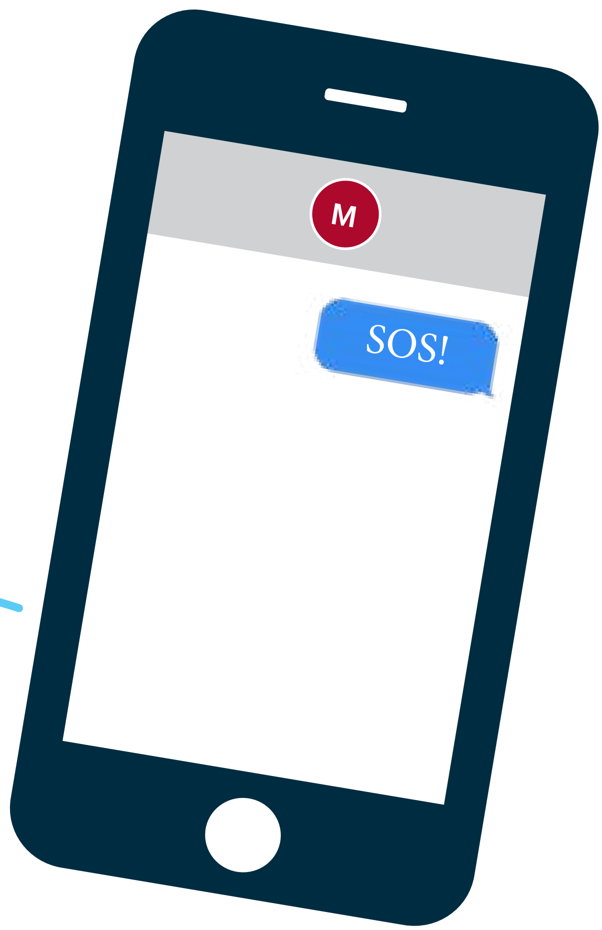


consume more power, so devices needing to conserve their power must accordingly limit their maximum-bandwidth. Just like Netflix or Youtube use up lots of power on your phone, you wouldn't want to be using any high-bandwidth applications with these devices.

In order to approach the issue of getting victims back online, our team devised a hybrid routing protocol, or set of computer instructions, which allow devices to communicate. This protocol can connect a series of small battery-powered devices such as phones in a network which is structured much like a mesh. On a high level, each device using our protocol keeps tabs on the other devices surrounding it. It frequently sends "hello" messages to assure that the neighboring devices know that it is still in the area and connected to the network, but it can also send more meaningful messages destined for other devices in the network. Like a game of telephone, messages travel device to device until they reach their destination.

After some development of our protocol, we had confidence that it would work in theory, but we understood that it needed to be tested in a practical setting as well. Accordingly, our research team investigated hardware options to test our protocol, and after some consensus as to what would best model the devices found in emergency situations, we chose Xbee© Wireless Radios, which can be operated with very little power and on low bandwidth. These radios were used in tandem with Raspberry Pi© Microcontrollers (mini-computers) to enable wireless communication, as these microcontrollers use little energy.

After a semester of research, our team found many successes. We implemented the ability to transmit audio across our wireless, low-power devices, and extended this idea to transmit other kinds of data as well. Due to the nature of our network, transmitting audio and other intensive data was a huge task to surmount, as we couldn't be wasteful with the



limited band-width available. We see a bright future in our protocol and are continuing to optimize its efficiency and scalability as our research moves forward. In addition to optimizing our protocol, our team is also performing trials to assure the reliability of our protocol and hardware. We wouldn't want our network to go offline in the midst of an emergency, so this is an important task.

As a long term goal, our team plans to scale up testing to more devices and make practical use of our discoveries. Our protocol could see future implementation in handheld devices like phones, tablets, and laptops, or even emergency-specific devices such as search-and-rescue robots. Additionally, as we continue to explore the implications of our research, we are investigating the possibility of alternate reality (AR) integration, which may aid in the process of helping people escape various emergency situations.

So the next time you pull out your phone, don't forget about its many amazing capabilities--with some work, they may someday save your life.

Ethan Perry is an undergraduate computer science student and researcher at the Colorado School of Mines. He is a member of the Pervasive Computing Systems (PeCS) Research Group, working under the mentorship of Dr. Qi Han and specializing in wireless sensor networks.