Studying bacteria communication for future nanoscale networks

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Researchers at Georgia Tech are investigating how to harness nanonetworks for diagnostic purposes.

(PhysOrg.com) -- Think the future of communication is 4G? Think again. Researchers at the Georgia Institute of Technology are working on communication solutions for networks so futuristic they don't even exist yet.

The team is investigating how to get devices a million times smaller than the length of an ant to communicate with one another to form nanonetworks. And they are using a different take on "cellular" communication—namely how bacteria communicate with one another—to find a solution.

Georgia Tech Professor of Electrical and Computer Engineering Ian

Akyildiz and his research team—Faramarz Fekri, professor of electrical and computer engineering; Craig Forest, assistant professor of mechanical engineering; Brian Hammer, assistant professor of biology; and Raghupathy Sivakumar, professor of electrical and computer engineering—were recently awarded a $3 million grant from the National Science Foundation for the project.

Over the next four years, the team will study how bacteria communicate with each other on a molecular level to see if the same principles can be applied to how nanodevices will one day communicate to form nanoscale networks.

If the team is successful, the applications for intelligent, communicative nanonetworks could be wide ranging and potentially life changing.

“The nanoscale machines could potentially be injected into the blood, circulating in the body to detect viruses, bacteria and tumors,” said Akyildiz, principal investigator of the study. “All these illnesses—cancer, diabetes, Alzheimer’s, asthma, whatever you can think of—they will be history over the years. And that’s just one application.”

Nanotechnology is the study of manipulating matter on an atomic and molecular scale, where unique phenomena enable novel applications not feasible when working with bulk materials or even single atoms or molecules. Generally, nanotechnology deals with developing materials, devices or structures possessing at least one dimension sized from 1 to 100 nanometers. A nanometer is one billionth of a meter.

Most of the nanoscale devices that currently exist are primitive, Akyildiz said, but with communication the devices could collaborate and have a collective intelligence.

That’s the question researchers are tackling—how would such nanonetworks communicate? Because of their size, classical communication solutions will not work. The team is turning its attention to nature for inspiration.

“We realized that nature already has all these nanomachines. Human cells are perfect examples of nanomachines and the same is true of bacteria,” Akyildiz said. “And so, the best bet for us is to look at bacteria behavior and learn how bacteria are communicating and use those natural solutions to develop solutions for future communication problems.”

Bacteria use chemical signals to communicate with one another through a process called quorum sensing, which allows a population of single-celled microbes to work like a multicellular organism. Originally discovered several decades ago in unusual bioluminescent marine bacteria, it is now believed that all bacteria “talk” to one another with chemical signals.

Microbiologists are beginning to learn the “languages” bacteria speak and what activities are controlled by this cellular communication. Many disease-causing pathogenic bacteria use quorum sensing to turn on their toxins and other factors to use against a host. Potential therapeutics are currently being developed by some researchers that are designed to disrupt quorum sensing by infectious bacteria.

“A single pathogenic bacterium in your body is unlikely to kill you,” said Hammer, a microbial geneticist. “But since they communicate, the entire group orchestrates this coordinated behavior using chemical communication and the end result is that they work as a group to kill their host. So can we use that same information in a positive way by harnessing and understanding the limits of the communication?”

Georgia Tech researchers Hammer and Forest will focus on experimentation to better understand the elements of bacterial communication, and then work with the electrical and computer engineering experts on the team to translate their findings into a possible communication model for nanonetworks.

"This is really revolutionary research," said Fekri, professor of electrical and computer engineering. "No one has looked at these issues before. We are dealing with the big challenges. It's going to require a lot of talent and hard work to address them."

The project is expected to pave the way for research in nanoscale communication. The range of applications of nanonetworks is incredibly wide, from intra-body networks for health monitoring, cancer detection or drug delivery to chemical and biological attack prevention systems.

At the end of four years, the team hopes to demonstrate the basic and fundamental underlying theories for communication of nanodevices. They also hope to develop a simulation tool for the public to use to see how machines can mimic bacteria communication, which will hopefully attract other researchers to get involved in investigating this area further.

"Existing paradigms for network protocols and algorithms do not apply anymore. This is beyond the frontiers of networking research," said Sivakumar. "It's really something that could change things and no one has done this before."

A great strength of the Georgia Tech research team is its interdisciplinary nature.

"We're excited to combine science and engineering as well as our respective tool sets, whether genetic engineering, genetic sensing or network communications theory to tackle this system-level problem—this grand challenge in nanotechnology," said Forest, an expert in biomedical engineering.

Provided by Georgia Institute of Technology