# Can Artemis Deliver 5G Service On Your 4G Phone?

## Start-up Artemis Networks aims to boost wireless data capacity with its pCell technology. But experts are skeptical

By Ariel Bleicher
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"This is going to change everything," said Steve Perlman in a New York City hotel room in February, two days before revealing that his new start-up, Artemis Networks (http://www.artemis.com/), plans to commercialize its pCell wireless technology. "We can deliver in 2014 all the goals of 5G on 4G phones," he said, including more network capacity and faster, more reliable connections.


Photo: Artemis Neworks

**The Anti-Cell:** Artemis Networks' pWave radio access points transmit data to multiple wireless devices at once using the same slice of spectrum.

Many wireless experts aren't convinced. "This is a promising technology, but some of the claims seem too good to be true," says Lingjia Liu of the University of Kansas, in Lawrence.

Based in San Francisco, Artemis is pitching pCell as a radical change to the way wireless networks operate. The company aims to replace today's congested cellular systems with an entirely new architecture that combines signals from many distributed transmitters to create a tiny pocket of reception, or "personal cell," around every wireless device. With enough transmitters, each centimeter-wide pCell could use the full bandwidth of spectrum available to the network, making its capacity "effectively unlimited," says serial entrepreneur Perlman (http://spectrum.ieee.org/computing/networks/steve-perlman-on-how-onlive-will-change-gaming), Artemis's CEO.

"If they've done what they say they've done, it's an absolutely remarkable achievement," says Giuseppe Caire (http://ee.usc.edu/faculty_staff/faculty_directory/caire.htm), a multiple-antenna systems expert at the University of Southern California, in Los Angeles.

That's a big "if." Artemis has made public few details behind the technology, and many experts doubt that pCell can live up to the company's claims. "Everyone is thinking, 'Is this just smoke and mirrors? Is it a repositioning of existing tech? Or is it something radically new?' " says Peter Jarich, a vice president at market intelligence firm Current Analysis, in Washington, D.C.

Perlman's nine-person team began filing patents on the technology behind pCell a decade ago, calling it DIDO (http://www.rearden.com/DIDO/DIDO_White_Paper_110727.pdf), for distributed input, distributed output (https://www.google.com/patents/US7599420?pg=PA32&dq=7,599,420&hl=en&sa=X&ei=IJPDUY51hdjSAZ-CgfgN&ved=0CDYQ6AEwAA). Most wireless researchers refer to this kind of approach as distributed (or coordinated) multiuser multiple input, multiple output (MU-MIMO (http://ieeexplore.ieee.org/search/searchresult.jsp?action=search&sortType=&rowsPerPage=&searchField=Search_All&matchBoolean=true&queryText=(MU-MIMO))).

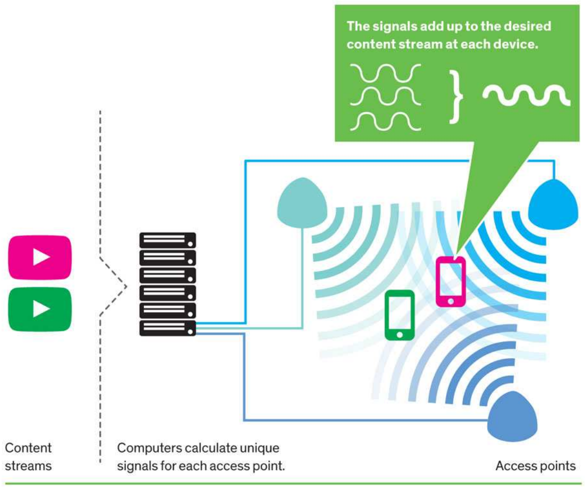


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Illustration: Erik Vrielink

**Exploiting Interference:** Artemis Networks' pCell technology uses simultaneous transmissions from many distributed transmitters to deliver full data capacity to each wireless device.

Regardless of its name, Perlman believes his technology is key to solving the wireless industry's biggest problem: the exponential growth in data traffic (http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html). "For operators, it's the best of times and the worst of times," he says." People want more data, but the operators "don't have the physical capability to deliver it (http://news.cnet.com/8301-1035_3-57612021-94/verizon-admits-network-faces-traffic-pressure-in-big-cities/)."

It isn't for a lack of ideas. Engineers are pursuing plenty of them, including small cells (http://spectrum.ieee.org/telecom/wireless/a-surge-in-small-cell-sites), millimeter-wave spectrum (http://spectrum.ieee.org/telecom/wireless/millimeter-waves-may-be-the-future-of-5g-phones), beam forming, and advanced cell coordination (http://spectrum.ieee.org/telecom/standards/lte-advanced-is-the-real-4g). The LTE-Advanced standard, for example, already supports simultaneous connections to multiple base stations.

But Perlman thinks that many of these fixes are just clever kludges for an outdated system. The real bottleneck, he argues, is the fundamental design of the cellular network. "There is no solution if you stick with cells," he says.

What's wrong with cells? In a word, interference. Base stations and wireless devices must carefully coordinate their transmission power and spectrum use so that they don't jam one another's signals. This ability to divide spectrum resources among many users has been at the heart of cellular systems since they emerged in the 1980s. It's also the reason why data rates tend to plummet when many users try to use the same cells or roam between them. Although a 20-megahertz-wide 4G LTE channel can theoretically support about 75 megabits per second, the average throughput to a single user is typically only a fraction of that.

Artemis's pCell technology turns traditional cellular architecture on its head by exploiting interference rather than trying to avoid it. To deploy such a system, an operator would first need a data center connected by fiber or wireless line-of-sight links to radio transmitters distributed near its customers. Roughly the size of hatboxes, these access points would be unlike ordinary cellular base stations. "They're dumb devices," Perlman says, adding that they would serve merely as waypoints for relaying and coordinating transmissions.

To deliver data to a wireless device such as a smartphone, the data center would first fetch it from the content provider. But rather than transmit the stream through a single transmitter, as in a traditional cellular system, the data servers would send signals simultaneously through all of the access points in your phone's range—as many as dozens at a time, Perlman says.

Of course, if every transmitter broadcast the same signal, it would drown out other phones trying to connect to the network. So instead, the data center would use the positions of the access points and the channel characteristics of the system, such as reflection and fading, to calculate a unique waveform for each access point. Although indecipherable when they left the transmitters, these waveforms would add up differently at each phone to form a signal that delivers the desired data.

As each phone moved about, and as other devices connected to or dropped off the network, the data center would continuously recalculate new waveforms so that every user maintained a good connection. To upload data, the process would happen in reverse: Each phone would transmit simultaneously to a cluster of access points, and the data center would resolve the individual signals mathematically, using the differences in channel characteristics. "There's no handoffs, and no one has to take turns," Perlman says. "You could literally light up a whole city using all the same spectrum."

In theory, every pCell antenna adds another full channel of bandwidth to the network. For example, if your network uses a 20-Mhz-wide channel capable of delivering 70 Mb/s, deploying 10 antennas would increase the total capacity to 700 Mb/s. If there are more users than antennas, they would share the 10 available channels in time or frequency.

Perlman has claimed that pCell technology could eventually increase the capacity of today's cellular networks as much as a thousandfold. But experts say that any performance gains will be limited by the processing capability at the data center and the speed and reliability of links to the access points. "You should be able to collect channel information, compute the signals, and send them back to the transmitters in less then 10 milliseconds," USC's Caire says. "According to our simulations, we see gains of about a factor of 10 for realistic scenarios. Much more than that, I'm skeptical."

At Columbia University in New York City, Perlman demonstrated pCell technology communicating with 4G LTE (http://spectrum.ieee.org/tag/LTE/) phones and other devices. Compatibility with LTE would allow users to roam seamlessly between the two networks without having to buy new handsets. Artemis's engineers achieved this feat by simulating LTE base stations in software, using these virtual radios to inform the waveform calculations. However, MU-MIMO experts argue that such compatibility will be much more difficult to maintain in real-world environments.

Artemis is manufacturing pCell access points with small-cell provider PureWave Networks and is planning for large-scale trials in San Francisco. The company expects commercial rollouts by the end of 2014.

Wireless experts say that Artemis has yet to prove it can overcome several difficult obstacles, including the large-scale coordination of transmissions from many access points and the integration of pCell clusters into existing cellular networks. "These are rigorous engineering challenges," says Zhouyue "Jerry" Pi, a senior director of Samsung Research America in Dallas. "It's not easy to make this kind of distributed MIMO work and create benefits."

Still, some experts concede that technologies like pCell would make sense in congested hot spots such as airports, sports stadiums, and city centers—places where operators are already investing in dense clusters of small cells and where users don't move around much. "But is it really going to revolutionize the data capacity of the whole world?" Pi asks. "I doubt that."

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