

**News & Analysis**

## Do Linear's Dust Networks Matter in IoT?

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### 6LoWPAN to include Time Slotted Channel Hopping

MADISON, Wis. — There is no one-size-fits-all Internet of Things (IoT) solution. The IoT deploys a variety of radios and network topologies, depending on use-case scenarios and requirements. Both ubiquitous Internet Protocols and wireless sensor networks have given rise to the IoT, but in connectivity, two constants prevail: reliability and low power.

Lately, a number of so-called "connected consumer products" -- such as Google's Nest thermostats, wearable devices, talking refrigerators and smart homes -- have sucked all the oxygen from today's IoT debate. But, before that, there was Dust Networks. More accurately, a concept called SmartDust arrayed numerous tiny sensors to detect, trace and report back the state -- light, temperature, vibration, chemicals and other features -- of the physical world.

Indeed, way before the phrase "IoT" was coined, Kris Pister, a professor of electrical engineering and computer sciences at the University of Calif., Berkeley, started in late 1990s the SmartDust project with DARPA funding. He co-founded Dust Networks in 2004. Dust Networks, then, conceived a clear vision for a wireless sensor network, and outlined how it should behave.

Over the last decade, Dust Networks has been busy adapting its wireless mesh network technologies to the industrial market -- typically by replacing wired networks already deeply embedded in factory floors and industrial process facilities.

### Conspicuously absent?

Since late 2011 when Linear Technology acquired Dust Networks, Dust hasn't changed its industrial market focus.

Dust's sensor networks are installed in Chevron's oil refinery in Calif. The GlaxoSmithKline plant in Cork, Ireland also uses wireless mesh networks to monitor the pharmaceutical company's new water storage tanks. Dust's robust wireless networks play a critical role predicting precious water supplies, gathering real-time water content data from the snowpack in the Sierra Nevada Mountains of eastern California.

More than 30,000 networks -- designed by Dust and sold by its customers -- are installed in 120 countries, according to Linear.

Today, Linear has two product lines: SmartMesh WirelessHart and SmartMesh IP. The former complies with the WirelessHART (IEC 62591) standard designed for industrial applications. The latter complies with the 6LoWPAN standard, providing native IPv6 addressability to every node.

While Dust Networks plays in two worlds -- non-IP and IP markets, the work Dust has done thus far seems conspicuously absent from today's overhyped IoT headlines. Was Dust's vision (and technology) simply ahead of its time? More to the point, how relevant is Dust in today's IoT world?



Joy Weiss, CEO of Dust Networks at Linear Technology.

We recently caught up with Joy Weiss, president and CEO of Dust Networks at Linear. In a wide-ranging interview, Weiss, who is celebrating her 10<sup>th</sup> anniversary at Dust this year, laid out what Dust was originally set up to do and what it has accomplished: creating a genuinely reliable, low-power wireless sensor network in the harshest conditions.

### **Time Slotted Channel Hopping**

Most significantly, Weiss discussed how some basic Dust technologies developed for its Time Synchronized Mesh Protocol -- described by the company as the underpinning of the WirelessHART standard for industrial applications -- are about to penetrate IP-based personal area networks.

This work is currently taking place at the IETF 6TSCH (pronounced "sixtus") working group, said Weiss.

TSCH stands for Time Slotted Channel Hopping. Designed to work by dividing time into "slots," it provides a mechanism to map timeslots to channels with a pre-assigned hopping sequence. The Time Synchronized Mesh Protocol developed by Dust includes TSCH media access layer.

Founded in 2013, the IETF 6TSCH working group is co-chaired by representatives from Cisco and Dust Networks. The group hopes to define an open standard for building and maintaining a TSCH schedule in a 6LoWPAN network. While it's likely to be 12 to 18 months before the work is complete, Weiss said, "Our approach is to get some of our technologies incorporated into the standard." Noting that a lot of companies are contributing to the work, she stated, "Once the standard is complete, we believe we can implement it and execute on it better than our competitors." Showing a flash of competitiveness, she added, "We still have a few more tricks up our sleeves."

Following is an excerpt of EE Times' interview with Weiss.

## **No wires for communication and power**

**EE Times:** So, what was the original vision of wireless sensor network?

**Weiss:** I wasn't a co-founder of Dust Networks, but I joined the company early on. Considering the expected advancements of sensors, microcontrollers, and radio, our vision then was to create this tiniest thing -- operated by battery or by using energy harvesting -- that can sense, detect, and take the information in the physical world and use it in applications.

**EE Times:** That's how the idea for a wireless sensor network was born?

**Weiss:** Bear in mind that there was nothing new about the sensor network. Sensors have been around. A game-changer was the idea to do it at an ultra-low power and without wires. I mean, no wires for both communication and power.

**EE Times:** What conditions did your wireless sensor network have to meet in order to cater to the real-world applications?

**Weiss:** First, we needed to develop a large-enough industrial wireless network -- that must be very reliable -- to detect what's going on with their industrial processes.

Second, we had to use no wires at all -- no wires even for power. Unlike other communication technologies such as Bluetooth and cellular phones whose power only last so many hours and they expect to be plugged in for recharge, we had to build a wireless network so that people can walk away from, for example, pipelines in Siberia, not thinking about replacing batteries for many years.

Third, this had to be a wireless sensor network simple to deploy. We're working with people walking around with tools in their tool belts. They weren't going to replace what they've used for decades (communication protocols like HART standard in industrial applications) with IP. The wireless sensor network had to be so simple that it required no training.

**EE Times:** How do you compare your technology with others?

**Weiss:** There is a range of technologies that play in a wireless sensor network. It includes everything from a garage door opener to Bluetooth, which is great in a personal network, and Near Field Communications (NFC), which you literally need to be next to a thing that you need to operate. They are all good technologies but they're not very reliable for a wireless sensor network that must covers nodes in a hundreds of acres of physical environment.

**EE Times:** What was the impact of Linear's acquisition on Dust Networks?

**Weiss:** In early days, we only had three people trying to sell our wireless sensor network. With Linear's acquisition, we now have a couple of hundred sales people. We're also exposed to a vast number of applications and companies Linear works with in the industrial, automotive and communications market. Linear, by design, is not into the consumer market, and that's well aligned with our focus.

**EE Times:** Looking back on early 2000s when nobody was talking about IoT, what differences do you see now?

**Weiss:** Ten years ago, the wireless sensor network was my soapbox. That was the thing all my buddies and I thought the world needed. The wireless sensor network has then become a subset of today's bigger IoT world, where a cast of characters -- like Cisco, General Electric, and Intel -- are trying to sort out a range of issues including the network's efficiencies,

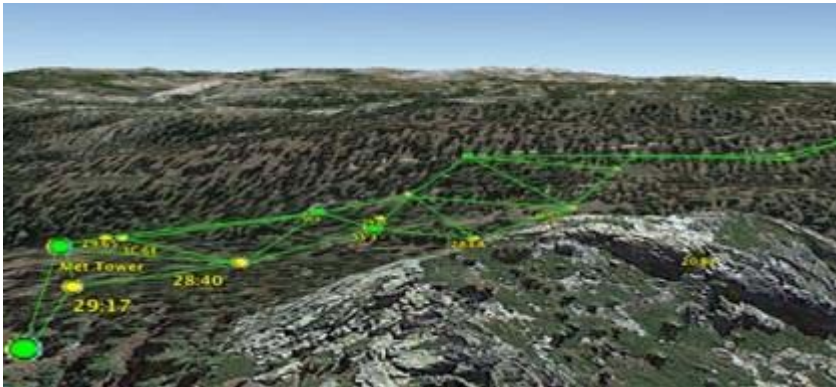
operating cost, and big data.

The wireless technology [for both data and power] and high reliability are still very important and relevant [in IoT].

**EE Times:** Dust Networks today have two product lines: SmartMesh WirelessHart and SmartMesh IP. Do you encounter customers who tell you that they want to transition from WirelessHART sensors to IP-based wireless sensor networks?

**Weiss:** For legacy systems in industrial applications, it's important to preserve the Hart standard from the asset management perspectives. When Hart sensors in the network interface with an infrastructure, the system needs to know what to do with data.

In a case like SierraNet program, where the system measures temperature, humidity, snow depth, soil moisture, etc., in remote environments, SmartMesh IP-enabled sensors do a great job for researchers working on the web.



Wireless sensor network installed at Duncan Peak in the Sierra Nevada mountains. Sierra\*net (<http://systems.berkeley.edu/wsn/>), an initiative between UC Berkeley and UC Merced, is aimed at studying mountain hydrology and improving the forecasting and control of water supplies by using SmartMesh-enabled sensors.

But if it were a wireless sensor network in oil refineries, no. Our customers value the legacy system that runs on the Hart standard.

**EE Times:** Of all the technologies Dust Networks pioneered for wireless sensor networks, which specific building blocks are you contributing to the IP-based networks?

### **Contribution to 6LoWPAN network**

**Weiss:** We are contributing to the 6LoWPAN networks our time-synchronized channel hopping technology originally developed for the industrial process market.

At the IETF 6TSCH working group, which we co-chair with Cisco, we are working to fuse Time Slotted Channel Hopping (TSCH) technology with IETF 6LoWPAN standards.

**EE Times:** Tell me what exactly this IETF 6TSCH working group is set up to accomplish.

**Weiss:** The working group has codified to bake time-slotted channel hopping into the protocol for the IP-based network. We are talking about the kind of network that needs to be very reliable and run at very low power.

In essence, all the nodes have a pre-determined scheduled time to talk, so that the radio duty cycle is kept very low. This helps yield years of battery lifetime. The nodes are also set

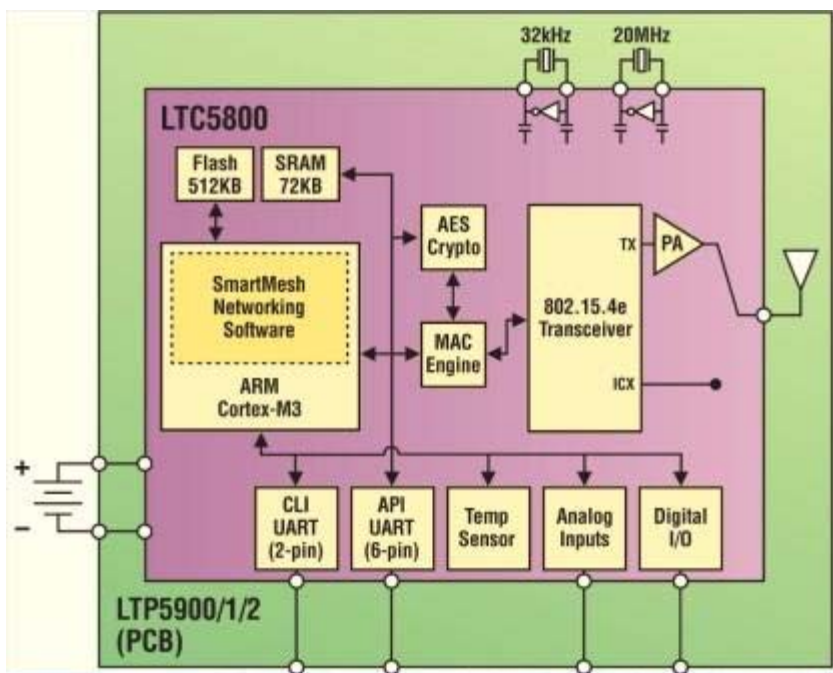
up to randomly choose a specific channel to talk, thus minimizing interference. Time-synchronized schedules and channel hopping dramatically reduce the chances for the network to be brought down to a grinding halt.

**EE Times:** How is this approach different from a specification like ZigBee, which is set up to transmit data over long distances, creating a mesh network? Isn't ZigBee also for a low data rate, long battery life, and secure networking?

**Weiss:** The key difference is that in ZigBee, certain nodes, the ones that need to relay data, must be plugged into the wall, while other ZigBee nodes are kept asleep most of the time. [Note: So-called ZigBee end device may contain just enough functionality to talk to the parent node, but it cannot relay data from other devices.]

ZigBee is lucky to have found applications such as a smart grid and a smart house, where they can use certain nodes plugged into the wall.

ZigBee, however, didn't serve our goal of catering to the market where wire-free solutions -- no wire either for power or data -- are required.



The LTC5800, an SoC designed to work with WirelessHART and IP wireless sensor networks, integrates all radio circuitry components, including an onboard power amplifier and an ARM Cortex M3 32-bit microprocessor, requiring only power, ground, and an antenna for robust wireless connectivity.