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What is smart dust and how its spread is changing the world around us

A new generation of smartdust devices will enable real-time wireless data collection, which will lead to a change in understanding of engineering systems, healthcare, and interaction with the environment. How such devices appeared, and what is hindering their development so far - in the material of the journalist Leonid Chernyak, prepared specifically for TAdviser.

In the early 90s of the 20th century, the joint efforts of the American defense agency DARPA and the Rand Corporation created the first stand-alone information devices mote (a speck of dust, a particle) the size of a matchbox. They consisted of sensors that take certain indicators of the environment, a computer, a transmitter and a power device (from the mains, batteries or solar cells).

Dust distribution & Data Reception - dust distribution and data collection; Handheld Data Receiver - handheld data receiver; Item of Interest - target; Smart Dust - smart dust
These mote were intended exclusively for military and intelligence purposes, but already 5-7 years later, as a result of the “sensory revolution” that had begun at that time, similar civilian devices appeared. At the same time, the modern name of smartdust technology was born (smart dust), and its individual component is still called mote. The mote that got out of control of the special services were conceived for various purposes, for example, to control complex engineering structures, primarily bridges, degrading during operation under the influence of external factors (precipitation, wind, temperature, vibration, salt causing corrosion). Possibly due to the lack of such control, the Genoa bridge collapsed in August 2018. Glaciers, forests, volcanoes, the ocean and everything else need constant monitoring.

Experimental copies of the mote of the early 2000s looked something like the device shown in the figure below. It was made at the University of Berkeley, the academic center of the new movement. Professor Kirs Pister, known for his work in the field of microelectromechanical devices and the founder of Dust Networks, became the leader of the direction. The enthusiasm of the creators and the traditional left-wing radical mood for Berkeley gave rise to the slogan: "Sensors of the whole world - unite!" Analysts became interested in innovation and Gartner, without hesitation, placed smartdust at the starting position in their hype curve in 2003 with the prospect of implementation in 10 years

Experimental instances of mote
And there was something to think about. The idea of smart dust is as obvious as it is so difficult to implement. It is no coincidence that the next time smartdust technology appeared on the Gartner curve was only in 2013. But since 2015, every year it has been placed at the very starting point with more than a decade of prospects for achieving technology maturity. The main reason for the repeated rollback to the previous position was the lack of preparedness of network and communication technologies.

Until recently, very specific "dusty nets" remained completely original. They were created in isolation from other types of networks, but by no means out of a desire for originality. It was a forced measure, since there was nothing on the market that met their requirements.
The starting point for the mote network approach is the fact that, by definition, the transmitter power of any given device is negligible. As a result, the Multi-hop wireless technology was chosen to create the network, which is based on the chain principle, namely, each of the nodes serves as a repeater for the others. The full-mesh topology guarantees reliability and fault tolerance. Inside the network, data transfer is carried out using its own (proprietary) TSMP (Time Synchronized Mesh Protocol) protocol developed by Dust Networks, and then the network is connected to the Internet through a gateway. For a company with fifty employees, this is an achievement.

Sensor node - sensor node; Battery - battery; Connection to sensors - connection with sensors; Radio - radio; Processor - processor; Gateway - gateway; Internet - Internet; Query for information - a request for information; Processed Data - processed data; Database - database; Observer - an observer.
In a decade and a half, mote sizes have shrunk to a few cubic millimeters and cost to $10 or less. But this is still not enough for the mass distribution of smartdust, since the issue of communication remains. The situation may fundamentally change with the advent of fifth-generation mobile communication technologies Bluetooth 5.0 and 5G. In this case, there is no need for a hotel network, and each mote can be connected directly to the Internet.

Modern mote, 2018
The new generation of smartdust will enable real-time wireless data collection, which will change the way we think about engineering systems, healthcare, interaction with the environment. Billions, if not trillions, of devices capable of transmitting data and

Feedback interactions will be able to transmit on request a variety of available physical and chemical indicators of the environment. Devices can be powered by batteries, extract energy from the environment (vibrations, light). They can be located in any of the most inaccessible places. There is reason to believe that smartdust, as an all-encompassing phenomenon, will eventually absorb the Internet of Things (IoT), a symbol of the Fourth Industrial Revolution.

By analogy with the WWW (World Wide Web), we can say that the world is turning into a single Real World Web using smartdust. It is still difficult to imagine a life where awareness is limitless, where we will learn everything from a trivial message about the need to replace a toothbrush to obtaining reliable information about all other engineering and natural objects.

However, the world of complete information openness is threatened by the Big Brother effect described by James Orwell in the novel 1984. This danger is usually remembered when talking about social networks, Big Data, and in many other cases, people come into contact with various forms of tracking them. Therefore, one of the main tasks of future smartdust technologies will be the preservation of private space (privacy).

After 2013, a wave of start-ups, still modest in scale, has risen, preparing the field for their participation in smartdust. Most of them did not rise to the system level of Dust Networks, going the other way, and setting themselves limited goals to justify the money invested in them. For example, Koto Air (Slovenia), QwikSense (Holland), Wynd Technologies and Birdi (both US) offer systems for monitoring the atmosphere in homes, schools and hospitals. American CivicSmart - parking management.

Obviously, these companies are preparing for the future, solving particular problems, they are implicitly developing sensors designed to be connected via fifth generation communication channels.

But there are companies with more serious goals, among them Cubeworks (USA), which produces subminiature sensors and the Cubisens platform for collecting information and storing data.

CubeWorks Sensor
The CubeWorks sensor consists of four components on a single chip:

ARM Cortex M0 processor and 4KB memory
Charger
radio transmitter
Sensor
Power consumption in ready mode is 8 nW. It increases during transmission, but a charger that delivers 10 nW per square millimeter in room lighting conditions, combined with a battery, provides an unlimited period of operation.

Large vendors are also paying attention to smartdust, primarily IBM. The corporation has traditionally developed the topic of pervasive computing, logically close to smartdust. However, now it is probably turning towards smartdust.

The blue giant does not do everything quickly. Popular wisdom says that IBM begins to develop a market segment only if it is more than a billion. Apparently while the corporation is waiting, but obviously at the start.

The key point for smartdust is a cheap and efficient processor. It can be made under the condition of mass production, so in preparation for the future at the Think 2018 conference, the corporation announced the world's smallest computer. Its size is 1 sq. mm. Despite its small size, it is comparable in power to Intel 8086. And in this square millimeter, in addition to the processor and memory, there is a photocell that powers the device and a built-in photodiode/photodetector pair that provides optical communication with the outside world. The cost of the device in mass production is less than 10 cents.

The successors of this computer, but communicating via radio, can become the basis for future smartdust devices. Until then, a stand-alone computer with optical communication can act as a label that certifies the authenticity of the product. It is impossible to fake it, and it costs nothing to read data using a smartphone. Mass production of these kinds of tags will be the go-to for smartdust for the foreseeable future.

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