

Safeguarding the Vaccine Cold Chain to Deliver Safe Medicine for Kids

Nexleaf Analytics is using Intel® technology and IOT/Analytics to help solve a critical healthcare challenge.



ColdTrace 5 is a wireless Remote Temperature Monitoring (RTM) solution using innovative edge-to-cloud analytics to collect data and report on vaccine refrigerators in rural clinics and health facilities.

Challenge

One of the hallmark achievements of modern technology is the ability to develop safe and effective vaccines to combat serious diseases and relieve human suffering. The process of research, experimentation, production, and testing that results in a successful vaccine is long and expensive. But even after the vaccine is approved and ready for shipment, significant challenges face the healthcare providers tasked with distributing the vaccine and inoculating patients. One of the most difficult of these challenges is faced by doctors and nurses serving populations in remote areas of the world: maintaining a “cold chain.”

Most routine vaccines are temperature-sensitive, typically requiring storage between 2°C and 8°C. If conditions in a refrigeration unit fluctuate beyond allowable levels, even for a short time, the efficacy of the vaccine can diminish. Temperatures that vary widely, or for a significant period of time, can result in a completely ineffective drug.

After a vaccine has lost efficacy due to temperature rise, re-cooling will not restore it to its original potency. Similarly, many vaccines are freeze-sensitive and can be damaged if temperatures fall too low. Worse still, once a vaccine has been damaged by temperature fluctuation, its impotence may not be noticeable to healthcare workers, who may end up inoculating patients with a drug that fails to deliver the targeted level of protection from disease—if, indeed, any protection at all. The result is not only increased human suffering but also a waste of precious healthcare resources.

Maintaining a cold chain is particularly challenging in areas where electrical power delivery is limited or inconsistent, or where the availability of high-quality refrigeration equipment is inadequate. According to a [joint statement](#) by the World Health Organization and UNICEF dealing with low- and middle-income countries, 56% of these regions' refrigeration equipment required to maintain a constant cold chain is either poorly functioning or non-functional. Similarly, a [WHO study](#) in India found that a disturbing 73% of freeze-sensitive vaccines looked at had been subject to freezing somewhere in the supply and distribution chain.

The typical point of failure to maintain a proper temperature range occurs at a specific stage of the distribution change: static storage. That means monitoring and managing temperatures at this point is critical—and that's where Nexleaf ColdTrace provides a solution.

Nexleaf's ColdTrace 5 has successfully scaled to protect the vaccine supply chain for over 12 million babies—or 1 in 10 of the infants born on earth each year.



Nexleaf Analytics

“Our mission is to preserve human life and protect our planet by designing sensor technologies, generating data analytics, and advocating for data-driven solutions to global challenges.”

Nexleaf Analytics is a non-profit company created to bring technological solutions to real world problems in low- and middle-income countries. To achieve their mission of preserving human life and protecting the planet, they concentrate on areas that have a direct impact on the well-being of billions of people every day. In addition to protecting the vaccine cold chain, Nexleaf solutions also address clean household energy use. One of their core initiatives aims to reduce the harmful effects of household cooking stoves and improve the lives of over three billion people who use these stoves to cook their daily meals.

Nexleaf’s work is supported by the Bill & Melinda Gates Foundation, Google.org, Gavi, Ministries of Health, and many other partners around the world.

Nexleaf and Intel

ColdTrace was created through a joint project carried out by Nexleaf and Intel Corporation.

As the world’s foremost microprocessor provider and an industry leader with a history of innovation across a broad range of technologies, Intel is a truly international corporation that ranks as one of the forty largest companies in the world¹. Nexleaf, conversely, is a small non-profit. Nevertheless, these two very different organizations share several principles and values that inform their initiatives and efforts.

Intel’s stated reason for existence is shown on the [corporate website](#):

Intel’s mission is: To create world-changing technology that enriches the lives of every person on earth.

In addition, Intel’s vision for the future centers on data:

The Intel vision: We are on a journey to be the trusted performance leader that unleashes the potential of data.

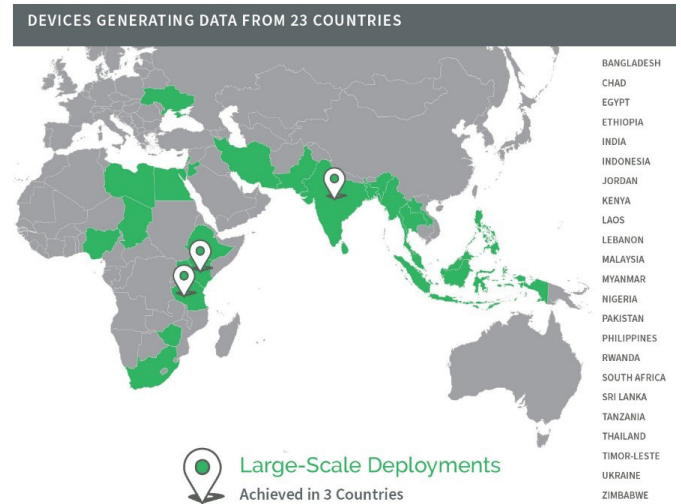
A central theme joining Nexleaf and Intel is clear: The desire to leverage the power of data to provide real benefits for

human beings. This common ground was not lost on Nexleaf CEO and Founder Nithya Ramanathan, whose career started in Silicon Valley, where she designed chips for both Intel and Hewlett-Packard.



Nithya Ramanathan,
Nexleaf Founder and
CEO

In 2015, Nithya and Narayan Sundararajan, Senior Principal Engineer and Director of Applied Machine Learning at Intel, met to discuss the potential for the two companies working together. They quickly realized they shared a deep



Areas served by Nexleaf products

interest in using technology for the betterment of the world in general, particularly in lower-income areas. Further discussions and planning ensued and, after careful study, Intel committed to creating a reference design for a temperature-monitoring product that would become ColdTrace 5.

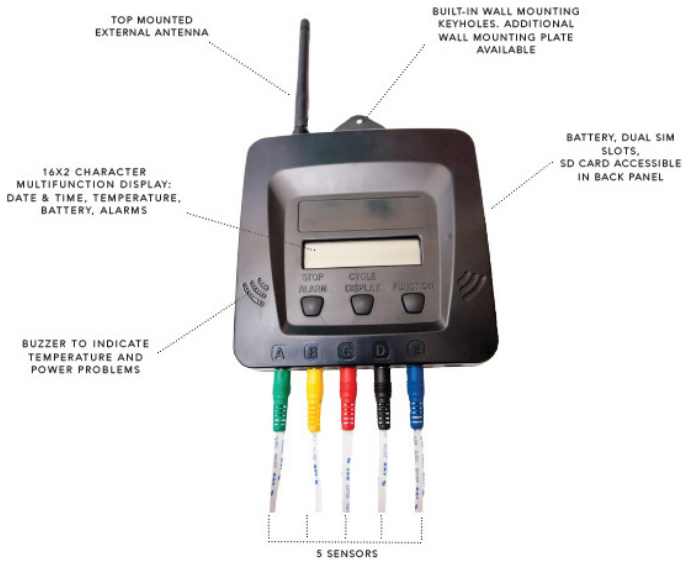
The new product had to meet several objectives:

- It needed to reliably collect and send temperate data using the existing communications infrastructure to the cloud.
- It needed to be reliable and scalable enough for wide-spread use in a range of challenging environments.
- It needed to have a low Bill of Materials cost to make wide adoption and distribution practical.

Embracing this challenge, Intel brought together engineers from a range of company business units in India, the US, and the UK. Working as a team with Nexleaf, they first developed a design and schematics. Once those were approved, they proceeded to assemble hardware, firmware, and software to create a working version. They also put together a Configuration Management plan to guide product finalization and manufacturing. Nearly twenty Intel engineers were involved in the efforts, which came to completion in just nine months. The entire effort was subsidized by Intel on a reduced cost basis.

ColdTrace 5

The result of the Nexleaf-Intel collaboration was **ColdTrace 5**, a remote temperature monitoring unit designed for use with refrigerators that store vaccines (or other temperature-sensitive medical supplies). ColdTrace 5 continuously monitors the temperature in refrigerators, collecting data 24/7/365. Functioning as an edge device on the Internet of Things, it communicates via cellular networks, providing customizable analytics, reports, and tools for the healthcare workers and administrative authorities who are responsible for maintaining vaccine distribution.



Features

The ColdTrace temperature sensor probes are placed within the vaccine refrigerator, and the ColdTrace device is positioned nearby, often mounted to a wall. The device measures the temperature using the sensor probes and processes the readings. When ColdTrace 5 senses that the temperatures within a refrigerator have risen above (or fallen below) a prescribed range, it can not only sound an audible alarm on-site, but also send alerts to staff and authorities.

Alarms can be configured as needed by individual sites:

- SMS and email alerts can be sent to phones or PCs when temperatures are too high to low, or when the power goes out. Immediate alerts give staff the best chance to address the problem quickly, before stored vaccines are damaged or ruined.
- A tiered alert system can be configured to send notifications to healthcare workers and supervisors at client, district, state, and national levels.
- Messages can be customized for delivery on set schedules, including as daily performance updates. “All is well messages” can be sent twice each day to provide peace of mind for staff and confirm that the system as a whole is up and running.
- Data logging and transmission settings are also highly configurable.

Data collected and sent by ColdTrace 5 provides the basis for responsive cold chain maintenance. Real-time temperature data can be used to:

- Identify chronically failing units.
- Remotely diagnose common reasons for failure using temperature data signatures.
- Prompt fast response phone calls to the facility to address problems.
- Verify that repairs are working.
- Plus, ColdTrace 5 can be set to store data in the cloud or in specific in-country databases. A secure website is made available for authorized users.

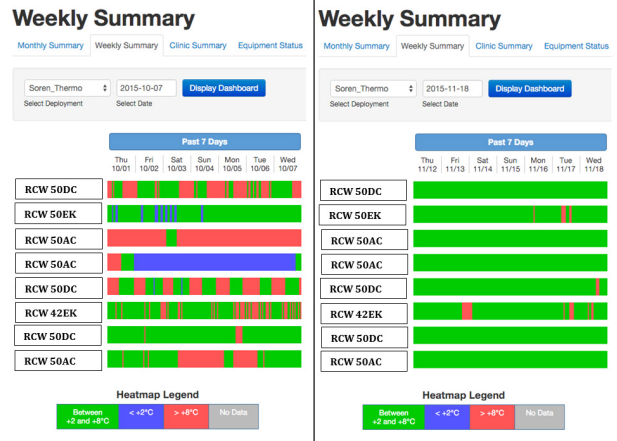
ColdTrace 5 is specifically designed for use in remote and rural environments. The units feature:

- Five temperature sensor devices for redundant monitoring.
- SD card data storage.
- Dual SIM capabilities.
- External antenna.
- Optional solar panel connectors and long battery life for robust, uninterrupted performance.
- Quick and easy installation.

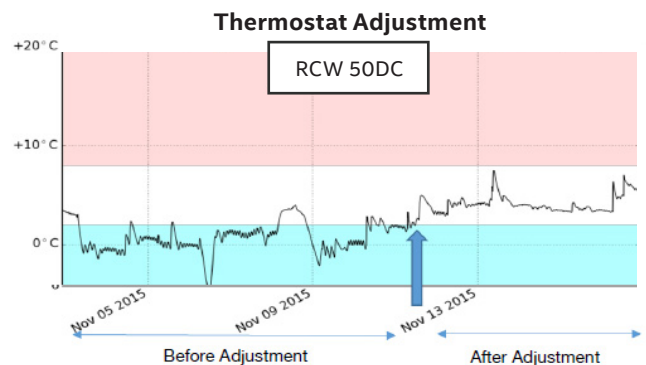
ColdTrace 5 is built on a GL865-QUAD GSM/GPRS modem developed by Telit, an Intel partner and IOT communications company. Enabled by Intel’s 2G cellular chipset, the modem provides outstanding performance and value, as well as long-term design protection for product stability.

Reporting

ColdTrace 5 supports a range of useful reports and graphs, including those shown here. Reports like these can be accessible to local staff and Ministry officials as desired, and can be used to demonstrate both the value that technology can provide in improving immunization systems and the cost-effectiveness of that technology. Ministry staff can use the data to not only track performance, but also to set budgets and plan future deployments.



ColdTrace dashboard weekly summary showing the performance of eight units before and after thermostat adjustment.



ColdTrace dashboard showing temperature data experiencing cold and freezing excursions before thermostat adjustment, then performing in range after the adjustment.



Nexleaf cold chain temperature monitoring

Results of Effective Monitoring

As of early 2021, approximately 16,450 ColdTrace units are protecting vaccines and enhancing immunization distribution programs in 26 countries.

That this protection is critical has been confirmed by research. A study of cold chain maintenance by Nexleaf and the Mozambique Ministry of Health² concluded that use of Nexleaf’s ColdTrace can significantly help reduce problems caused by temperature fluctuation in vaccine refrigeration

units. A key finding of the study was that Remote Temperature Monitoring could result in a 63%-68% reduction in cold alarm durations, as opposed to previous non-RTM measures. In addition, overall refrigerator uptime increased and the average number of cold events went down.

Next Steps

While work to scale the ColdTrace5 continues, future collaborative efforts between Nexleaf and Intel are in the planning phase, including a Kenyan project to improve the medical equipment infrastructure to help in the fight against COVID-19. Another project will focus on using visualization and data analytics to analyze temperature data in order to more comprehensively evaluate and improve the efficiency of cold chain monitoring and vaccine distribution in general.

Where to Get More Information

- Nexleaf: <http://www.nexleaf.org/>
- Intel: www.intel.com
- Telit: <https://telit.com>



Nurse²:

“When I received an SMS alert, I realized the fridge was unplugged accidentally...so I corrected the problem.”



Technician²:

“Before there as a lack of information about fridges. Now there are improvements, as I get information about any problem that occurs inside the fridge; it facilitates a quicker intervention....”



Ministry of Health staff²:

“While on field distribution, we received high temperature alerts due to power outage. We communicated with another colleague in province to load ice packs into the fridge, to request fuel for the generator, and to monitor temperature to prevent loss of vaccines.”



1. Forbes

2. Why Fridges Fail Part 2: RTM Data for Maintenance, Nexleaf Analytics, VillageReach, 2016

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