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Breaking the battery barrier

How to plan a battery-free future for IoT asset tracking

The battery problem in IoT

By the end of 2018, there were around 22 billion IoT connected devices in use around the world – and forecasts suggest this could grow to 50 billion by 2030[1].

In business, industry, healthcare – almost any setting, in fact – smart beacons and sensors are tracking everything from lighting conditions and temperature to the location and use of equipment.

Yet this explosion in the implementation of smart technology could be held back by a seemingly mundane issue – battery power. Powering billions of IoT sensors will require billions of batteries. And therefore, billions of battery changes and disposals.

Even in this best case scenario for battery life, the number of battery changes is staggering. If we had 50 billion devices with a battery life of 10 years, we would be changing 14 million batteries a day. And with a more realistic battery life of three years, that figure grows to 46 million a day.

Putting that in a practical context, an IoT deployment of 10,000 connected devices – such as in a large hospital, warehouse, or manufacturing shopfloor – would require the timely replacement and disposal of over 800 batteries per month.

As well as being an obvious sustainability issue, the need to change batteries across a large number of devices can have a significant cost in both purchasing batteries and paying people to replace them.

So, what to do about this battery barrier? This whitepaper explores the use cases for asset tracking, the range of solutions available, and how to solve this unsustainable power problem.

[1] https://www.statista.com/statistics/802690/worldwide-connected-devices-by-access-technology/

“*We produce life-saving hospital equipment such as ventilators, and our customers need to be able to find these quickly. Tracking devices to help them do this are usually battery powered, and all batteries eventually need changing. Doing this in thousands of devices creates cost, and this is especially painful in a hospital when it needs to be coordinated around lifesaving procedures. IoT trackers powered continuously by harvesting energy from their environment would be better for these critical workflows.*”

Jannes von Zech, *Business Development Manager, Draeger*

IoT asset tracking from industry to healthcare – why we need it?

Before we come on to the battery problem, let's take a quick look at why it is becoming a rapidly growing problem.

Employees at facilities such as hospitals, manufacturing shop floors and warehouses need to be able to locate equipment and assets quickly and easily, and assess how they are performing. For example, if assets need to be kept at a certain temperature, that temperature must be monitored. If an expensive piece of medical equipment is needed in an emergency, it needs to be located immediately.

More mundanely, lots of things go missing in busy workplaces - accidentally or intentionally - causing downtime whilst people look for them, and cost of replacement if they don't turn up quickly. Being able to quickly locate them saves a lot of money.

The advent of the low-cost, low-power tracking and connectivity technologies such as GPS and Bluetooth Low Energy (BLE) and radio frequency identification (RFID), has led to an explosion in IoT technologies that can track and monitor these important assets. According to market research company Mordor Intelligence, the global asset tracking market was valued at $17.14 billion in 2020 and is expected to reach $34.82 billion by 2026[2]. But all of these trackers need power and right now that means batteries.

[2] https://www.mordorintelligence.com/industry-reports/asset-tracking-market

Solutions for asset tracking

The below table details some of the most common types of asset tracking solutions.

Tracking technology	How it works	Considerations
Bluetooth Low energy	Calculates proximity and transmits data via Wi-Fi access points	Power source required but low power and easy to deploy
Ultra-wide band	Calculates positions based on multiple inputs.	Accurate and resilient, but high cost. Power source required.
Passive RFID	RFID antenna can calculate position of tags	Low cost and no battery needed, but trade off in limited functionality and data collection/transmission
LPWAN	Tracks using GPS and transmits data via a local (LoRa) gateway, which then backhauls data for analysis	High range and rich data collection. Expensive and high-power requirement.
Cellular	Tracks using GPS and transmits data directly via mobile network.	Near-unlimited range, no local gateway required. Expensive tags, and mobile data packages required. High power requirements.

The many challenges of battery powered IoT devices

According to a report by IDTechex, *"Internet of Things nodes (sensors) cannot be deployed in hundreds of billions if their batteries have to be replaced"*. In fact, the report estimates that at least 80% of the potential for IoT will be denied us if it relies entirely on battery powered sensors and trackers. This is because, to realise the IoT's full potential across a number of different sectors, sensors need to be working decades from now, even when they're inaccessibly embedded in machinery, buildings, or even trees[3].

But even now, batteries are a limiting factor for businesses deploying IoT sensors and asset trackers. Some of the reasons highlighted by companies managing IoT deployments include:

Hours of annual maintenance

All batteries eventually need to be replaced. At the moment, most devices have an operational life of over 10 years, while the batteries that power them last three years or less.

The cost of accessing and replacing dead batteries – because such processes must still be done manually – is often much greater in resources and man-hours than the cost of the new battery itself. A whole planning and maintenance regime is needed specifically to manage battery replacements, and avoid device downtime. Some replacements may need specialist electricians. And in many cases it's not just the battery but the whole integrated sensor that must be replaced.

Let's take the example of tracking hospital beds. According to the Kingsfund, the number of hospital beds in NHS England stood at 141,000 in 2019/20[4]. If every bed was tracked, in order to keep a real time record of location and availability, that would mean 141,000 trackers. At a 3-year life span, this would mean 47,000 battery changes per year. This entails a financial cost, not just in terms of the cost of the batteries, but also the maintenance hours spent on locating and replacing the batteries, not to mention disruption to medical workflows.

Environmental harm

According to recent EU-funded research, about 78 million batteries powering IoT devices will be dumped globally every day by 2025[5]. Lithium batteries commonly used in IoT trackers may contribute substantially to environmental pollution and adverse human health impacts, due to potentially toxic materials. An NIH report explains that lithium batteries pose health risks to humans due to the leaching of cobalt, copper, and other substances, and they can harm the environment through leaching substances like thallium and nickel[6].
The battery sector is working on how to efficiently recycle batteries, but proposed solutions are not yet operating at scale.

If these devices are rolled out in the coming years by the billions or tens of billions, as predicted, it could have dire consequences for the environment.

And that's if batteries stay cheap and readily available. With the growth of electric vehicles there will be mounting demand for battery materials such as lithium, copper, and cobalt, pushing up the cost of batteries.

Companies pursuing sustainability strategies will need to explore options other than batteries to meet their targets.

Downtime and data gaps

Critical devices will involve power tracking and pre-emptive battery replacement. Less critical ones will wait until the battery dies to replace it, creating black spots in data and user frustration at not being able to use the device's functionality.

Limits to sensor functionality

Batteries are often the largest part of an IoT sensor system, leaving engineers limited choices of which batteries to add to their sensors[7]. In addition, the size, weight, and dimensions of the battery can restrict both the types of applications a sensor or tracker can perform and which other components the battery can coexist with on the sensor's board.

Batteries also limit where a tracker can be deployed for long term applications, as it has to be in a location that's accessible for battery changes. If a battery needs to be changed the enclosure needs to be designed so that it can be opened, and this makes it difficult to achieve high IP rating (protection from water, dust, etc). Sealed battery powered sensors, on the other hand, need the whole sensor to be disposed of when the battery runs out. An energy harvesting sensor is a permanent power source that can be sealed in an enclosure, which is useful where sensors are exposed to the elements or need to undergo treatments such as sterilisation.

> *We help businesses track people, products, and services. Our trackers need power, which means batteries. But batteries are a pain for our customers who need to put in place a regime to replace them – often in their thousands – before they run out. And although batteries claim to last 10 years in an IoT device, this is based on perfect operating conditions and most struggle to get past four in a real-world environment.*
>
> Graham Fenton, *Managing Director, Codegate*

[3] https://www.idtechex.com/en/research-report/battery-elimination-in-electronics-market-impact-iot-6g-health-care-wearables-2021-2041/809

[4] https://www.kingsfund.org.uk/publications/nhs-hospital-bed-numbers

[5] https://cordis.europa.eu/article/id/430457-up-to-78-million-batteries-will-be-discarded-daily-by-2025-researchers-warn

[6] https://pubs.acs.org/doi/abs/10.1021/es400614y

[7] https://www.electronicspecifier.com/products/iot/the-key-to-calculating-battery-life-in-the-iot

Energy harvesting: The alternatives to battery-powered IoT

Energy harvesting is an alternative solution to battery power. It's based on converting the energy available in a device's immediate surroundings to electrical power. We take a look below at three of the most promising options.

Light harvesting

Light is a common power source, and most of us are familiar with solar panels and photovoltaic (PV) cells.

Most associate PV with harvesting energy from direct sunlight. However, the same principle can be redesigned to harvest energy from indoor lighting. The latest technologies can easily generate enough energy from bright indoor lighting to power a constantly transmitting low power IoT device, and can power most low power IoT devices with low or intermittent light.

Given the ubiquity of light in most working environments, this opens up the possibility to power many tracking and monitoring applications on power generated from lighting.

BLE Asset Tracking Tag powered by Lightricity PV Energy Harvester. Pictured tag is around 1/6th the size of a credit card.

Movement harvesting

Converting kinetic energy into electrical power can be done in many ways.

Electromagnetic induction – the production of an electromotive force across an electrical conductor in a changing magnetic field – has been the primary method for converting motion into electric power and can be seen in large scale generators. This method, on a smaller scale, can be used to harvest energy from vibrations, making it a viable power source for IoT devices that monitor constantly moving or vibrating machinery.

Piezoelectric generators harness the ability of certain materials to generate an electric charge in response to applied mechanical stress. They are smaller and cheaper than electromagnetic harvesters. Commercial energy harvesters based on piezoelectric effect are now entering the market, but so far they still suffer from reliability issues.

A third type could harness the Triboelectric effect – a type of contact electrification on which certain materials become electrostatically charged after they are separated from a different material with which they were in contact. There are, as yet, no commercially available triboelectric harvesters. However, there is great interest in them as they could be used in disposable electronics, powering of smart fabrics, floor power generation, and ocean wave power generation, for example.

Temperature difference harvesting

When no light or movement are available, a thermal gradient could be used to produce power. The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa via a thermocouple. A thermoelectric device creates a voltage when there is a different temperature on each side.

This type of energy harvesting is very inefficient – typically 2-5%. However, it can still provide sufficient power for some IoT applications. For example, generating power by recovering waste heat from internal combustion engines, exhaust pipes, and industrial processes.

Everlasting power from indoor lighting – with Lightricity

Our own solution to the battery problem uses photovoltaic panels that harvest power from indoor lighting to provide everlasting power to IoT devices.

Our technology is the world's most efficient indoor PV technology (though it works outdoors too). It converts indoor light sources to energy with approximately 30% efficiency – a more than six-fold improvement on conventional PV, as validated by the UK's National Physical Laboratory. A panel the size of your fingertip will power your IoT device forever. Even in extremely low indoor light. Our technology can be sealed in the device and operate at temperatures from -40 to +200 degrees, opening possibilities to power devices not previously thought possible with indoor IoT

We offer two solutions. For those designing new connected devices, our customisable PV panels can be integrated into any low-power IoT device as an alternative to batteries. For IoT systems integrators, we offer off-the-shelf, easy-to-integrate, PV-powered sensors for many common measurement and tracking applications.

> *We have Draeger devices in UK hospitals, with tracking tags powered by Lightricity's PV and they are working brilliantly*
>
> *Jannes von Zech, Draeger*

[2] https://www.mordorintelligence.com/industry-reports/asset-tracking-market

In conclusion

Asset tracking needs are expanding all the time. IoT has enabled us to easily track everything from cargo travelling across continents, to vital equipment within a hospital. However, these exciting developments could come at an unsustainable environmental and financial cost if we don't address the need for battery power.

While it's clear that we won't be saying a final goodbye to batteries just yet, there are now options available that will allow asset tracking systems to become far less reliant on batteries. Those deploying large scale IoT projects should start having conversations about the options to provide everlasting power through harvesting energy from their immediate environment, and gradually reduce their reliance on time-limited and environmentally damaging batteries.

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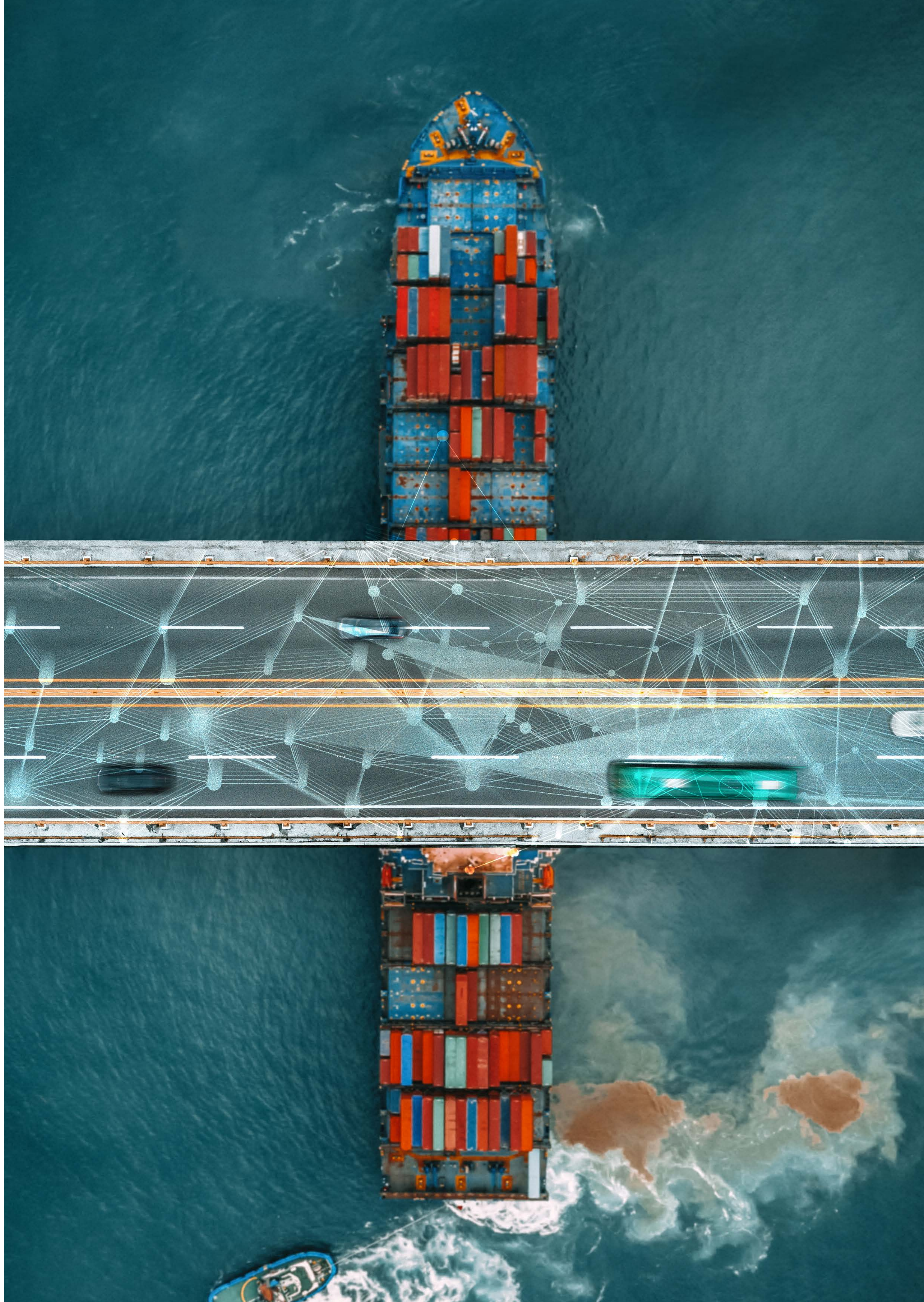

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