
IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

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How Energy Harvesting is Key to Unlocking True Value of Steam Trap Monitoring

IDEA 2021, September 27th to 29th

Unlocking a trillion-unit ecosystem

An Internet of Everything.

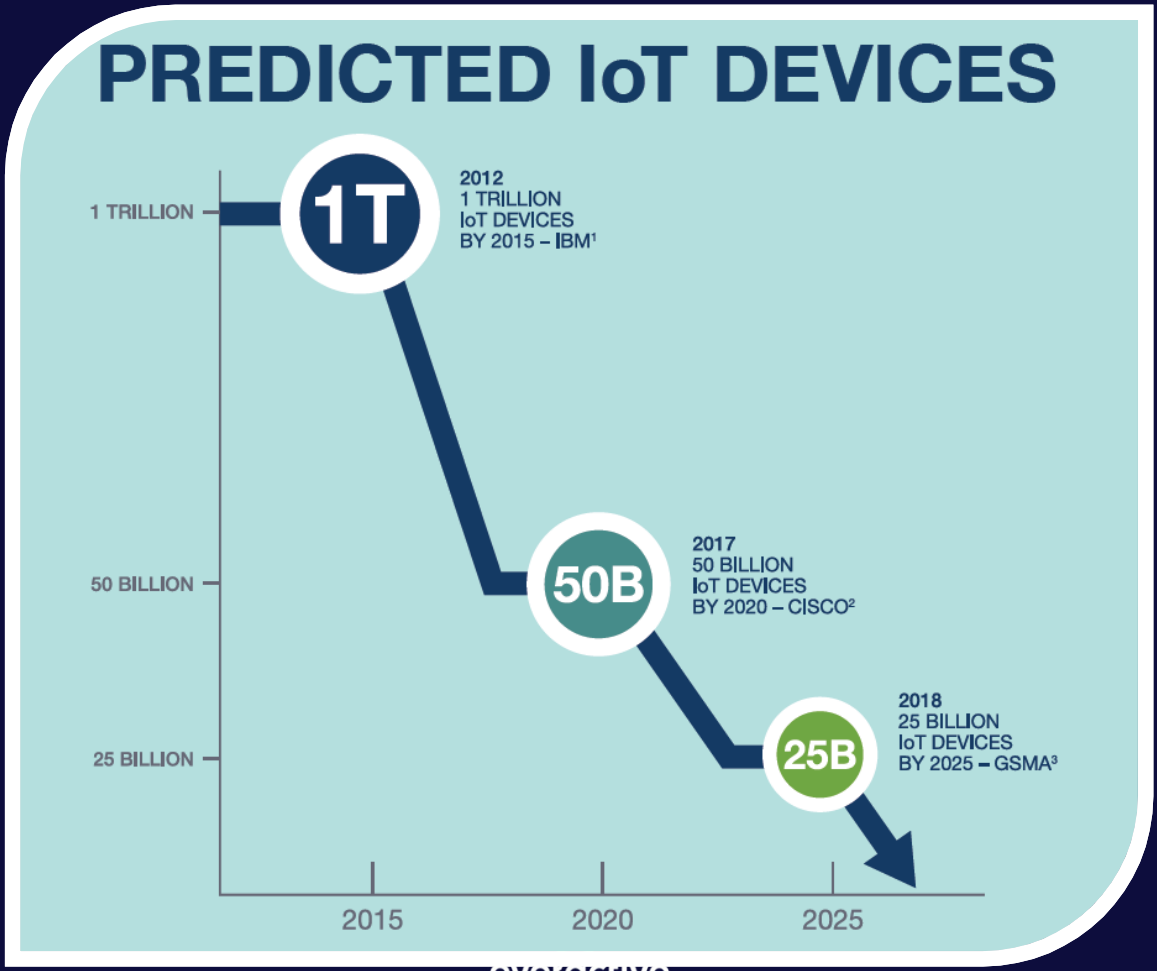
- Small set-and-forget nodes
- Condition & location of anything
- Direct node-to-cloud (w/ 5G IoT)
- High-density, edge neural networks
- Feed into major data platforms

The “new normal” needs pervasive remote monitoring

Real-time visibility across all assets requires:

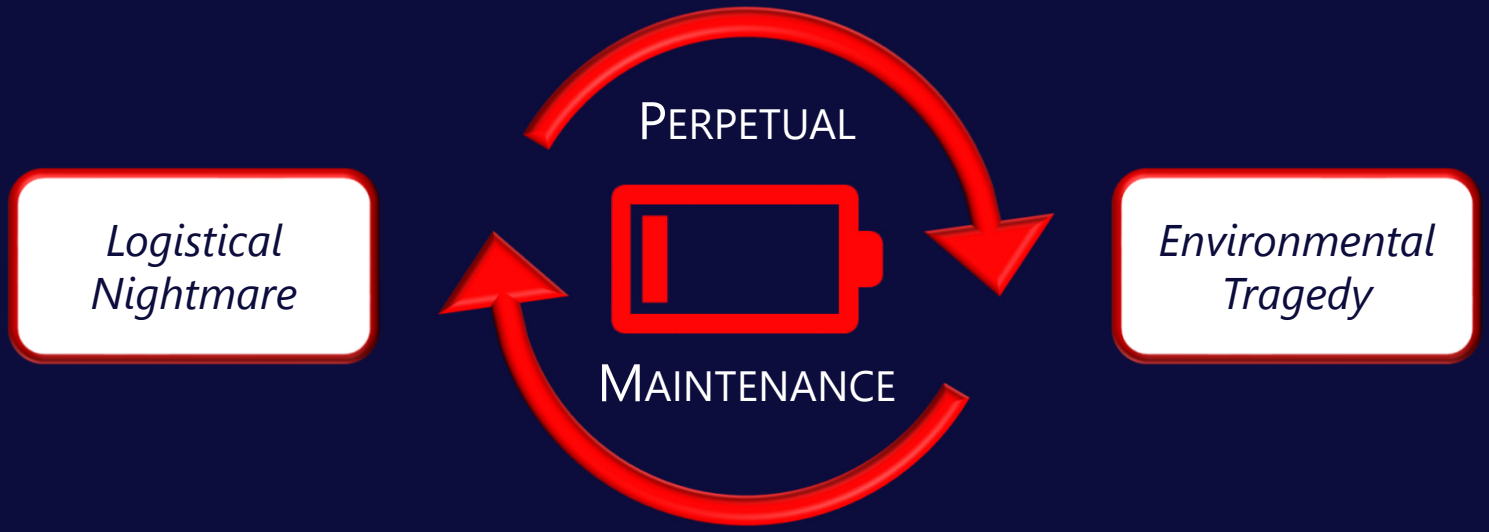
- ✓ LOTS of sensors
- ✓ Maintenance-free devices
- ✓ Continuous data streams
- ✓ End-to-end solutions
- ✓ Cost-effective deployments

The IoT has not lived up to the hype



Why have we fallen short?

1. Batteries undermine the value of the IoT

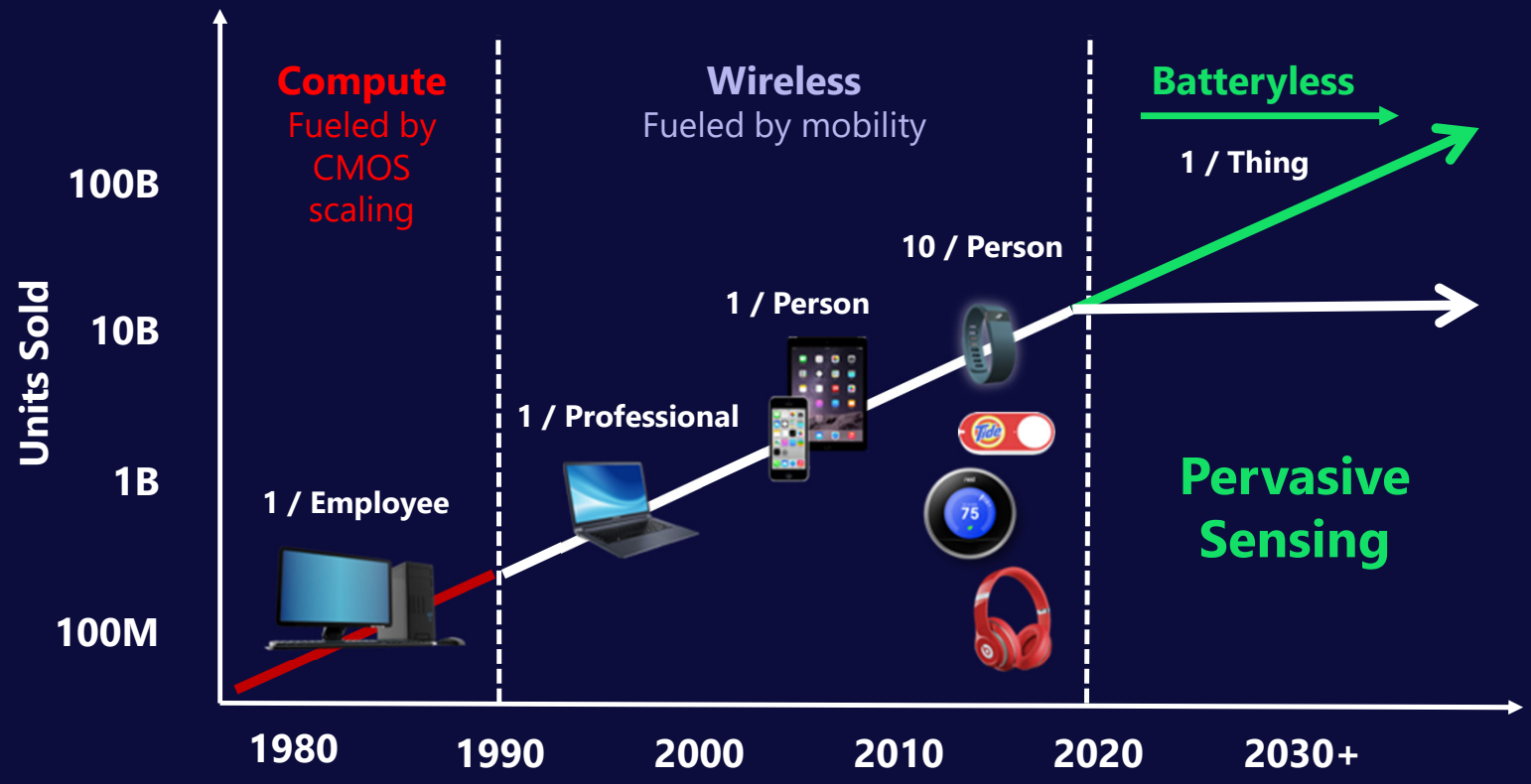


1 trillion sensors with 3-year battery lifetime =

913M replacements <u>per day</u>

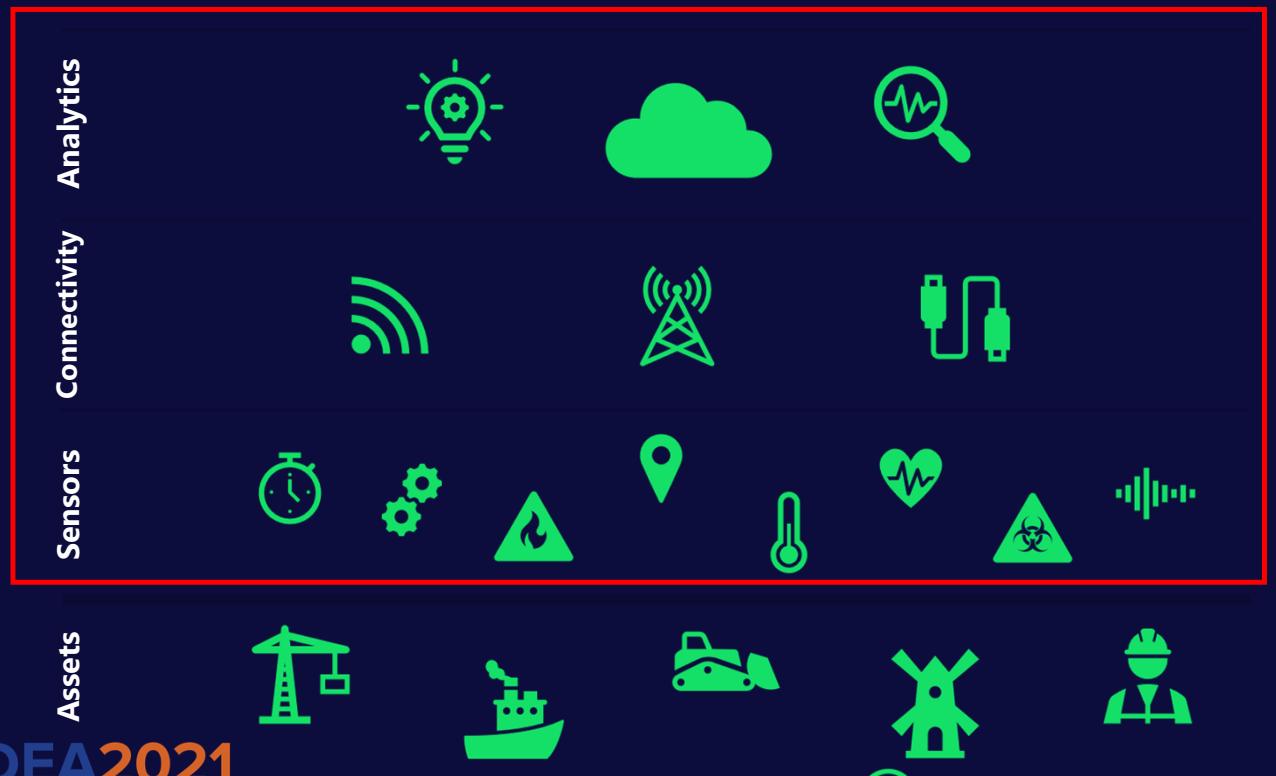
Why have we fallen short?

1. Batteries won't get us there…



Why have we fallen short?

3. Required integration of fragmented offerings



Fragmented Offering

- Multiple solutions
- Different technologies
- Many vendors to manage
- Integration costs
- Cumbersome compatibility

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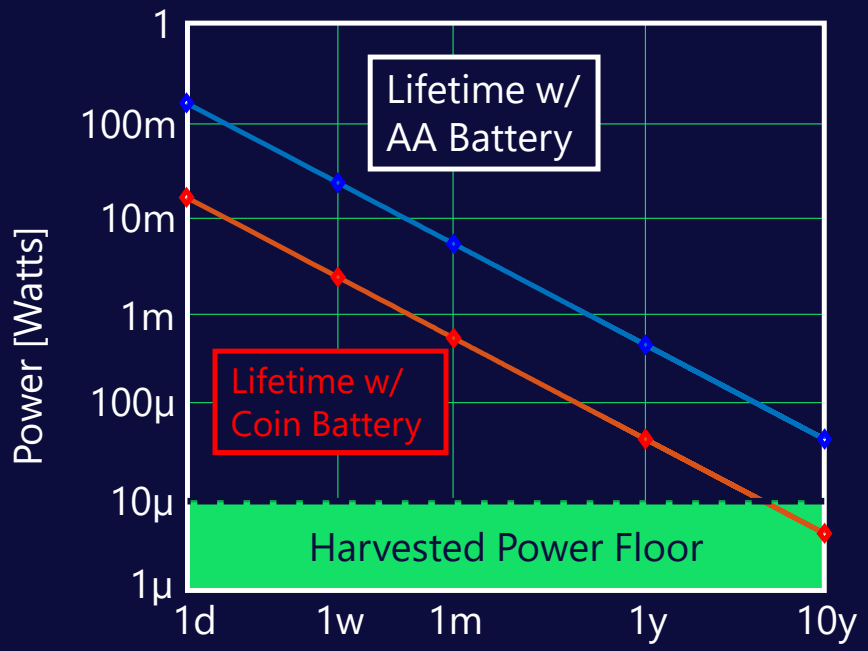
Renewable energy sources at the micro scale



Energy Source	Power Density
Outdoor light	1000µW/cm^2
Human motion	330µW/cm^3
Vibration	200µW/cm^3
Thermal	40µW/cm^2
Indoor light	10µW/cm^2

1 µWatt = 0.000001 Watt

- ✓Always-on ultra-low power radio
- ✓Sub-V_T digital processing
- ✓All power from 5ºC ΔT or > 200 Lux

Cloud Analytics
Always-On Network
Self-Powered Nodes
Custom SoCs

- ✓Lowest power + low latency
- ✓Up to 1km bi-directional range
- ✓Thousand-node density

Self-Powered monitoring overview

1 **Batteryless Technology**

2

Delivered Benefits

- ✓ Maintenance-free devices
- ✓ Wealth of new data sets
- ✓ Continuous data streams
- ✓ End-to-end solutions
- ✓ Cost-effective deployments

Actionable insights sold as-a-service

- *Cloud Analytics*
- *Always-On Network*
- *Self-Powered Nodes*
- *Custom SoCs*

3 **Full-Stack Systems**

3 **Targeted Solutions**

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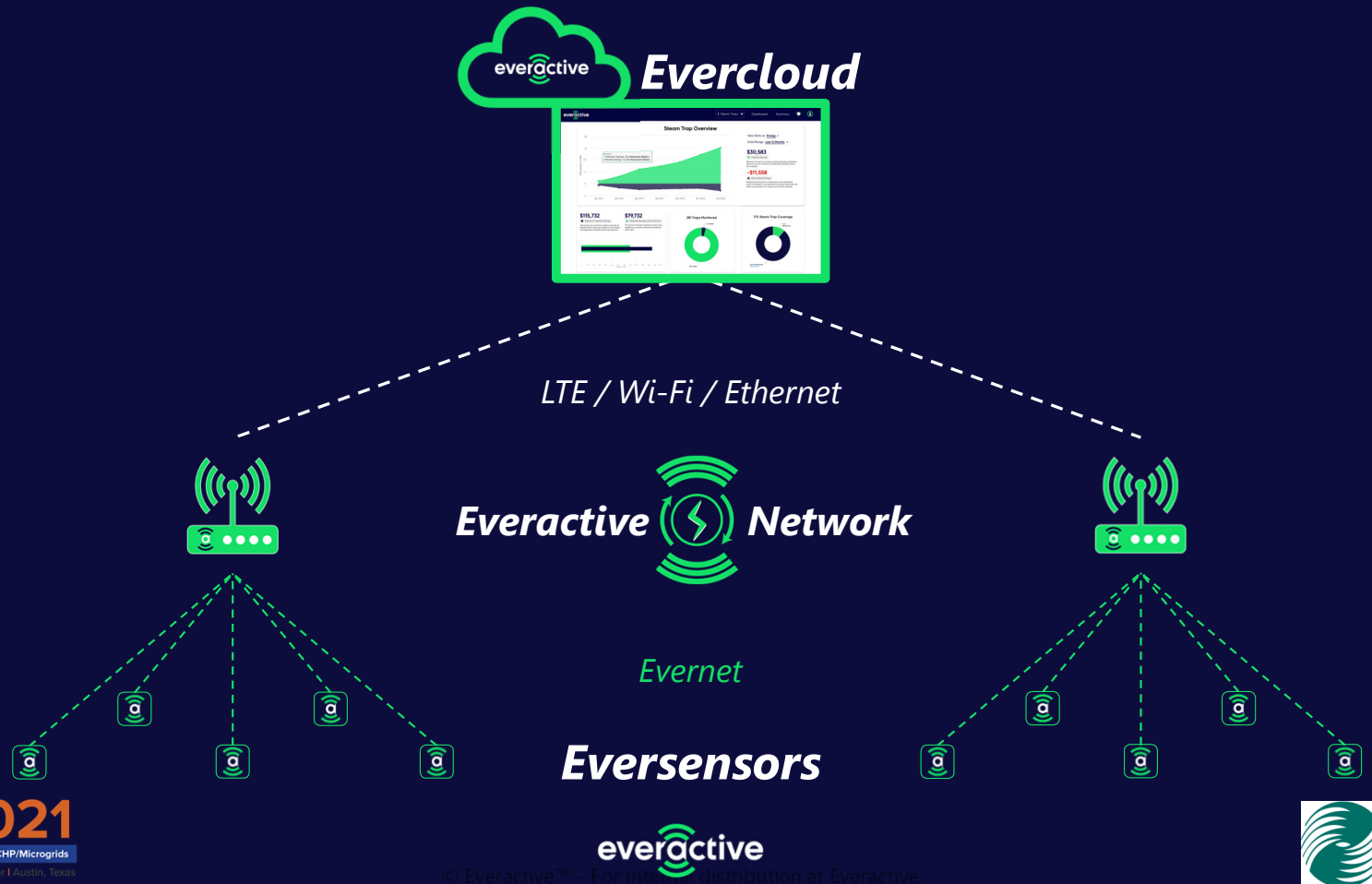
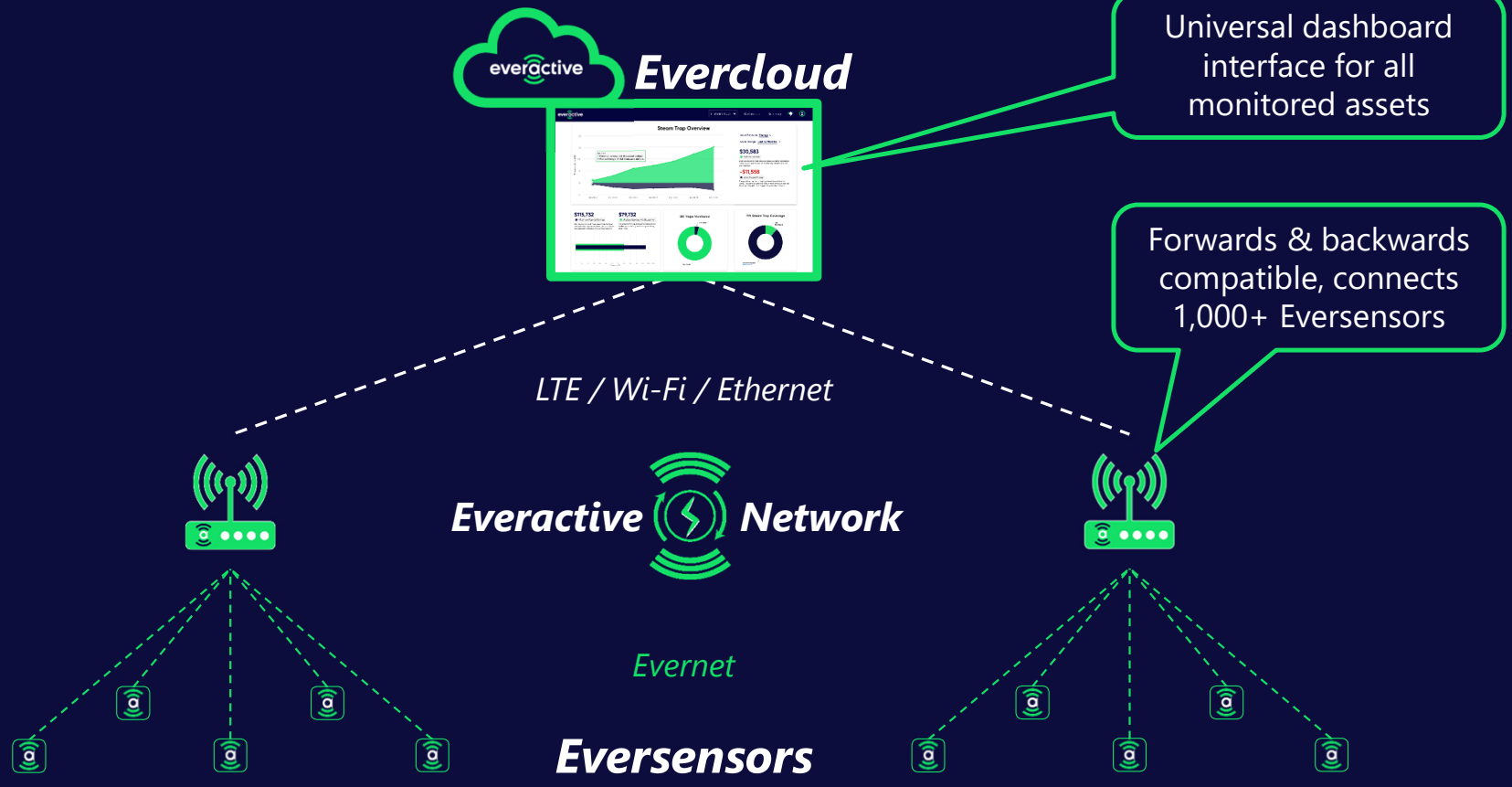
Self-Powered wireless monitoring solutions



Self-Powered wireless monitoring solutions



Self-Powered monitoring solution elements

Hardware Components

Cross-Platform Software

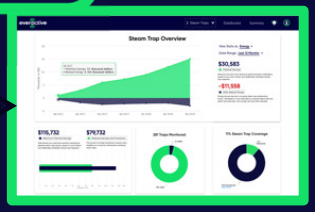
Protocol overview

Evernet
Proprietary communications in 2.4GHz & 915MHz

Supports hardware whitelisting and two-way mutual certificate authentication

Gateway

Evercloud



AWS
S3 Storage and EC2 Compute Instances host all User-level applications, accessible via HTTPS. Notifications via Email, SMS or API.

Eversensors

LTE / Wi-Fi / Ethernet
Carrier Independent onboard modem connects to AT&T, Verizon, Sprint, T-Mobile

Transmissions are sent via secure MQTT with AES-256 Encryption. Cloud data store on AWS supports Encryption-at-rest.

Notifications where and when you want them

Worldwide access to insights and raw data

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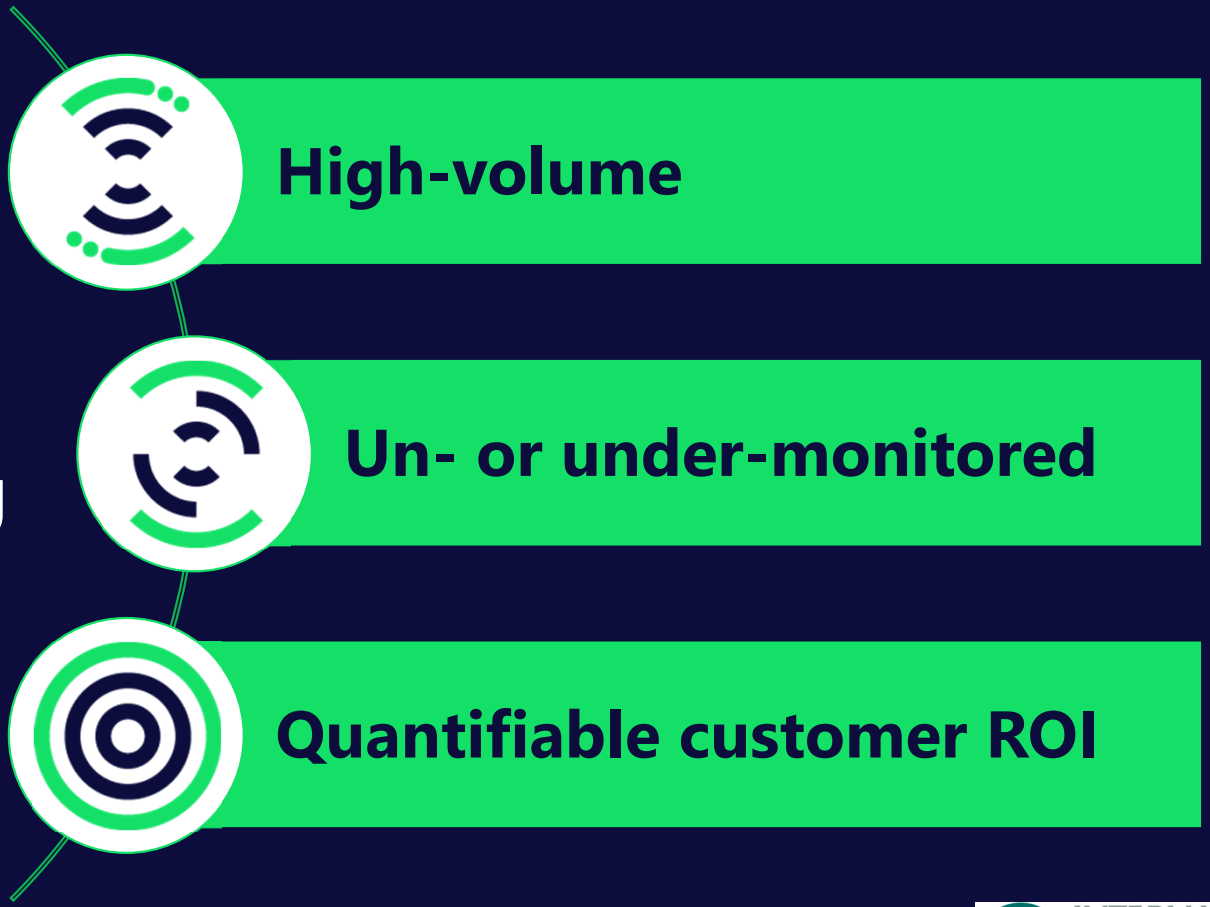
Superior wireless technology

Protocol	Power	Time On	Range	Nodes per Gateway	Data Rate	Industrial Penetrability
Evernet	**Batteryless**	**Continuous***	800 ft. *	**1,000s***	0.25 Mbps	**Strong sub-GHz**
Zigbee	Low	Once per minute	100 ft.	20-50	0.1 Mbps	Weak 2.4 GHz
Bluetooth Low Energy	Low	Once per minute	100 ft.	20-50	1 Mbps	Weak 2.4 GHz
Sigfox	Low	1-2 times per day	> 1 mile	1,000s	< 0.1 Mbps	Strong sub-GHz
NB-IoT	Medium	Once per hour	> 1 mile	1,000s	< 1 Mbps	Strong Cellular
LoRaWAN	Medium	Once per hour	> 1 mile	20-80	< 0.1 Mbps	Strong sub-GHz
Symphony Link	Medium	Once per hour	> 1 mile	100s (w/ repeaters)	< 0.1 Mbps	Strong sub-GHz
Mioty	Medium	Once per hour	> 1 mile	1,000s	<< 0.1 Mbps	Strong sub-GHz
Wireless HART	High	Continuous	100 ft.	100	0.1 Mbps	Weak 2.4 GHz

*Supporting up to 1,000 Eversensors per gateway with less than 1% PER in a harsh industrial environment (path loss coefficient of k = 2.37)

Target applications of self-powered monitoring

Self-Powered Asset Monitoring



Initial applications gaining rapid market traction

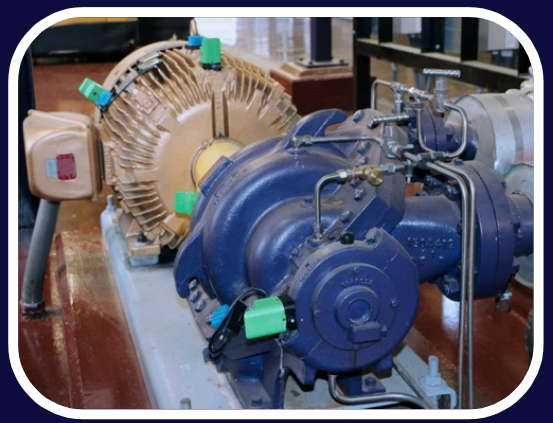
Reducing costs of:

- **Downtime**
- **Maintenance**
- **Energy**
- **Safety**

Steam Traps Applications

> *I do not use battery-powered devices since I am unwilling to trade one maintenance event for another.*
>
> ***– Maintenance & Reliability Leader***

Rotating Machines Applications



Colgate-Palmolive, Saputo, 3M, MARS, Morgan Stanley, Merck, mizkan, Trinity, Hills, United States Air Force, University of Virginia, NIH, University of Michigan, Danone

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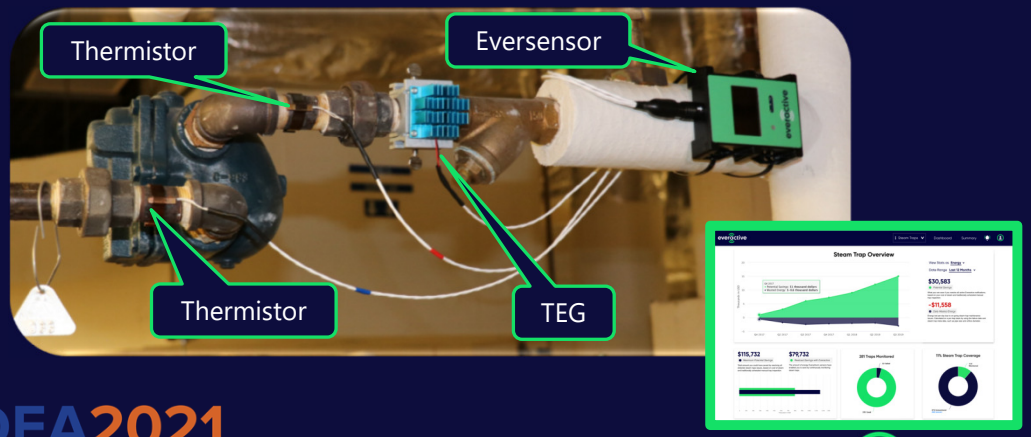
Steam Trap Monitoring (STM)

Cross-industry pain point

- **$50+ billion** in lost energy & downtime
- **300+ billion** gallons of water waste
- **300+ million** metric tons of CO_2 emissions

Annual, global estimates

STM Elements



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*Compelling returns**

Upfront HW **$0**	Installation per Trap **< 10 min.**
Net Annual Savings **$1,271,522**	Annual CO_2 Savings **28k tons**
Payback Period **3 months**	5-Year ROI **4.2x**

** Estimate for outfitting 1,000-trap process manufacturing facility*

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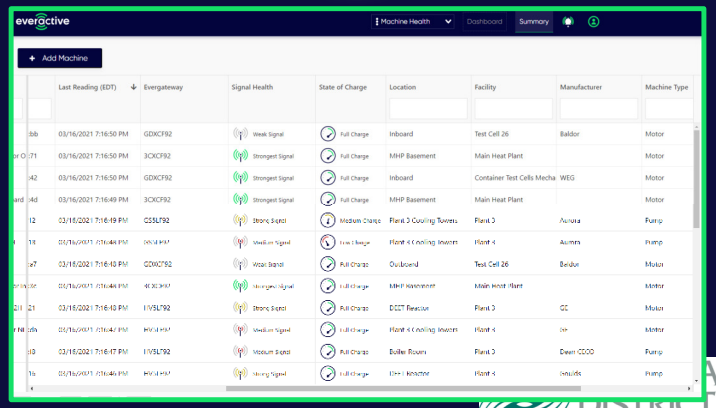
Aplication Protocol Interface (API)

Why It Matters

- Connect batteryless sensor data into existing software platforms → CMMS, EAM, ERP, historians, and more
- Best of both worlds: self-powered sensor data + single “pane of glass”
- Integrate data streams to correlate new insights

How It Works

- Utilize connectors built for specific platforms & uses cases
- Integrator or on-site administrator can connect to all STM + MHM measurements / analysis with RESTful API endpoints & webhooks
- Documentation written to OpenAPI 3.0 spec



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University Campus Case Study

Key Assumptions

Steam traps	500
Avg. PSI	60
Steam cost	$10 / 1k lb.
Orifice size	$^{7}/_{32}$ inch
Cold failure	$20,000

Upfront HW
$0

Net Annual Savings
$187,821

5-Year ROI
1.48x

Installation per Trap
< 10 min.

Annual CO_2 Savings
3,350 tons

Payback Period
5.2 months

	Yr. 0	***Yr. 1***	***Yr. 2***	***Yr. 3***	***Yr. 4***	***Y.r 5***
Gross Savings:	$0	$312,821	$312,821	$312,821	$312,821	$312,821
Hardware:	$0	$0	$0	$0	$0	$0
Installation:	$11,250	$0	$0	$0	$0	$0
Everactive Monitoring Service:	$0	$125,000	$125,000	$125,000	$125,000	$125,000
Utility Rebate:	$0	$0	$0	$0	$0	$0
Net Savings:	**($11,250)**	**$187,821**	**$187,821**	**$187,821**	**$187,821**	**$187,821**

Hershey Testimonial

"If the IoT system required battery replacement, it is a failed system."

"STM is sustainable over time, gives us the best possible chance to catch failures and I'm excited about the long-term partnership."

Phil Reynolds
Maintenance Manager, Hershey's

"When you implement a system, you want to ensure that it is sustainable over time. When the system starts to run itself, you know you've really got something."

Short-term roadmap for self-powered sensing

Single Hardware + Software Platform

Supported Harvesters*	
Photovoltaic	☑
Thermoelectric	☑
EMF	☐
Vibration	☐

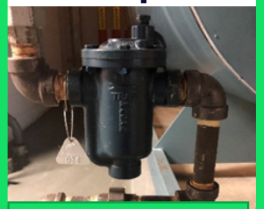
Supported Sensors*	
Ambient Temp.	☑
Remote Temp.	☑
Relative Humidity	☑
Lux	☑
Accelerometer	☑
Magnetometer	☑
Pressure	☐
Acoustic	☐
Ultrasonic	☐
Gases (multiple)	☐

☑ - in current production product(s)
☐ - supported by platform

Existing & Future Products

Batteryless sensing for ...

Steam Traps



2019

Rotating Machinery

2020

Filters

Preliminary

Corrosion

Preliminary

Gases

Preliminary

Heat Exchangers

Preliminary

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Technology & product roadmap

	Gen 2	Gen 3	Gen 4+
Silicon Platform	30 µW, harvest from 8°C ΔT or 200 Lux	1 µW, harvest from <5°C ΔT or 10 Lux	0.1 µW, harvest from 1°C ΔT or 5 Lux
	250m NLOS wireless range	1km NLOS wireless range	3km NLOS wireless range
	Temp, Humidity, Acceleration, Acoustic, Pressure, Gas	+ Localization, Low-Res Imaging	+ High-Res Imaging, User-Defined
	FFTs with HW accelerators	Inference & anomaly detection	Tiny ML, object detection
	TODAY	→	→

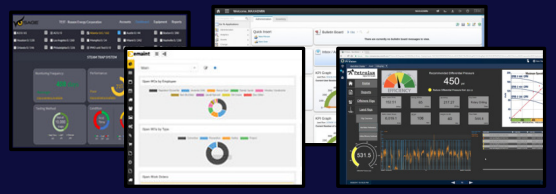
Future Applications

Each Gen enables more scalable & cost-effective answers to key IoT segments and use cases

- **Condition-Based + Predictive Maintenance:** *monitor equipment & infrastructure across plants, campuses, and commercial buildings*
- **Environmental Monitoring:** *monitor a range of conditions for safety, quality, compliance*
- **Asset Tracking:** *pinpoint location of anything throughout fixed setting or supply chain*
- **Connected Home:** *environmental & safety monitoring*
- **Wearables:** *worker tracking & connected health*

Data Analytics

Maintain proprietary cloud and enable easy integrations to customers preferred "pane of glass"



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What does that mean for IDEA members?

Out-of-the-Box Service → **No Added Maintenance** → **Maximized Returns**

Thank You!

Self-Powered Insights
for the Physical World.

Rafael Reyes
Director Product Marketing
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Q&A

Thank You!

BACKUP

Machine Health Monitoring

Maximize Facility-Wide Returns

- ✓ Prevent unplanned downtime
- ✓ Increase uptime & availability
- ✓ Improve overall equipment effectiveness
- ✓ Reduce electricity consumption
- ✓ Extend machine life

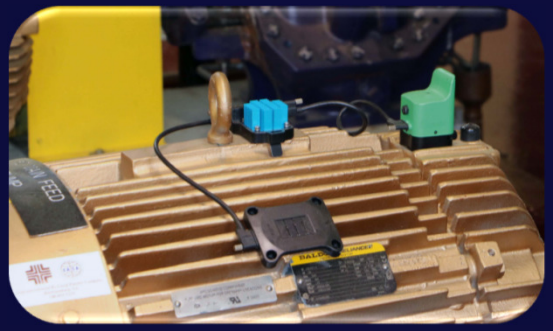
Lower Total Cost of Ownership

- ✓ No added, ongoing battery maintenance
- ✓ No upfront capital expenditures
- ✓ Subscription-based, real-time data analytics
- ✓ Intervene <u>only</u> when & where needed

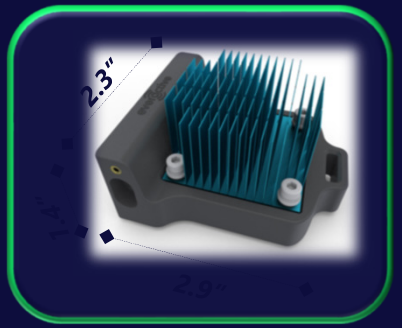
Cost-effective monitoring for ***<u>all</u>*** *rotating equipment*

Deploy on "Balance of Plant"

Eversensor



Energy Harvester



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Relief Valve Monitoring

Product Description

Monitor relief valves to identify release events as they occur and detect pop-ups and leaks to improve compliance, reduce GHG emissions, decrease downtime, optimize resources, mitigate safety issues.

Data Collected

» Differential pressure
» Temperature

Customer ROI Drivers

» Minimize downtime
» Reduce scheduled maintenance
» Avoid EHS issues

Markets

» Manufacturing
» Power Generation
» HVAC

Filter Types

» Bag filters
» Filter presses
» Cartridge filters

Filter Monitoring

Product Description

Monitor debris accumulation to determine when filter needs to be cleaned or replaced to ensure air quality and energy-efficient operation of the application.

Data Collected

- Differential pressure
- Temperature

Customer ROI Drivers

- Minimize downtime
- Reduce scheduled maintenance
- Avoid EHS issues

Markets

- Manufacturing
- Power Generation
- HVAC

Filter Types

- Bag filters
- Filter presses
- Cartridge filters

Gas Monitoring

Product Description

Monitor worksites and facilities for the presence of various gases above thresholds that indicate leaks and present environmental, health & safety issues, as well as production quality and process optimization concerns.

Data Collected

- Various gases (PPM or %concentration)
- Temperature
- Humidity

Customer ROI Drivers

- Avoid EHS & compliance issues
- Minimize production loss
- Reduce scheduled maintenance

Markets

- Oil & gas
- Petrochemical
- Manufacturing
- Mining
- Medical

Gases Sensed

- O_2
- CO_2
- CO
- NOx
- CH_4
- NO_2
- NH_3
- VOCs
- Others

Corrosion Monitoring

Product Description

Monitor corrosion levels to predict and prevent pipe and take pitting that can lead to leaks and uncontrolled releases that present EHS and production risks.

Data Collected

- Ultrasound
- Impedance detection
- Temperature
- Humidity

Customer ROI Drivers

- Minimize downtime
- Reduce scheduled maintenance
- Avoid EHS issues

Markets

- Oil & gas
- Petrochemical
- Manufacturing

Asset Types

- Pipes
- Tanks

Heat Exchanger Monitoring

Product Description

Monitor for fouling to determine the optimal cleaning schedule in order to reduce scheduled cleanings and/or manual inspections.

Data Collected

» Temperature (4x)
» Pressure or flow

Customer ROI Drivers

» Minimize downtime
» Minimize production loss
» Reduce scheduled maintenance
» Reduce energy + emissions

Markets

» Manufacturing
» Petrochemical
» Power generation
» HVAC

Heat Exchanger Types

» Shell & tube
» Plate & frame
» Air cooled

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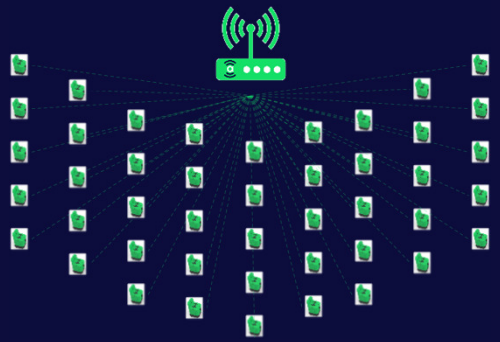
A 1,000x Technology Breakthrough

Cloud Analytics

Always-On Network

- ✓Lowest power + low latency
- ✓Up to 1km bi-directional range
- ✓Thousand-node density



Self-Powered Nodes

- ✓Always-on ultra-low power radio
- ✓Sub-V_T digital processing
- ✓All power from 5°C ΔT or > 200 Lux

Custom SoCs

Tech Stack

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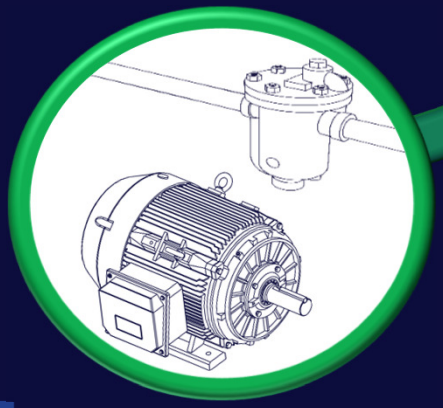
Everactive technology solves key IoT challenges

✓ Insights from **new data streams**
✓ Real-time alerts & notifications
✓ Cross-platform, easy bridges

End-to-end solutions



No batteries required

✓ **Continuous** sensing & wireless transmission
✓ Using only low-levels of **harvested energy**
✓ IP66 | Class I, Division 2 | wide operating range

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The easiest way to generate massive new data sets

Gen 3 Eversensor

Always-On Network

- ✓ Lowest power + low latency
- ✓ Up to 1km bi-directional range
- ✓ Thousand-node density per gateway

Self-Powered Nodes

- ✓ Low-levels of harvested energy
- ✓ Continuous sensing & transmission
- ✓ Distributed edge computing

Gen 2 Eversensor

Custom SoCs

- ✓ Always-on ultra-low power radio
- ✓ Sub-V_T digital processing
- ✓ Energy harvesting PMU

Tech Stack

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What we provide: Easy-to-use software