

Daintree Edge-to-Cloud Whitepaper

Executive Summary

The world of IoT is accelerating. Secure, user-friendly platforms are spreading across the market, enhancing our day-to-day lives, providing valuable data solutions, and replacing standard building automation and asset management systems.

Enterprise IoT (EIoT) offers much more than traditional building automation. There is little room in our modern collaboration economy for static or proprietary infrastructure. Forward-looking solutions must embrace the dynamic nature of our business landscape and provide flexible, secure, and scalable system architectures that provide value that will transform and advance with technology.

Powerful edge platforms are multi-purpose, encompassing a wide variety of devices and allow for constant addition of third-party devices as control points or for data collection. Linking to an equally powerful and flexible cloud platform that is open to developers and easily integrated with third-party applications builds a system that is “open at the top” and “open at the bottom.”

Integrated solutions leveraging open communication protocols, adaptable hardware strategies, and centralized data collection are poised to propel EIoT solutions into our offices, factories, and retail environments like never before. **Current, powered by GE** with Intel technology, is transforming smart building management through an open, wireless control solution that maximizes the value of building assets, unlocks operational efficiencies, and digitalizes intelligent environments. A digital ceiling provides the connected sensors and building controls, in addition to energy-efficient LED lighting, needed to gather information about a physical space. That data can act as the foundation for better business decisions, smarter space utilization, and streamlined operations.

Integration and Extensibility

The EIoT transformation must coexist and even integrate with legacy systems to maximize adoption. For years the Niagara platform, installed on a Java Application Control Engine (JACE) gateway, has served as the leader in edge integration. Now with the advent of Niagara Edge Light (NEL) EIoT gateways may enhance their standard functionality with the capabilities of Niagara. Current by GE offers this capability in their Wireless Area Controller (WAC), which acts as a ZigBee wireless gateway and a JACE in a single form factor, allowing connection to existing systems and extension with wireless devices.

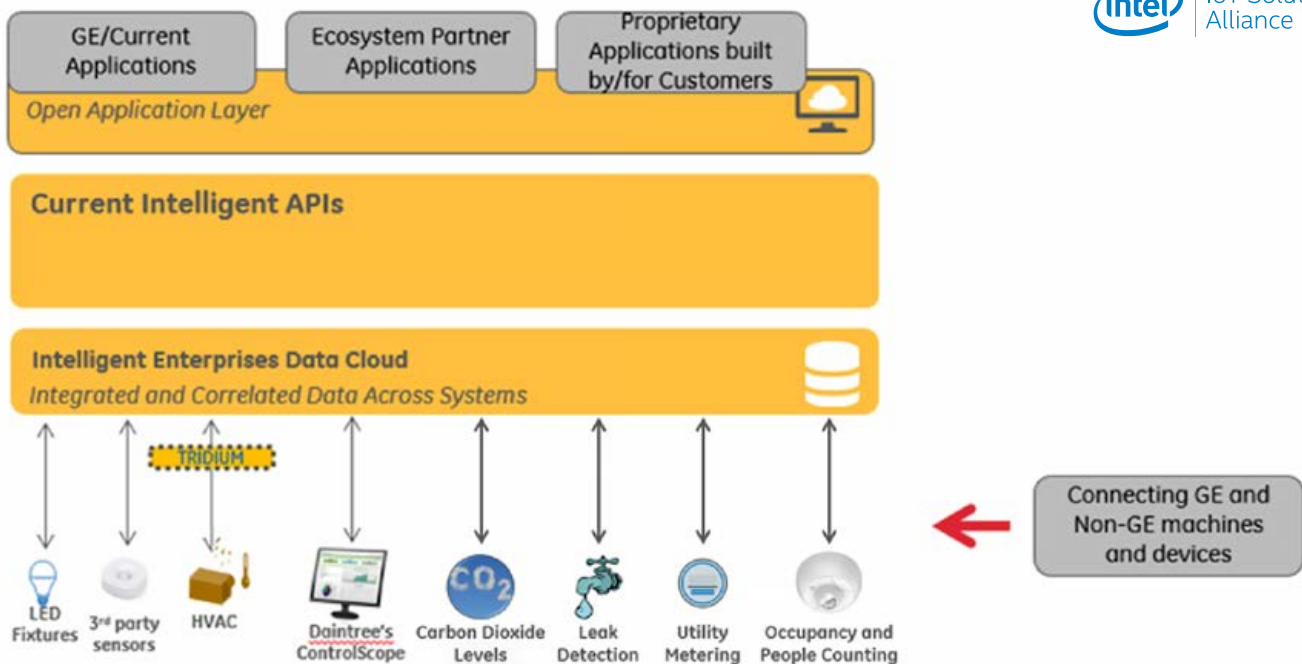
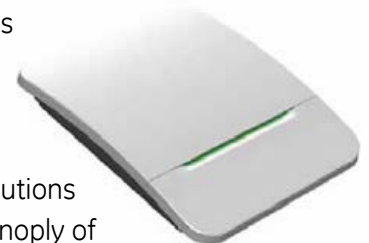


JPMorgan Chase adopted a forward-thinking strategy to manage energy and water consumption for their portfolio of retail bank branches. By choosing Current's Daintree EloT platform, they received a scalable, economic, and (especially important) secure solution to monitor and control assets including irrigation, lighting, and HVAC.

Mike Norton, Managing Director of Global Real Estate at JPMorgan Chase, describes Current's solution:

"This program is a win-win-win. It's good for our employees, our customers, and the environment. From a sustainability standpoint, the LED installation allowed us to cut energy consumption by 50%; the Building Management System installation allowed us to reduce electricity and gas usage by 15% and water usage by 20%." Mike adds: "These upgrades [also] provide a consistent, comfortable environment for customers who visit our branch."

Daintree edge and cloud solutions are designed to be highly extensible. Most nodes are capable of accomplishing multiple control and sensing data collection tasks at once. Current's Intelligent Environment enables software developers to leverage this data to create custom solutions. Existing software vendors can enhance their offering by tapping into APIs. Current has developed an ecosystem around their solutions that anchors them to the market and provides customers with an ever-growing panoply of use cases for their new IoT infrastructure.



Use Cases

Benefits of the EloT revolution are not limited to energy and resource usage. Data collection and occupant engagement present excellent opportunities to drive outcomes.

Indoor Positioning is a revolutionary concept to track people and assets within a building. By installing lighting with coded photo bands, the camera of any smart phone can act like a GPS antenna, relaying its exact location to multiple services,—enhancing the shopping experience, driving revenue, and providing data to retailers about their shoppers' behavior.

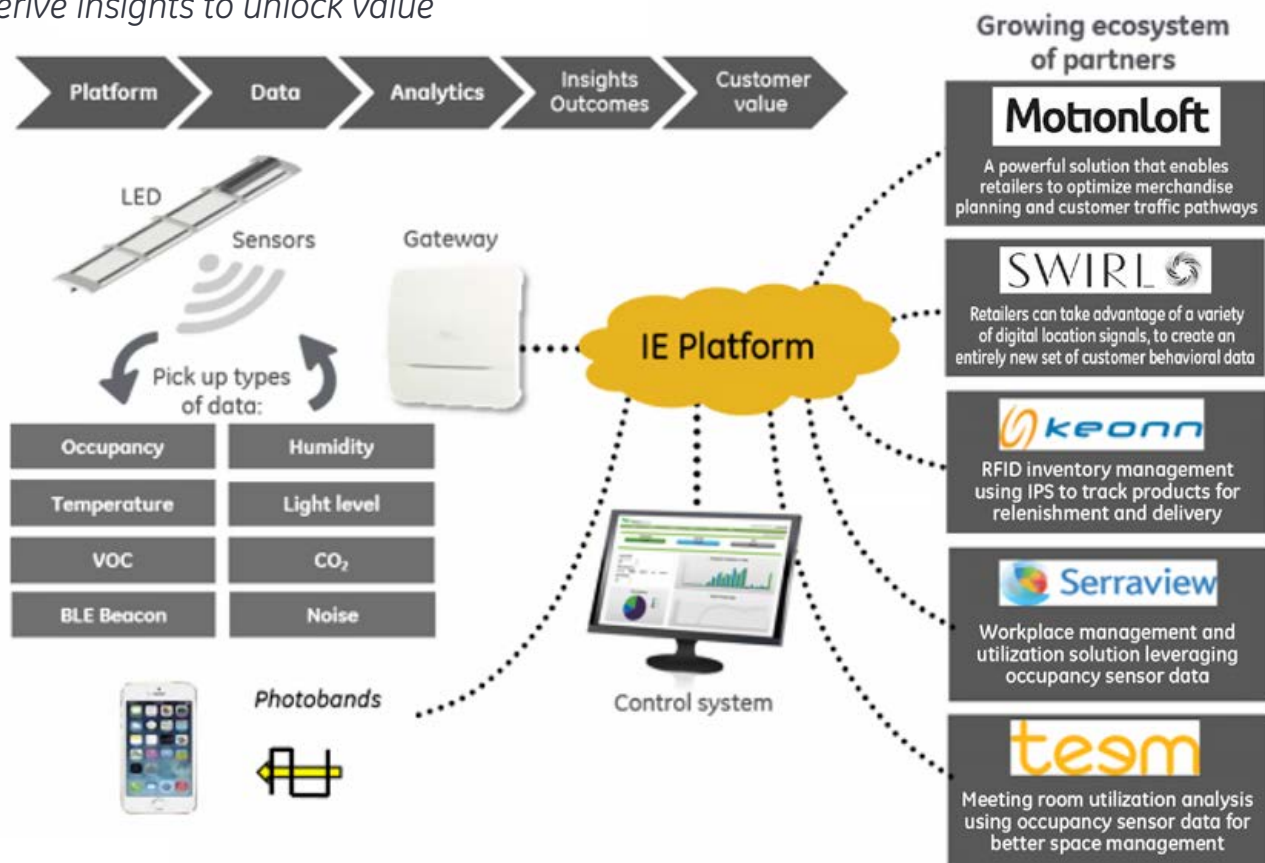
In addition to native shopper analytics and heatmapping provided as a cloud service, Current by GE could partner with software companies like Point Inside to provide retail analytics, Mowingo to engage customers and drive revenue, and Keonn to track products and inventory.

Space management is quickly becoming a critical asset for commercial offices. On the same infrastructure as lighting controls, sensors may be added to detect room occupancy, furniture use, and even count occupants in an area. This data may be ingested by specialty space management software to provide valuable insights leading to effective management of real estate and cost savings. Desks and conference rooms can even be reserved via employee smart phone apps or automatically booked when occupied.

Current partners with companies like iOFFICE and Teem to provide robust office management, hotdesking, conference room scheduling, and analytics services.

Intelligent Nodes + IE Platform + App Partners

Derive insights to unlock value



ZigBee

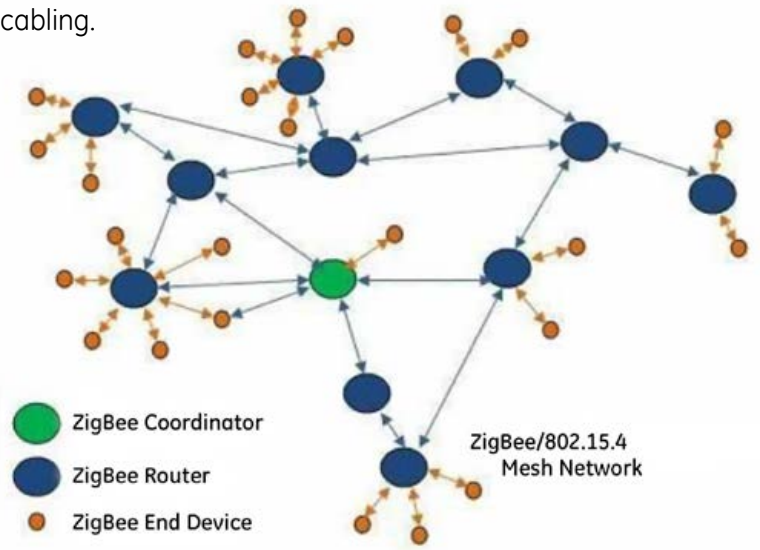
Open standards are the foundation of any true IoT architecture. They open the door to entire ecosystems of devices tailored to a myriad of use cases and liberate users from the restrictions of proprietary systems.



Popular among IoT solutions is the ZigBee wireless protocol, which is built on the IEEE 802.15.4 standard and designed for low-power, high-resilience networks of sensors and controls. ZigBee's reliability comes at the price of bandwidth, and so it is not suitable for high data rate applications like video or large file transfer, instead focusing on managing large networks of small, low bitrate devices. Communication between devices on the network is encrypted to avoid any security concerns.

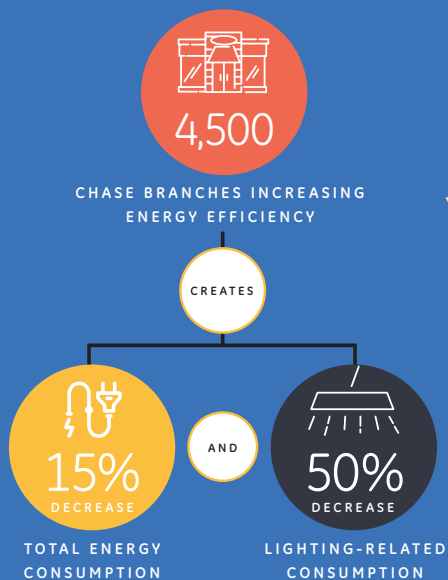
Wireless deployments are superior to hardwired in a multitude of ways. By "cutting the chord," customers can easily execute phased installations and add equipment in the future without expensive contract work to run cabling.

Communication over traditional signaling protocols (0-10v, binary input, etc.) is possible with universal wireless adapters, allowing the use of third-party sensors.



Success Story

For banking giant **JP Morgan Chase**, GE outdoor LED products are part of a larger initiative to decrease overall lighting-related energy consumption by **50%**. The world's largest lighting installation, this project involves parking lots and outdoor areas at 2,500 Chase branches and their corporate offices, as well. A reflection of the bank's ongoing commitment to sustainability, it's helping Chase reach their goal to reduce greenhouse gas emissions **50%** below 2005 levels by 2020.



Digital Engine: Data Aggregation & Processing in the IE Platform

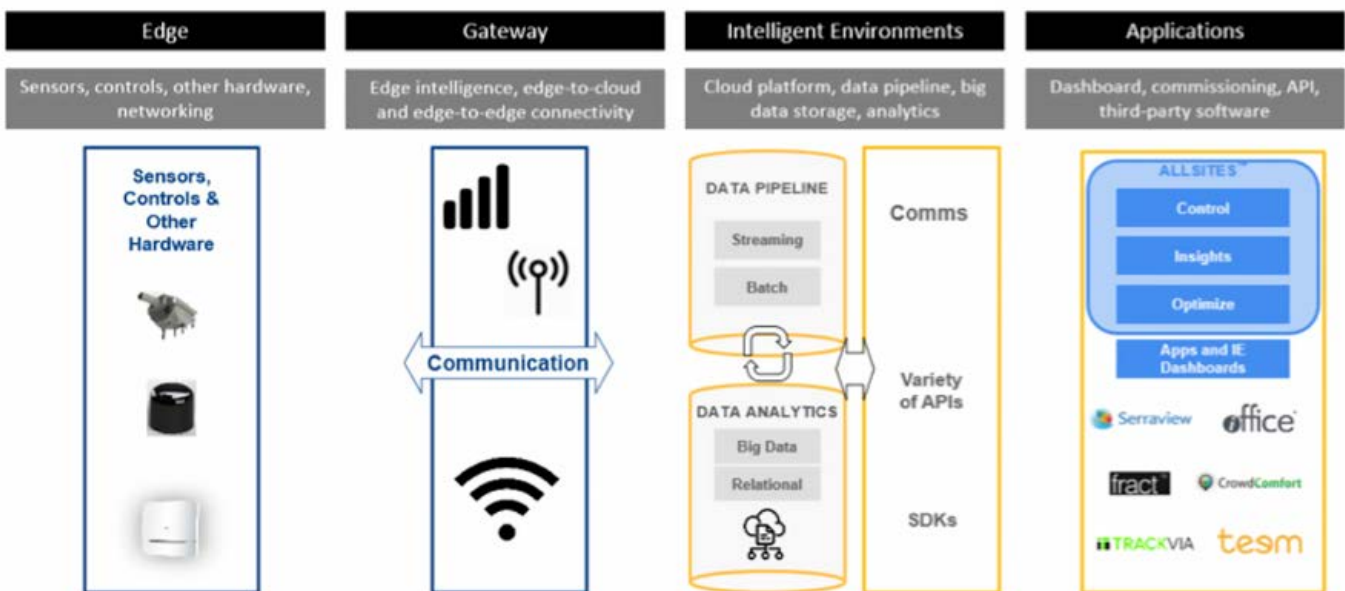
As big data usage rapidly expands across industrial, retail and commercial markets, many technologies are emerging to facilitate the collection, aggregation, and utilization of edge device data—accelerating organizational productivity, increasing operational efficiency, and reducing overall costs.

Big data coupled with API accessibility has the potential to transform how organizations ingest, process, and integrate real-time data across IoT cloud systems and applications, which enrich analytical insights and lead to value growth and cost-saving outcomes. But how does an organization leverage the power of big data and APIs? What is needed to build an effective digital engine? What technologies are most crucial to adopt and utilize within an organization’s technology stack environment?

Open-at-the-bottom infrastructure means device agnostic support, industry standard protocols and is an important differentiator that sets apart solutions. In an intelligent environment, thousands of data points will be streamed from multiple locations, across multiple sites. The data must be properly managed, kept high-quality, secure, and available for near real-time and historic analysis.

In order to build a reliable, scalable and robust IE platform, world-class technology solutions, which have the capability to harmonize within a technology stack, must be considered. Let’s look at the critical elements needed to drive an effective digital engine to power a true intelligent environment.

The Fundamentals of an Intelligent Environment



IoT Gateway

One of the core components of any IE platform infrastructure is the ability to store, transform, and stream varietal and complex data types with the expectation of low latency deliverability. To ingest edge device data from specific endpoints and push it to a cloud repository, an IoT gateway such as RabbitMQ is needed. That gateway must support IoT-relevant protocols including AMQP, STOMP, AMQP 1.0, HTTP, and most importantly the MQTT protocol, which is considered the standard protocol for the IoT. The gateway acts as a database intermediary between the edge device and the IoT cloud platform.

Utilizing a data processing intermediary layer such as RabbitMQ between edge and cloud systems protects the operational integrity of the platform by decoupling edge-to-cloud dependencies while maintaining data flow and integration continuity. It does this by separating the sending and receiving of data asynchronously. The IoT gateway acts as its own reliability factor, and therefore the system is at reduced risk of being a single point of failure and bringing down entire operations.

Other advantages of a IoT gateway like RabbitMQ may include the ability to:

- Push work into background processes, freeing web servers to handle more users
- Scale the most frequently used parts of your system without having to scale everything
- Handle what would have been catastrophic crashes with relative ease
- Deal with seemingly impossible response time requirements for webhooks
- Write all services in different languages, within unique application environments

Analytics Engine

Once an IoT gateway has been established to handle the initial data ingestion from the edge device network, large-scale data must be processed via an analytics engine such as Apache Spark. The analytics engine acts a data broker between the IoT gateway and the cloud database environment, which enables data processing to take place multiple times faster than with other data processing technologies. The role of the analytics engine within an IE platform environment is to significantly improve data processing times and overall performance for both batch processing and real-time data streaming (micro-batch processing). Using Apache Spark to run batches and micro-batches enables real-time data streaming, using the state-of-the-art DAGScheduler, a query optimizer, and physical execution engine.

Apache Spark also powers a stack of development libraries including SQL, DataFrames, MLlib, GraphX and Spark Streaming, which combine SQL, streaming, and complex analytics data processing within a single technology stack. Furthermore, the analytics engine makes it extremely easy to utilize over 80 high-level operators to build parallel apps by using them interactively from Scala, Python, R and SQL shells.

Database Infrastructure

Perhaps the most critical component of any IE platform is the database, which typically must support multiple data types and complex data structures. This can be achieved by implementing relational (SQL) and non-relational (NoSQL) database infrastructure types such as PostgreSQL and Cassandra. Cassandra is an Apache-based database solution that utilizes linear scalability and proven fault-tolerance without compromising performance for mission-critical applications. The Apache Cassandra database environment is used for non-relational data structures, including times-series data, that can be conjoined with relational data that resides in a more traditional relational SQL database, such as PostgreSQL. Ultimately, data can be surfaced to a dashboard layer, such as AllSites, for viewing and manipulation.

To handle the intense processing requirements of time-series data, a robust linear scaling system like Cassandra must be used to handle massive volumes of data flowing into the system, with the ability to determine the right amount of capacity needed based on data flow. Another compelling feature of Cassandra is that there is no single point of failure within the database environment. Even if there is a temporary loss of multiple nodes, there would be a negligible impact to the overall performance of the remaining data clusters within the database.

It is no surprise that some of the largest and most sophisticated companies in the world use Apache Cassandra for its ability to scale and easily handle massive datasets. Companies such as Current by GE, Netflix, Hulu, Instagram, eBay, Apple, and Spotify all have Cassandra working in interesting ways as part of their enterprise technology stacks because of its ability to scale, reliability and high-performance factors.

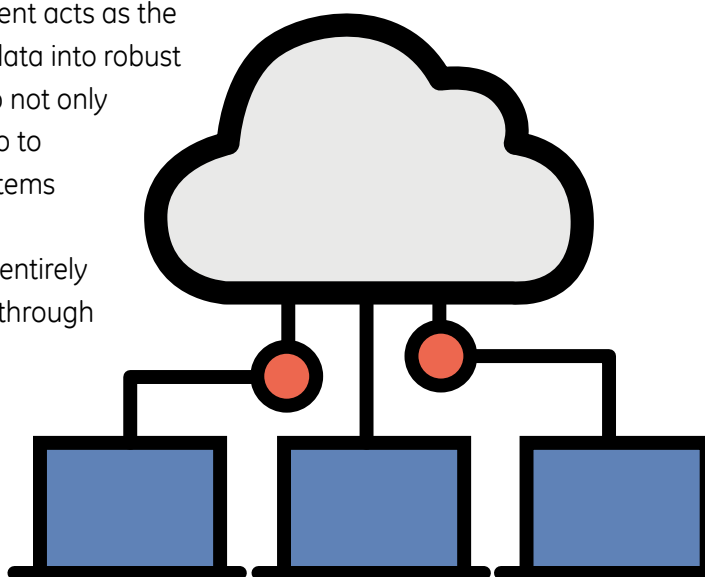
In addition to a non-relational database, the IE platform will need to include a relational database to handle physical model information such as building layouts, multi-floor buildings, offices and rooms, etc. The physical location information is defined within the relational database and interacts with the time-series data handled by the NoSQL database, which harmonizes the accessibility and speed of delivery at scale to an end user application. A common but powerful relational database that is often used is PostgreSQL.

PostgreSQL is one of the world's most powerful open-source object-relational database systems, with over 30 years of active development and deployment. PostgreSQL comes with many features aimed to help developers build applications, protect data integrity and build fault-tolerant environments, and to help manage data no matter how big or small the dataset. The solution is completely open source and highly extensible, making it ideal to manage multiple data types and build out custom functions.

The Role of APIs: Data Integration & Utilization

After the foundational components of an Intelligent Environment infrastructure are put in place, data can then be extracted or transferred to any third-party application or system via the use of APIs. The most common approach to accessing edge device data through APIs is to subscribe to a data feed, which is typically setup using a webhook or web socket service. By embracing an open-at-the-top philosophy, all data can be accessed and transferred in multiple formats such as JSON, XML, CSV, and so on. Data can be seamlessly accessed from within any technical environment and used within virtually any system or application. Current by GE utilizes open APIs in precisely this way, leveraging edge device data in its AllSites enterprise platform—a unified controls and analytics application for managing energy and assets.

Leveraging APIs, Current by GE empowers organizations to not only manage and control lighting remotely, but also enables them to tap into edge device data and have it available from within a controlled, nicely designed dashboard user interface. This data can also be combined with any third-party dataset to enrich and enhance the analytical insights and output. In this case, Current acts as the information pipeline, turning valuable edge device data into robust APIs, which give organizations tremendous power to not only liberate data to generate analytical insights, but also to leverage and utilize that data within third-party systems and applications. This creates a powerful disruptive environment for innovation and the development of entirely new business models and ways of monetizing data through value creation never thought of before.



Software Developer Kits

Current by GE's approach to IPS is based on the utilization of both Bluetooth Low Energy (BLE) beacons and VLC systems, which require both a standard and mobile SDK to operate. A standard SDK typically powers and maintains an LED fixture sensor unit with the latest security updates, communication protocols, and standards. This type of SDK enables communication with the location-based services infrastructure to read and cross-reference BLE beacon IDs with site configuration files to determine device position. Alternatively, a mobile SDK may be available for integration with third-party mobile applications suitable for indoor positioning use cases. In a traditional LBS and IPS environment, a standard SDK enables a device running an integrated mobile application to track IDs from LED fixture embedded VLC / BLE Beacon IDs, while a mobile SDK determines and presents device position to integrated mobile applications for application use directly on the mobile device.

A common setup to power IPS and LBS solutions may:

- Install and commission fixture(s) with VLC and embedded BLE beacons
- Setup mobile device SDK to track beacon ID and to determine proximity and position
- Enable API access to commissioned site beacon list through an IE platform cloud web service
- Manage BLE beacons and ID rotation process and scheduling
- Coordinate BLE beacon ID rotation process
- Configure ISV applications by site and floor plan for visualization
- Process position event and visualize onsite floor plan

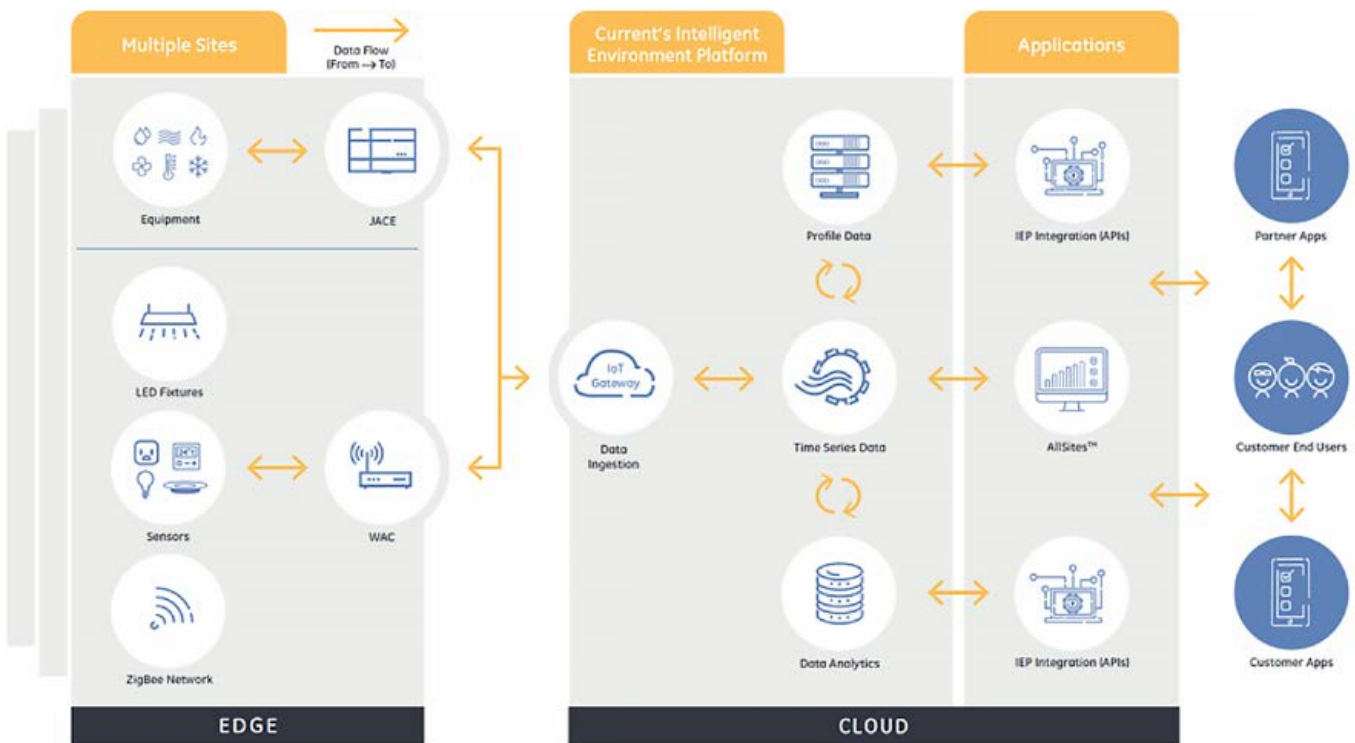
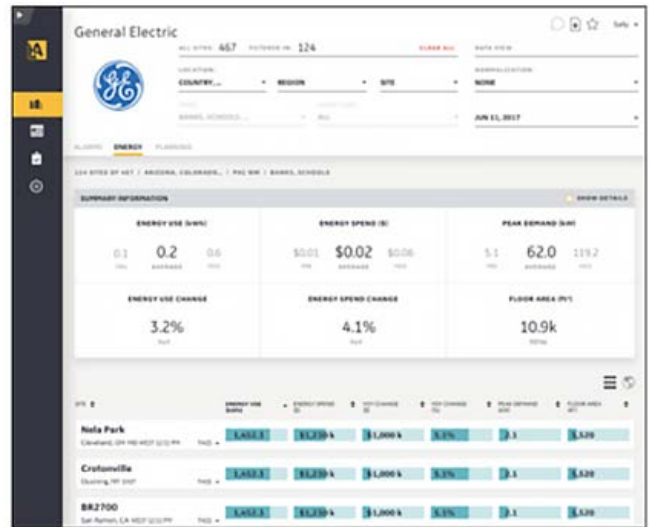
Specifically, the LBS Mobile SDK provides an indoor positioning solution using Current, LBS infrastructure comprised of luminaires with integrated Photobands and BLE beacon technology. The technology is compatible with a wide range of LED lighting products, including both dimmable and non-dimmable luminaires.

When the SDK is used by a mobile application, a mobile device running the integrated application uses the front-facing camera or Bluetooth radio to determine device positions by cross referencing information presented by the luminaire above with site commissioning information. The SDK presents the device position information to the integrated application to support indoor positioning use cases.

Unified Analytics & Controls with AllSites

Today, companies with multiple locations face a familiar challenge—how to maximize energy efficiency and cost effectiveness of operations across the enterprise given the diversity of lighting, HVAC, plug load and refrigeration systems, often from many different vendors, spread across multiple geographic locations. Companies need a unified approach for managing their real estate portfolios that not only considers the efficiency of these systems, but also lays the foundation to optimize how productive these spaces are for their occupants and can enhance the utilization and experience of the space for building occupants. They need a solution capable of delivering energy efficiency and business productivity outcomes at scale and in real time.

AllSites, Current by GE's unified controls and energy management app, is a sophisticated solution that provides the tools to transform how enterprises approach multi-site energy management, leveraging big data analytics built on Current's Intelligent Environment Platform. Organizations now can look across their commercial, retail, or industrial facilities and unify energy and lighting management operations into one centralized application. This gives executive management teams a significant advantage, as they are now able to remotely optimize operations, reduce energy consumption, and decrease costs like never before. It also enables leadership to gain unique insights to better understand how and where energy is consumed, identify operational issues such as lighting and HVAC failures, and project future energy needs.



Third-Party Productivity Applications: Making Data Work for You

Daintree is one of the leading open wireless controls solutions, which delivers dramatic energy savings and operational efficiency improvements in a simpler, more cost-effective way than ever before. **Daintree** helps smart buildings run more efficiently and with increased productivity while also providing a platform for the Internet of Things.

Daintree enables the collection and aggregation of data at the edge of business operations, while APIs deliver the promise of integrating that data into third-party systems and applications, such as ISV productivity apps. Leveraging an open-at-the-top framework enables organizations to fully control their data and choose how to utilize it, whether for optimizing existing business processes or to generate incremental revenue through entirely new business monetization models. No matter the use case, organizations can now use edge device data to strategically outperform the competition.

Once device data has been successfully routed from edge to cloud, it can be mapped and integrated into hundreds of productivity apps, to help organizations begin to unlock powerful insights to generate higher cost-savings, increased productivity and optimal efficiency across their portfolios.

App Ecosystem: Experts in Your Industry & Your Goals

Our open platform is built to use third party apps for significant gains in energy and beyond. You benefit from our curated ecosystem of over 125 app partners, each an industry expert.

Preselected industry-specific starter kits:

Office



*Optimize Productivity
& Space*



*Optimize Productivity
& Space*

Retail



Inventory Management



Shopping Behavior



Shopping Behavior

Industrial



Site Performance



Inventory Management

Fract

A key example of how edge device data may be integrated into a retail productivity app to impact operations can be found by examining the software solution Fract. Fract helps businesses increase market share in their locations via a geoSpatial artificial intelligence platform that integrates a variety of data points to generate actionable insights for improved revenue and ROI. Fract typically works with business intelligence and store planning departments to help understand and improve poor performing locations and optimize incremental revenues.



Fract provides crucial environmental, demographic, and product assortment data that can be conjoined with Current by GE's edge device data through the IE platform API to enhance overall retail operations. For example, outdoor weather conditions may correlate with the amount of time a customer spends shopping inside of a retail store. As the outdoor temperature rises and the weather becomes increasingly warmer, customers may remain inside of a retail location longer, leading to a larger basket size and/or value. From an alternative perspective, perhaps the outdoor temperature did not correlate to any change in customer purchasing behavior, in which case a retail business owner would focus on more important factors that contribute to purchasing behavior. Other, similar questions retailers may ask may include, what types of products sell better under specific weather conditions? How does weather impact customer foot traffic? Does a certain customer demographic purchase an increased amount of a product under specific circumstances?

By optimizing for environments that drive customer behaviors at the product, category, and store level across the enterprise, Fract's AI platform can help determine if the energy saving methods not only reduce cost, but also impact revenues.

Combining organizational edge device data and third-party data within a productivity app can lead to powerful outcomes. Leveraging Fract as an IoT partner, organizations will be able to get a better understanding of their customer environments and will be able to extract precision of data with increased granularity of sensors, using cross-data comparisons and correlation feeds to drive insights. These types of data processes will lead to improved in-store performance and greater localization at the store and department level.



Motionloft

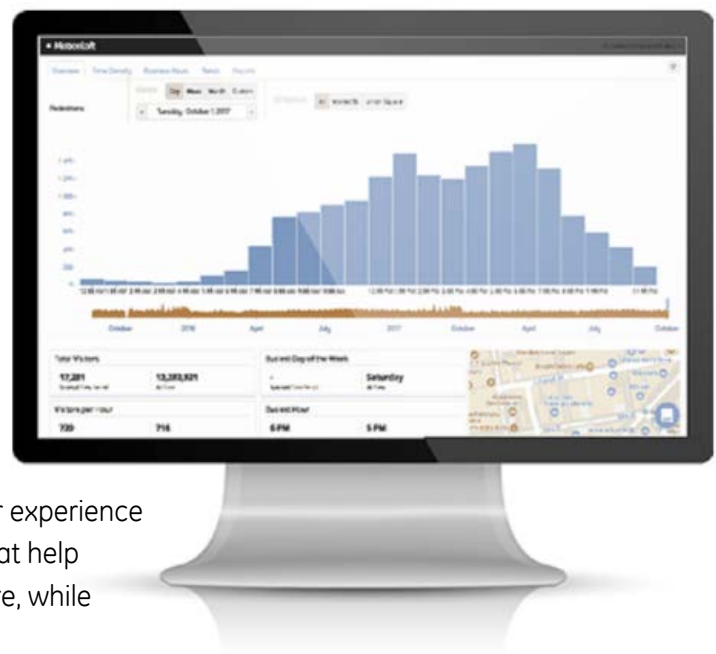
A powerful solution that enables retailers to optimize merchandise planning and customer traffic pathways is Motionloft. Motionloft is an AI-powered ViMo tracking solution that leverages the NVIDIA TX1 processor to convert stereoscopic video into meaningful data like people counts, traffic, pathway and dwell time analysis.

By using machine learning and artificial neural networks, Motionloft's data can be viewed in real-time dashboards or combined with other data sets to provide a holistic view of business operations and better inform decisions.

Motionloft

Using this powerful technology combined with Current by GE edge data, retailers have the opportunity to incorporate indoor positioning and location-based data into their business operations to optimize the customer shopping experience, maximize the endcap and shelf space, and make better decisions about product

placement in relation to in-store customer behavior. Perhaps a retailer would like to notify customers of a coupon or promotion while they are visiting a certain aisle in the store. Maybe a retailer wants to track the number of people who checkout each day and analyze the busiest times of day to best optimize counter lines or product placement. By analyzing customer traffic pathways and how much time they spend in certain areas of the store, a retailer can strategically predict where to place a product to maximize sales. Utilizing data, a retailer now has powerful tools to optimize the in-store customer experience and checkout process by improving store layouts that help customers shop more efficiently throughout the store, while increasing the average dollar spent per customer.



Keonn

Keonn is one of the leading manufacturers of RFID hardware and software products for the retail, healthcare, industrial, and logistics spaces. They provide RFID systems that help retailers improve loss prevention, track and manage inventory, track and analyze customer pathways, and so on.



In addition to the powerful data that Keonn provides to enhance retail operations, edge device data from Current by GE's IE platform and partner ecosystem can also be incorporated into the aggregated dataset. By doing so, Keonn can not only expand their own analytics footprint, but also help to drive powerful customer-centric programs and campaigns for retailers. For example, the popular trend of buy online, pickup in-store (BOPIS) has created vast opportunities for retailers but has simultaneously created challenges for those who do not embrace new technology and data-driven solutions. Because of the constant development of new, more insightful technologies, there is a growing demand from retailers to develop and adopt new technologies that can quickly and accurately help employees locate in-store products or merchandise for delivery to customers.



By providing the right tools and technology, retailers can empower employees to successfully manage and run programs such as BOPIS, with incredibly positive results. To run such a program, a highly accurate indoor positioning system must be used to track and locate store inventory, at the right time. Retailers must be able to track inventory and enable employees to locate that inventory no matter where it is, even if it hasn't been inventoried by an in-store scanner. Combining Current by GE's indoor positioning, location-based wayfinding and the Keonn data intelligence ecosystem, retailers can fully take advantage of implementing customer-focused programs aimed at increasing in-store checkout sales while decreasing overall product loss.

More About Current's Daintree Platform

The **Daintree** "edge," meaning the devices themselves, are a functioning switch, sensor, actuator, monitor and network carrier with the ability to scale effortlessly to cover tens of millions of square feet and thousands of facilities.

Daintree Enterprise is among a growing list of emerging solutions adding intelligence to the edge in a quest to deliver short-term benefits from IoT applications. Since most of these products represent an investment in long-term infrastructure and a commitment to a given path, the decisions made today may have decades-long implications. **Daintree** is one of—if not the—most reliable and mature options on the market. The **Daintree** team pioneered the use of mesh RF in commercial building technology. With much of our team intact after over 15 years, delivering virtually all of the industry firsts, 300 million square feet of active users and almost 10 years of ControlScope application development, the maturity of the solution is orders of magnitude beyond that of every other lighting oriented IoT solution provider in the market.

Current is already leading the pack when it comes to providing banks with the IoT applications they want, and we will continue to offer the most flexible and all-encompassing platform. Current supports the ZigBee Building Automation Standard in its entirety. There are dozens of regularly deployed devices manufactured by the large ZigBee ecosystem enabling a dramatic range of applications in lighting, HVAC, power metering, environmental sensing and beyond. While there are many ZigBee solutions offered by the majors, not one is purely interoperable; they have built their businesses on the leverage of a proprietary offer. The benefits of a large standards-based ecosystem include competition at the device level, your choice of hardware manufacturers and ultimately your choice of software providers. The investment in a true standards-based technology will provide SunTrust the ability to select another software supplier without removing and replacing hardware. No other edge-to-cloud IoT solution provider in this space can make this same claim.

The open standard environment allows Current to utilize a large variety of hardware in creating the ideal solution for the specific application. For example, we offer Zan Compute, a ZigBee-based janitorial sensor for on-demand maintenance, as well as analog integrated multi-gas sniffers (RKI) for restroom monitoring. And the highly accurate people-counting sensors that are so integral to analyzing the customer experience are Zigbee mesh-friendly and were first brought to customers by Current. That's in addition to the combined outdoor and indoor lighting monitoring and control systems that are viewable under a single enterprise interface.



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