

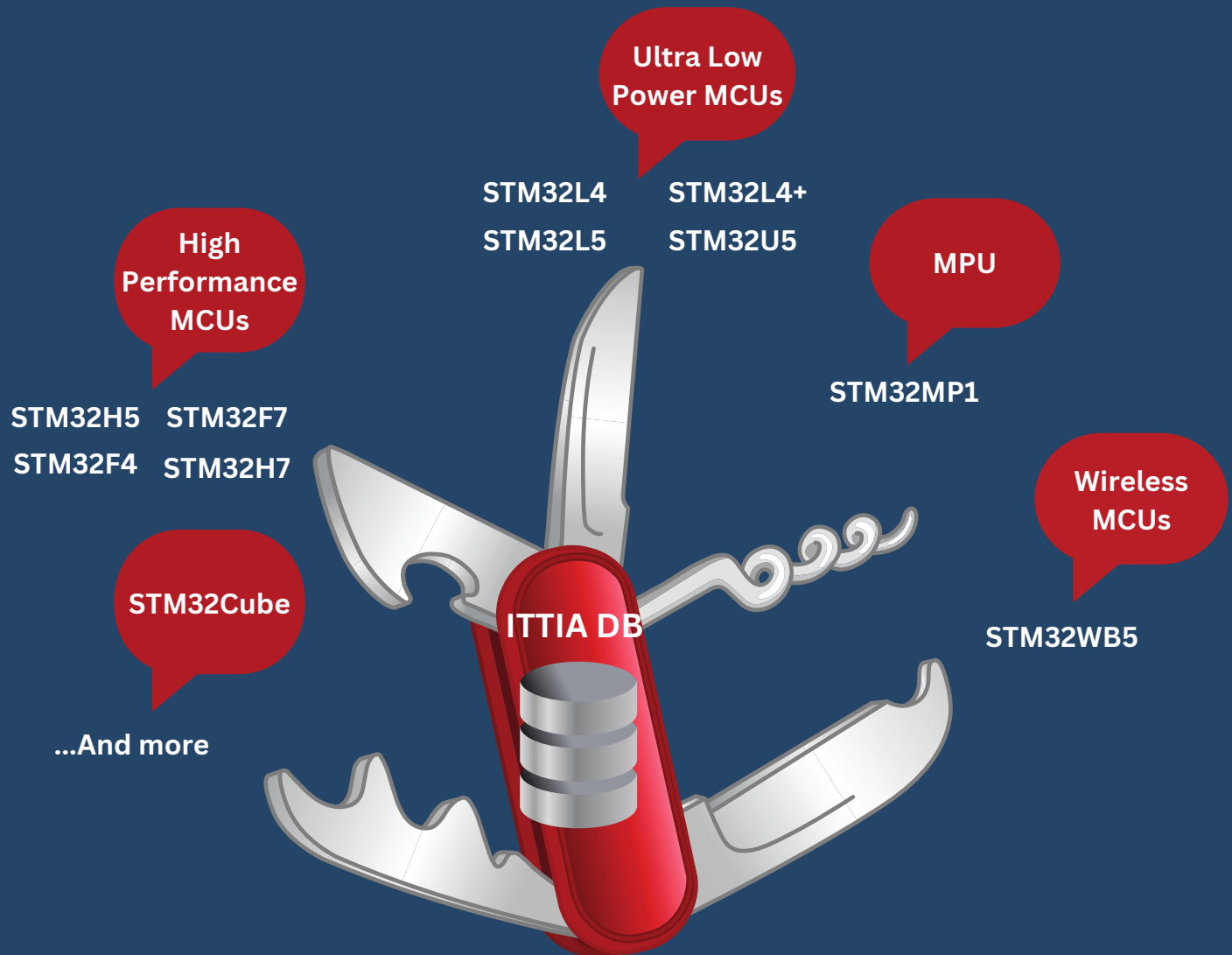
BOOST **STM32** DEVICE **DATA** PROCESSING & MANAGEMENT

2024

REFINE DATA, STORE INFORMATION
ALL AT THE EDGE

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"A SYNOPSIS OF CURRENT CHOICES FOR STM32 DEVICE DATA PROCESSING AND MANAGEMENT."



"RECORD ALL METRICS, EVENTS, LOGS, AND OTHER DATA POINTS. ACQUIRE REAL-TIME PERCEPTION."

Overview

In the wake of the Internet of Things (IoT) and Artificial Intelligence (AI) era, applications running on an edge network, such as STM32 devices from STMicroelectronics, need to be able to absorb, process, and interpret data points at a high sample rate. A crucial part of many embedded systems are microcontrollers (MCUs), which are increasingly in charge of gathering, processing, and managing the data that arrives and passes through them via sensors and other datapoints. The procedure begins locally with devices like STM32 where manufacturers are searching for creative ways to comprehend and monetize every bit of data that they can collect.

Meanwhile, there are difficulties that real-time device data management brings. To solve these challenges, we designed ITTIA DB IoT embeddable database software that enables interactive queries to be run on data streams to filter, aggregate, split, and combine datapoints prior to transmission or storage. With just one platform, developers can choose from three different data engines offered by ITTIA DB IoT: stream processing, time series, or relational table data management on supported STM32 devices. ITTIA DB IoT is an embeddable database that is small enough to run on a microcontroller, like STM32, and flexible enough to be customized.

Modern embedded systems applications require the flexibility to launch fresh data collection campaigns at any moment, receive ongoing updates, or terminate the campaign before querying the campaign's final outcomes locally at the device. This minimizes both the cost of data transmission and data maintenance while prioritizing the critical information needed to make decisions. ITTIA DB IoT includes the database features needed to scale up the deployment and management of edge devices and related data workloads. It is designed for embedded systems devices such as STM32 to meet the demands of data workloads operating in resource-constrained, field-deployed devices. It is built to combine lightweight time series data management and data processing through support for HTAP queries. ITTIA DB IoT's hybrid transaction/analytical processing (HTAP) architecture is the best method to enable analytical processing on the same data store that is also used to perform transactional processing.

Devoted ITTIA DB developers have partnered with STMicroelectronics to provide an exceptional, premium commercial grade data platform for STM32 devices. Organization of data is made easy by ITTIA DB IoT queries, which allow analysis within STM32 applications at the point of origin of each datapoint.

We will explain issues resolved by ITTIA DB IoT for STM32 applications in this white paper.

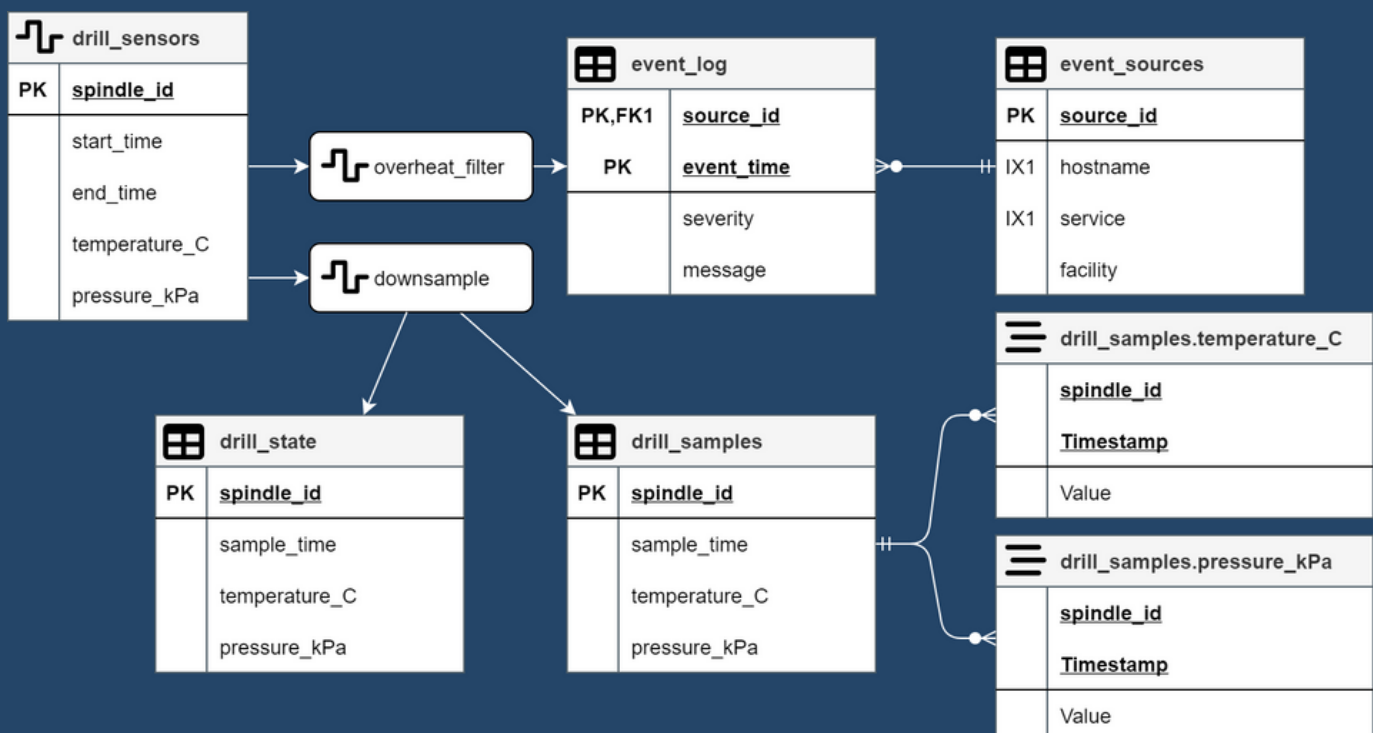
Use Case: Gain Insight by Streaming Fresh Data with STM32 in an Industrial Drill

Device manufacturers must design software to process a high volume of time series data in real time with high throughput. For real time events, the device must react with low latency. Many decisions need to be made concurrently in multiple threads, tasks, and processes while processing results are captured to local flash media.

In industrial automation, complex machines continuously produce and consume data about a series of real-world tasks. For example, an industrial drilling machine must monitor the temperature of the drill bit and apply a cooling fluid to prevent overheating. If the temperature exceeds a certain threshold, the machine must stop operating to protect the equipment. After a certain amount of use, the drill bit must be replaced, and other maintenance must be performed from time to time.

Many of these activities can be automated by embedded software installed on the industrial drill. On an STM32 device embedded in an industrial drill, ITTIA DB IoT can be used to monitor drill bit temperature and cooling fluid pressure, log significant events, such as overheating, and analyze stored data for preventative maintenance:

- Measure temperature and pressure at a high sample rate.
- Update recorded sample values once per second.
- Respond to high temperature events with predictable, low latency.
- Query data recorded in the event log..



Real-time data collection campaigns

The influx of real-time data from sensors and other sources can cause data congestion and impede the flow of insights needed for making decisions. Real-time data needs to be collected, processed, and transmitted right away. When data is used for navigation, tracking, measurement, and other purposes, there is frequently delay in its timeliness. Such data needs to be processed utilizing real-time database.

There are difficulties that come with collection and managing data in real-time on STM32 devices. To solve these challenges, ITTIA DB IoT enables interactive queries to be run on data streams to filter, aggregate, split, and combine data points prior to transmission or storage. Applications running on STM32 devices can embed ITTIA DB IoT and have the flexibility to launch fresh data collection campaigns at any moment, receive ongoing updates, or terminate the campaign before querying the campaign's final outcomes. In this way, data transmission is minimized but important information required to make decisions is prioritized.

Real-time data streaming and monitoring

Real-time analytics is a field that involves continuously ingesting, indexing, analyzing, and either transmitting or storing a sizable volume of data points on STM32 devices. Data points need to be tracked, searched, filtered, combined, and handled in accordance with predetermined queries. Now, with ITTIA DB IoT, developers can construct firmware programs to dynamically aggregate, filter, split, and combine real-time data into a series of processed events using ITTIA DB IoT for STM32 devices. This makes it possible for sensor devices to perform ongoing analysis, interpret all the raw data, spot concerning events, and release and preserve insightful discoveries.

Data categorization and organization

Data organization and the benefits of data classification are the primary value of the ITTIA DB IoT integration with STM32 applications. Data categorization is the process of organizing data based on its characteristics and attributes, and then assigning class labels that describe a set of attributes that apply to the corresponding data sets. Without limitations, this is a well-known procedure for enterprise systems now available for STM32 embedded devices. Giving unstructured, raw data significant class features and allowing stake holders to arrange and draw conclusions from a set of data points are possible with STM32 devices.

Storing clean data

Like many other computing platforms, there are STM32 devices that must process and filter a large amount of data before storing only the relevant portions. What is involved in cleaning STM32 data? Data cleansing is the process of ensuring that data is reliable, consistent, and valuable.

Through data retention restrictions that eliminate outdated data, or by detecting unwanted data before it is stored, STM32 applications can refine data and store valuable information with ITTIA DB IoT. There are several benefits to having clean data. Data cleaning decreases power consumption during data transmission and removes a large amount of unwanted raw data storage when multiple data sources are merged into a single dataset.

Time series data management

Embedded system applications frequently store multiple data points sampled at different speeds. ITTIA DB IoT, an embedded time-series database, is designed to store and retrieve related timestamp-value pairs. Because of this, STM32 applications can successfully query any combination of recorded data points, measure values from sensory devices, and examine how those data points change over time. The ability for STM32 applications to monitor, store, and analyze real-time data at all times is one of the primary benefits of ITTIA DB IoT time series offering. ITTIA DB IoT is optimized for STM32 devices to store time series through associated pairs of time(s) and value(s).

Data integrity and scalability

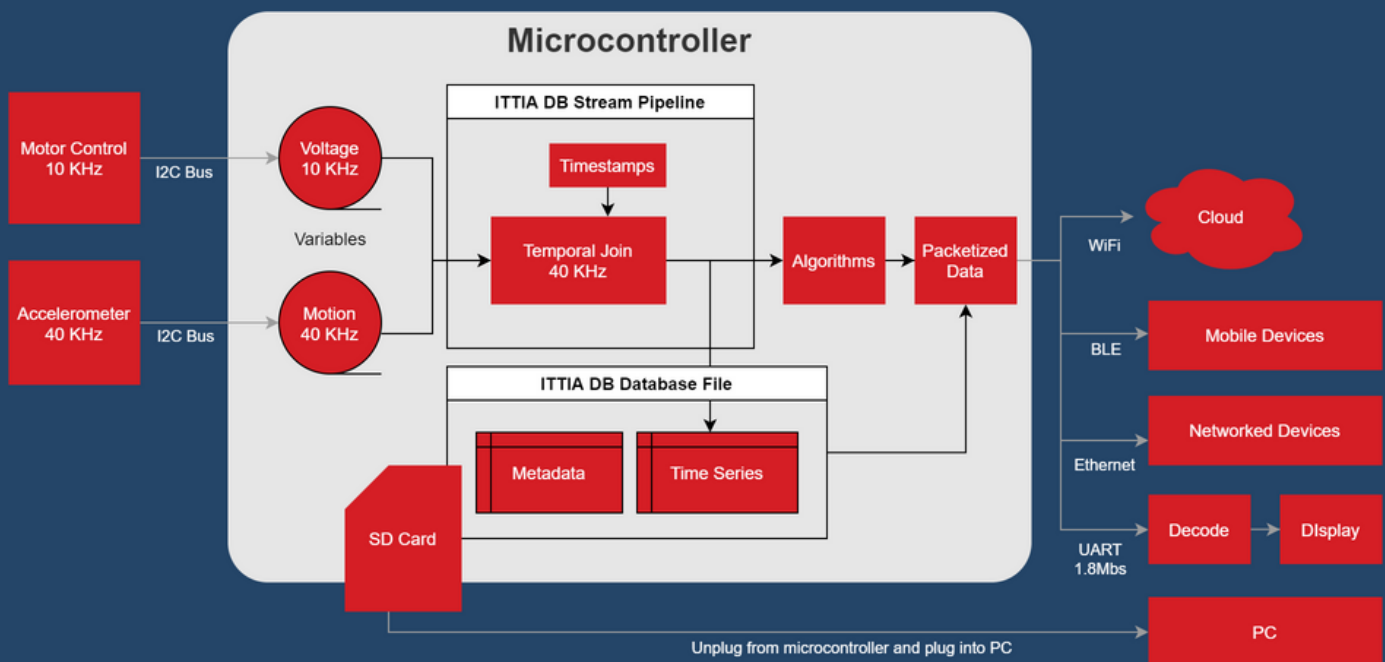
Data produced by data points such as sensors need device data enablement for deeper understanding and connections between operations and decision-making components. Since these data-driven diagnostics are utilized to support systems intelligence and decision-making capabilities, their integrity is essential. Therefore, as data utilized by embedded systems gains more and more influence over decision-making processes, it becomes increasingly important for STM32 devices to understand data and make prompt, confident, and accurate decisions.

Furthermore, data integrity becomes even more crucial as machine learning (ML) and artificial intelligence (AI) are used to support decision-making more often. To ensure that AI models accurately reflect the reality that the system is forecasting, they must be grounded in high-quality training data, and their inferences must be supported by high-quality operational data. ITTIA DB IoT offers data integrity by ensuring that data is stored and processed according to the data model specified by STM32 application developers. In addition, ITTIA DB IoT provides a path for device manufacturers to scale up STM32 applications to different levels of computing by enabling data features and functionality only when additional resources are available.

Use Case: Sensor Fusion by Synchronizing Timestamped Variables on STM32

Combining data from high frequency data sources is not trivial for data that originates from the Internet of Things. Sending every sampled value to the Cloud consumes a significant bandwidth cost, but processing data on IoT devices themselves requires synchronization of the data sources before algorithms are run on Cortex-M MPUs. Design decisions, such as where to store the data and the medium of communication, will further limit the rate data can be processed.

Consider a ceiling fan that combines data from voltage and motion sensors to identify correlations that affect efficiency and lifetime. By measuring voltage from the motor control at 10 KHz and motion data from an accelerometer at 40 KHz, an STM32 microcontroller can achieve sensor fusion. ITTIA DB's temporal join operator combines data from various timestamped data sources within a configurable time interval. The results are sent to various algorithms and stored as time series in an ITTIA DB database file. The results are sent to various algorithms and stored as time series in an ITTIA DB database file.



Data extracted from ITTIA DB can be divided into packets and sent over any medium, such as WiFi, Bluetooth Low Energy (BLE), Ethernet, or UART. Alternately, if the database file is stored on an SD card, it can be unplugged from the microcontroller and accessed directly on a PC or similar system.

Accuracy, completeness, consistency, and validity

Data quality, a quantitative measure of a dataset's compliance with correctness, completeness, and validity standards, is a prerequisite for any data governance activities utilizing STM32 embedded systems. The level of data quality that the system needs to make the finest data-driven decisions is provided by ITTIA DB IoT, which is designed with MCUs in mind.

An STM32 embedded system can trust data and use it to make better decisions only when the quality of the data satisfies the requirements of the use for which it is designed. Nevertheless, ITTIA DB IoT is designed for STM32 devices to aid in the diagnosis of underlying undesirable data when a data constraint isn't satisfied.

Data quality, data processing and management are becoming more and more crucial as manufacturers integrate automation, artificial intelligence (AI), and the Internet of Things (IoT) into their operations. With ITTIA DB IoT for STM32 devices, manufacturers of embedded systems can measure how well a dataset meets criteria for accuracy, completeness, validity, consistency, uniqueness, timeliness, and fitness for various purposes.

Data ownership

With STM32 modern devices, the amount of data generated at the edge is increasing at an exponential rate. Because of these reasons, data is extremely important, and because of issues with cost, performance, and privacy, handling massive datasets in one distanced place is becoming less and less feasible.

Instead of moving all raw data to a centralized place where computing power is plentiful, it is desirable and possible to move the computation near to the data source. ITTIA DB IoT for STM32 devices offers data computing at the edge which includes significant data cost reduction potential. STM32 device data management is much more appealing when combined with qualities like data ownership, decreased latency, optimum bandwidth consumption, offline or autonomous operation, and adherence to regulatory or security criteria that depends on physical location.

Security

Data access hugely magnifies embedded system security challenges, since devices must connect and communicate to each other, as well as the outside world. This offers intruders and bot networks new opportunities to enter the device and access the unprotected data. What can you do to protect device data? For STM32 devices with layers of protection, ITTIA DB IoT includes encryption and the ability to support hardware security layers, in addition to the security implementations developed by ST in the context of security assurance.

ITTIA SDL is conformant to the principles of IEC/ISO 62443. ITTIA security practices and features assist manufacturers of IoT edge devices with advanced and integrated software development methods, infused by a secure development life cycle (SDL) based on zero trust principles, enabling makers of IoT edge devices to mitigate unpredictability. From product conception to end-of-life, ITTIA adheres to a secure-by-design development methodology, and ITTIA DB offers a complete solution to secure data on IoT devices.

Performance and Footprint

Processing data closer to the source reduces the amount of data flowing to and from the primary network, leading to lower latency and better throughput. However, performance and footprint are major challenges with any embedded system development discipline, including STM32 devices. These device applications usually perform many different tasks on data stored in the database. Some tasks perform best when run in parallel, allowing long-running activities such as synchronization to complete without first stopping normal operations. Tasks can be performed by a single application with multiple threads or tasks.

ITTIA DB IoT for STM32 devices provides development flexibility so you can design data models, database schemas, and application code to solve complex queries with high performance, small footprint and enable rapid application development. ITTIA DB IoT is a highly concurrent database, offers applications to work with multiple queries and supports reads and updates to the database at the same time. ITTIA DB IoT provides development flexibility so you can design data models, database schemas, and application code to solve complex queries with high performance and enable rapid application development.

Affordability

Traditional flat file data management and free open-source alternatives are expensive when it comes to embedded systems, mostly because of the large upfront costs involved in customizing, maintaining and providing updates. Manufacturers prefer to focus on their own business and do not become a database company. In addition, they prefer to minimize time and headache in integrating data management solution with real-time operating systems, hardware, etc. That is why they invest in advance and select ITTIA.

ITTIA DB IoT, a specialized database designed for embedded systems, including STM32 devices, silently embeds and runs on the system and largely results in lower initial and long-term expenses. Since a large quantity of data is now processed and maintained locally on the device, there will also be significant savings on cloud data storage. In addition to this cost saving, real-time data retrieval can also fully remove the requirement to move data from a device to other systems and the cloud.

Integration Challenges

A unique set of data challenges arises when developing programs for embedded STM32 devices, including scalability, real-time performance assurance, integration, and interoperability issues, and more. STM32 applications are almost always part of larger systems, such as automated industrial equipment, digital watches, smart buildings equipment, camera and cars auxiliaries are a few examples.

Real-time operating systems, hardware, IDEs, integrated data management software, and other components are frequently found in these systems. These embedded solutions must work with limited memory, computing power, and energy availability while responding immediately to all inputs within the planned time range.

Furthermore, embedded software needs to be adaptable to changes in its operating environment since hardware components such as CPUs, sensors, and other parts may change over time. For embedded software, portability and autonomy are extremely challenging requirements. The main difficulty is making sure that every component functions effectively and cooperatively with one another. It's not an easy operation, and manufacturers will always need to use caution when selecting the database that will allow for hardware and software integration.

Apart from the data platform specifically built for contemporary embedded computing, ITTIA engineers are well known for assisting and granting customers access to their knowledge and expertise.

ITTIA DB IoT for STM32 devices

ITTIA DB IoT is a member of the ITTIA DB family that is made specifically for constrained Cortex-M devices. It supports time series, relational tables, and data streams in a single portable software library, and developers can choose any combination of these engines.

ITTIA DB IoT is designed to offer embedded systems real-time data processing and data management for a variety of data points, including metrics, events, logs, and more. Performance, compact size, and adaptability are the significant features of ITTIA DB IoT for embedded systems.

Conclusion

Manufacturers selecting STM32 devices have a strong need for a dependable data management system, whether it is for monitoring human health, controlling a building's temperature in real time, or drastically increasing a robot's capacity to operate autonomously. The need to capture time series data with data management is becoming clearer as hardware and product requirements must meet the demand of modern edge computing. A wide variety of STM32 devices can benefit from the modern embedded edge database ITTIA DB IoT. ITTIA enables manufacturers to closely focus on their application and rely on ITTIA DB IoT software and ITTIA's expertise, starting from design and development, and continuing all the way through deployment and production.

Contact ITTIA today and learn how ITTIA DB IoT efficiently solves your greatest STM32 data management challenges.

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Embeddable Edge Data Management