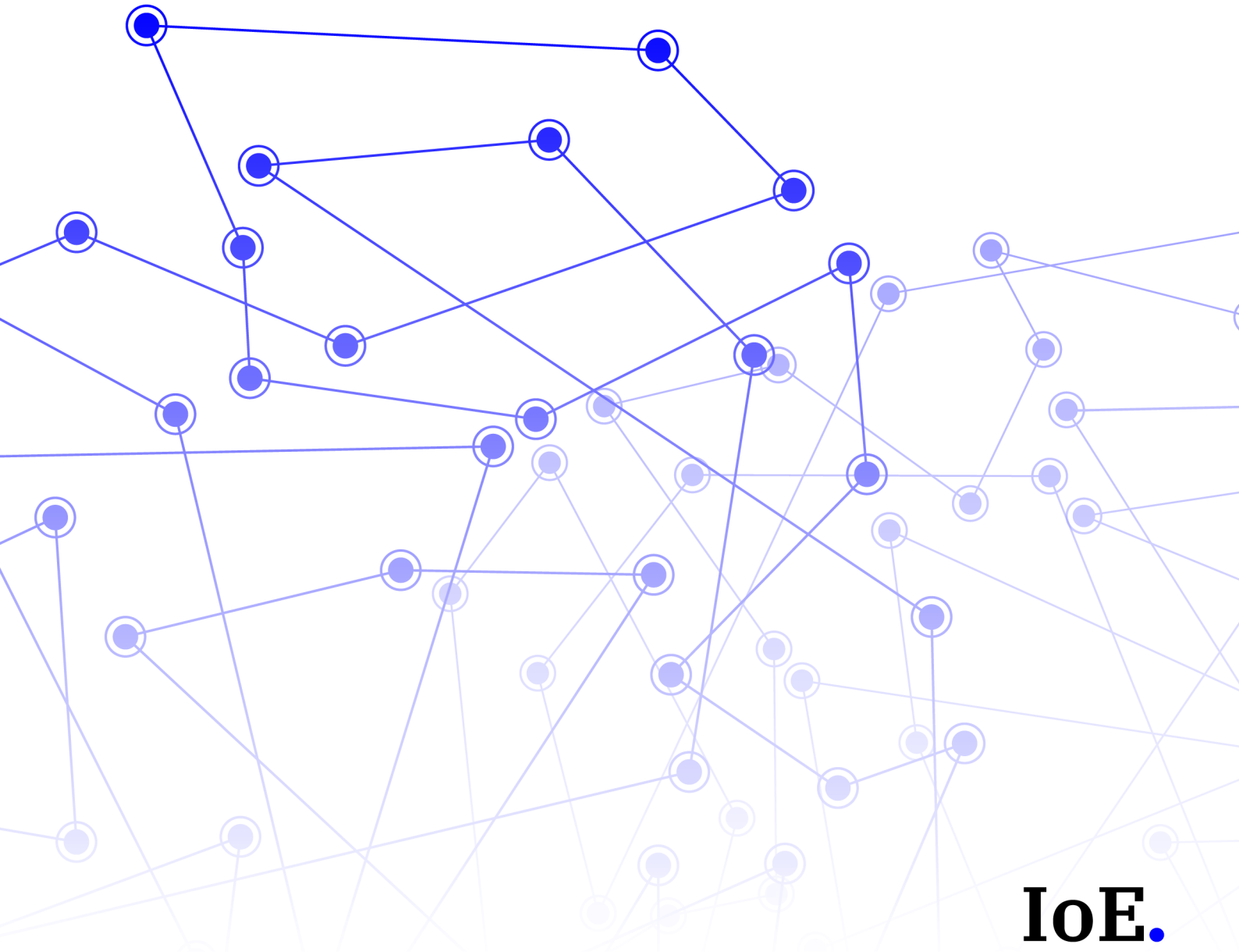
Cost-effective Internet of Things (IoT) traffic monitoring

Internet of Everything Corporation's Eden system's IoT data management & AI analytics on-premises leads the way to a highway of opportunities



IoE.

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Abstract

The internet of things (IoT) is moving into all aspects of our lives and industries. We are living in a moment where technology has the potential to make a real difference on a global scale. Humans are starting to be aware of the impact of our way of living.

Carbon emissions are reaching unsustainable levels, increasing the greenhouse effects and setting our only home, planet earth, in a dire situation. One of the issues regarding this problem is transportation. The pollution produced by vehicles is one of the reasons carbon emissions are at dangerous levels.

There is still hope to turn the tide; IoT and other technological innovations and optimizations, e.g., artificial intelligence (AI), digital twins, machine learning (ML), and blockchain technology, have the potential to start building better paths.

In the following presentation, we will discuss where technology stands today and how it needs to change to become a real asset in the dawn of the fourth industrial revolution, also known as Industry 4.0. We will concentrate on how IoT traffic monitoring can become cost-effective by moving from a centralized model to a decentralized model.

To present this, first, we will go through the disadvantages of centralized solutions, e.g., cloud service providers. We will show new options that can become tangible assets for data management of massive IoT deployments like traffic management systems.

Our final insights will focus on the opportunity Internet of Everything Corporation (IoE Corp) provides for IoT to monitor traffic cost-effectively. The IoE Corp's Eden system is now open for early access by applying to its Planet Partner Program.

Introduction

Since Henry Ford's assembly line began to produce vehicles by the thousands (the T Model reached fifteen million by the end of its lifecycle in 1927)[1], cars have been and continue to be essential. In 2015, around 947 million passenger cars and 335 million commercial vehicles were operating worldwide[2]. Being able to manage these numbers is a challenging process, as history has proven. Accidents, congestion, pollution, stress, and roadwork are some side effects of traffic on society.

Advancements to better vehicle fluidity are a top priority today, as these developments reduce accidents, pollution, stress, and roadwork maintenance. The fourth industrial revolution dawn, the interconnectivity between the digital and the physical, sets technology at the forefront of innovation. Massive internet of things (IoT) deployments have the potential to:

- Lower overall costs
- Provide safer working conditions
- Open new revenue opportunities
- Implement higher efficiency
- Raise living standards
- Reach the UN's sustainability goals

There are certain obstacles to tackle to achieve all these fantastic objectives setting humankind at a higher conscious level and working toward a better future. In the following lines, we will concentrate on the advantages of IoT to traffic monitoring, although IoT applications are being introduced throughout all industry verticals.

What is IoT traffic monitoring?

Monitoring traffic is not something new. We have all seen cameras set at specific locations, e.g., highways, city entrances, and car parks. What is happening today with IoT monitoring traffic is the capacity for these devices and sensors to communicate with each other and take action without human intervention. A simple example is when speed limit signs automatically indicate your driving speed and alert you if you exceed those limits.

IoT developments offer various services and products to help traffic monitoring become a real asset, ultima-

tely saving lives. In this sense, IoT monitors traffic development moves at neck-breaking speeds, resulting in data management cost-effectiveness issues. But before we deal with the cost-effectiveness problem, let's look at the positive IoT traffic monitoring provides.

The sole purpose of IoT is to monitor traffic in real-time. Unlike conventional traffic management systems, IoT monitors traffic as it happens; this way, traffic lights can change the times from green to red depending on the traffic flow. In other words, depending on traffic density at a given moment of the day, the time it takes to change from green to red can vary. In practical terms, if you are waiting for the light to turn green and the car flow is low, IoT traffic monitoring via its sensors can, in real-time, change predetermined times.

Applying these technological advancements to traffic can exponentially help reduce congestion, alert first responders of a collision, and send drivers real-time information. The use cases are endless. Therefore, the need to implement IoT, artificial intelligence (AI), machine learning (ML), and digital twins is paramount for traffic to enter the fourth industrial revolution as a real asset. There is no discussion about this aspect of technology's potential for traffic management.

Now that we have provided clear examples of IoT's benefits to enhance better driving conditions, let's look at why we have yet to reach IoT's full potential.

Centralized IoT data management issues

Big data has entered the zettabyte era, in digits - 1,000,000,000,000,000,000,000. This situation strains current data management systems, e.g., the cloud (Figure 1). Centralized server centers have been around for over two decades, providing excellent solutions for the necessities large and medium companies require. Unfortunately, the zettabyte era's paradigm shift spotlights weaknesses in a centralized data management system.

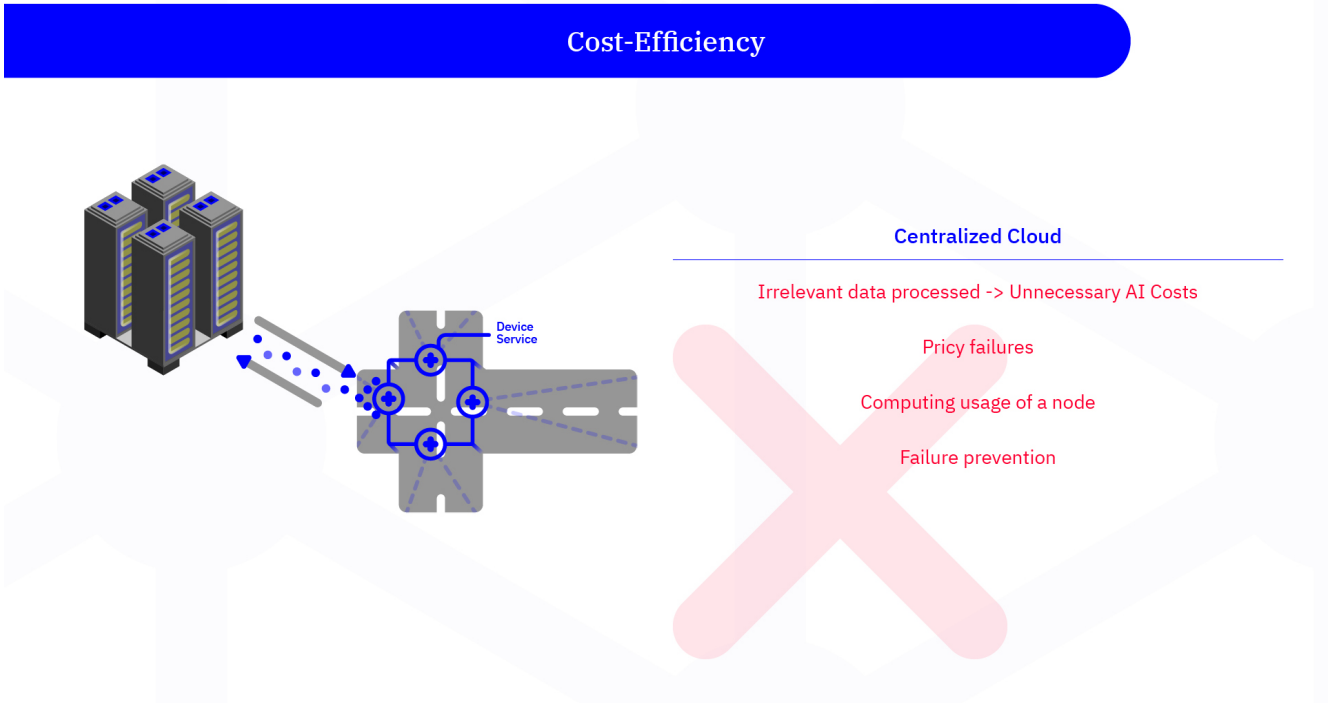

Figure 1. Data management cost-efficiency issues of centralized cloud providers

Cloud service providers' modus operandi requires all data to be moved to these large server centers for the data to be stored, processed, analyzed, and sent back to the source. Moving all raw data in this way opens up vulnerabilities with the potential to create traffic havoc and send monthly bills exorbitantly high. As it is on topic, imagine in five years, car manufacturing deploys in the market zetta-vehicles. Road infrastructure could not keep up, so traffic jams, pollution, stress levels, and accidents would skyrocket.

The same thing is occurring with data management now via the only solution currently to handle big data. Data generation has immensely overgrown the infrastructure, and to continue through the same path would be to enter the dead horse theory.

- The tribal wisdom of the Lakota Sioux - "If you find out you are riding a dead horse, the best strategy is to dismount and get a new horse."

The cloud is a dead horse in the zettabyte era; thus, trying to ride this horse with solutions like:

- Get a better whip.
- Change the riders.
- Set up a special committee to analyze the dead horse, or even better, hire an army of consultants and perform an in-depth analysis of the dead horse.
- Organize visits to other organizations and countries, and understand how foreign cultures manage to ride dead horses.
- Lower the standards to a level where dead horses become competitive.
- Reclassify dead horses into "life-disabled resources."
- Hire external staff to ride the dead horses.
- Harness dead horses together to increase overall speed.
- Allow additional budget to boost the performance of dead horses.
- Conduct a study on productivity and determine if lighter riders could improve a dead horse's performance.
- State that "it is crystal clear: since dead horses don't need to be fed, they are less costly and thus contribute more to profit than live horses."
- Redefine the standards to include all horses' categories.

This solution will not help, but if we look at recent years when IoT's deployment has constantly been growing, the only data management system at hand has been the cloud, i.e., a dead horse. We have been riding the dead horse and trying to find ways to make it come to life when the only viable solution is to find another better horse and, if possible alive.

Why is the cloud a dead horse?

Before presenting other solutions to tackle current data management issues for large IoT deployments, let's give facts to corroborate the dead horse theory. There are various problems with the cloud; these are:

- Data management costs
- Sustainability eco-friendly and economical
- Cybersecurity and privacy
- Real-time data

Data management costs

Although we have already mentioned this aspect, it is crucial to understand how it affects holistically. Taking the fact that we are setting the situation on traffic, the problems cloud service providers bring to the stakeholders' table in terms of costs go from increased taxes for citizens and poor-quality data to information for first responders.

First, let's look at the citizens. Traffic management is set up on budgets that, in most cases, are provided by the taxes the governments plan. These include building better infrastructure for vehicles to circulate; for example, constructing additional lanes to a highway, building tunnels for drivers to reach destinations faster, and fixing potholes.

The U.S. DOT (Department of Transportation) 2022 budget proposal[3] presented a total budget of $539,950 billion. This includes:

- **Repair American Roads and Bridges** - $115 billion to modernize the bridges, highways, roads, and main streets that most need repair.
- **Road Modernization** - $50 billion for the design, planning, and construction of roads that should be upgraded and modernized, adding complete streets, bike, pedestrian, and bus facilities, ADA features, and/or resiliency measures.
- **Bridge Investment Program** - $40 billion to substantially improve the Nation's 618,000 bridges' condition and act on those most critical to economic activity and least resilient to climate change.

These three proposals add over $200 billion to the budget. As mentioned, technological advancements can lower costs, provide safer working standards and increase DOT efficiency. But by riding a dead horse, the more data moved to server centers, the more the costs will build up, reaching unsustainable levels.

Sustainability, eco-friendly and economical

Data centers have been, since their inception, burdened with massive energy consumption to keep rows and rows of servers cool. As such, the carbon footprint of ICT (Information and Communication Technology) could create up to 3.5% of global emissions by 2025, surpassing aviation and shipping[4].

Many tech dragons are investing in renewable energy to run their data management systems to counter this reality. But to keep these data processing machines running on a 24/7 basis, fossil fuels are the only way. If we remember data generation has entered the zettabyte era, things will get more challenging for these hyper-scale data centers.

Here is where economics comes into the equation for these dead horses to keep pace with data generation, the infrastructure required to build enough data centers would have a five-year turnaround. In addition, there are the continuing costs of moving raw data to centralized locations to move it back to the source, increasing bandwidth costs.

Cybersecurity and privacy

There is no discussion here; cybersecurity and data privacy are essential when IoT monitors traffic. The chaos that a cyberattack can cause by hijacking a traffic management system can result in life-threatening situations. As we have seen, cloud service providers are not immune to hacks.

The future of the automotive industry is moving into the realm of self-driving vehicles; therefore, technology is taking a more prominent role. The idea behind autonomous driving cars, trucks, or buses is to make roads safer, eliminate human errors, and offer a 24/7 service as machines do not require sleeping time.

Sounds great! But how will this process reach its full potential if we continue down the centralized data center path? One point of attack is a reality within centralized systems, which means a hacker or, even worse, a cyberterrorist only requires access to one entry to take control of a system.

In 2015, Charlie Miller, a security researcher at Twitter, and Chris Valasek, director of Vehicle Security Research at IOActive, tested their ability to hijack a car (Jeep Cherokee). They were successful via a hacking technique known in the security industry as a zero-day exploit. They were able to send commands through the Jeep's entertainment system to its dashboard functions, steering, brakes, and transmission, all from a laptop that may be across the country. You can read more about this via Wired[5] magazine.

Just imagine the consequences of a well-thought-out hyper-scale attack by a cyberterrorist group capable of taking control of N.Y.C's traffic lights. The potential to reach these levels is very real.

Real-time data

Latency is the time it takes for a given command to reach the data center and return to the source. It is a well-known problem we all have suffered when trying to access a website, and we must wait for a couple of seconds or, worst case scenario, minutes. What usually happens is we move along to another website. No problem. Plenty of websites provide the same information, right?

But when talking about traffic management, moving to another website is out of the question. Critical infrastructure like roads must provide real-time data 24/7. There are no buts here; if this is impossible to assure, the technology is unacceptable. Moving data to server centers thousands of kilometers away inevitably opens latency issues without mentioning possible bandwidth bottlenecks.

Remember the zettabyte era? Well, one of the problems is bandwidth bottlenecks. In the same way, traffic jams are created - too many cars at a given moment (rush hour) overwhelm infrastructure, creating long-lasting queues. The same happens with data moving through the wired internet.

From what has been presented, the cloud is a dead horse for massive IoT deployments. Therefore trying to rearrange it in the hope it will one day adapt to ensure proper data management is fighting a losing battle. With all this said, it does not imply the cloud should be eliminated from working processes; it is still a great way to work remotely or build a website. But other options must be studied for critical data, like IoT, to monitor traffic.

IoT to monitor traffic on the edge

Ok, now that we have gone through the issues, centralized solutions bring massive IoT projects such as traffic management. Let's move out of the gloomy atmosphere, where it seems we are doomed, and shed a light of hope for the fourth industrial revolution to live up to its promise.

To start, we must understand that IoT devices and sensors all work at the "edge," i.e., on-premises. Thus, traffic light sensors, cameras, and first responders' communications must reside at the edge to perform at their best. But how can this be achieved? Edge computing.

- Edge computing is a distributed computing paradigm that brings computation and data storage closer to the data sources. Wikipedia

We can state that IoT is a form of edge computing, and implementing it can mitigate the obstacles cloud computing creates. For example, it improves response times and saves bandwidth. Moving away from the cloud and centering data management on edge computing provides the following advantages:

- **Privacy and security** - By keeping data processing, storage, and analysis on-premises, we avoid the vulnerabilities of moving data to server centers, e.g., cyberattacks and data breaches. A decentralized trust model is required to deploy a secure edge computing infrastructure successfully; we will look at decentralized models further down the line. Another interesting aspect is data ownership shifts from service providers to end-users.
- **Real-time data** - A well-designed edge platform, as it keeps data management at the source, can outperform traditional cloud-based systems. Short response times are paramount for traffic management; therefore, traffic management systems must be planned to work on-premises.
- **Cost-efficient** - Again, the capacity to keep data management at the source removes the bandwidth cost to move data to data centers. As traffic produces vast amounts of data, this solution can significantly reduce costs, costs that ultimately are paid by taxpayers. So if traffic data management costs can be reduced, taxes can also be lowered, resulting in happier citizens.

To summarize, edge computing is an innovative approach providing traffic management systems the prerequisite to monitor traffic data successfully. Moving forward, we continue, as promised, looking at decentralized models to achieve security for edge computing.

What are decentralized digital models?

Cloud computing is based on a centralized model. Therefore, data is moved to one point for storage, processing, analysis, and delivery; data centers. In contrast, edge computing requires a decentralized model, meaning data is distributed throughout the network topology, all nodes have access to all the data generated, and it is stored, processed, analyzed, and delivered equally.

Having this type of system creates advantages security-wise because if there is an attempt by a cyberterrorist group to bring down the system. A decentralized model alerts the network of a malfunctioning node. Thus it is ignored by the rest of the network nodes, and as data is spread equally throughout, the system can keep working without the compromised node. Other nodes in the network will take over the workload of the infected node until it is fixed or replaced.

For a decentralized model to work effectively, there needs to be a system creating trust between the nodes. Blockchain technology is a great way to achieve trust as it provides immutability and, through manifests and a consensus, the data moved between the nodes is verified, implementing trust. Having this setup creates an Online Private Garden.

How does an Online Private Garden work?

To keep it simple, each device in an Online Private Garden service knows each other and shares a blockchain; the blockchain keeps track of all data movements and verifies that data received comes from another trusted node on the blockchain.

The data movement checksums saved in the blockchain also create the possibility of calculating if a device node deviates from its assigned task. This is important as any node that deviates from its job should be isolated and examined as it could be infected by malware, or the hardware can be erroneous.

IoT traffic monitoring cost-effectiveness via decentralized edge models

Industry 4.0 is here to stay, and digital adoption, connecting the digital and physical, is not an option anymore; it is a necessity. The positive impact it can provide to all industry verticals, society, and the ecosystem is so high that ignoring it can be very costly.

As with all revolutions, be they industrial or social, there is a thin line between total disaster and complete success. Today, corporations, governments, medium and small businesses, and societies must look at the opportunities at hand and take full advantage of them. Although the first stepping stones might be taken with certain distrust, moving into unknown grounds always brings doubts.

Going back to the start of this presentation, Henry Ford failed in his first attempt to create a motor company. He even declared bankruptcy. Therefore, do not be scared of taking chances and moving away from the status quo; embrace change and pioneer it. There will be obstacles to tackle as implementations prove adjustments must take place for IoT to monitor traffic cost-effectively via a decentralized edge model.

Constant development is part of innovation, vehicles continue to evolve, and today we are talking about autonomous cars. Likewise, the only realistic option to manage zettabytes of data in the fourth industrial revolution dawn is via decentralized models that work at the source. In hindsight, we should have kept web-based centralized solutions from massive IoT projects altogether.

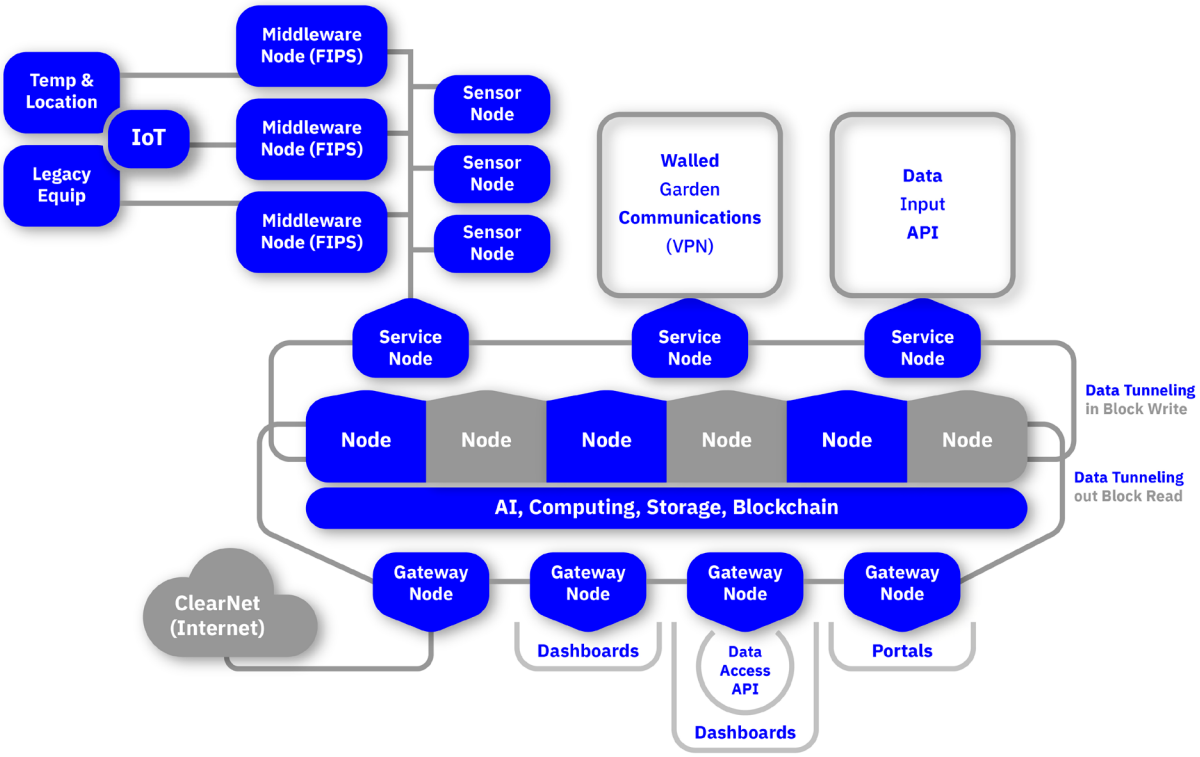

Figure 2. Internet of Everything Corporation's IoT deployment in and out data use case

What was done was done, and the past can not be changed, but we can control our future, and technology provides a blank canvas on which we can draw a fantastic future. In a place where traffic congestions, potholes, and accidents are minimal, autonomous vehicles can drive safely because technology keeps their security safe and sound.

But to realize this opportunity, we must venture into unknown grounds. IoT, artificial intelligence (AI), digital twins, machine learning (ML), and the internet of everything (IoE) are all reasonably new technological innovations. Their potential is a fact, but the paths leading to success are still being paved. Like when Christopher Columbus paved the way to the Americas, technology is now paving the way to a new global world.

IoE Corp's EDEN for cost-effective IoT traffic monitoring

Internet of Everything Corporation is soon launching a breakthrough technological advancement. The Eden system is designed specifically for IoT (Figure 2).

It considers all IoT requirements for it to reach its full potential. The decentralized software platform's flexibility is ready to service all industry verticals.

Deploying EDEN into a traffic management system gives real-time data-to-information refinement. Cybersecurity is blockchain-based, and an autonomous knowledge-based AI works the underlying orchestration mechanics.

There is no need to move all raw data to server centers mitigating bandwidth costs and latency issues.

EDEN use cases for IoT traffic monitoring

The Eden system is a decentralized model based on scalable device clustering. A solution providing cost-effective, sustainable, and secure results for traffic monitoring.

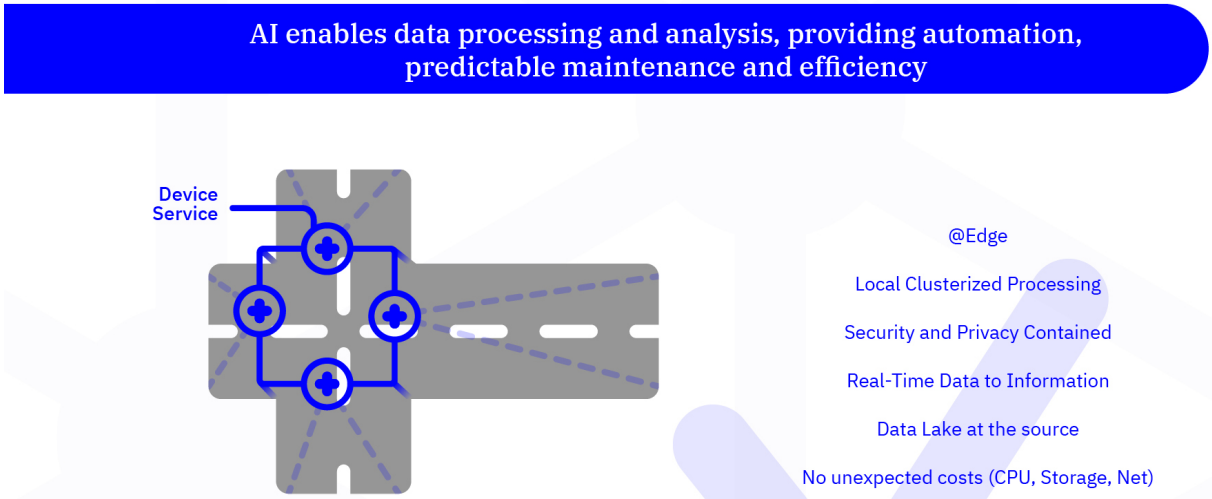

Figure 3. IoE Eden System for cost-effective IoT traffic monitoring

IoE Eden three-layer for city traffic routing

Eden offers a three-layer architecture: intersection, knowledge, and decision layers. The first layer is where the data is generated, for example, cameras. At the knowledge layer, the information is event-based and processed; thus, there are no events if there is no traffic during a period, so there is no need to send this data to a server.

A system providing local IoT devices to work as a cluster to perform Data to Information refinement. A solution that gives the third layer, the decision layer, information that helps decision-makers to actuate quicker and more precisely, be it an autonomous machine or a first responder.

Another benefit is the capacity to immensely reduce the costs of moving raw data to server centers.

Road maintenance, as we have presented above, requires budgets to reach billions of dollars. With IoE Eden, budgets can be drastically reduced by implementing predictive maintenance.

Predictive maintenance for traffic management

The possibilities IoT devices and sensors provide with AI analysis make predictive maintenance a reality. This means, for example, potholes can be fixed before they happen. Constant monitoring of roads and using AI to analyze the data can predict when a pothole will occur.

Giving this service to citizens and commuters lowers taxes and mitigates the collateral costs of potholes, as these damage vehicles. It also reduces fixing times and the necessity of closing roads.

But to be able to service predictive maintenance cost-effectively, a decentralized digital approach is a must. In the same way, the three-layer architecture is used for road cameras; it can also be applied to predictive maintenance. AI analysis is costly, economically and ecologically.

The Internet of Everything Corporation introduces informed infrastructure with embedded AI to solve this problem. By having embedded AI at the source, inside the devices, the data generation is not done on all the

data but using floating windows. In this way, we can have pattern mining in data streams, and as a pattern is identified, computing kicks in.

A solution that provides data to information refinement in tiers, generating useful AI-processed information at the source (Figure 3). That is exceptionally efficient in massive IoT deployments as the data that needs to be refined into information is not constant but bursting.

Conclusion

IoT traffic monitoring is indispensable for optimizing road fluidity, maintenance, and first responders' actuation. But there are certain adjustments required for it to move forward. IoT and AI are setting enormous strains on current centralized data management systems like traffic regarding cost-effectiveness, data privacy and security, and sustainability.

Having presented the above, the way forward must be through decentralized models, blockchain secured, and running on sustainable computing languages. Here we have presented Internet of Everything Corporation's Eden System to help reach IoT's full potential to monitor traffic.

Currently, we are open to accepting new partners into our Planet Partner Program. You can apply by clicking on the following link:

https://partners.ioecorp.com/apply-partner

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