Bloor

White Paper

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IBM Informix and Edge Analytics

According to Gartner 75% of enterprise data will be generated at the *"edge"* by 2025, compared to 10% in 2019. On the one hand this will be driven by an increased desire for real-time capabilities with minimum latency and, on the other, it will be enabled by the increased availability of 5G technology.

Executive summary

According to Gartner 75% of enterprise data will be generated at the *"edge"* by 2025, compared to 10% in 2019 (***see here***). On the one hand this will be driven by an increased desire for real-time capabilities with minimum latency and, on the other, it will be enabled by the increased availability of 5G technology. Indeed, the optimal location to act on data in terms of speed and cost is closest to where it originates, minimising network latency and removing the costs of moving the data, which may be financial, but may also be related to delayed decision making and/or to governance and sovereignty issues.

In practice, not all devices need to be smart, and not all environments require multi-tiered (edge device, gateways, centralised [usually cloud-based] processing and similar) architectures: it will depend on the application. For example, a *"smart meter"* typically does no more than forward a reading to a collection point and perhaps provides some limited information about usage for the householder. Conversely, you might have embedded database capability in a cell tower that is intended simply to identify dropped calls or in a wind turbine that will adjust turbine blades according to pre-defined rules based on atmospheric conditions. Then again, in a preventative maintenance scenario, sensors not only provide readings to a collection point for analysis but will also need to be able to raise alerts based on pre-defined conditions. Thus there is a wide spectrum of requirements, but as a rule of thumb, for large deployments, it is reasonable to work on the basis that some sort of intelligence is required in each of these tiers but the closer to the centre you go the more advanced the requirements will be. At the centre there will typically be a requirement to support hybrid operational/ analytic requirements and there may also be a need to provide conventional data warehousing capabilities for longer-term analysis of data that has been collected.

In this paper we will discuss what is required from a database that supports edge computing and, more generally, Internet of Things (IoT) environments, but with the emphasis on the edge. We will do this with specific reference to IBM Informix. This has a long and illustrious history. In particular, it is well known as a platform for supporting applications developed by third parties and ISVs, primarily for use in (distributed) transactional environments. This is because Informix is a robust offering that combines high performance and functionality with minimal administrative requirements. However, this paper does not discuss these features of the product in any detail. Instead, we are here concerned with the use of IBM Informix for edge computing within Internet of Things (IoT) environments, which is IBM's database of choice for these deployments. While Informix has been proven at enterprise scale for more than twenty years, edge is an emerging use case, which should be reassuring to any existing users that might have been concerned about continuing investment into this database product.

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At the Edge

The centre of data's gravity is shifting to the edge of the network. The optimal location to act on data in terms of speed and cost is closest to where it originates. If those actions are performed in the core this will – depending on the use case – be based on outdated data and can never be real time. There is therefore a danger that it can be sub-optimal. Every movement of data has a cost, decision latency and security risk. However, the origin points (edge devices) of data can be highly distributed and often disconnected, so it is not simply a question of collecting and processing your data as close to the edge as possible, but it is also a question of how the whole network of edges, gateways and central processing interacts: see ***Figure 1***. In other words, it is one thing discussing how Informix can be deployed within edge devices and quite another with how that interacts with the rest of the environment. We will return to this latter point later but for now we will concentrate on embedding IBM Informix.

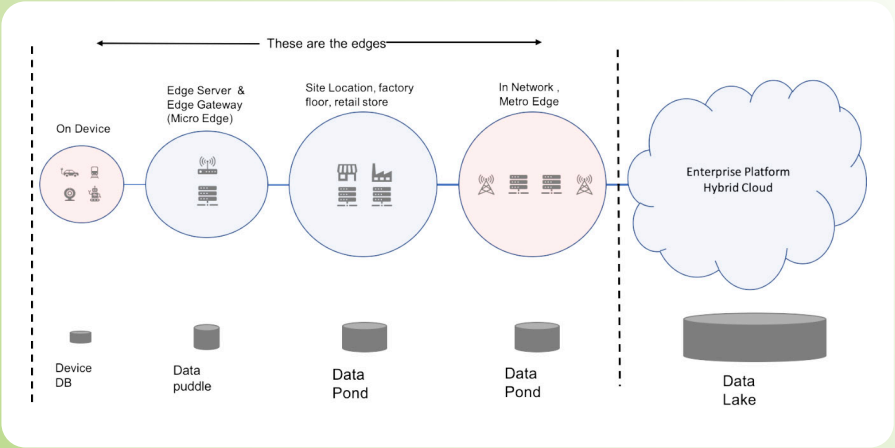

Figure 1:
How a network of edges, gateways and central processing interacts

As mentioned in the previous section, IBM Informix has a long history of being embedded in a variety of applications and this suggests that the product is both easy to implement and deploy, and secure (with encryption: a key requirement for communicating from the edge). Going beyond this, while there are many similarities between embedding a database into a general-purpose application and embedding a database into a device or gateway, there are also differences. In particular, at the device level database footprint is a major consideration and for both devices and gateways cost is an issue, as often there may be thousands of devices each running an instance of the database. In the case of the former, the footprint of IBM Informix is just 100 Mb.

More generally, the main requirements for embedding a database are that you can fire it up and forget about it, that it performs adequately, that it is robust and does not fall over, that it is flexible enough to support deployments in different types of devices and gateways, and that it is easily updated (without appreciable downtime) when requirements change. In so far as IBM Informix is concerned all of these can be taken as given. However, there are three points worth discussing.

Firstly, it is essential that any embedded database is invisible and remains that way. This is true regardless of whether you are simply collecting data and passing it on or whether you are performing some analytics on the data. In the latter case, in order to get good performance, you need, at least in conventional environments, to create indexes, materialised views and other such database constructs in order to achieve that performance. While this is feasible it is not flexible in the event that additional requirements need to be supported. Every time you add functionality within the device or gateway you will need to change the supported indexes. Worse, different workloads may mean that different indexes, materialised tables and so forth will be differently suitable for different customers. Moreover, these workloads may change over time. What this will mean is that the database will need to be tuned on an ongoing basis in order to maintain performance, which is impractical in IoT environments. For all of these reasons a traditional relational database will not be suitable for embedding at the device or gateway level, precisely because these all require exactly this sort of tuning. Fortunately, this is not the case with IBM Informix because the product includes self-

healing and self-tuning autonomics that handle these embedded environment requirements automatically.

Secondly, continuing on the topic of being able to support changes within edge environments, whether it is additional application functions or new database features, it is imperative that these can be provided easily and simply and from a remote location. IBM Informix now supports microservices which means that such upgrades can be made using Docker containers at the device level with (Red Hat) Kubernetes being supported for orchestration in higher level gateways and more complex devices.

Thirdly, there are some elements of database flexibility that need to be discussed with specific respect to edge environments. Support for things like geo-spatial and time series data we will discuss later. In the context of flexibility, you must bear in mind that an IoT implementation may consist of multiple types of devices and gateways doing different things. Moreover, the sort of data you are collecting and processing may change over time. For both of these reasons a database that supports a flexible schema will be preferable and as a result of these considerations IBM Informix supports JSON (where each data object has its own schema) as first-class objects within the database. This is important not just from a flexibility perspective but also because JSON is commonly used as a data exchange medium from devices and gateways. Moreover, IBM has recognised that there is substantial existing use of MongoDB within the IoT community, so it has also implemented API compatibility with MongoDB, a wire listener that acts as a mid-tier gateway between MongoDB and IBM Informix, and the database supports BSON (binary JSON), which is the form of JSON supported by MongoDB. This works by allowing a traditional table to include a BSON column to store traditional and flexible data in a single object.

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Analytics and AI

> **Given its history of supporting third party vendors, IBM Informix is especially targeted at analytic applications although, of course, it supports business intelligence and data mining tools such as IBM Cognos, Watson Analytics and SPSS (via integration with IBM Cloud Pak for Data) as well as products from other suppliers.**

There is a need to distinguish between analytics and analytic applications. The difference between these two is that the latter provides a packaged approach whereas the former is more tool-based. Analytic applications may be deployed at any level within an IoT environment whereas analytics per se will typically only be required at the centre. If you consider that processing at the edge and at collection points is going to be automated then this makes sense: it is only at the centre that people, as opposed to processes, are going to want to query and investigate the data that has been collected.

Given its history of supporting third party vendors, IBM Informix is especially targeted at analytic applications although, of course, it supports business intelligence and data mining tools such as IBM Cognos, Watson Analytics and SPSS (via integration with IBM Cloud Pak for Data) as well as products from other suppliers. Moreover, these IBM integrations allow you to train AI/ML models using these tools and then deploy these models at the edge, leveraging Informix-based local data.

From a functional point of view, we need to consider analytics and analytic applications separately. Analytics has traditionally been thought of as separate and distinct from operational or transactional functions, but Informix can support both transactional and common analytic functions without need to move any data out of the database. The big advantage is that you only require a single system with a single hardware implementation to do this, which potentially means reduced up-front costs. It has the additional advantage that you don't need to move data from one environment to the other and there is no need to synchronise the data. Furthermore, a single set of administrative requirements means lower on-going costs.

Analytic applications in an IoT environment, on the other hand, are pre-built but also tend to be hybrid in nature, typically combining sensor-based or machine-generated data into applications that have both operational and analytical implications. An example is smart metering. Another common example is in motor insurance, where companies are increasingly installing telemetry into vehicles to monitor the quality and speed of driving, which can lead to a bonus for the driver if he or she drives well. These types of applications often include a real-time or near real-time element. For example, in the example quoted the collection of the data needs to be real-time to support notification of emergency services in the event of an accident (sudden deceleration followed by lack of movement). Similarly, you may require support for geo-spatial data and/or time stamps, where it is important to know the location and/or time at which something happened.

Key Features

Having defined, at a high level, the unique requirements of edge applications, it is time to turn our attention to IBM Informix in more detail. We have already discussed some aspects of that product, most notably its support for flexible schemas, but there are a number of others. In particular, there are key features of IBM Informix that lend themselves to IoT environments, which we will discuss in turn. However before doing so it is worth emphasising that all of these features are part of a single platform that can be implemented within a single instance of the database. Moreover, unlike some competitive offerings Informix at the edge is fully featured and not stripped down in any way.

Replication Technologies

IBM Informix has a broad portfolio of data replication technologies available to manage data movement between various edge layers and central cloud capabilities. These include High Availability clustering, Enterprise Replication, Flexible Grid and sharding. Each has its particular purpose and solves a particular problem, but the first two of these technologies are the ones most relevant to edge computing. All of them can be deployed concurrently within an instance.

For those requiring high availability, the High Availability cluster provides real-time clones of a primary node. The clones can be distributed geographically to provide protection against localised natural or man-made events. If the primary or any other node fails, any of the clones can provide near-instantaneous coverage for the outage. Additional technologies support the ability to transfer applications from a failed node(s) to surviving nodes without administrative interaction. This technology can be extended to provide protection against errant and significant SQL operations providing a simple and easy way to recover from them.

Those needing to distribute data within their IBM Informix environments can use Enterprise Replication (ER) to define *"what"* data is sent *"where"* and *"when"* it's sent. The definitions can be at scale such as moving the entire database or as small as relating to a single column when its values are between X and Y.

Time series and geo-spatial data

There are many applications that require an understanding of time. For example, in capital markets you need to know when a trade was initiated and when it was completed. In smart metering and other sensor-based environments you will be taking measurements on a regular basis and you need to know what value was recorded and at what time. You also need to handle data that arrives out of time sequence. To enable this Informix supports a native TimeSeries datatype with relevant data stored as illustrated in ***Figure 2***. Note that this is much more efficient than would otherwise be the case for a relational database, which would typically have multiple rows for each Meterid: one for each time stamp. Specialised compression capabilities are provided. In addition, if it is a regular time-series Informix allows you to skip the storage of the time stamps altogether. If readings are static – subject to intervals you define – you can compress the results or filter them out. A variety of windowing data analytic functions – moving, static, rolling and so on – are provided.

> **We were looking for an enterprise-class database that was truly tailored for use in an IoT environment, and IBM Informix fit the bill perfectly. With Informix, we get excellent scalability and strong security, and can manage both structured and unstructured data effectively. What's more, the platform has a very small footprint, making it ideal as an embedded database.**
>
> **Petrosoft (see www.ibm.com/case-studies/petrosoft)**

MeterId	Reading
1001	2016-01-01,daily,{(12.34, 12567),(12.56,9000),(12.35,55567),...}
2002	2016-05-05,daily,{(199.08,6780),(198.55,3405),(198.12,250),...}
2011	2016-09-01,daily,{(9.34,8067),(9.56,9000),(9.40,10780),...}

Figure 2: Informix supports a native TimeSeries datatype

Ingestion is via the Informix Time-Series Loader, which is parallelised to ensure high performance.

You can access TimeSeries data either using a virtual table interface, which makes the TimeSeries data look relational; or you can create user-defined routines (UDRs) using stored procedures, C (for which further functions are provided) or Java. These UDRs are registered with the database optimiser and used for query and other CRUD

purposes. While HCL/IBM do not have partnerships with any third-party visualisation vendors, there are users employing tools such as Grafana and Tableau (via ODBC/JDBC connectivity) together with Informix TimeSeries. Of course, the product integrates with IBM Cognos. Sophisticated analytics, such as pattern matching, are available, as shown in ***Figure 3***. There are specific TimeSeries API capabilities to support anomaly detection and other advanced analytics.

Geo-spatial support is also important in a number of IoT-based environments. For example, in logistics, where you are tracking (and re-routing) delivery vehicles. However, for Informix Geo-spatial capabilities represent an important complement to TimeSeries and Informix supports around 20 different co-ordinate systems with built-in indexing and native support for spatial datatypes. There is tight integration with ESRI and support for GeoJSON. A more detailed discussion of these capabilities is available, see ***IBM Informix time-series and spatial capabilities***.

Finally, it is also worth commenting on the utility of the spatiotemporal capabilities provided by Informix. These are not limited to traditional logistics examples, but also allow you to answer questions like *"what was the location of bus number 3435 at 2019-03-01 15:30?"*, *"when was a delivery truck within 100 meters of the Good Food Diner between February 2-4, 2019?"*, *"when was taxi number 324 at the Superlative Hotel?"*, *"how long do buses stay in our repair shop?"*, or *"which taxi driver witnessed an accident by finding which taxi was nearest to the location of the accident at 9:00 am?"*

Figure 3: Pattern matching with IBM Informix TimeSeries

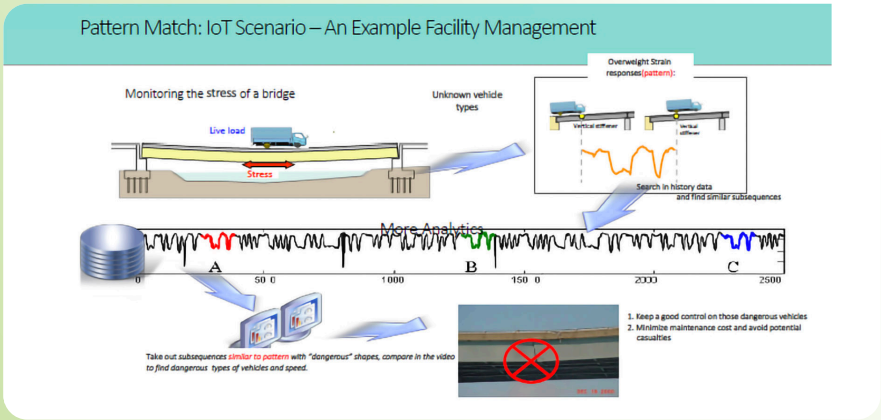
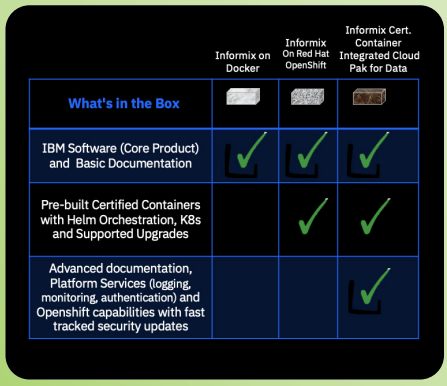


Figure 4: Informix supports a microservices-based architecture



Containerised deployments

Informix supports a microservices-based architecture that leverages Docker containers and Kubernetes, as illustrated in ***Figure 4***. According to ***www.microservices.io*** *"microservices… is an architectural style that structures an application as a collection of loosely coupled services, which implement business capabilities. The microservice architecture enables the continuous delivery/ deployment of large, complex applications."* Such services are typically small, independent, and loosely coupled. In practice, this means that if you have built an application on top of Informix then this will allow you to package up that application with all of its parts, libraries and dependencies and ship it out as a single solution. And, further, should you need to update any part of that application, then you will only need to re-ship the affected parts of the application. You will not require a full re-deployment. This makes life much simpler and more efficient when deploying in edge and cloud environments, provides separation between the concerns of application developers versus IT operations, and supports the principle of continuous delivery. Informix also offers advanced capabilities with respect to failover and restoration.

Cloud deployment

Many IoT implementations will employ a cloud component and it is therefore relevant that IBM Informix runs in the Cloud, on any suitable PaaS (platform as a service) environment, including Amazon, Microsoft Azure and Google as well as IBM Cloud. A multi-tenancy approach is supported with features specifically for this purpose: for example, the ability to limit memory and connections for client databases and to restore tenant databases to a point in time.

Application Development

Finally, within this section, it is worth commenting on some of the specific features that Informix supports for the purposes of application development. Specifically, those features that you might not expect to find. To begin with, see ***Figure 6***, which illustrates the wide range of drivers, languages and listeners supported by the database. It also includes a built-in change data capture feature that supports the ability to stream data to external targets.

In addition, Informix supports a capability called *"Smart triggers"*, which provides a flexible mechanism for applying selective triggers on data changes within a table. Specifically, Smart triggers create notifications that are pushed outside the database whenever a relevant event takes place. To take a simple example, suppose you are a bank, and you want to be alerted whenever an unusually large deposit is made into a client's bank account: perhaps because you are worried about money laundering, or because you want the opportunity to offer financial advice. Using Smart triggers, you can define a trigger within your application – using SQL select statements and predicate clauses, implemented within the Informix database – which will notify you, via what are known as *"push notifications"*, whenever such a deposit is made. In other words, smart triggers are a way of implementing event-driven processing. This is important within edge computing because such event-based notification is often of significant importance.

Figure 5:
IBM Informix can be deployed as required

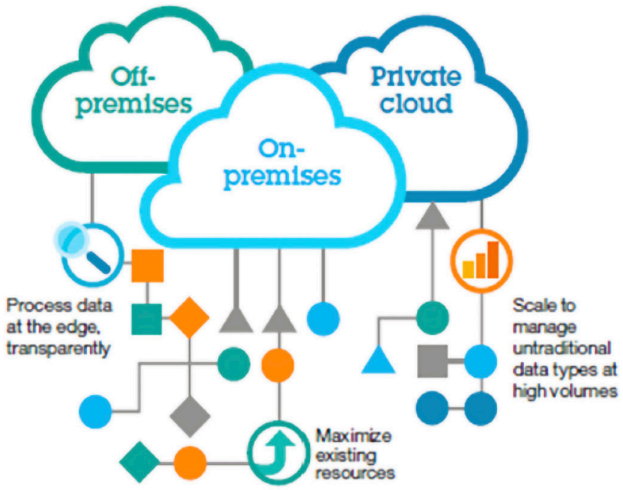
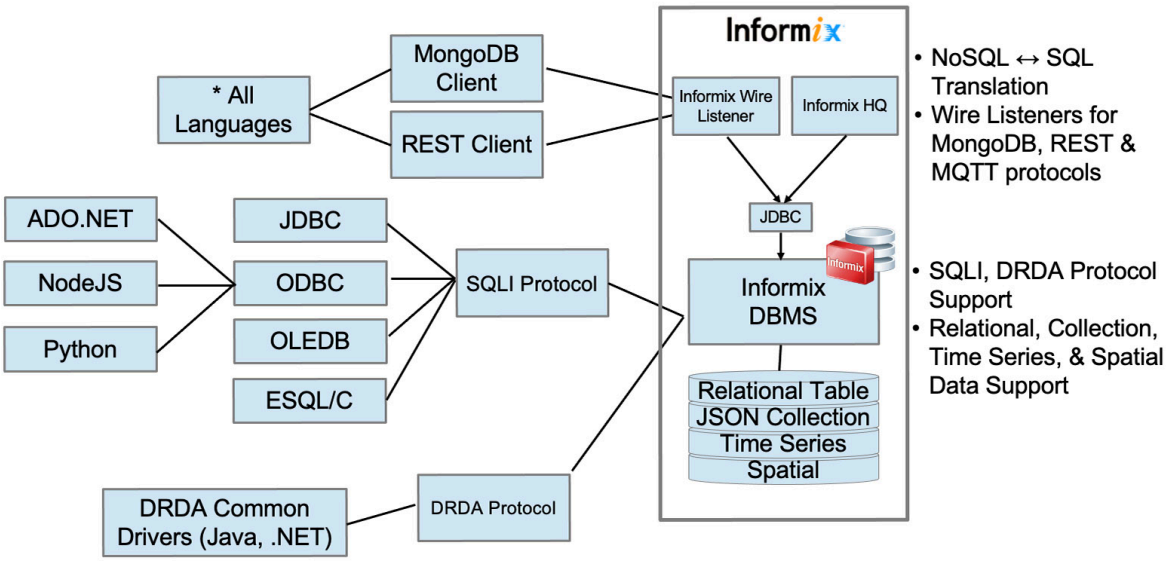


Figure 6:
The wide range of drivers, languages and listeners supported by database



Complementary IBM technology

IBM Informix is included as an optional part of IBM Cloud Pak for Data. This has a number of important implications. To begin with, it means that all the deployment options of Cloud Pak for Data are supported: on-premises, in the cloud (as discussed above) or on hyperconverged platforms.

Informix now tightly integrates with Cloud Pak for Data's AI, machine learning and predictive analytics capabilities. In addition, it means that Informix can leverage the Data Virtualization offered as a part of Cloud Pak for Data. it is worth describing this because IBM's capabilities in this area are both innovative and ahead of other offerings in the market. To understand how this technology works, it is worth comparing how it differs from conventional approaches to data federation, shown in ***Figure 7***, with IBM's use of a computational mesh, illustrated in ***Figure 8***.

As can be seen, the key difference is that the computational mesh may not only perform analytics locally but also within a remote constellation. Given that moving the data across the network is one of the biggest issues with traditional data federation techniques this can considerably improve performance. Moreover, when the remote computational mesh is deployed, it may also result in reduced compute costs as it allows you to tap into any excess compute capacity you may have either adjacent to or co-located with your data sources. Data sources supported by the computational mesh include the Db2 family, Netezza, BigSQL, Informix, Oracle, SQL Server, various open source databases, a number of streaming products, multiple mainframe environments, generic JDBC access and several third-party data warehousing databases. Note that Data Virtualization integrates with the IBM Enterprise Data Catalog.

Finally, but by no means least, Informix is a part of IBM edge solutions. This contains a number of elements including edge-enabled applications and solutions, IBM Edge Computing Manager, IBM Services for IoT Security and, most relevant to this discussion because IIBM Informix directly integrates with it, IBM Edge Application Manager.

Without going into too much detail (this is a paper on Informix, not Edge Application Manager), ***Figure 9*** should provide a flavour of what Edge Application Manager provides: it is designed to allow you to create, deploy, run, secure, monitor, maintain and scale business logic applications and analytics (including AI and machine learning) across edge-based deployments. This is important, along with IBM's other edge offerings, in supporting the distributed environment that is inevitable in any IoT deployment.

Figure 7:
Classic federation and edge computing

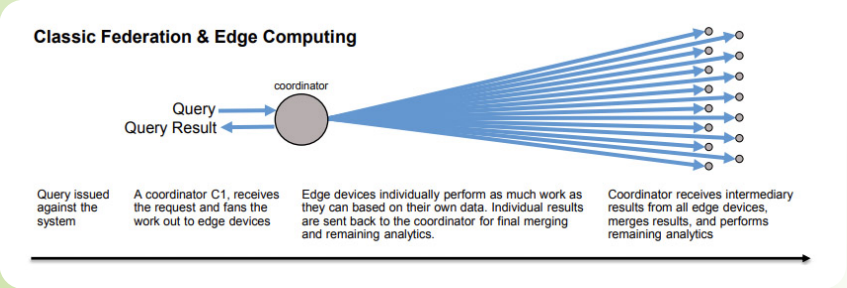


Figure 8: IBM use of computational mesh

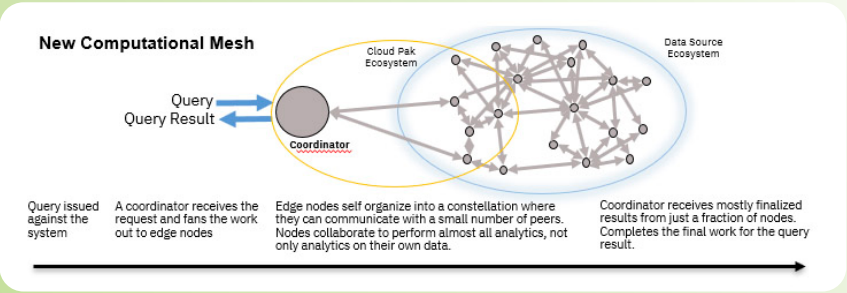
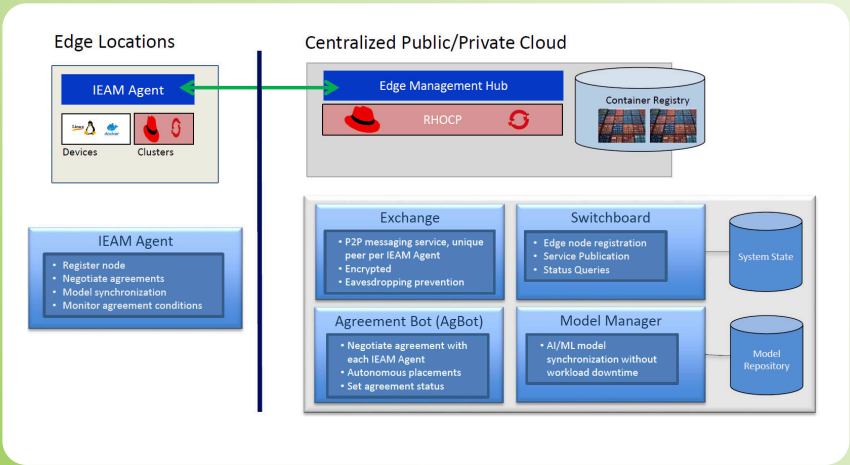


Figure 9: What edge Application Manager provides



Conclusion

We are impressed with IBM's approach to edge computing, providing a holistic set of offerings that span the IoT space, along with Informix's place within, and integration to, that strategy. More generally, we have sought to examine the suitability of IBM Informix for supporting IoT environments, either as an embedded database at the edge or in collection points, or in the centre. Depending on where it is implemented there will be rather different requirements. However, in our opinion IBM Informix is well-suited to IoT regardless of where it needs to be deployed. At the device and gateway level the product has a long-standing reputation as a *"fire and forget"* database that can be easily installed and maintained while, in the centre, it has the sort of capabilities and performance characteristics that suit hybrid operational/analytic environments. On top of this, native time series and geo-spatial support are requirements for many IoT use cases, so IBM Informix is well-placed in this market.

FURTHER INFORMATION
Further information about this subject is available from
www.bloorresearch.com/update/2639

About the author

PHILIP HOWARD
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Philip started in the computer industry way back in 1973 and has variously worked as a systems analyst, programmer and salesperson, as well as in marketing and product management, for a variety of companies including GEC Marconi, GPT, Philips Data Systems, Raytheon and NCR.

After a quarter of a century of not being his own boss Philip set up his own company in 1992 and his first client was Bloor Research (then ButlerBloor), with Philip working for the company as an associate analyst. His relationship with Bloor Research has continued since that time and he is now Research Director, focused on Information Management.

Information management includes anything that refers to the management, movement, governance and storage of data, as well as access to and analysis of that data. It involves diverse technologies that include (but are not limited to) databases and data warehousing, data integration, data quality, master data management, data governance, data migration, metadata management, and data preparation and analytics.

In addition to the numerous reports Philip has written on behalf of Bloor Research, Philip was previously editor of both ***Application Development News*** and ***Operating System News*** on behalf of Cambridge Market Intelligence (CMI). He has also contributed to various magazines and written a number of reports published by companies such as CMI and The Financial Times. Philip speaks regularly at conferences and other events throughout Europe and North America.

Away from work, Philip's primary leisure activities are canal boats, skiing, playing Bridge (at which he is a Life Master), and dining out.

Bloor overview

Technology is enabling rapid business evolution. The opportunities are immense but if you do not adapt then you will not survive. So in the age of Mutable business Evolution is Essential to your success.

We'll show you the future and help you deliver it.

Bloor brings fresh technological thinking to help you navigate complex business situations, converting challenges into new opportunities for real growth, profitability and impact.

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