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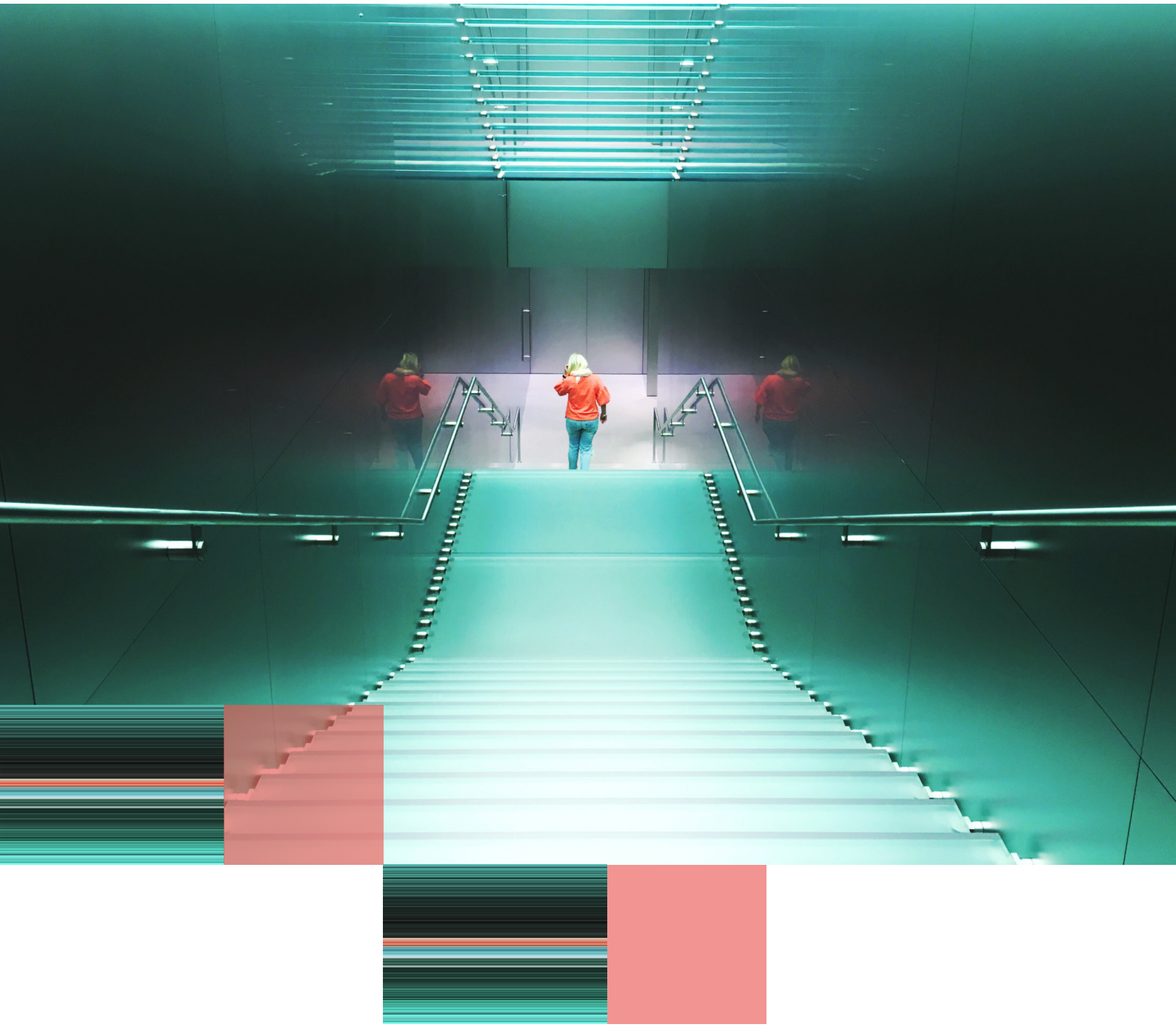
Prediktor MAP Gateway

WHITE PAPER



Executive Summary

This whitepaper describes the Prediktor MAP Gateway, which addresses four key pillars of Industrial Information Management within the Industrial Internet of Things-world (IIoT), namely:

- Interoperability
- Reliable & secure connectivity
- Contextualization
- Elimination of application engineering efforts

The overall objective of such a system is to provide a **standardized, unified, reliable and secure** means of accessing operational data from different assets via enterprise systems– **not only standardized on protocol but also standardized on data semantics.**

Typically, this approach is especially challenging in brown-field installations where non-standard protocols and unplanned- or non-standard semantics are present.

The Prediktor MAP Gateway provides an industry-unique standardized protocol with a **unified way of accessing, displaying all kinds of data associated with an industrial asset, which facilitates** a highly efficient way to build practical IIoT applications. Therefore, Prediktor MAP Gateway is a 'software platform' that can quickly and easily build IIoT applications at scale.

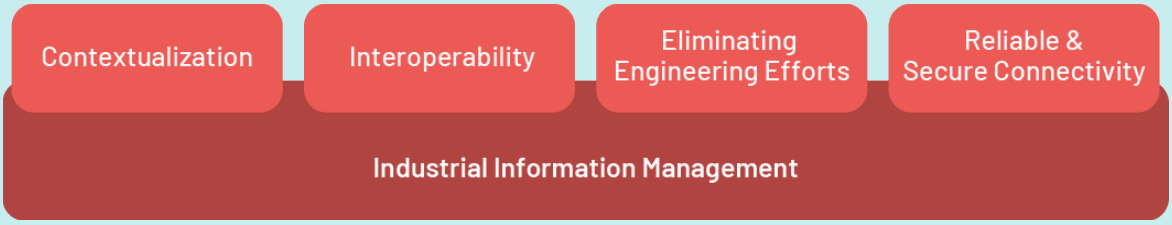


Figure 1: The Four Pillars of Industrial Information Management

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Content

IIoT Concepts

Contextualization

Basic industrial historians often store only sensor data as numerical (time series) or binary (ones and zeros) numbers. More advanced tools can also store metadata such as timestamps, quality indicators, and/- or descriptive information, enhancing the value of the data. However, such simple information is often not enough for applications to act upon the data correctly. The journey from sensor data to actionable information requires that the data is set in context, which effectively helps reduce the amount of 'engineer' logic or reasoning required to understand what the data means. Prediktor MAP Gateway is unique in its ability to bring; context to unstructured data, provide context to already contextualized data and expose the same data in different contexts. Contextualization is beneficial and necessary in many scenarios, but there are two key areas where the benefit of contextualization is clear, namely:

Diverse and distributed asset environments & **Operational technology (OT) big data scenarios**.

Organizations and applications characterized by a combination of diverse and distributed asset environments and OT Big Data will boost considerably by utilizing the Prediktor MAP Gateway.

Interoperability

Prediktor truly believes that for IIoT solutions to be rolled out across the Customers' Enterprise, that 'plug-and-play' is the only way forward in the industrial world – plug-and-play is by far the best way to transfer data and how you understand all that industrial information – at scale. Prediktor MAP Gateway also provides a standardized and unified way of accessing operational data from different assets – both standardized on protocol and context. Prediktor MAP Gateway utilizes **OPC UA Information Models** (OPC UA IM) to achieve interoperability on the data level. OPC UA IMs offer standardization on multiple operational levels, such as OEM (design) data to Asset Enterprise (Site) and even to an entire 'industry level'– the latter achieved by introducing OPC UA **companion** Information Models.

Engineering Efforts

Resource engineering time – whether done internally or procured externally – is expensive. Therefore, engineering IIoT solutions with minimum effort using contextualized data in standard formats and protocols in a plug-and-play world is the key to success and value. Contextualization and interoperability bring a lot to the table separately; in combination, the potential is incredible for the IIoT Industry.

Reliable & Secure Connectivity

Engineering / operational decisions are made based upon a review of all the available data possible. Therefore, trust (veracity) in the information presented to the engineer/operator from the operating processes/systems assumes that the data **extracted** from those systems is accurate. Prediktor MAP Gateway takes a **serious approach to data veracity** by ensuring reliable and secure connectivity to the Enterprise OT systems. Periodically, when data sources deliver spurious information, there must be a means to detect, alert and (if possible) even rectify this 'bad' data. This functionality is inbuilt in Prediktor Map Gateway as standard. Should data flows be interrupted– even for extended periods–, an essential requirement is the ability to catch up with historical data. Prediktor MAP Gateway delivers a market unique 'catch up' capability unsurpassed in the industry today!

Prediktor MAP Gateway Overview

Prediktor MAP Gateway is a component-based architecture that serves Industrial Internet of Things (IIoT) **interoperability** purposes with various industry-standard protocols and approaches.

The product utilizes OPC UA technologies in the strive for interoperability and openness in industrial operations.

Some highlights of the Prediktor MAP Gateway are:

- Aggregating server capabilities for scalability
- Several connectivity options: inbound & outbound
- Robust, field-proven: complete IIoT-enabling platform
- Premium storage rates and capacity
- Unified & multiple semantic model exposure
- Enterprise-wide access to all operational data

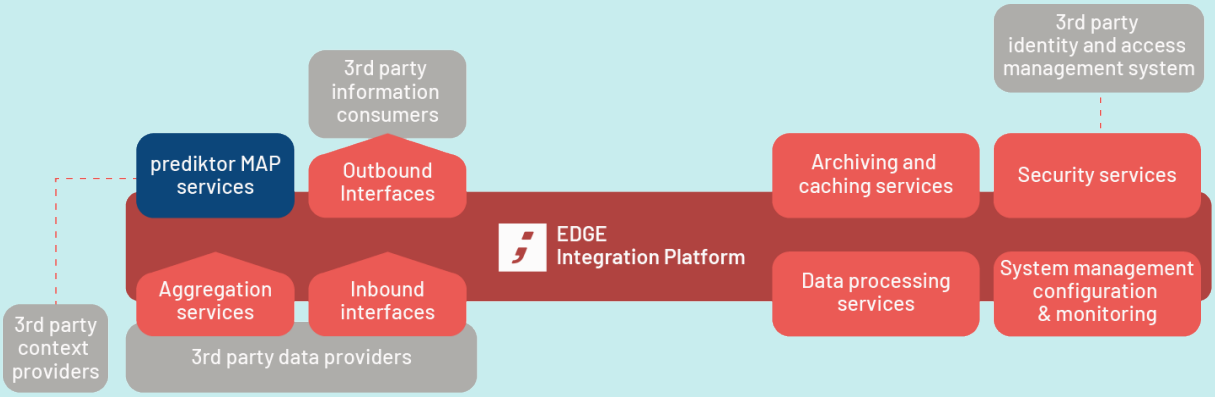

Figure 2: Example of Prediktor EDGE Connectivity incorporating MAP Services.

This architecture's component strategy assures that each deployment can balance the right level of functionality and complexity without sacrificing robustness.

More information on the OPC UA protocol is available from the OPC Foundation at: https://opcfoundation.org/about/opc-technologies/opc-ua.

The following subsections describe the key functionality of the Prediktor solutions set.

Enterprise Deployment of OPC UA - Strategy

Prediktor MAP Gateway technology is easily deployed across an Enterprise - there are typically three tiers across the Enterprise, namely: **Plant**, **Operations** and **Enterprise**.

At the **Plant tier**, Prediktor MAP Gateway technologies' core role is to enable legacy or **OPC classic technologies** into a single 'Plant' structure that allows a basic entry point – to those systems – making all outbound interfaces available.

A combination of 'Plants' (or 'Producing Assets') gives rise to the '**Operations**' layer where a 'Group View' of Operational performance or optimization is preferable.

Prediktor MAP Gateway technologies' core role is to give **semantically** standardized information models exposure to each asset across the Operations tier – a galvanic barrier of both the security and system information flow bi-directionally between the office and the plant domain.

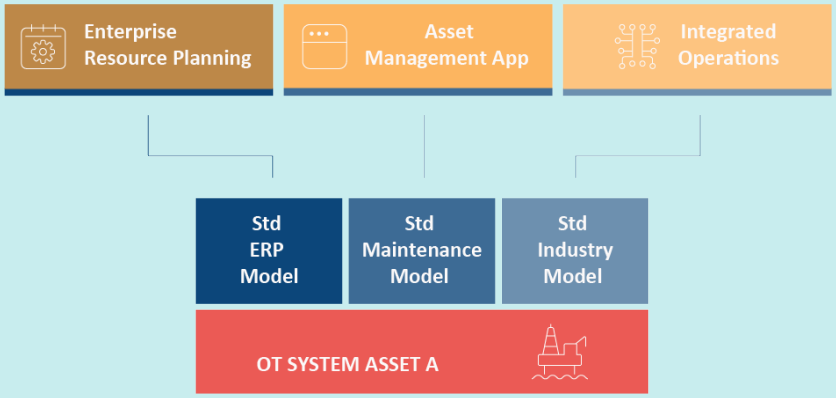

Figure 3: Example of Prediktor OPC UA Information Models

The **Enterprise tier** enables enterprise applications to see a single set of standardized contextualized representation of data structures right across the entire fleet of assets – be they Oil Producing Assets, Wind Turbine Generators, Hydro plants, Solar PV farms, etc.

The semantic mapping and **standardization** already done at the Operations level makes the Enterprise layer's overall management a simple and easy to manage task. This Enterprise OPC UA 'Information Model' approach 'future-proofs' any new installations at plant level as the standardized protocols within the solution will have a common interface to all plant data without disturbing any of the underlying plant systems.

Semantic Information Models

In the quest to make systems more intelligent, more autonomous and easily scaleable, a key IIoT concept is semantic/contextualized Information Modeling– the ability to express the meaning of data. Prediktor MAP Gateway exists to provide a digital representation (**Information Model**) of the assets, processes and Enterprise information in the form of a '**Digital Twin**' of the real-world– which simplifies the search for accurate data, increases understanding of that data and ease application development.

Digital Twin strategies use **OPC UA** Information Models, which are – effectively – 'information graphs' consisting of nodes and references. Nodes typically represent physical objects (e.g., a pump), data points, alarms, etc. The references between them represent their semantic (contextual) relationship and together, the nodes and references make up the **Information Model**.

OPC UA Information Models enable the concept of 'unification' – which allows taking a single information element, i.e., current real-time value, and applying other information elements like alarm conditions and historical trends to that single item, using the same reference, even if they have different sources. They make up the context of an object.

In this way, you have a clearly defined interface to all your technical assets independent of whether the asset is delivered by Vendor A or B. In the Prediktor MAP Gateway, the contextualized Information Model acts as a schema or index for unstructured or simple structured real-time values, historical trends or alarms and event sources.

In effect, the Prediktor MAP Gateway can host several models simultaneously, mapped to the same set of core information elements, without duplicating them. The different Information Models can serve other purposes such as integrated operations, enterprise resource planning and asset management in the automation domain. Since the purposes are different, Prediktor MAP Gateway will expose various aspects of the same core data through other simultaneous semantic models.

These models can be based on established standards within the various domains, such as **ISA S95**, Device Integration and PRODML. This approach enables a strategy for broader interoperability, where enterprise IT strategies can see a uniform and standardized set of Information Models across all assets.

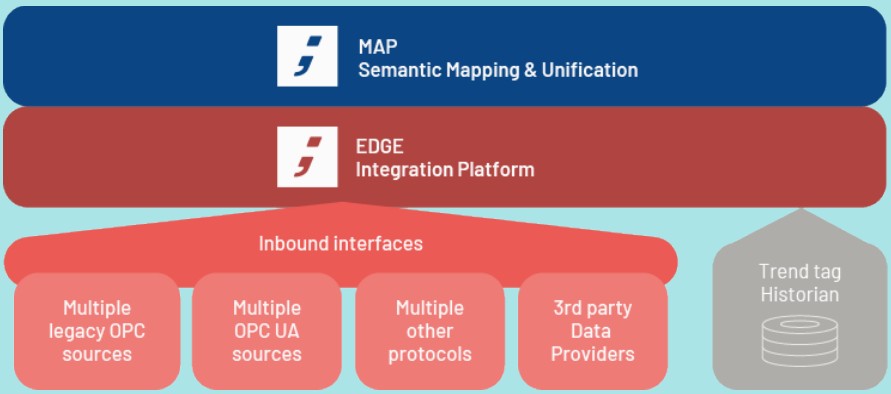

Figure 4: Example of Prediktor EDGE Connectivity incorporating Unification Services

Prediktor MAP Gateway facilitates this Enterprise strategy across a fleet of sites and production assets. Using the ISA S95 standard protocol, information models can be loaded into the Prediktor MAP Gateway and these existing information elements can be mapped to those models with our efficient engineering tools. Both guided/automatic and manual mapping are available. Exposure of these models through OPC UA is an essential aspect of such a strategy. Any model not exposed through an OPC UA stack will:

- Either lock the Enterprise to a reduced set of future system suppliers or
- Lead the Enterprise into a future with high integration costs over the lifecycle

Therefore, the system's ability to take up and map **new semantic models** without disturbing existing system functionality is an essential feature in our offering. An added benefit of this flexibility is the possibility of an incremental and iterative delivery process for the system across the Enterprise.

To serve enterprise standardization projects, Information Models can be mapped one at a time in Prediktor MAP Gateway solutions without disturbing operations at the site. At a later stage, the ability to load and map new models, like the ones being standardized through the facilitation of OPC Foundation, assures a viable '**future-proof**' strategy for as yet unknown interoperability requirements, without the need to know the details of those requirements today.

Prediktor Catch-Up

In case of communication loss between an OPC UA server and OPC UA client, most OPC UA servers provide a short-term **buffering** (or spooling) of time-series values. When clients re-connect after a communication loss, the server starts sending the buffered values. This standard OPC UA functionality only works on short-term communication losses and depends on client/server buffer settings and server storage capabilities.

To accommodate (or overcome) problems with lost data with a long-term communication failure, Prediktor has implemented our '**Catch-Up**' functionality in the OPC UA client. Unlike classic OPC installations, the Prediktor OPC UA client provides both Data Access (DA) and History Access (HA) through the same interface. The Prediktor approach of utilizing both the HA and DA channels gives the ability to retrieve data lost after (potentially even really) long-term communications failures.

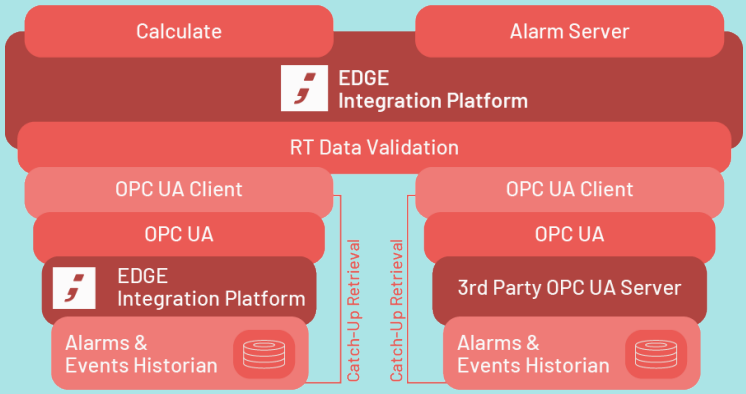

Figure 5: Example of Prediktor Catch – Up Architecture

Aggregation Services

Aggregation services are an efficient tool for **scalability**. The aggregating OPC UA server (or more than one server) acts as proxies for one or more individual OPC UA servers – which means clients can access the Aggregating server and expect to get the same information as if they were accessing an individual aggregated server.

This approach provides the possibility of constructing vast OPC server networks that are not restricted by physical or virtual servers' boundaries. In large systems, partitioning can be used to break systems down into smaller parts for development, maintenance, and monitoring. The Prediktor MAP Gateway supports three aggregating server patterns: Replicating proxy, Federating proxy and Basic proxy.

In **replicating proxy mode**, selected namespaces of the aggregated OPC UA server(s) are replicated in Prediktor MAP Gateway - which means Prediktor MAP Gateway hosts a copy of the address space of the aggregated server. The aggregated server's data variables are mirrored in Prediktor MAP Gateway using OPC UA subscription so that client subscriptions and read requests to replicated data variables are handled solely by Prediktor MAP Gateway, without involving the aggregated server.

History read requests to data variables are handled by the gateway or the Aggregated server, depending on the configuration. In federating proxy mode, the aggregating server maps multiple autonomous UA servers (or UA server namespaces) into a single federated UA server. There is no actual data replication between the aggregated UA servers and the Prediktor MAP Gateway as a proxy.

All client calls are routed and forwarded to the underlying servers and results/subscriptions are delivered back to the clients via the proxy. In basic proxy mode, Prediktor MAP Gateway, as an aggregating server, replicates data variables from the aggregated servers using OPC UA subscription. In this pattern, only data variables and their values are replicated. Metadata structures such as objects, object hierarchies and properties are not replicated in the aggregating server and hence not accessible for the clients.

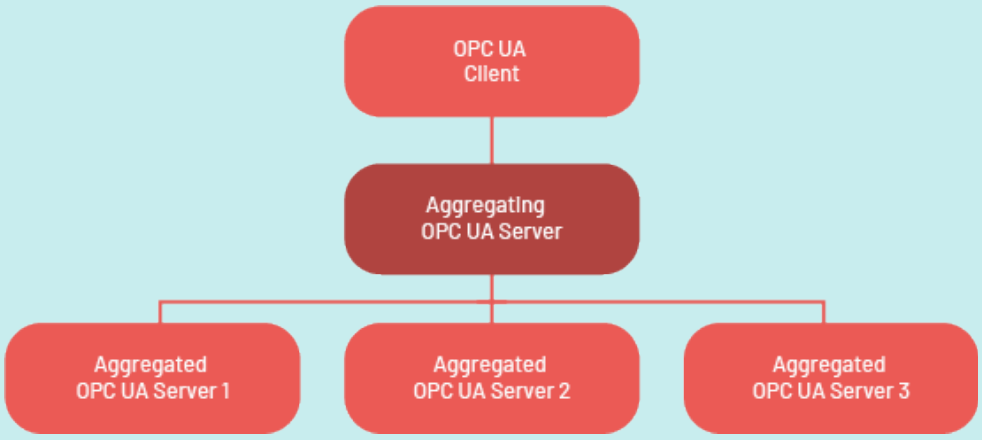

Figure 6: Example of Prediktor Aggregating Server approach

Data Processing Services

Several calculation modules are available, spanning from Soft PLC calculations and simple mathematical expressions to linear algebra and advanced mathematical simulation models. All calculations will end up with new values being exposed similarly as a measured value or event. An alarm server is also integrated as a standard. This server can be set up to monitor specific tags on specific conditions such as limit violations or lost signals. Distribution of alarms to other systems can be conducted over OPC UA, classical OPC AE, email or even SMS.

Archiving & Caching Services

All data captured can be stored in the integrated Prediktor EDGE time-series and event **historian**. Prediktor EDGE is a field-proven historian with superior performance and reliability that is seamlessly integrated with the Prediktor MAP Gateway. The aggregating server features allow for great freedom in terms of archiving and caching. On the one side, full long-term archiving can be supported fully in the gateway itself.

Alternatively, the gateway can store just a short time cache of new data serving operational client needs and forward requests for more extended time horizons further down in the architecture- to lower lever gateways or external OPC servers with historian capabilities. The time horizon to keep in the history cache is configurable - zero cache scenarios are also possible, meaning all historical requests can be forwarded to the underlying OPC UA architecture – no matter what your choice of caching is.

The integrated archiving service has been tested to cope with a sustained data archiving rate of 5 million VQT-records (value/quality/time) per second on non-clustered server setups. For extensive data set analysis purposes, 'lossy' data compression will tamper with data integrity and will be directly harmful. With an integrated archiving service, the data is always compressed 'lossless'- typical compression ratios vary from 50% to 90%. As a result, storage space requirements are very efficient. Typical installations average two bytes per VQT record.

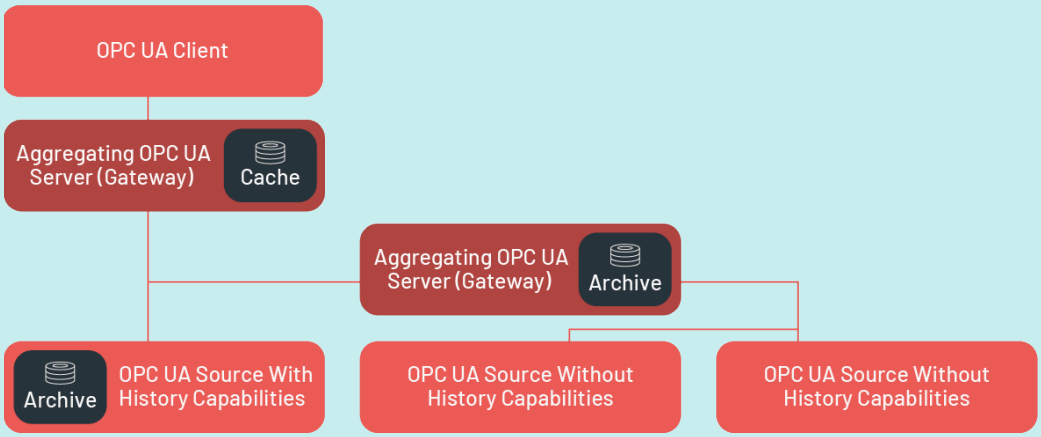

Figure 7: Example of Prediktor OPC UA Storage Options

Security

The Prediktor MAP Gateway is designed with a **role-based security model**, where client authentication can be handled by external IAM systems such as Active Directory, while the gateway handles authorization. The Prediktor MAP Gateway security server introduces these security roles and access control lists control access to all the Prediktor MAP Gateway resources.

Access to resources such as data items is managed using a dedicated experience in Prediktor EDGE Management Studio, where one can define sets of data items that share the same access control criteria and what operations are allowed with which roles.

When Active Directory validates client credentials, the client user's group memberships are returned to the Prediktor MAP Gateway security server. Internally in the security server, Active Directory groups are mapped to various security roles and this access to different resources in Prediktor MAP Gateway depends on the access granted within the actual roles.

In **IMS/IT-Secure** environments, firewalls are often required to block incoming traffic. These firewalls usually block incoming connections on open ports but do not block outgoing traffic. In normal circumstances, a connection is opened by the client before starting the OPC UA-specific handshake.

However, this approach will fail when Servers are behind firewalls with no open connection ports. To satisfy the requirements of secure environments, Prediktor EDGE supports the OPC UA reverse connectivity scenario, where the server opens the connection and starts with a ReverseHello message requesting that the client establish a Secure Channel using this connection.

System Management

The Prediktor MAP Gateway can operate in '**high availability cluster**' mode. A High Availability node consists of a Prediktor MAP Gateway instance with associated event databases and trend databases.

Each **node** of the **cluster** is (everyday situations) connected to underlying sources (redundant/non-redundant), exposing real-time data and history from the underlying sources and logs whilst also storing time-series data/events from the underlying sources to the databases associated with that node.

The cluster nodes are 'aware' of their peers' setup and govern historical data synchronization between them at the node's startup. The High Availability concept is designed based on the principles described in OPC UA Part 4 (Services).

Prediktor MAP Gateway supports non-transparent redundancy with hot server failover mode, meaning the cluster nodes do not exchange information or state, but operate on a standalone basis, continuously connected to the underlying systems to update internal state and history.

In addition to OPC UA Client/Server redundancy's general principles described in OPC UA Part 4, Prediktor MAP Gateway features concepts for config synchronization and history synchronization based on proprietary technology and definitions. The high availability concept can be used to achieve both redundancy and load balancing.

Non-transparent redundancy means clients themselves can identify what servers are available in the redundant server set.

Servers expose information telling the clients what modes of failover the server supports and the server's current state (service level) and endpoint information in the cluster. This information allows the clients to determine what actions they may need to take to accomplish failover.

The OPC UA hot server failover mode requires the redundant server-set to be powered on and 'up-and-running'. In scenarios where Servers acquire data from a downstream device, such as a PLC, then all servers are actively connected to the downstream device(s) in parallel.

The Servers have minimal knowledge of the other servers in their group and are independently functioning. When a server fails or encounters a serious problem, its service level drops, allowing the clients to select another server in the server set. The newly selected server returns to the redundant server set with an appropriate service level to indicate that it is available on recovery.

Cluster nodes are responsible for keeping the trend log and event log databases of the cluster nodes similar. The cluster nodes' trend logs and event logs are not expected to be bit-equal, but the goal is to extract similar logs from both servers and avoid significant log gaps due to cluster node downtime.

On the startup of a cluster node after downtime, the cluster node will immediately start to collect real-time data and events from the sources and contact other servers in the cluster to close the gap in the logs from the downtime.

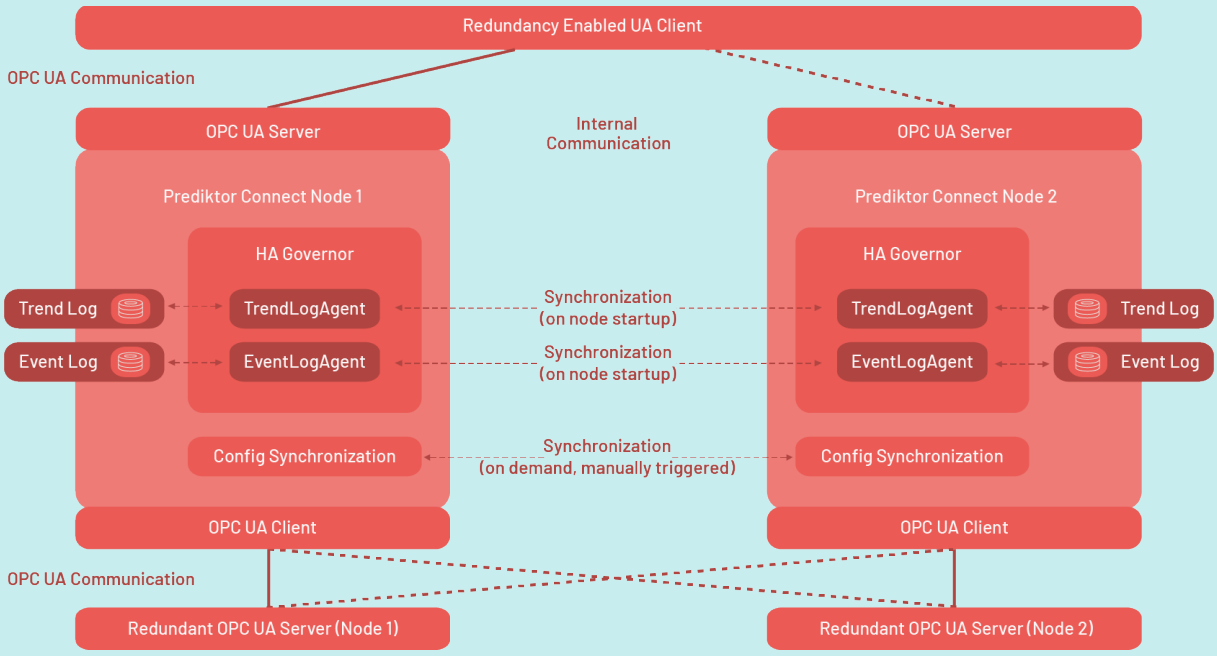

Figure 8: Example of Prediktor OPC UA Storage Options

Outbound Interfaces

The Prediktor system has extensive support for open industry-standard interfaces. Core outbound interfaces are OPC UA, including OPC UA PubSub, and classic OPC. These interfaces are exposed out of the core integration platform and are implemented natively in the platform.

This approach means that these outbound interfaces are the most efficient interfaces to use towards the system. For both UA and classic, both real-time (DA), history (HA/HDA), and events (AC/AE) are directly supported this way.

OPC UA supports both the UA binary protocol and the full W3C implementation of the communication stack. The OPC UA implementation also supports OPC UA companion standards available today or tomorrow through semantic modeling capabilities.

Inbound Data Capture & Validation

The key to all real-time applications is the integrity of the inbound data. Prediktor MAP Gateway features inherent inbound data validation steps using simple calculations to cover items such as range check, rate of change, quality, or 'watchdog' (e.g., sensor flatline) can be used.

Invalid data is, e.g., handled using alerts. More sophisticated statistical process control calculations can also be included – the options are endless.

To integrate with legacy data sources, besides extensive support for all the popular OPC Foundation protocols, there is support for a wide range of other protocols, such as Modbus, WITS0, WITS ML, text files and SQL database sources.

Buffering and spooling functionality are available to cope with temporary data communication failures. There is also an extended 'data catch-up' functionality to cope with long-term communication loss.

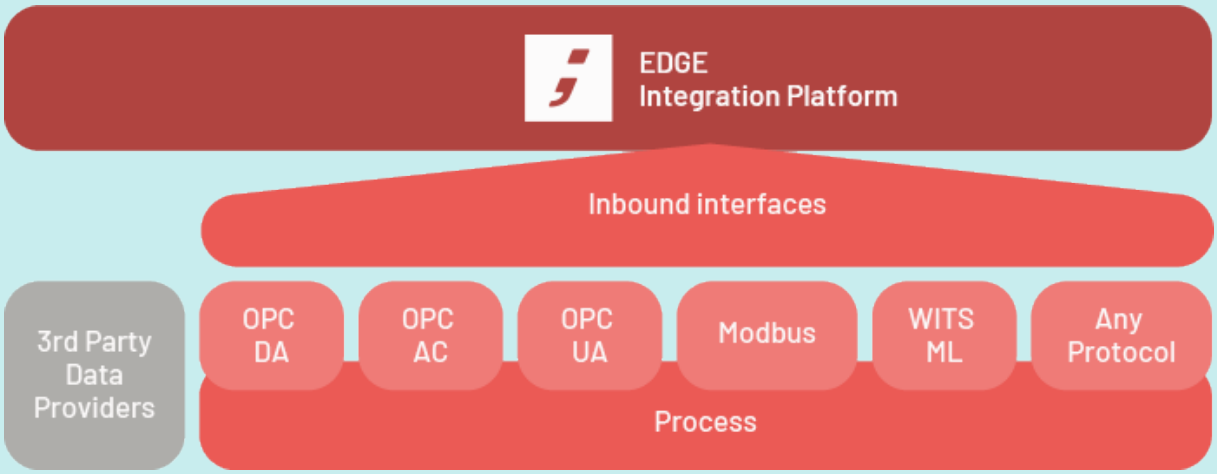

Figure 9: Example of Prediktor Edge Inbound Connectivity Options

Concepts for efficient implementation of old, non-standard, or site-specific protocols are available. New interface modules can be added to Prediktor MAP Gateway while running and will not interrupt the operational situation. Any captured sensor data can be associated with a well-defined unit of measure (UoM). Then for each UoM within a specific quantity type can be transformed into another UoM within the quantity type.

As an alternative to the gateway's inbound interface services, replication services for archived data are available. These services are set up with a publisher-subscriber model. A publisher will connect to a data source and, via communication with the subscriber on the gateway receiving side, assure that data is transferred in due time. This concept works robustly over non-reliable communication lines, such as satellite links. If there is a breach of communication– will the transfer continue where it left off when communication is re-established.

Prediktor EDGE Management Studio

All Prediktor MAP Gateway configuration and management is done in Prediktor EDGE Management Studio. Everything from top-down Enterprise semantic modeling to the detailed setup of signal propagation from data acquisition is configured within this tool. Management Studio can connect to several servers (gateways) and configure or view these servers' status.

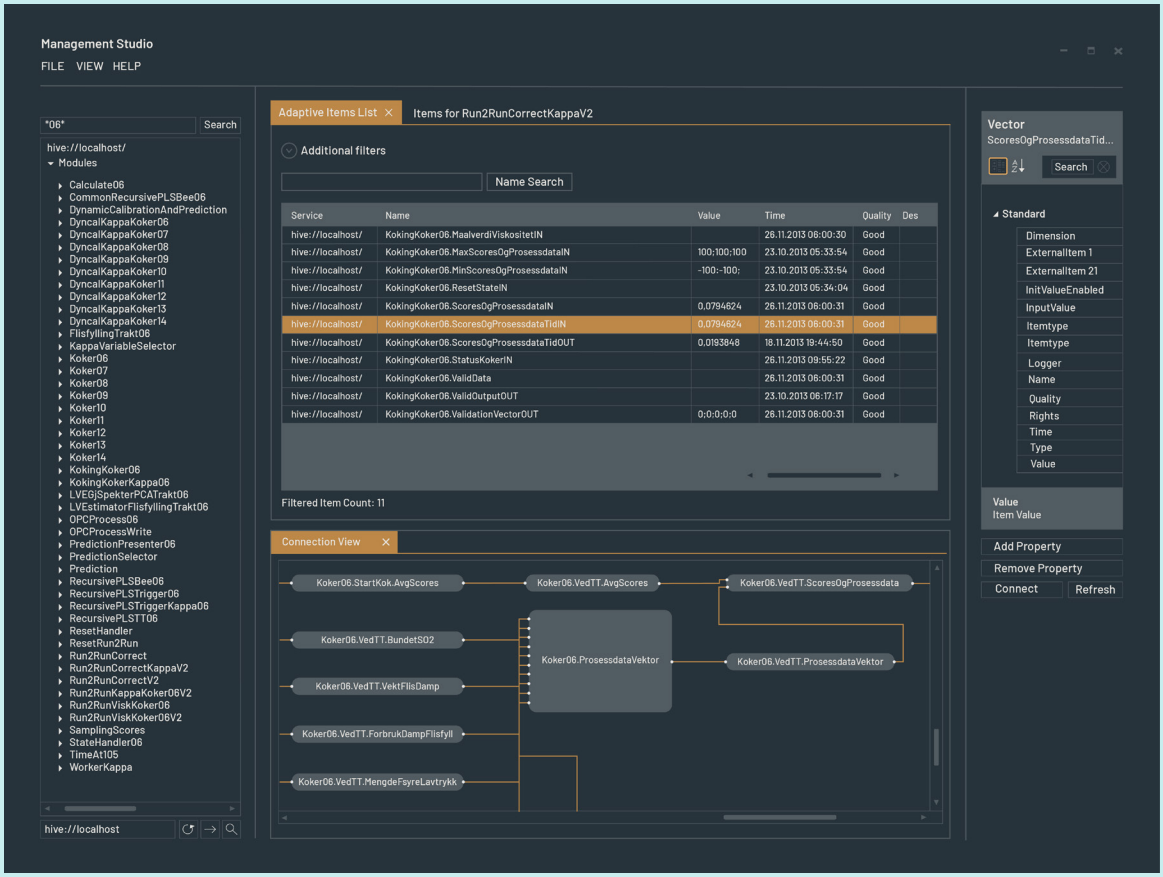

Figure 10: Example of Prediktor EDGE Management Studio

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Contact

Oil&Gas, Hydro & Industry

Robin Welch

Phone: +47 99 62 72 28
E-mail: robin@prediktor.com

Solar & Wind EMEA

Miquel Yafari

Phone: +34 619 712 191
E-mail: miquel.yafari@prediktor.com

Solar & Wind NA & Nordics

Steinar Jacobsen

Phone: +47 93 46 80 72
E-mail: steinar.jacobsen@prediktor.com

Solar & Wind Africa & APAC

Thomas Pettersen

Phone: +47 90 53 50 15
E-mail: thomas@prediktor.com

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