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Improving AVEVA™ PI System™ data reliability: A multi-layered approach

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AVEVA

What are we talking about here?

Defining some terms and setting the scope

- Context: time-series data in AVEVA PI System
- “Data reliability,” “data quality,” or “data integrity”?

Accuracy

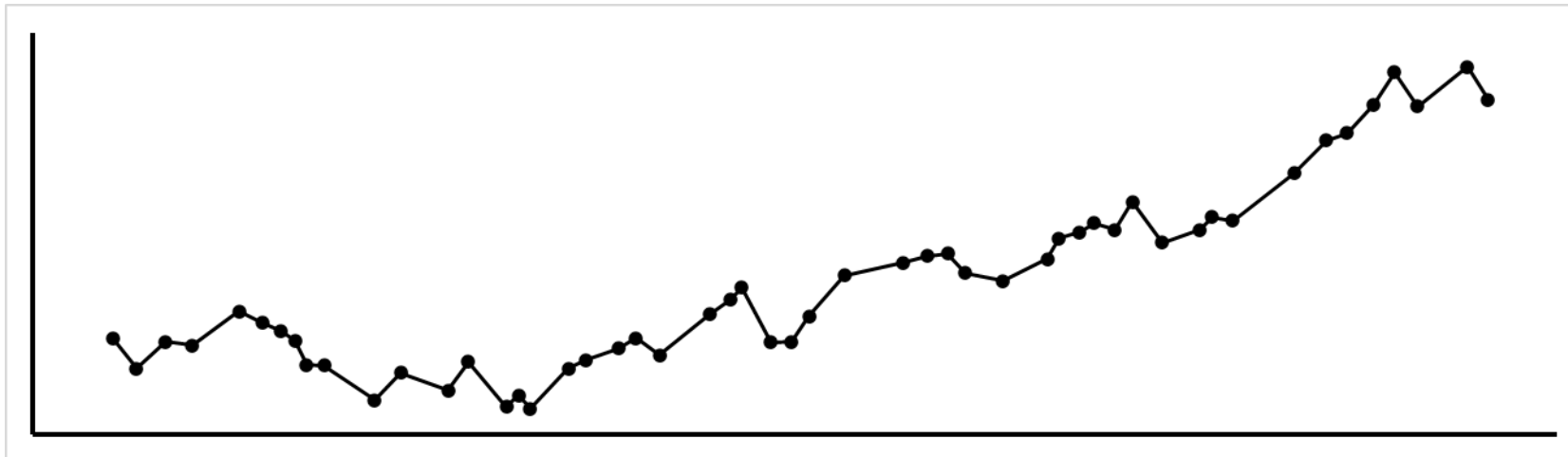
Is the data free from errors or misinformation?

Completeness

Did we get all the data?

Timeliness

Did the data arrive on time?



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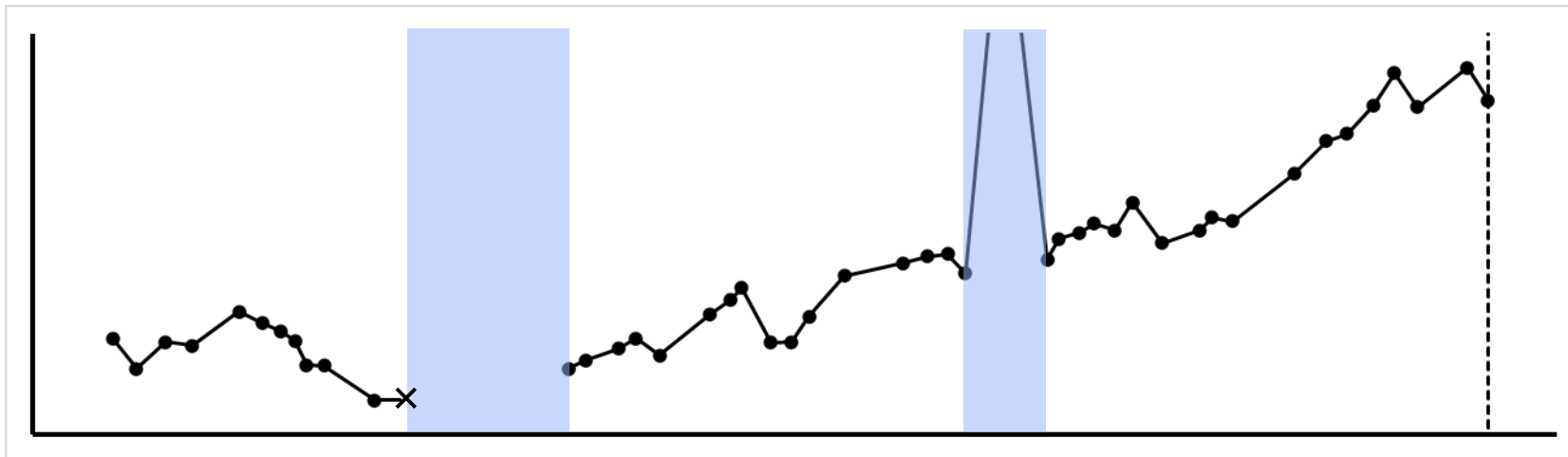
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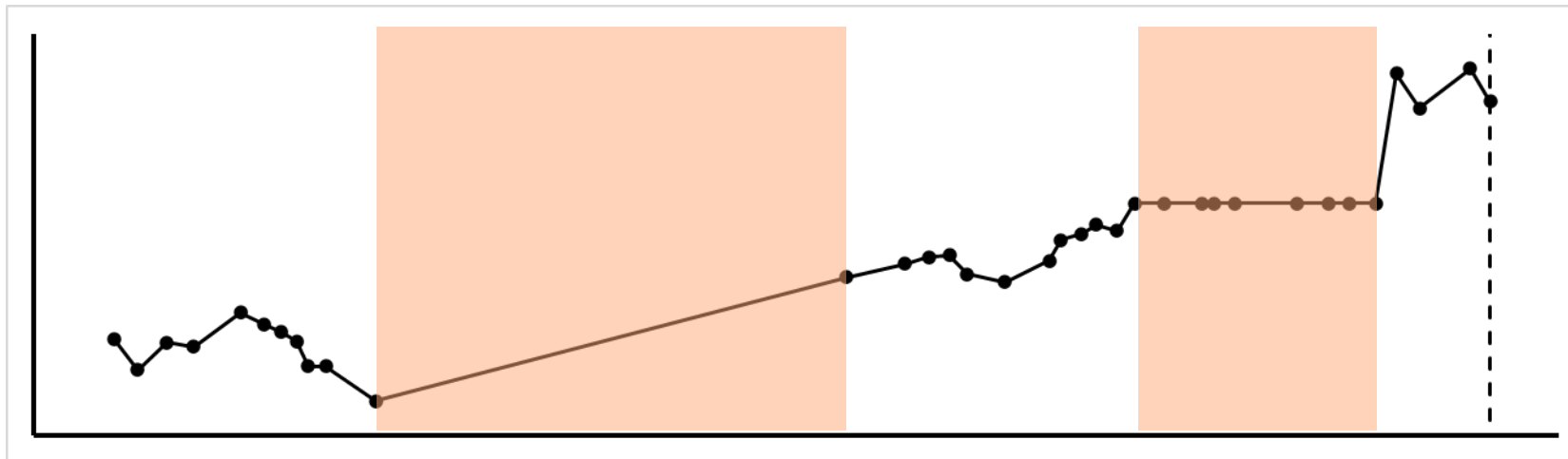
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Are there data gaps or flatlines?

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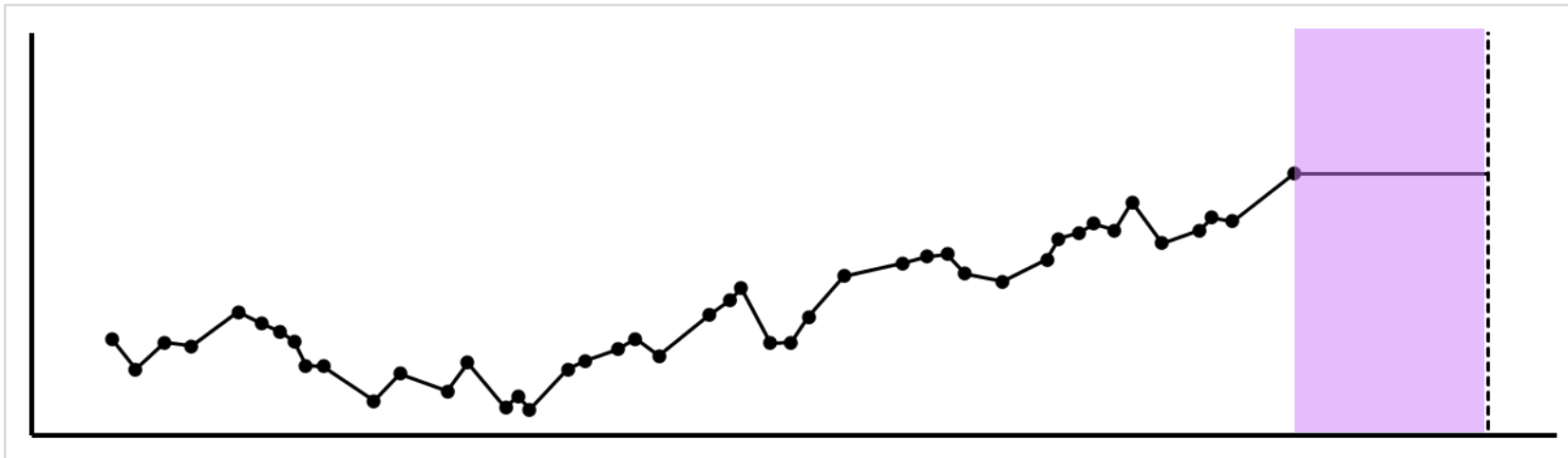
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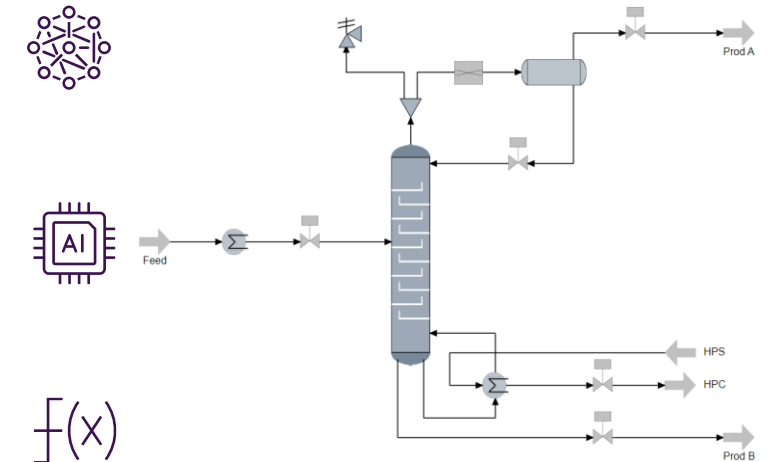
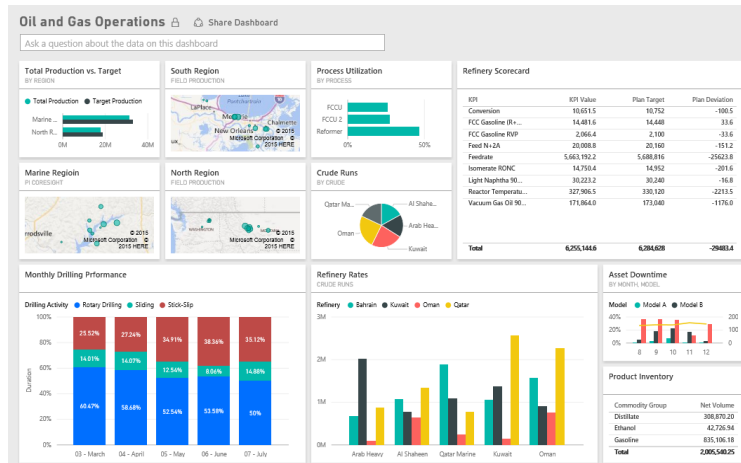
Is the data stale?



Why do we care about this topic?

Testimonials from AVEVA PI System administrators and business owners

- AVEVA PI System data feeds rollups for our corporate dashboards
- The data needs to be accurate
- AVEVA PI System is critical to monitoring our operations
- Users complain loudly when it's stale or bad
- Our modeling applications are sensitive to bad quality data
- We need to keep AVEVA PI System data as clean as possible.



Goals & approaches

- **Main goals:**
 - **Protect against issues that negatively impact data reliability**
 - **Identify and report issues as soon as possible**
 - ~~Not concerned with data cleansing or profiling~~
- **Approaches**
 - Governance and change management
 - High availability architectures
 - System monitoring
 - Monitoring of individual “tag health”

Data governance

Data quality and governance

Process and governance approaches

- Document and follow processes for changes to source systems and AVEVA PI System.
- Communication and collaboration are key.
- Data quality & governance - best practices (PI World 2019 San Francisco)

What is Data Quality?

Objective

- **Accessibility**
- **Appropriate amount of data**
- **Completeness**
- **Concise**
- **Consistent**
- Accuracy / Free-of-Error
- **Interpretability**
- **Security / Auditable**
- Timeliness

Subjective

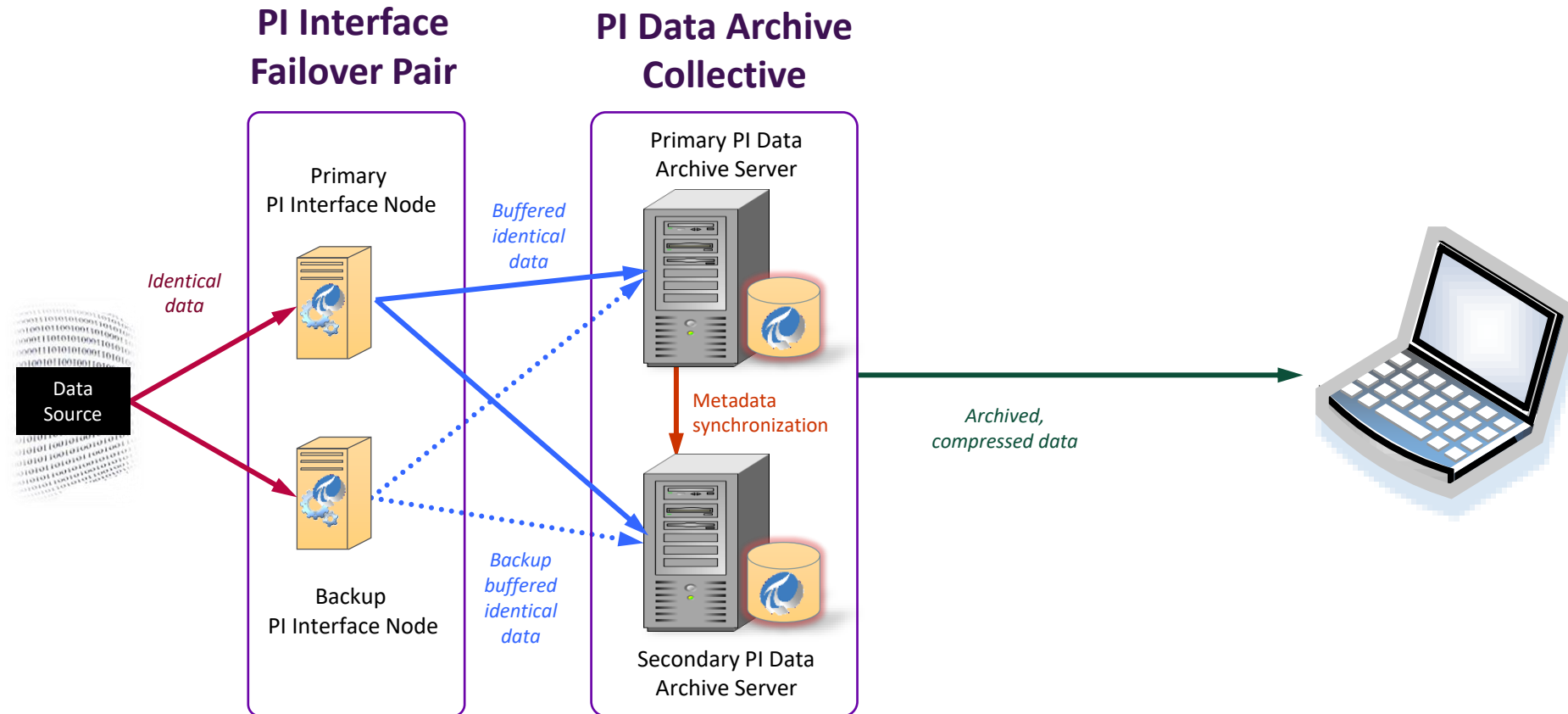
- Believability
- **Ease of Manipulation**
- Objectivity
- Relevancy
- Reputation
- **Understandability**
- Unique / Value-Added

OSISOFT PI World SAN FRANCISCO 2019 #PIWorld ©2019 OSISOFT, LLC

<https://resources.osisoft.com/presentations/data-quality-and-governance---best-practices/>

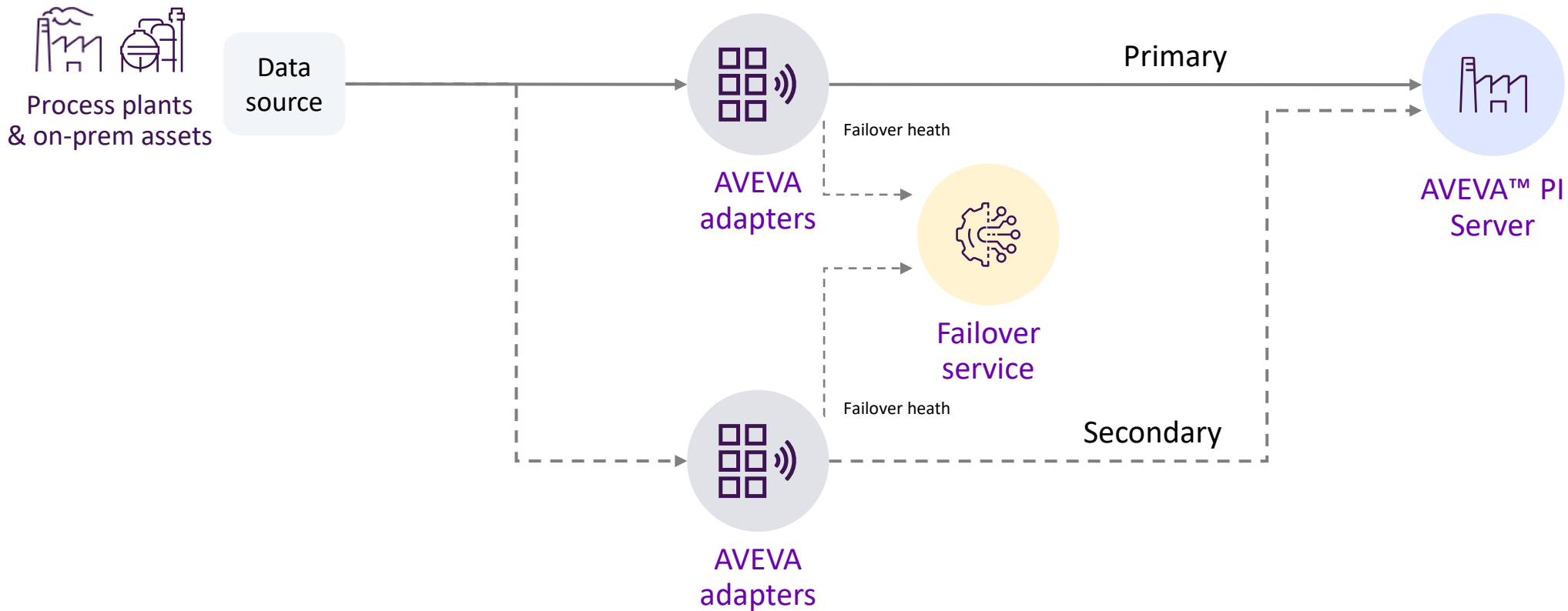
High availability (HA) architecture

High availability



AVEVA adapter failover: On-premises

Client-side failover

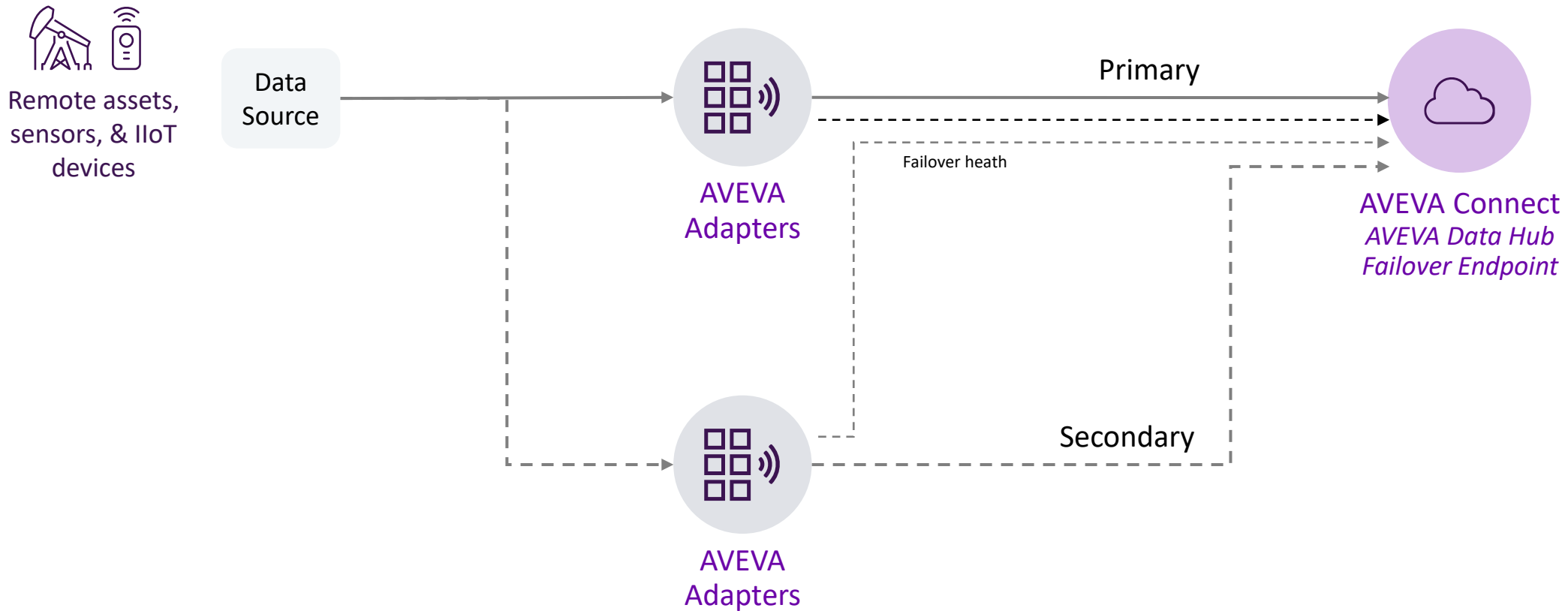


Failover modes:

- Hot
- Warm
- Cold

AVEVA adapter failover: Cloud

Client-side failover

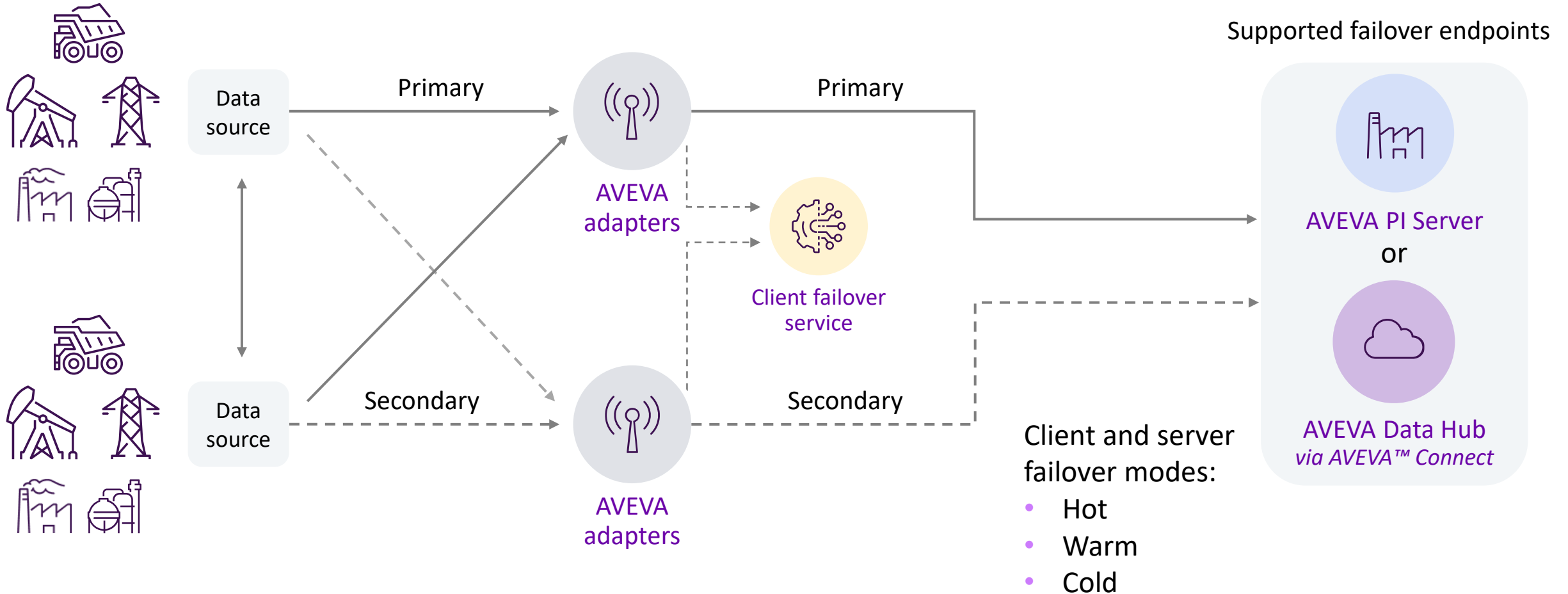


Failover modes:

- Hot
- Warm
- Cold

AVEVA adapter failover

Client-side and server-side failover for AVEVA PI Server and AVEVA™ Data Hub



System monitoring

Problems and challenges

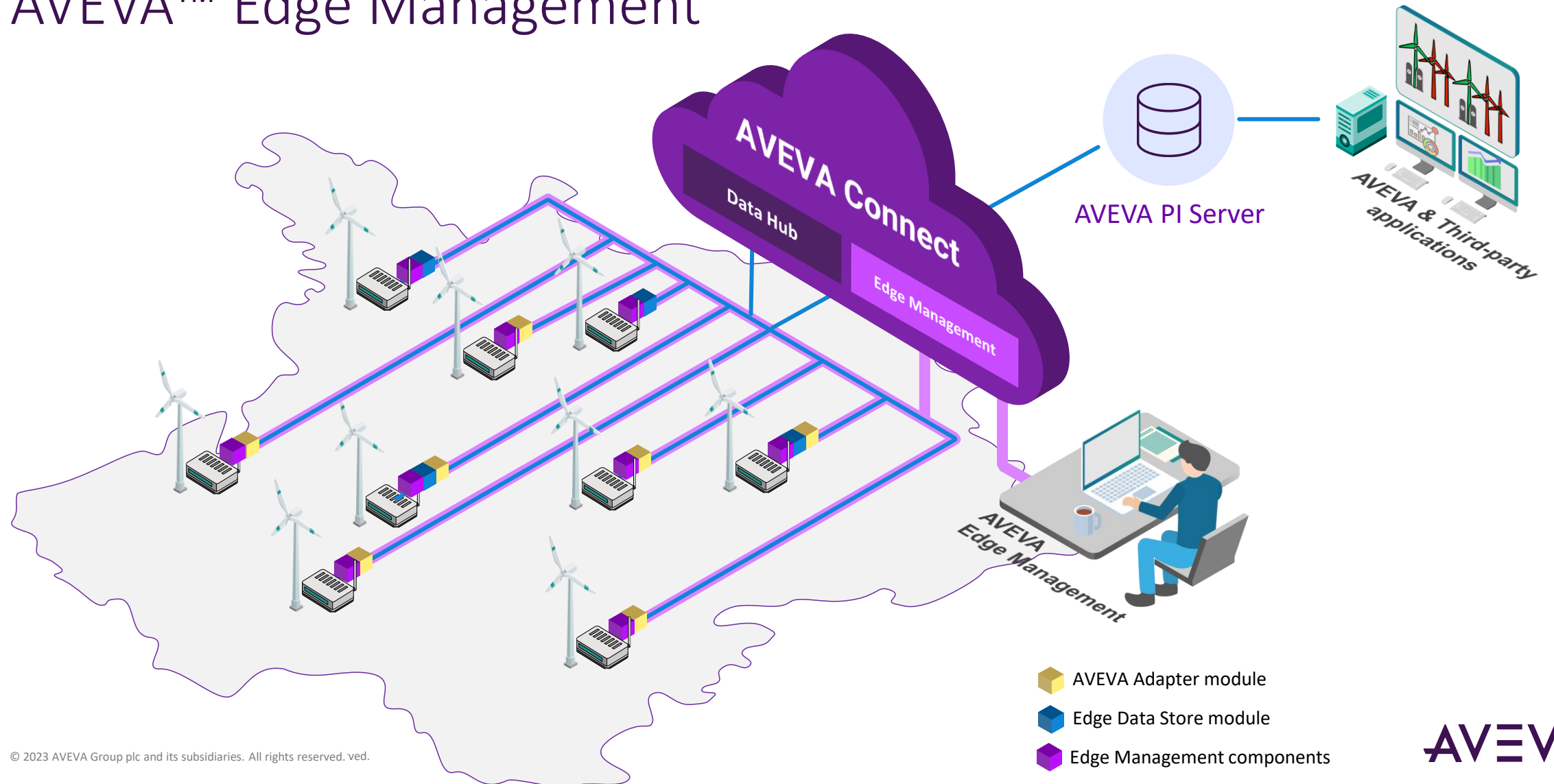
Hundreds of instances of connectors and interfaces can require around-the-clock observation

Tracking and monitoring

Quality degradation

Limited insight and visualization

Manage software deployments at scale with AVEVA™ Edge Management



Solution

With AVEVA Edge Management, we can now monitor

AVEVA™ Data Hub ▸ Edge Data Store & Adapters

Home | Data Management | Data Collection | Visualization | Analytics | Security | Developer Tools | Support

Systems ▾ Search for Systems 🔍

Status

- Good
- Starting
- Attempting Failover
- Connected / No Data
- Not Configured
- Server Error
- Lost Communication
- Device In Error
- Removed
- Shutdown

Visibility

- Show Active Systems
- Show Hidden Systems

Type

- AVEVA Adapter for Azure Event Hubs
- AVEVA Adapter for BACnet
- AVEVA Adapter for DNP3
- AVEVA Adapter for Modbus TCP
- AVEVA Adapter for MQTT
- AVEVA Adapter for OPC UA
- AVEVA Adapter for RDBMS

Device Name ↑	Status	Type	Version	Last Contacted	Tags
EdgeGateway1	⚠ Lost Communication	AVEVA Adapter for OPC UA	1.3.1.6	4 months ago	
EDGELINUX	⚠ Server Error	AVEVA Adapter for OPC UA	1.3.1.6	3 days ago	
EDGELINUX001	⚠ Server Error	AVEVA Adapter for OPC UA	1.3.1.6	3 days ago	
EDGELINUX1	⚠ Lost Communication	AVEVA Adapter for OPC UA	1.4.0.196	24 days ago	
EDGELINUX1	⚠ Lost Communication	AVEVA Adapter for MQTT	1.3.0.103	24 days ago	
EDGELINUX1OPCUA	⚠ Not Configured	AVEVA Adapter for OPC UA	1.3.1.6	3 days ago	
EdgeLinuxDevice	⚠ Not Configured	AVEVA Adapter for OPC UA	1.3.1.6	3 days ago	
EDGELINUXDEVICE1	⚠ Server Error	AVEVA Adapter for OPC UA	1.3.1.6	3 days ago	
EDGEPC1	⚠ Server Error	AVEVA Adapter for OPC UA	1.4.0.196	3 days ago	
EDGEPC1	⚠ Not Configured	AVEVA Adapter for MQTT	1.3.0.103	3 days ago	
EDGEWINDOWS1	⚠ Lost Communication	Edge Data Store	1.1.3.2	2 hours ago	
PRGWINDNP3	⚠ Lost Communication	AVEVA Adapter for DNP3	1.1.0.103	a year ago	
RMEDGE01	✅ Good	AVEVA Adapter for MQTT	1.2.0.59	a few seconds ago	
RMEDGE02	✅ Good	AVEVA Adapter for MQTT	1.2.0.59	a few seconds ago	
RMEDGE03	✅ Good	Edge Data Store	1.1.2.2	a minute ago	
RMEDGE03	✅ Good	AVEVA Adapter for MQTT	1.2.0.59	a few seconds ago	
RMEDGE04	✅ Good	Edge Data Store	1.1.2.2	a few seconds ago	
RMEDGE04	✅ Good	AVEVA Adapter for OPC UA	1.3.1.6	a few seconds ago	
SLTCSensor1	❌ Device In Error	AVEVA Adapter for MQTT	1.0.0.167	a few seconds ago	
SLTCSensor1	✅ Good	Edge Data Store	1.1.0.9	a few seconds ago	
SYDNSensor1	⚠ Lost Communication	Edge Data Store	1.1.0.74	a year ago	
UOCGR	⚠ Not Configured	Invalid	23.0.000	a year ago	

Items per page: 50 1 - 22 of 22

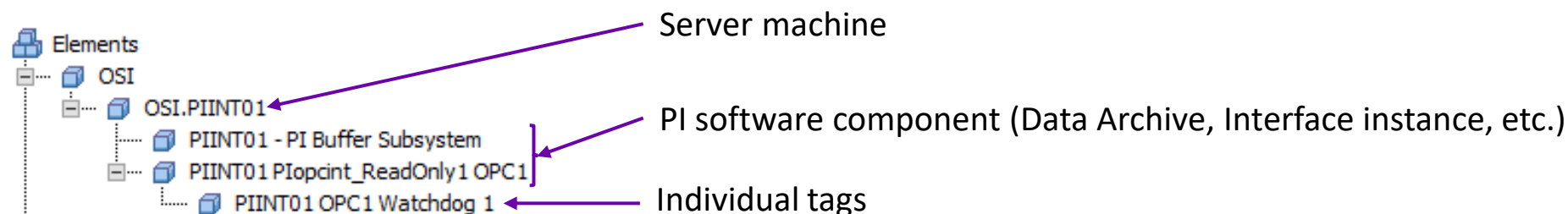


System monitoring with AF & asset analytics: PSM

AVEVA PI System status monitoring from AVEVA PI System technical adoption services

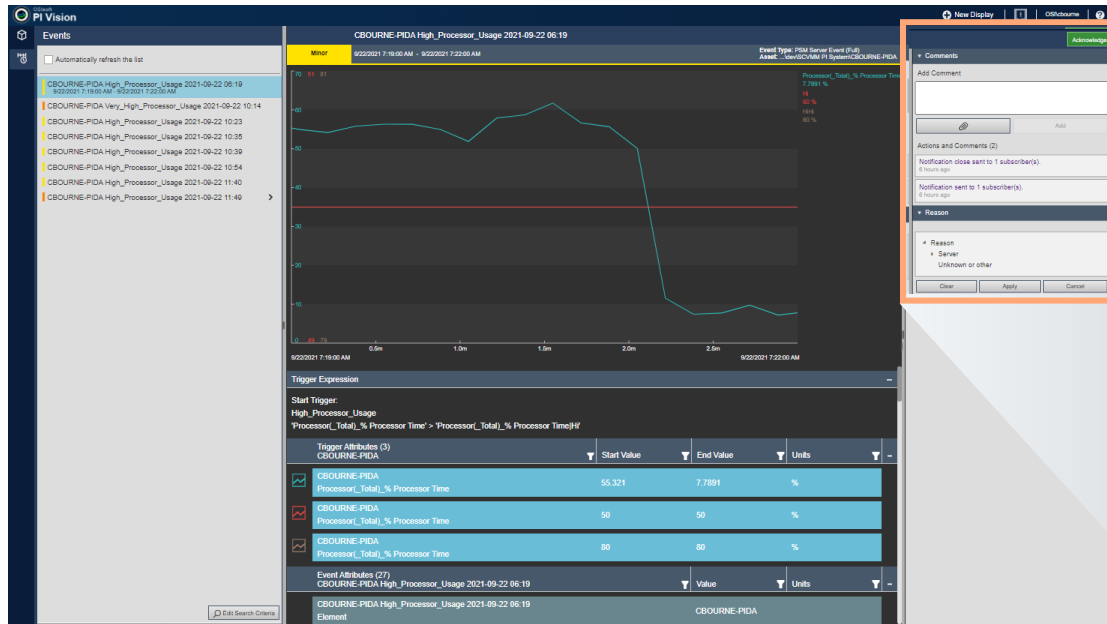
- The [AVEVA PI System monitoring service offering](#) includes AF templates to help with monitoring at several levels
- Leverages data from Perfmon, Ping, & TCP Response Interfaces

- Example:



- Server and component monitoring help minimize impact of wide outages (many tags).
 - Examples: poor service health, low I/O Rate, queuing data, and network issues
- Watchdog tags: key tags that can help identify data source or interface issues
 - Stale or flatline data

PSM: Identify & alert



Event frames

This inset window shows the 'Comments' section with an 'Add Comment' text area and an 'Add' button. Below it, the 'Reason' section is expanded to show a tree view with 'Server' selected, and the text 'Unknown or other'. At the bottom are 'Clear', 'Apply', and 'Cancel' buttons.

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- ## Add Context
- Reason attribute
 - Annotations
 - Acknowledgement

PSM: Identify & alert

The screenshot displays the PI Vision software interface. On the left, a list of events is shown, with the selected event being 'PISR01 - Data Archive Historical_Data_Corrupted_Archives 2021-05-07 17:54'. The main area shows a line graph of processor usage over time. On the right, the event details are displayed, including the event name, start time, and severity. Below the event details is a table of attributes:

Attribute	Value at Event Frame Start Time*	Value at Email Send Time*	Expected Value
PI Archive Subsystem_Corrupted Archives Count	1	1	0, there should not be any corrupted archives
PI Archive Subsystem_Archiving Flag	1	1	Value must be 1, if 0 data is not being archived
Average Archive Write Rate	3156.6	3156.2	>0
PI Archive Subsystem_Failed Archive Shift Flag	0	0	Value should be 0

Event: PISR01 - Data Archive Historical_Data_Corrupted_Archives 2021-05-07 17:54
Start Time: 5/7/2021 5:54:16 PM Coordinated Universal Time (GMT00:00:00)
Severity: Minor

The **PI Archive Subsystem** has detected archive corruption. One or more historical archive files are currently corrupted. These archives need to be reprocessed to fix the issue. You can access the list of archives from **PI SMT -> Operations -> Archives**. Look at the **Corrupt** column to know which archives are corrupted.

Attribute	Value at Event Frame Start Time*	Value at Email Send Time*	Expected Value
PI Archive Subsystem_Corrupted Archives Count	1	1	0, there should not be any corrupted archives
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PI Archive Subsystem_Failed Archive Shift Flag	0	0	Value should be 0

*Value at Event Frame Start Time can be different than Value at Email Send Time if this is a closure email, or if there is a delay sending the notification email and the value has changed

Troubleshooting steps

- The preferred way to reprocess archives is to use the online reprocessing capability in PI SMT. More information can be found here:

[Livelibrary Online Archive reprocessing](#)

- If the online reprocessing cannot be used then the offline archive utility (piarchss) must be used.

[Offline reprocessing 2367OSI8](#)

Link to this event in PI Vision: [Event Details Hyperlink](#)

Element Path: [\\PIMONITOR01\PSM](#) Example\PISCHOO1\PISR01\PISR01 - Data Archive

Notification Rule: Archive Corruption Alert

Notifications

PSM: Identify & alert

The screenshot shows the PI Vision interface. On the left, there's a list of events for 'CBourne-PIDA High_Processor_Usage'. The main area displays a line graph of processor usage over time. An event notification window is overlaid on the graph, showing details for an event titled 'PISR01 - Data Archive Historical_Data_Corrupted_Archives 2021-05-07 17:54'. The notification includes the sender 'PIMonitor@pischool.int' and the recipient 'student01@pischool.int'. Below the notification, there's a table with event details.

Attribute	Value at Event Frame Start Time*	Value at Email Send Time*	Expected
PI Archive Subsystem_Corrupted Archives Count	1	1	0, there s
PI Archive Subsystem_Archiving Flag	1	1	Value mu
Average Archive Write Rate	3156.6	3156.2	>0
PI Archive Subsystem_Failed Archive Shift Flag	0	0	Value shc

Fri 5/7/2021 5:59 PM
 PIMonitor@pischool.int
 PISR01 - Data Archive Historical_Data_Corrupted_Archives 2021-05-07 17:54
 To student01@pischool.int

Event: PISR01 - Data Archive Historical_Data_Corrupted_Archives 2021-05-07 17:54
Start Time: 5/7/2021 5:54:16 PM Coordinated Universal Time (GMT00:00:00)
Severity: Minor

The **PI Archive Subsystem** has detected archive corruption. One or more historical archive files are currently corrupted. These archives need to be reprocessed to fix the issue. You can access the list of archives from **PI SMT -> Operations -> Archives**. Look at the **Corrupt** column to know which archives are corrupted.

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Link to this event in PI Vision: [Event Details Hyperlink](#)

Element Path: \\PIMONITOR01\PSM Example\PISCHOOL\PISR01\PISR01 - Data Archive
Notification Rule: Archive Corruption Alert

The screenshot shows the AVEVA PI Server documentation page. The page title is 'Reprocess an archive'. It includes a table of contents on the left, a main content area with a note about reprocessing archives, and a procedure section. The note states: 'Using the Archives tool you can reprocess archives while they are online. Reprocessing archives repairs corrupt archives, and for archives that are not corrupt, reprocessing can potentially recover disk space or improve the speed of certain transactions.' The procedure section starts with: '1. In PI SMT, choose Operation > Archives. If you have any corrupt archive files, PI SMT prompts you to reprocess them.'

PSM: Identify, alert, visualize

AVEVA™ PI Vision™

PSM Interfaces & Buffering

Filtered Event Table Servers (Overview) Server (Detail) Interface & Buffer Data Archive AF/Analytics/Notifications Analysis Service

Interface Information (Click machine name for interface event list)

Buffer Subsystem Information (Click machine name for buffer event list)

Interfaces Stopped or Not Communicating w/ PI Server

Machine	Interface Name	Point Source	ID	Point Cnt	Device Status	PI Status	UpTime	IO Rate (evt/s)
PIINT02	PI opcint_ReadOnly1	OPC1	1	71.499	Good	Down	71 0.0 d	71.499 event/s

Interfaces Stopped or Device Status not Good

Machine	Interface Name	Point Source	ID	Point Cnt	Device Status	PI Status	UpTime	IO Rate (evt/s)
PIINT01	PI-opcint_ReadOnly1	OPC1	1	71.499	Device(s) in error	Communicating	71 0.0 d	71.499 event/s

Interfaces Statuses Good

Machine	Interface Name	Point Source	ID	Point Cnt	Device Status	PI Status	UpTime	IO Rate (evt/s)
PIINT01	PI opcint_ReadOnly2	PIINT01_OPC	1	71.499	Good	Communicating	71 0.0 d	71.499 event/s
PISRV01	PI-PITCPResp1	PISRV01_TCPRESP	1	71.499	Good	Communicating	71 0.0 d	71.499 event/s

Unhealthy Buffer Subsystems

Machine	Health	Capacity	Queued Events	Sessions Offline	Compression Ratio	Event Send Rates Total	Event Send Rates 000
PIINT01	Warning	71.5 d	71	0	11.2 :1	71.5	71.5
PIINT02	Critical	0.0 d	5.1642E+06	0	3 :1	71.5	71.5

Healthy Buffer Subsystems

Machine	Health	Capacity	Queued Events	Sessions Offline	Compression Ratio	Event Send Rates Total	Event Send Rates 000
PIAF01	OK	71.5 d	71	0	26.2 :1	71.5	71.5
PISRV01	OK	71.5 d	71	0	15.8 :1	71.5	71.5

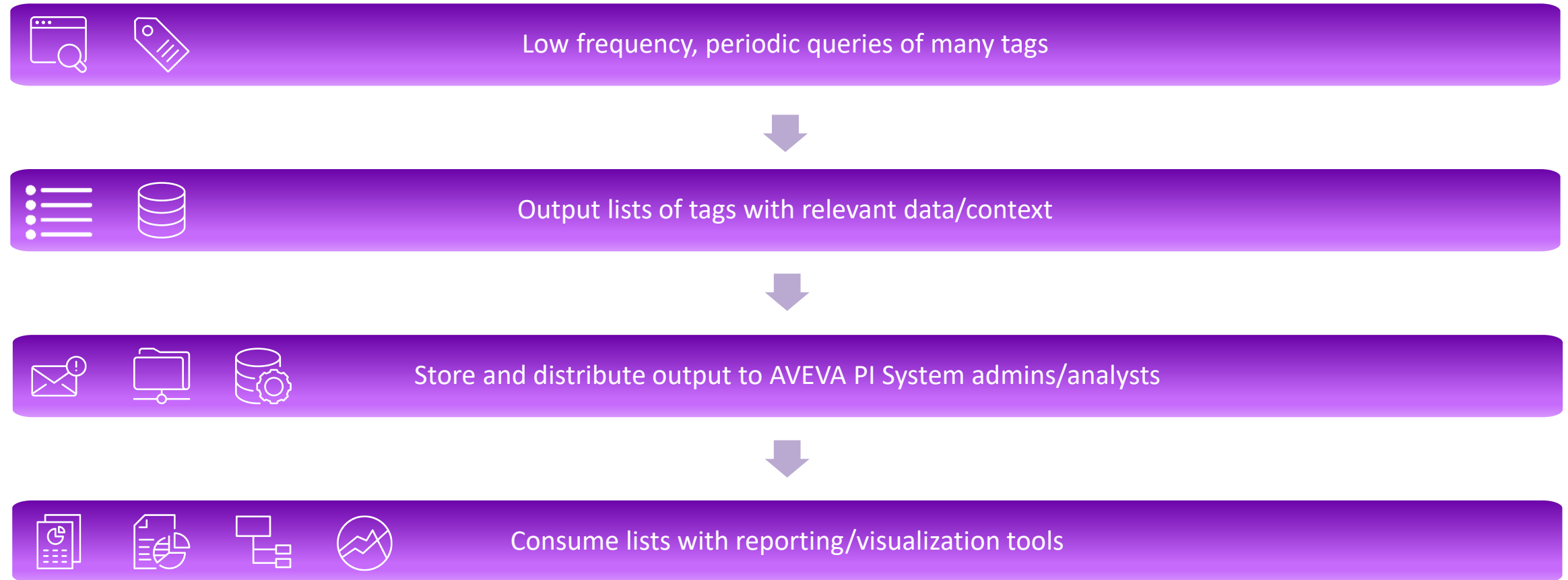
Tag-level monitoring

Monitoring tags with AF & asset analytics

- Extension of the PSM watchdog tag methodology
- Typically used for a subset of critical tags
- Scalability considerations:
 - Load on PI Analysis Service
 - Follow [Asset Analytics Best Practices](#) for better scaling.
 - Determine practicality of Notifications and design accordingly.
- Published customer examples:
 - [Monitoring Data Quality with Asset Analytics \(PW2018\)](#)
 - [Better Data Quality for Better Data Science with the PI System \(PW2018\)](#)

Name	Expression
vWatchPeriodStart	<code>'*' - Convert('Watch Period','s') //Convert watch period to seconds & subtract from current time.</code>
vBadChk	<code>If BadVal('Watchdog Tag') Then 1 //Bad Else 0 //Good</code>
vStaleChk	<code>If PrevEvent('Watchdog Tag','*') < vWatchPeriodStart Then 1 //Stale Else 0 //Fresh</code>
vFlatLineChk	<code>If vStaleChk = 1 Or vBadChk = 1 Then 0 //Flatline test = True for stale or bad tags even values aren't repeating Else If NumOfChanges('Watchdog Tag',vWatchPeriodStart,'*') = 0 /*Count changes in watch period. Values from System digital set do not get counted by NumOfChanges*/ Then 1 //Flatline Else 0 //Updating</code>
vOutOfRngChk	<code>If 'Watchdog Tag' < 'Watchdog Tag Minimum' Then 1 //Under range Else If 'Watchdog Tag' > 'Watchdog Tag Maximum' Then 2 //Over range Else 0 //In range</code>

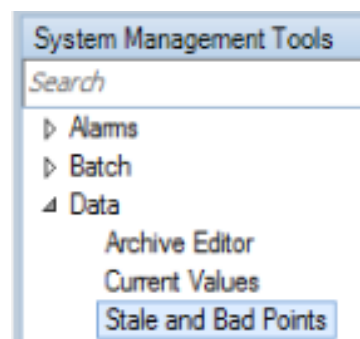
Tag monitoring: Bulk reporting & analysis methodology



Bulk method: The simplest approach

Stale and bad points plug-in in PI SMT

- Run manually by system admin



Search Options

Show: Stale Bad Both

Stale between: 1h, 3650d

Bad States: All System States Specific States

Quick search: Tag mask: * Pointsource: L Point Class: Any

Server	Collective	Stale	Bad	Tag	Pointsource	Timestamp	Value
-PI		X		Arrays.Mass Rate.31b0a8ca-af8c-4e1d-830c-1980ddebb47f	L	1/11/2021 9:53:33 AM	-0.07
-PI		X	X	Corsicana.Zone 01 COR.Oxygen Flow Maximum.8eed5c09-7212-5386-15cb-7bca94f67e85	L	10/22/2020 11:08:17 AM	Pt Created
-PI		X	X	DigStTagWithEmptyState	L	12/8/2020 3:39:48 PM	Pt Created
-PI		X		Element1.Tag Direction	L	1/11/2021 9:52:03 AM	0
-PI		X		Element2.Tag Direction	L	1/11/2021 9:52:03 AM	0
-PI		X		Element3.Tag Direction	L	1/11/2021 9:52:03 AM	0
-PI		X		Element4.Tag Direction	L	1/11/2021 9:52:03 AM	0
-PI		X		InStr Test Tag	L	7/7/2020 12:00:00 AM	DEF
-PI		X		Int Tag	L	10/15/2020 3:46:05 PM	2
-PI		X		Lab Test	L	3/2/2021 11:04:00 AM	8.00
-PI		X	X	Notifications Testing.Tag Direction	L	10/13/2020 3:45:35 PM	Pt Created
-PI		X		UOM Tests.Value StripUnits	L	1/11/2021 9:53:33 AM	212.555.44
-PI		X		UOM Tests.Value WithUnits	L	1/11/2021 9:53:33 AM	212.56
-PI		X		Variable v Attribute.Attribute Output.81009b33-27bd-4662-a978-ccee85430b4b	L	7/28/2020 2:57:43 PM	3
-PI		X		Variable v Attribute.Variable Output.1c4ab2cd-af82-4465-b64b-858a145723dc	L	7/28/2020 2:57:43 PM	4

- Output to CSV file
- Consume CSV with Excel

Bulk method: A more automated approach

Run script(s) on a schedule using AVEVA PI System developer technologies



Low frequency, periodic queries of many tags

Developer technologies

- Most typical: [PI AF SDK](#)
 - .NET app
 - Called from Powershell
- Older: [piconfig](#) (.bat files)
- Other possibilities:
 - [Powershell Tools for the PI System](#)
 - (sqlcmd or SQL Server) + [PI SQL](#) linked server

Scheduling options

- Windows Task Scheduler
- Other 3rd party tools
- SQL Server Agent (If using SQL Server)

Bulk method: A more automated approach

Output tag list(s)

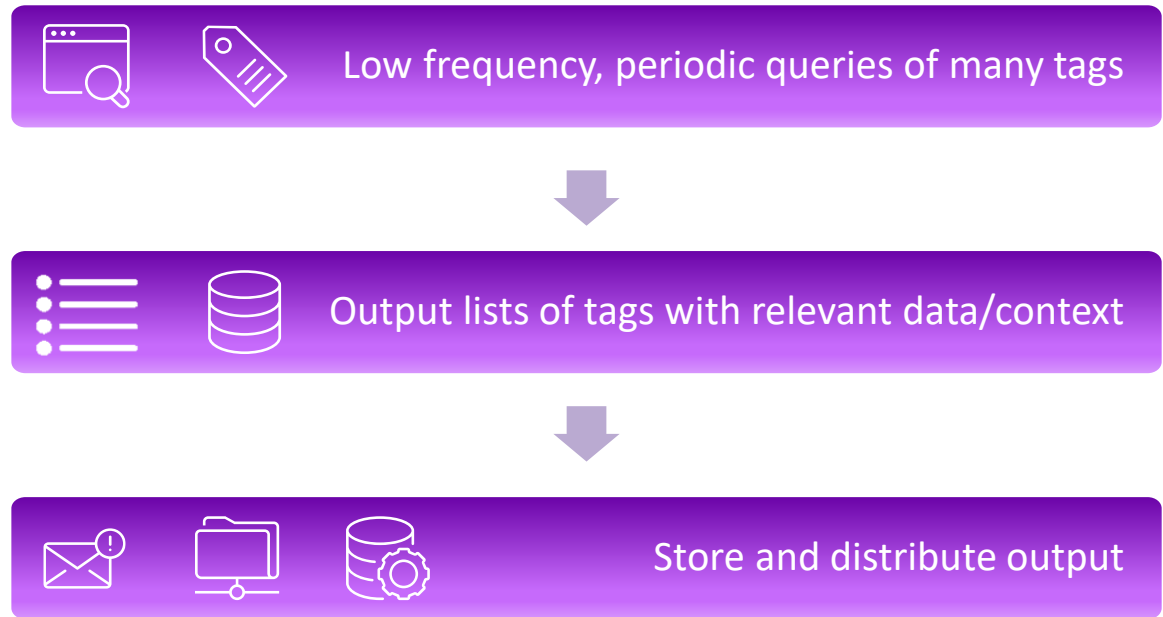


Example output options

- CSV files
- SQL tables
- PI tags for summary values
 - Example: stale tag count

Bulk method: A more automated approach

Store and distribute output to AVEVA PI System admins and/or analysts

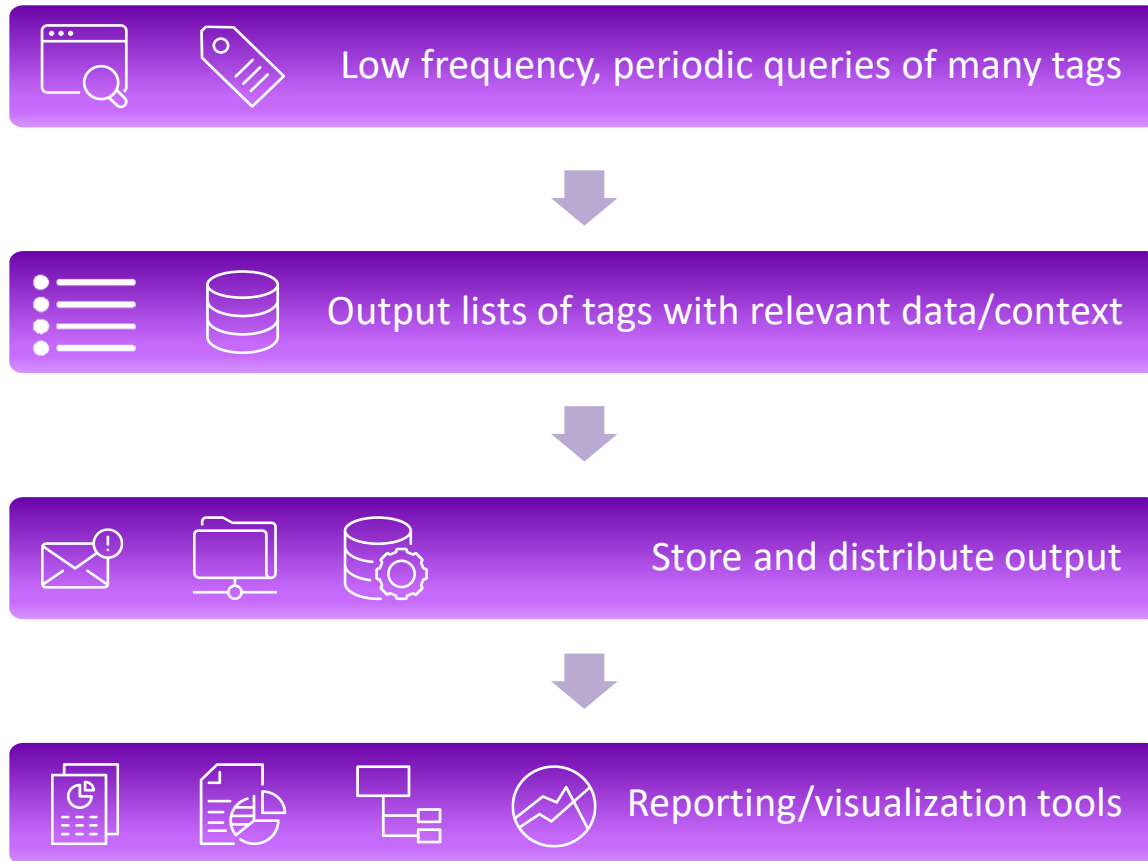


Example distribution options

- Share folder
- Notifications attachment or link
- SQL table

Bulk method: A more automated approach

Visualize and analyze the data



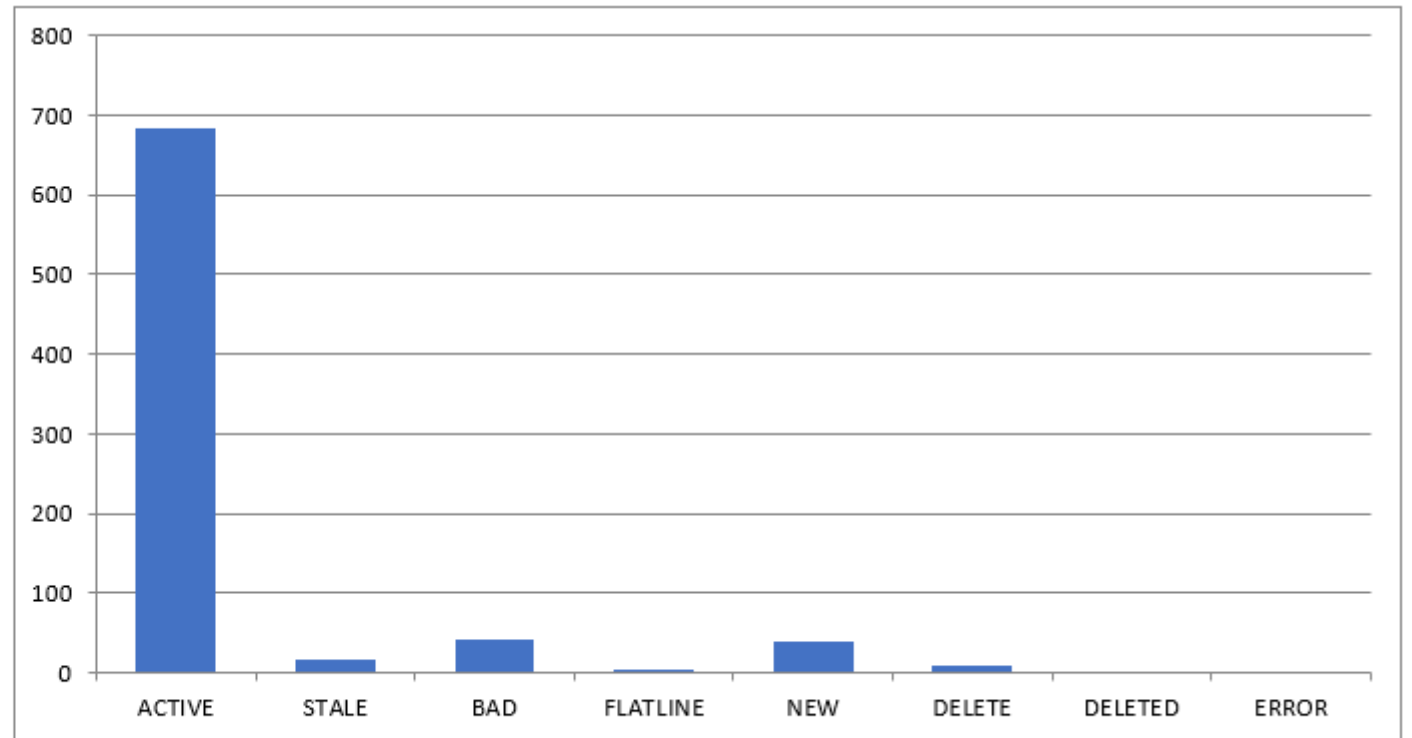
Example reporting options

- Excel
 - Filters
 - Pivot table/chart
- BI tools
 - Slice and dice on dimensions like failure type, point source, interface machine name, etc.
- AVEVA™ PI Vision™ dashboards
 - Summary values written to PI points
 - AF elements

Bulk Method: Reporting

Simple example in Excel with pivot table and chart

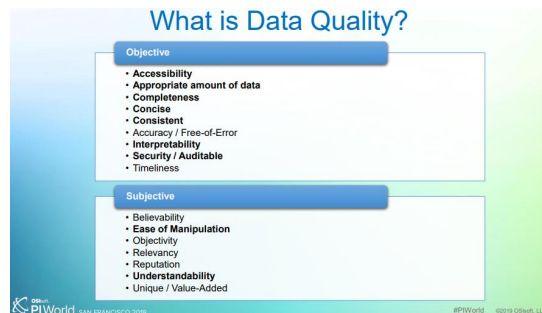
	Count	Percent	
ACTIVE	683	86%	<i>Points with recent good data</i>
STALE	16	2%	<i>Points with no recent data</i>
BAD	42	5%	<i>Points with bad value but good previously</i>
FLATLINE	4	1%	<i>Points with unchanging values</i>
NEW	40	5%	<i>Points with no good data but are new</i>
DELETE	9	1%	<i>Points with no good data but are old</i>
DELETED	0	0%	<i>Points deleted (refresh only)</i>
ERROR	0	0%	<i>Points that failed to be analysed</i>
TOTAL	794		



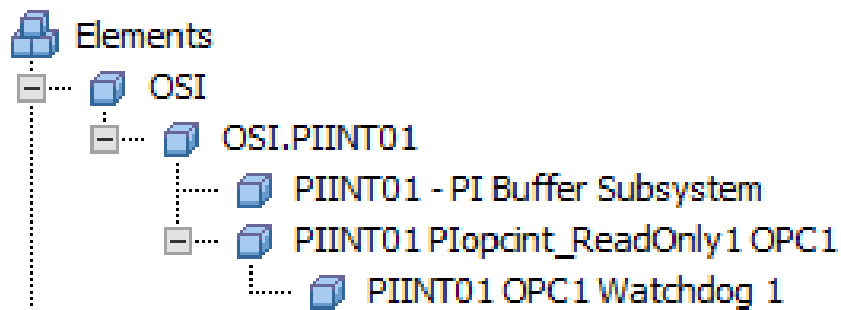
To Summarize

- Presented methods to help increase AVEVA PI System data reliability
- Suggested approaches:

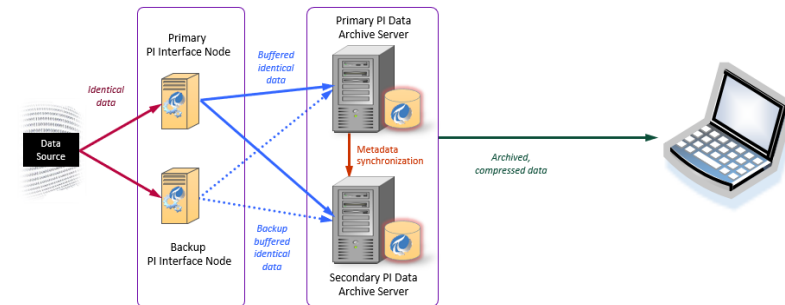
Better governance and change management



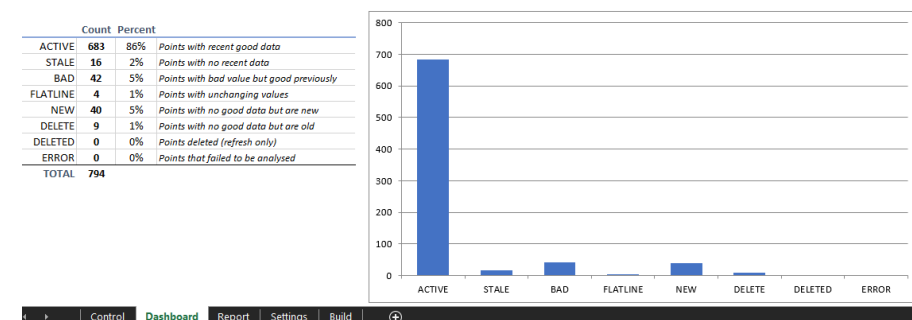
System-level monitoring



Use of high availability architectures



Tag-level monitoring





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Kranthi Kumar(KK) Tappita

R&D Partner Technologist, Program Management

- AVEVA
- Kranthi.Tappita@aveva.com

Questions?

Please wait for the microphone.
State your name and company.



Please remember to...

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Thank you!

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AVEVA is a world leader in industrial software, providing engineering and operational solutions across multiple industries, including oil and gas, chemical, pharmaceutical, power and utilities, marine, renewables, and food and beverage. Our agnostic and open architecture helps organizations design, build, operate, maintain and optimize the complete lifecycle of complex industrial assets, from production plants and offshore platforms to manufactured consumer goods.

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