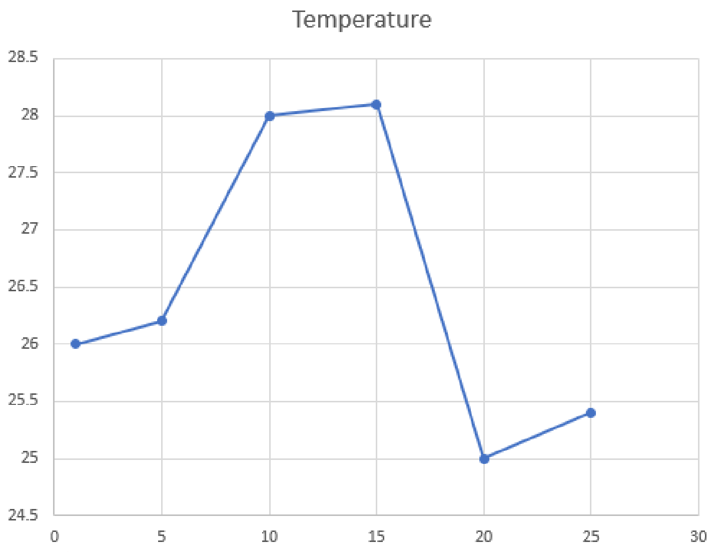
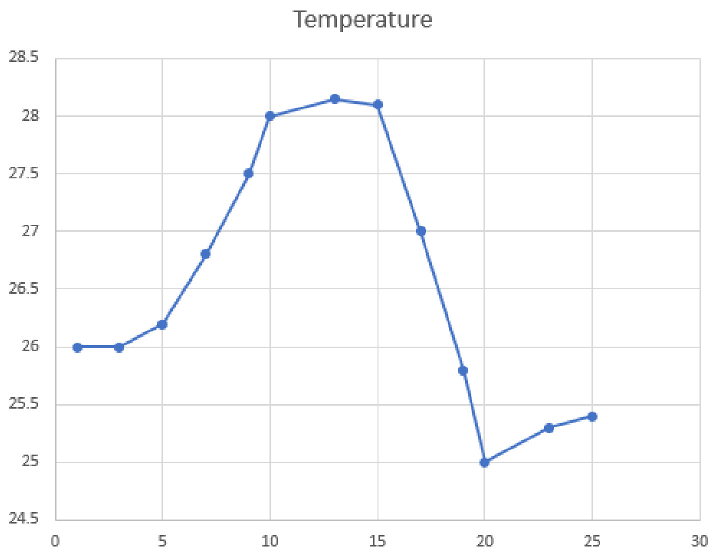
Exception, Compression, and their Impacts on PI System Performance

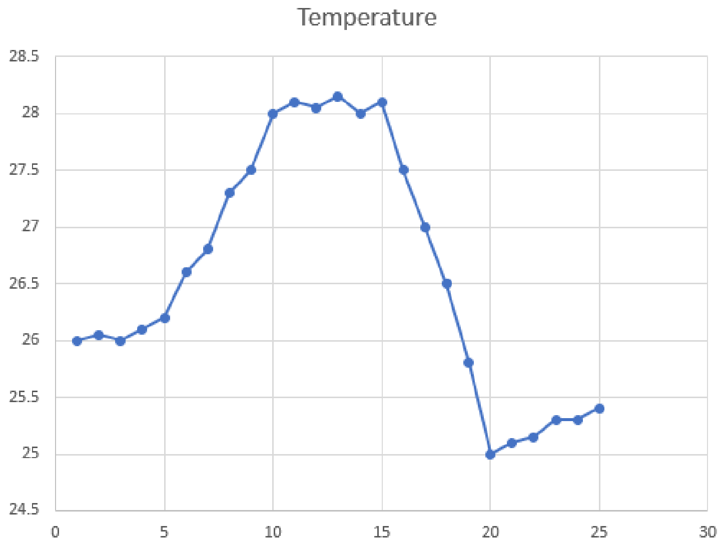
Brent Bregenzer

Staff Systems Engineer, AVEVA

Why do we filter data?







- Fewer “details”
- Better performance

- More “details”
- Worse performance

Goal: minimize storage of time-series events while maintaining information content of the data

How does filtering help?

Storing effectively the same information with fewer time-series events

- Better Data Archive performance
  - More efficient use of in-memory caching mechanisms for archive queries
  - Less stress on Update Manager to serve data to clients
- Lower storage requirements for Data Archive
- Lower bandwidth requirements for data movement

Why is this important to AVEVA™ PI System™ performance?

Performance issues often seen in downstream applications

- Data archive query performance
  - Slow response
  - Query timeout
  - Hitting ArcMaxCollect
- Vision: Slow initial loading for displays
  - Long time ranges
  - On-demand calculations (Ad Hoc calculations or AF Analysis Data Reference attributes)
- Analysis Service
  - Longer backfill times and more stress on the real-time calculation engine
    - More frequent triggering
    - Data for summaries (e.g., TagAvg) can’t be held in the data cache

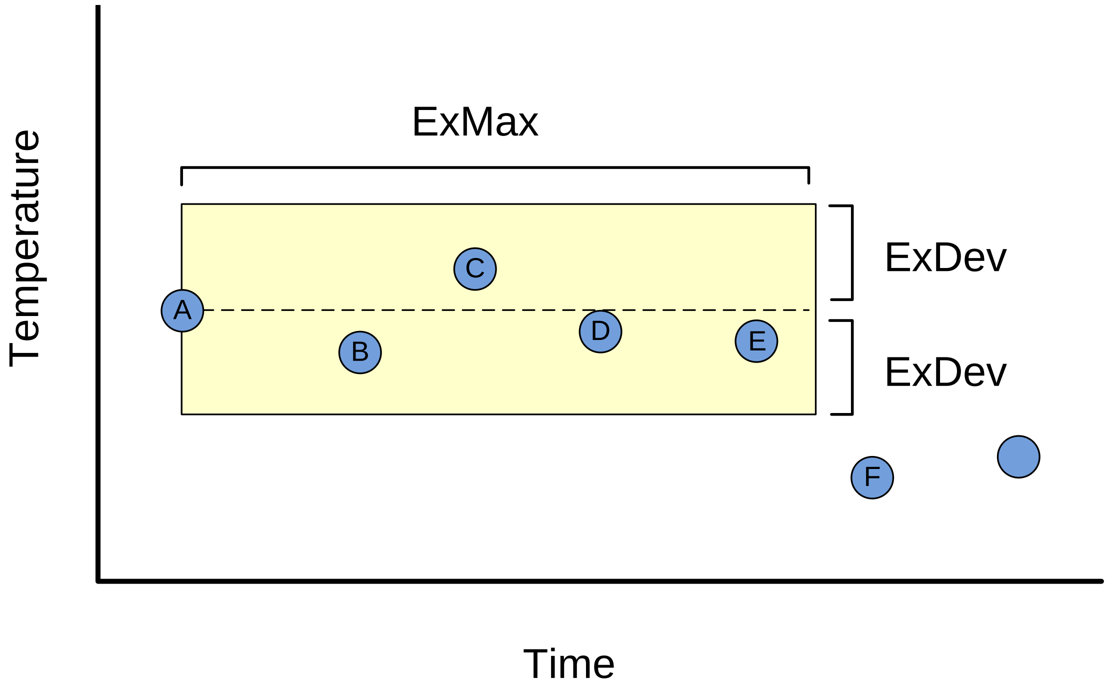
Details of filtering algorithms

Exception

Simple deadband to filter noise

- Performed by PI Interfaces only*
- Reduces events sent to Data Archive Snapshot
- Conserves network bandwidth
- Passing value and previous value get sent

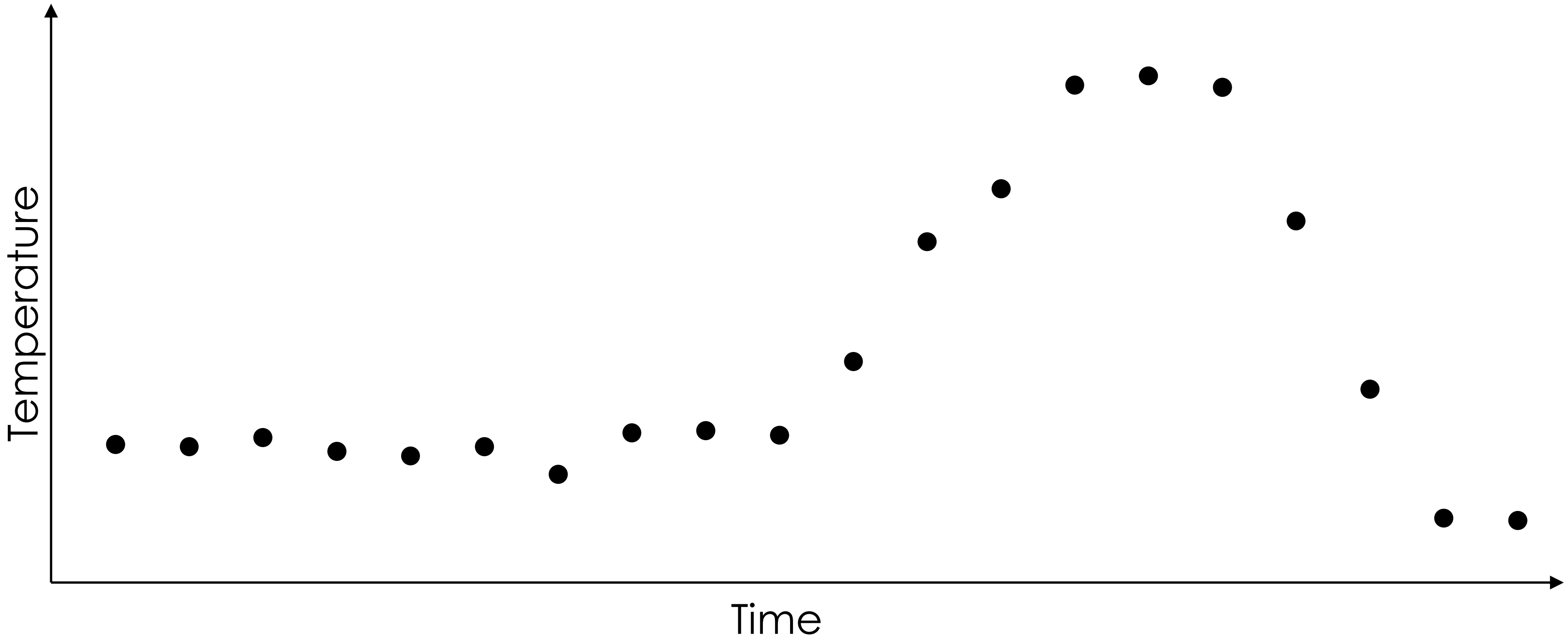
Name	Attribute	Description
Exception Deviation	ExDev	deadband size in tag's engineering units
Exception Deviation Percent	ExDevPercent	ExDev as percentage of tag's Span
Exception Maximum	ExMax	max time (in seconds) allowed between events



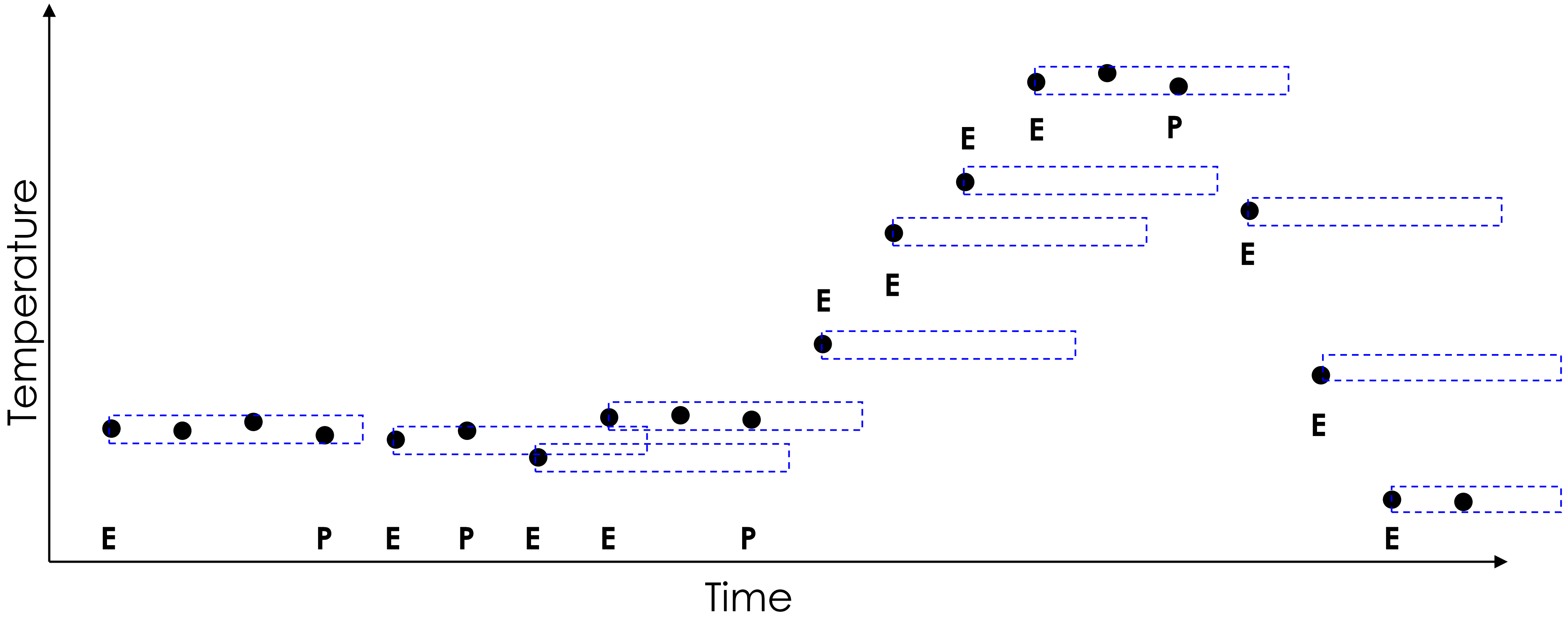
*AVEVA Adapters can do deadband filtering but ignore tag exception settings.
*PI Connectors do not do exceptions testing.

Example: Raw Data

- Raw values received from the data source
  - Without Exception and Compression tests, these would all be archived.



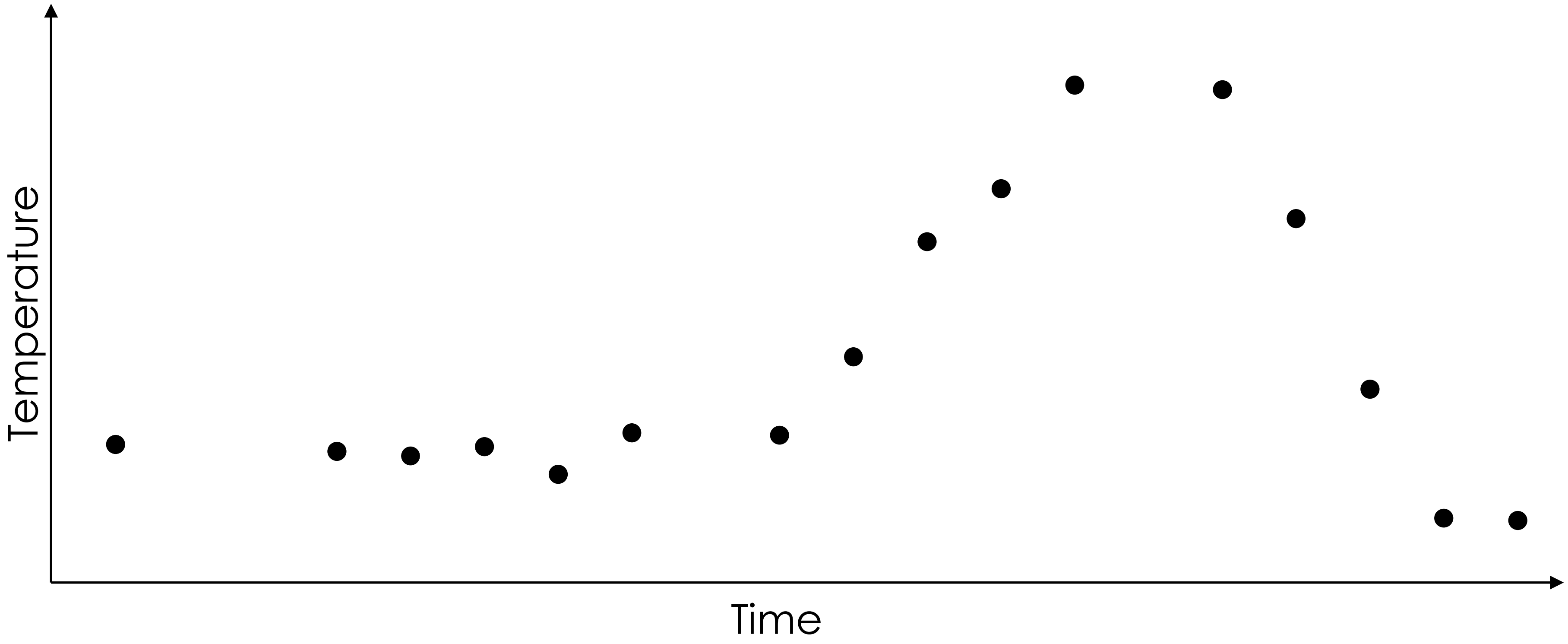
Visualizing the Exception Test



AVEVA

Exception Test - Results

- Successive values sent to the PI Server.
- When a value is sent, it becomes the new snapshot.

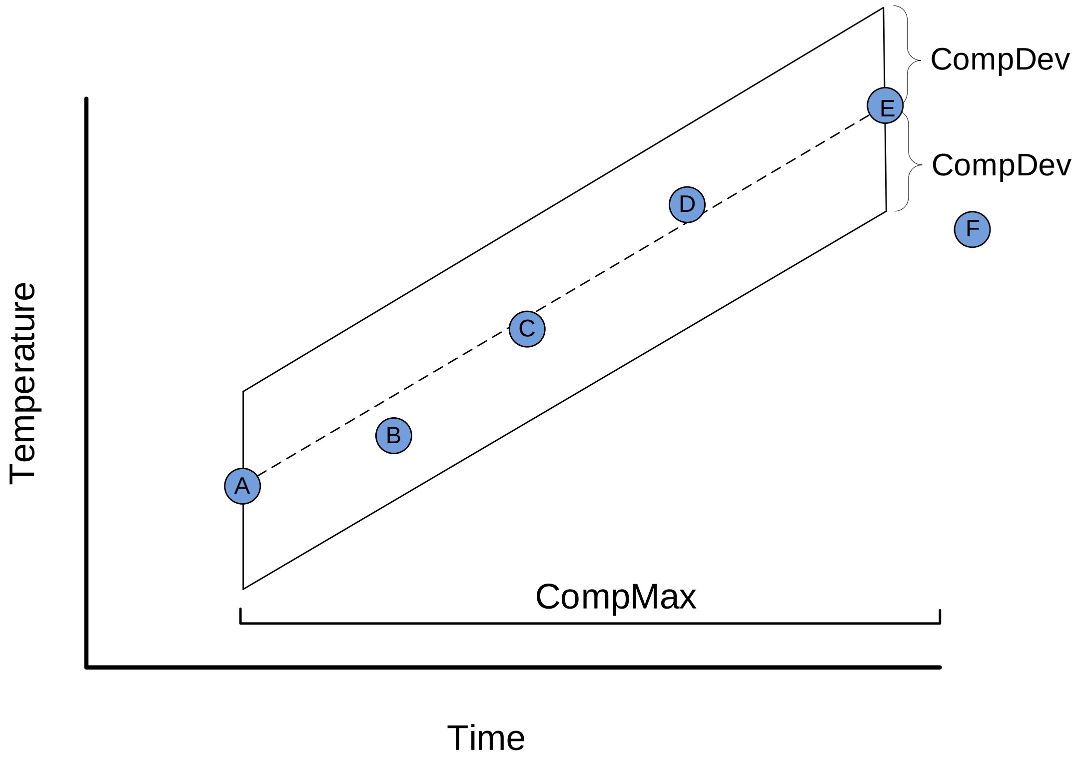


Compression

Use “swinging door” algorithm to eliminate data that can safely be recreated with interpolation

- “The goal is to filter out instrument and process noise and still record significant process changes.”
- Reduces the amount of data stored in the Data Archive
- Done by snapshot subsystem or compression marking in PI Buffer Subsystem
- Out of order (OOO) data bypasses compression.

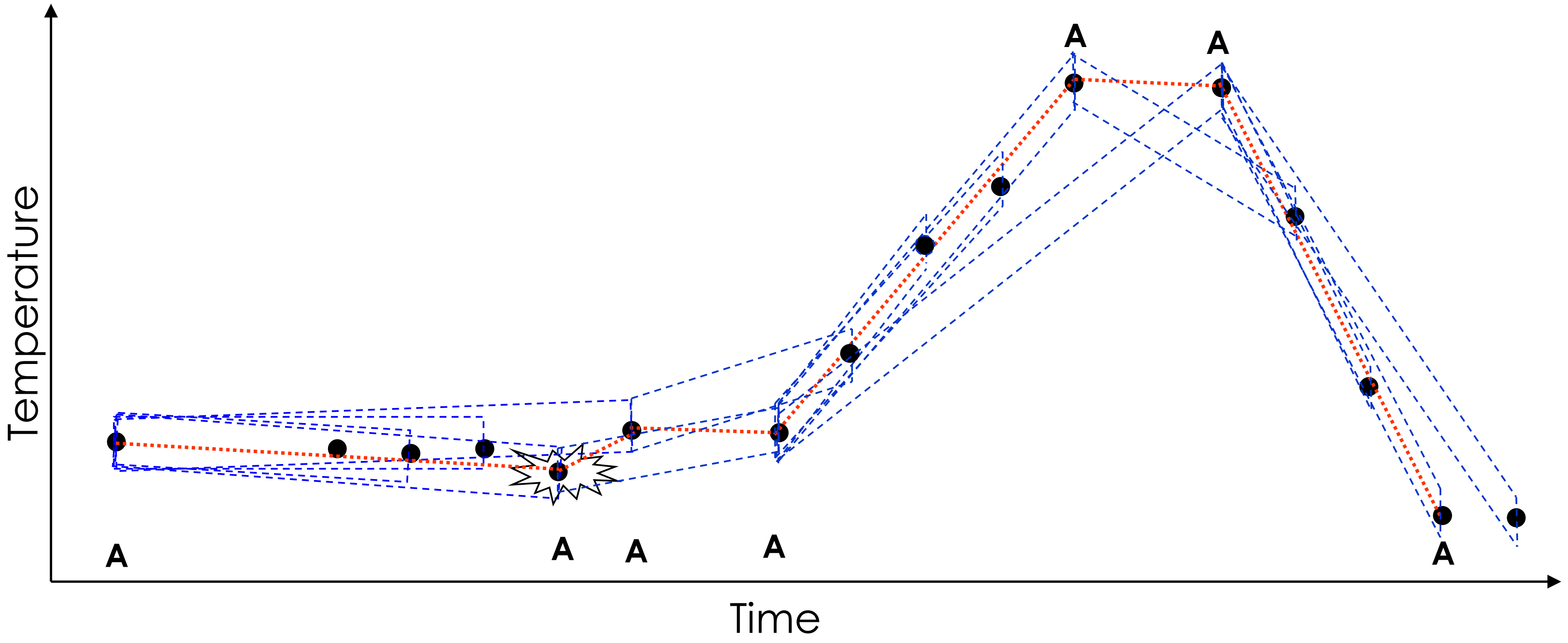
Name	Attribute	Description
Compressing	Compressing	On/Off Switch for compression
Compression Deviation, Compression Deviation Percent, and Compression Maximum: similar to Exception counterparts		



AVEVA

Visualizing the Compression Test

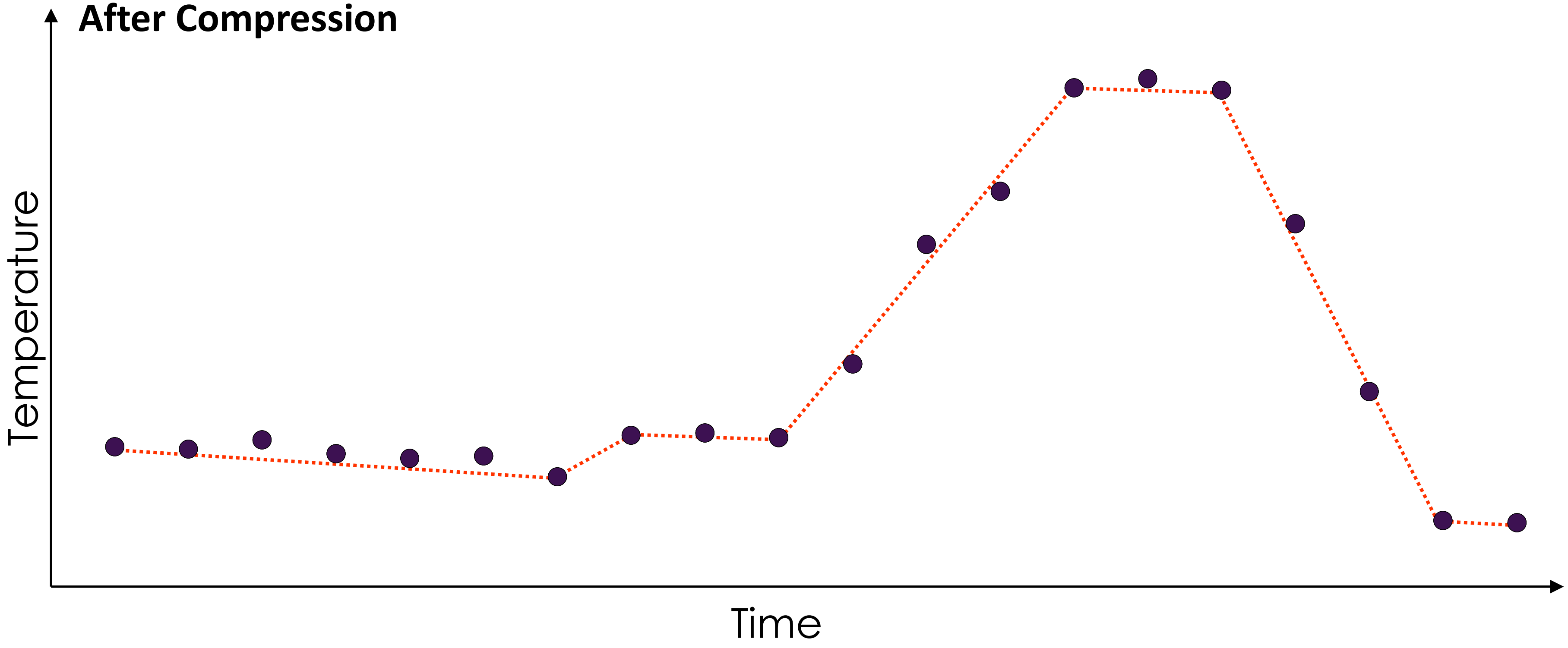
A: Value is Archived



Cumulative Results

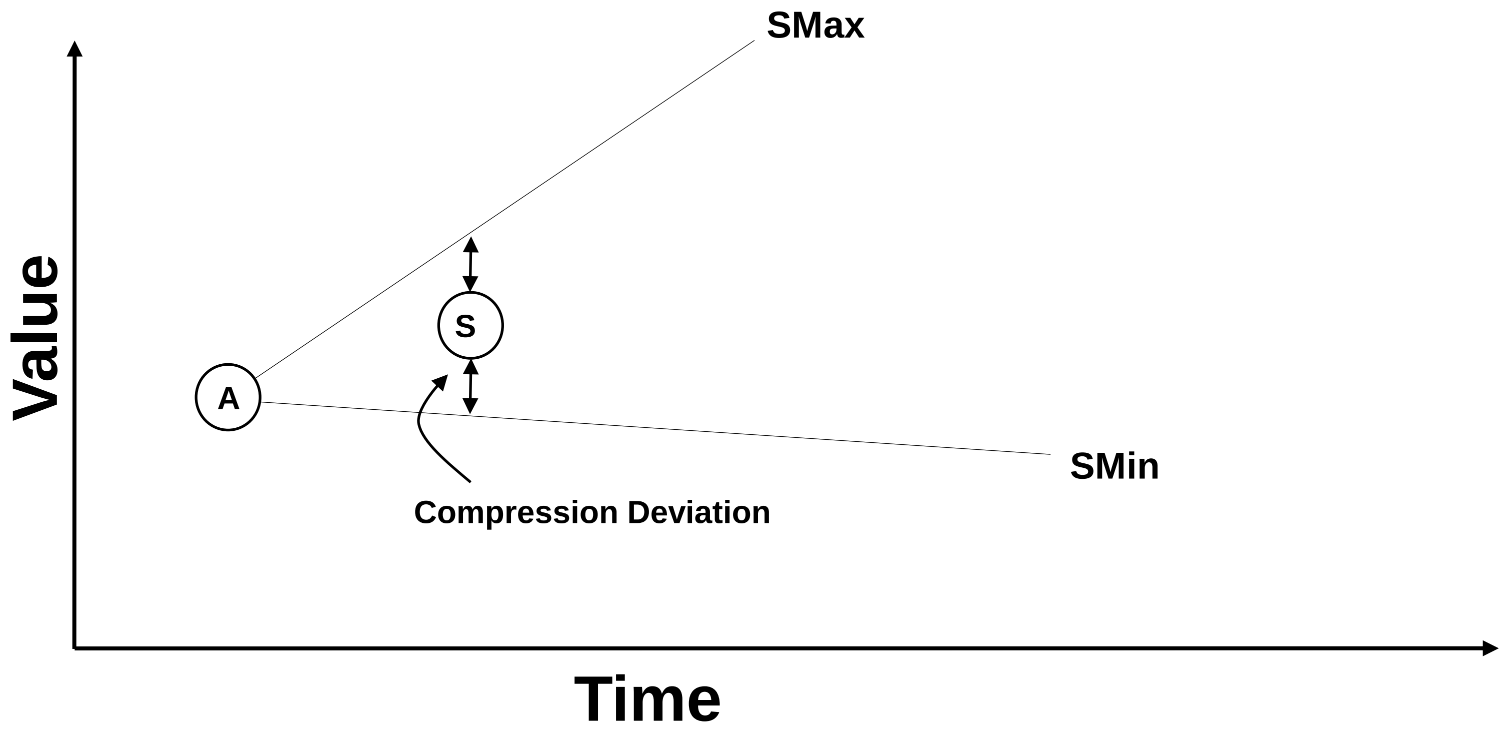
Raw values scanned

After Compression



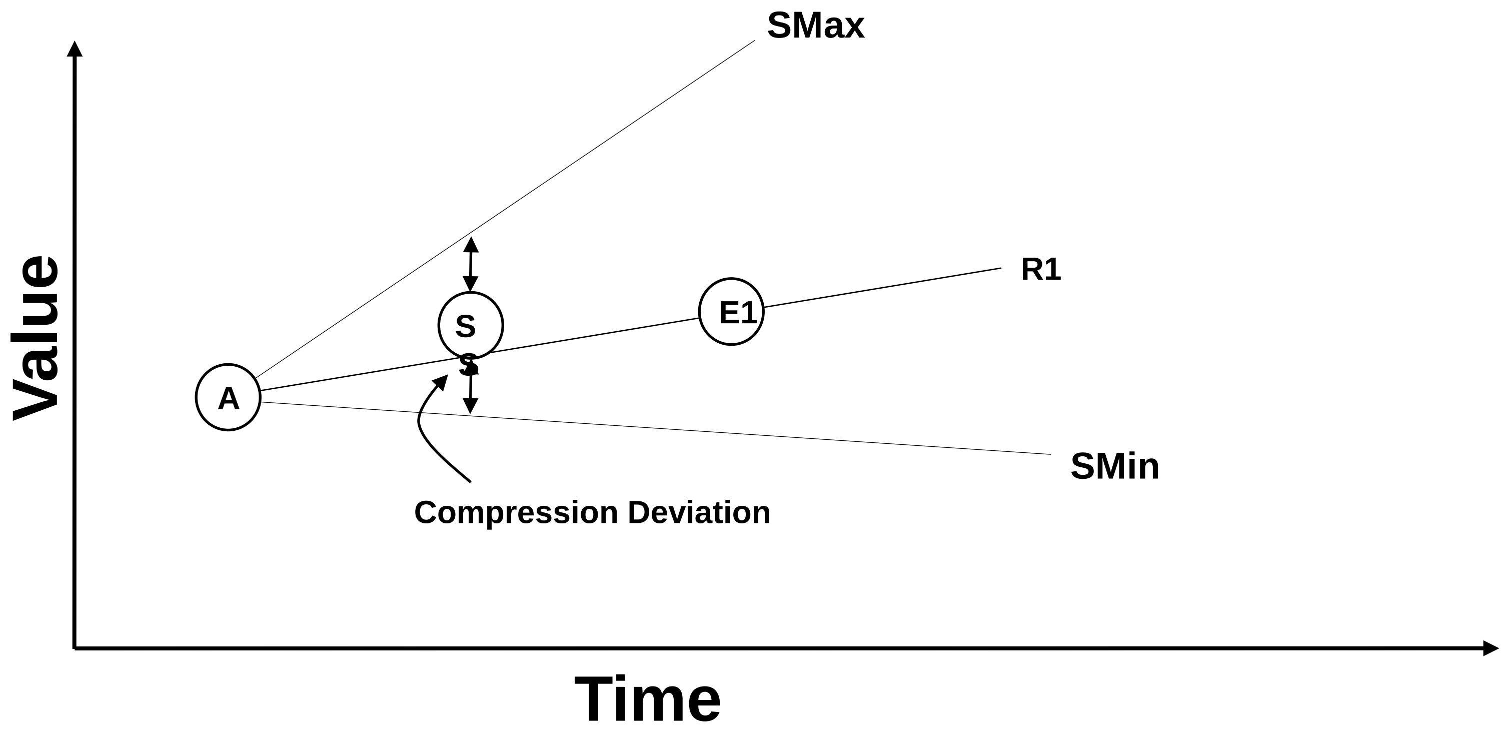
Compression Details

The swinging door algorithm



Compression Details

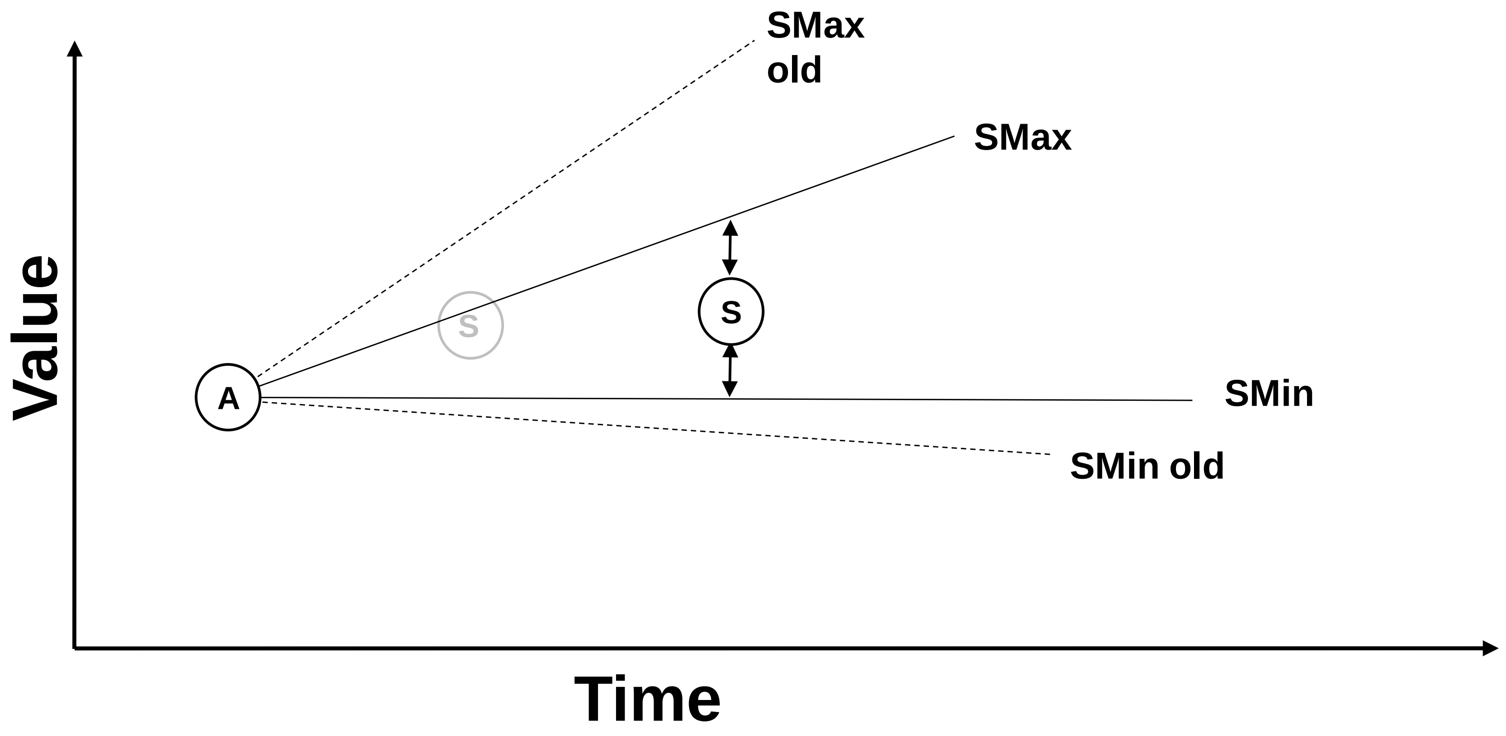
The swinging door algorithm



AVEVA

Compression Details

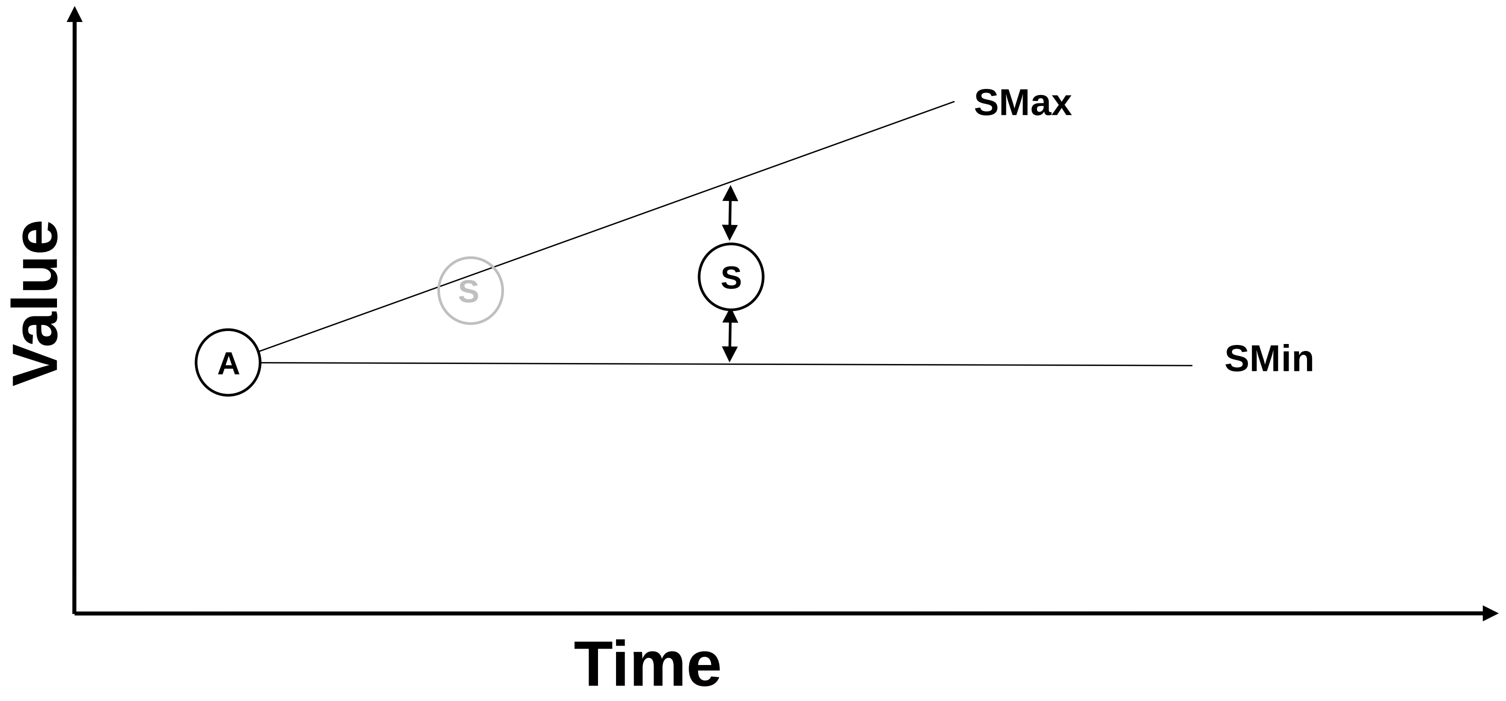
The swinging door algorithm



AVEVA

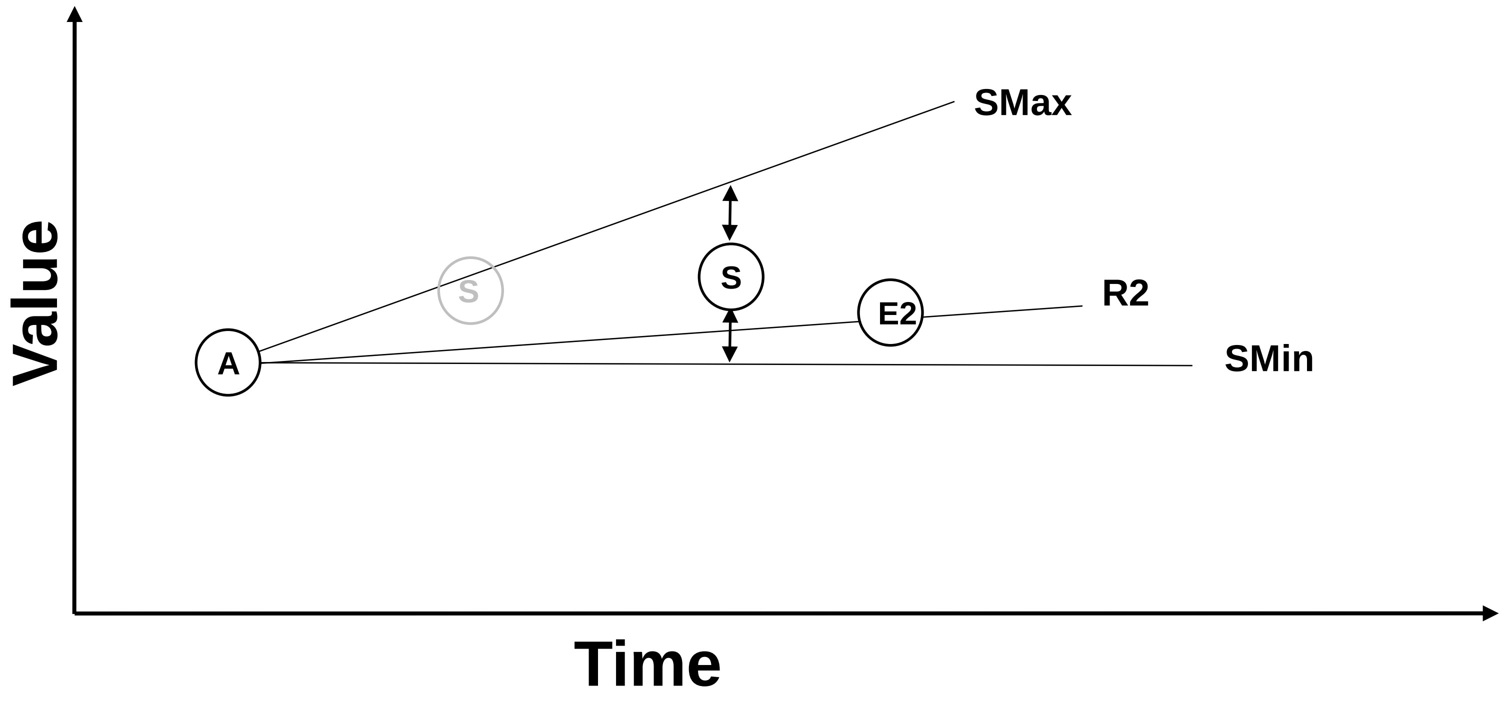
Compression Details

The swinging door algorithm



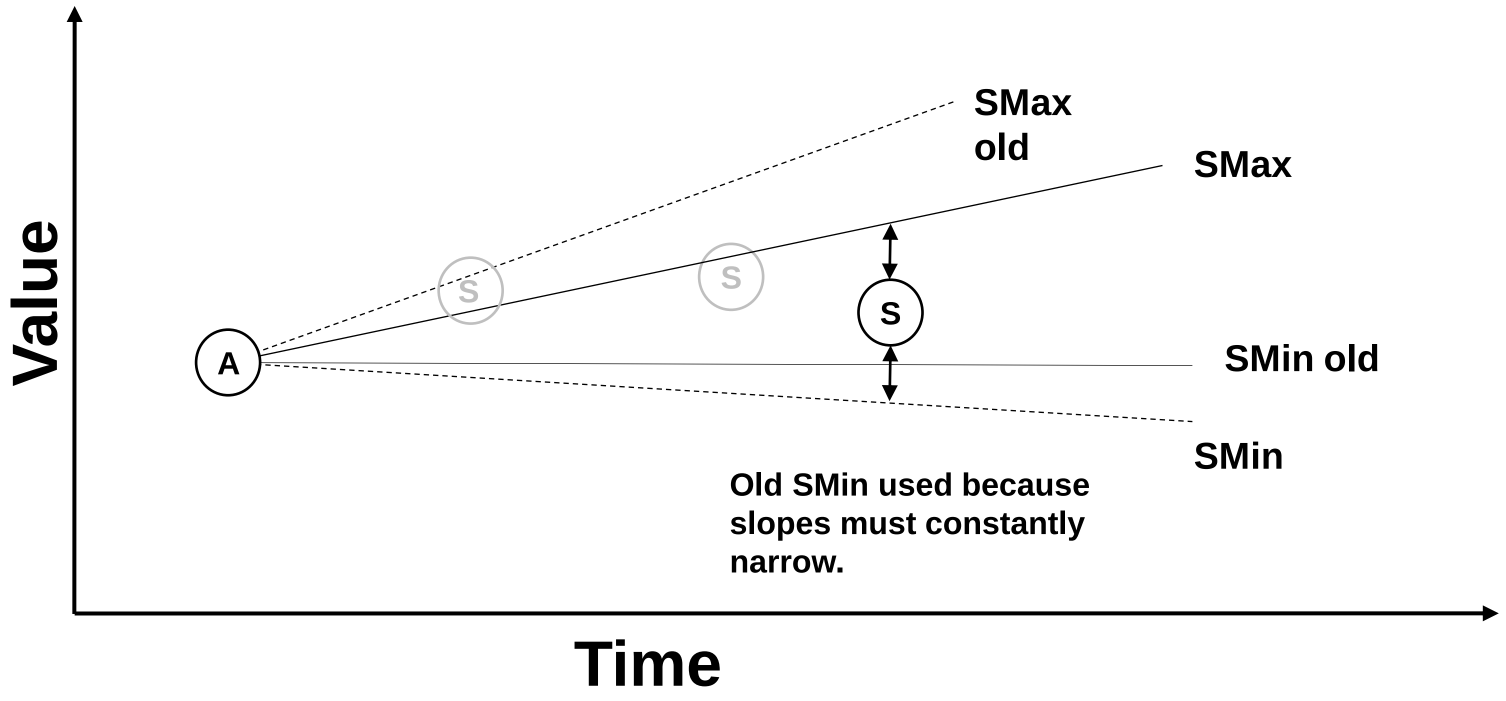
Compression Details

The swinging door algorithm



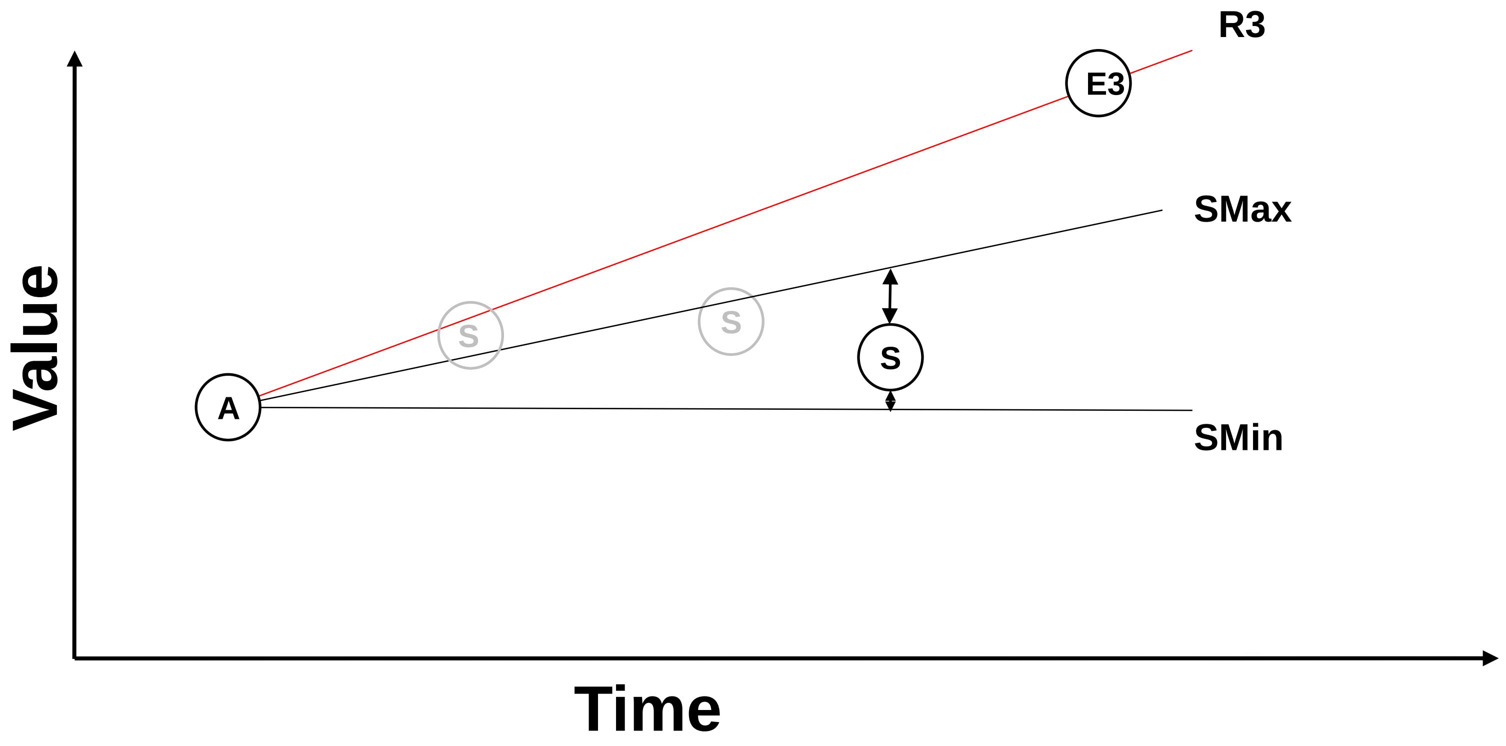
Compression Details

The swinging door algorithm



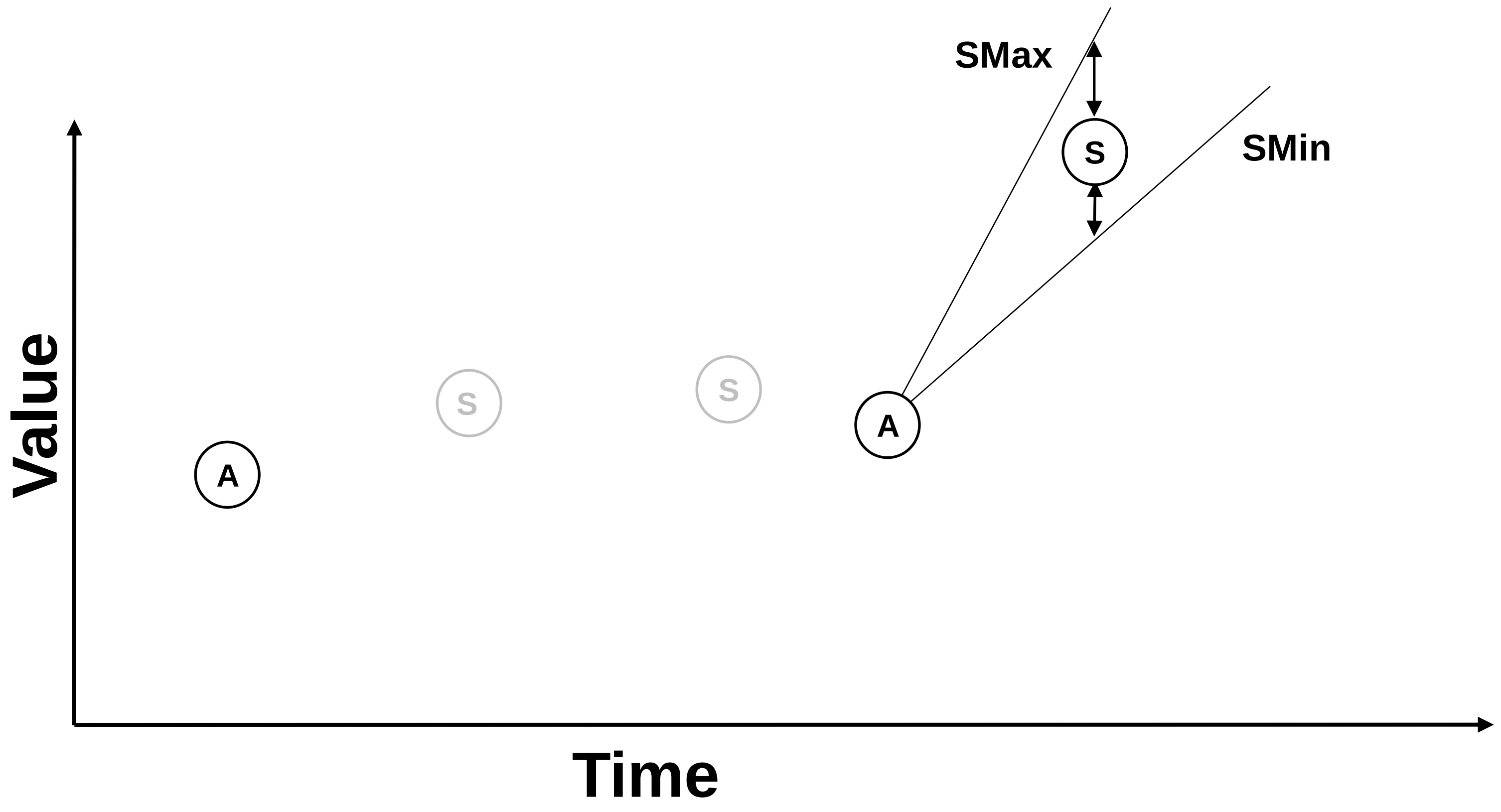
Compression Details

The swinging door algorithm



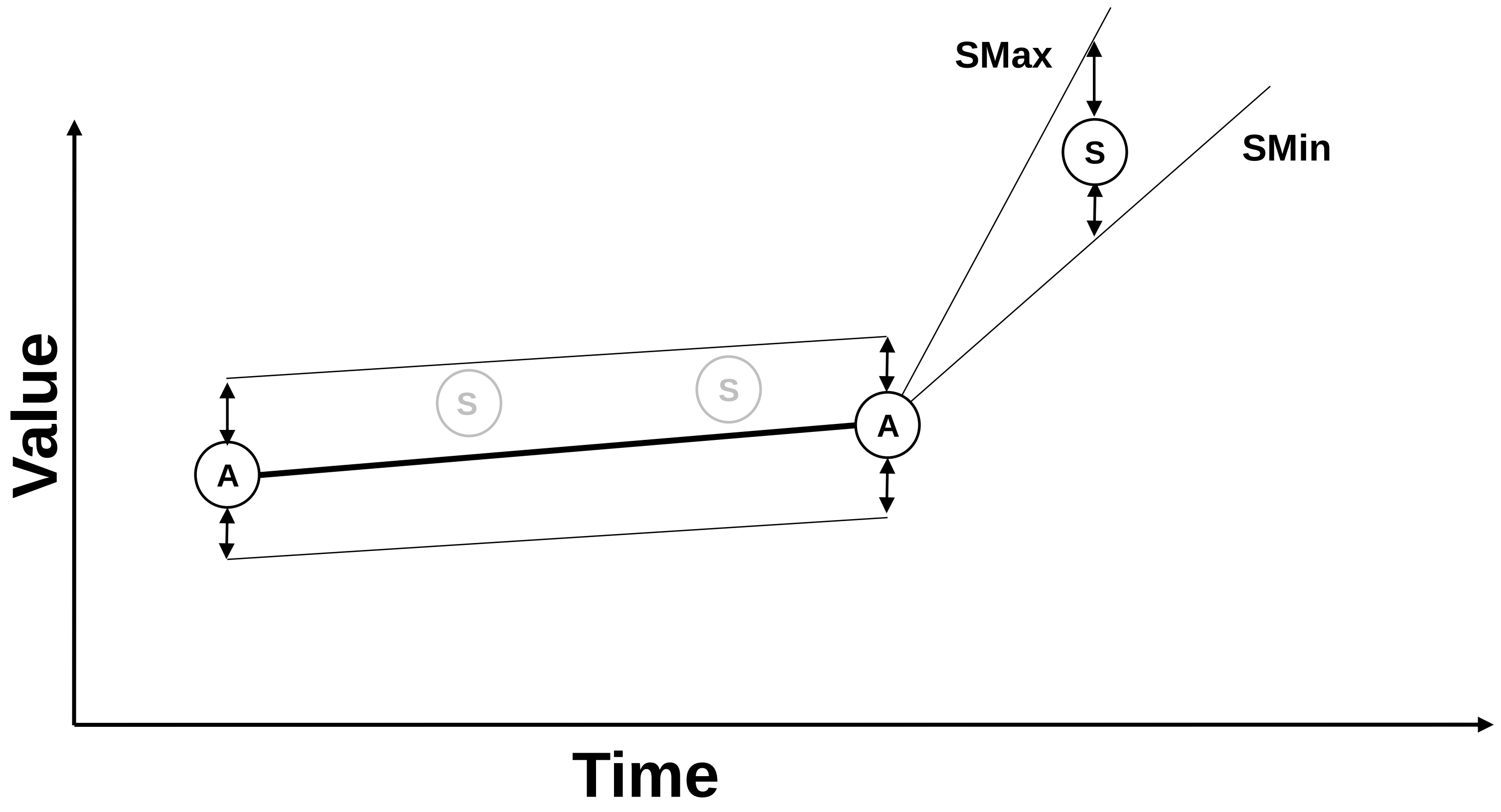
Compression Details

The swinging door algorithm



Compression Details

The swinging door algorithm



Things to Know When Adjusting Exception and Compression

Compression examples given also apply to exception

- CompDevPercent = the **percentage of** the tag's **Span** attribute
- CompDev = (CompDevPercent*Span)/100
- Changing CompDevPercent will automatically change CompDev based on the Span (and vice versa).

- Example 1:

Original Settings

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	1	1	100

1. Change compdevpercent

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	1	0.5	100

2. Publish to Data Archive
3. Retrieve values
4. ☑ 😎

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	0.5	0.5	100

AVEVA

Things to Know When Adjusting Exception and Compression

Compression examples given also apply to exception

- CompDevPercent = the **percentage of** the tag's **Span** attribute
- CompDev = (CompDevPercent*Span)/100
- Changing CompDevPercent will automatically change CompDev based on the Span (and vice versa).
- When values for CompDevPercent and CompDev are sent together, CompDevPercent overrides CompDev.
- Example 2:

Original Settings

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	1	1	100

1. Change compdev

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	0.5	1	100

2. Publish to Data Archive
3. Retrieve values
4. ?!?! ☹

Selected(x)	Name	ObjectType	compdev	compdevpercent	span
x	ExcCompSettings.Test	PIPoint	1	1	100

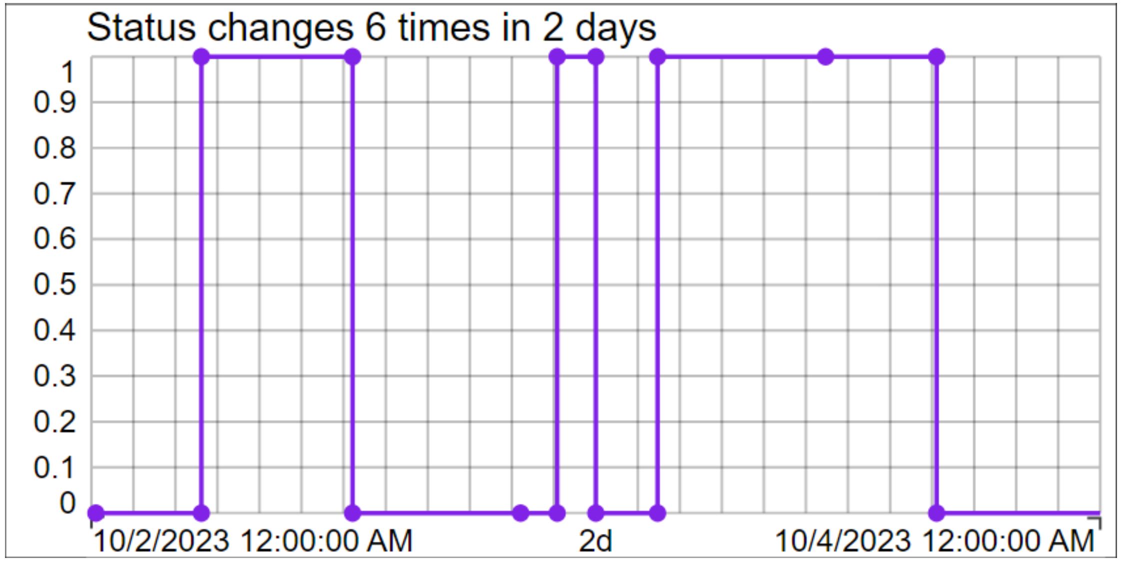
AVEVA

Basics of Compression and Exception Settings

- Default values are NOT zero

compressing	compdev	compdevpercent	compmax	excdev	excdevpercent	excmax	span
1	0.2	0.2	28800	0.1	0.1	600	100

- Compressing = 0 is NOT the same as Compressing = 1 + CompDev = 0.
- Example: 0/1 Status tag with no exception, 1s scan frequency, CompMax = 8h



Tag	48 hr Event Count
No Compression	172800
Minimal Compression	15

Customer Example: Downstream Oil And Gas

Downstream Oil and Gas | USA

Refining customer seeks performance gains through better use of data filtering.

Challenges

- Many tags set to use little to no exception or compression
- Complaints from users about slow query performance
- Complaints from users about slow loading in PI Vision
- Long backfill times for PI Analysis Service

Solution

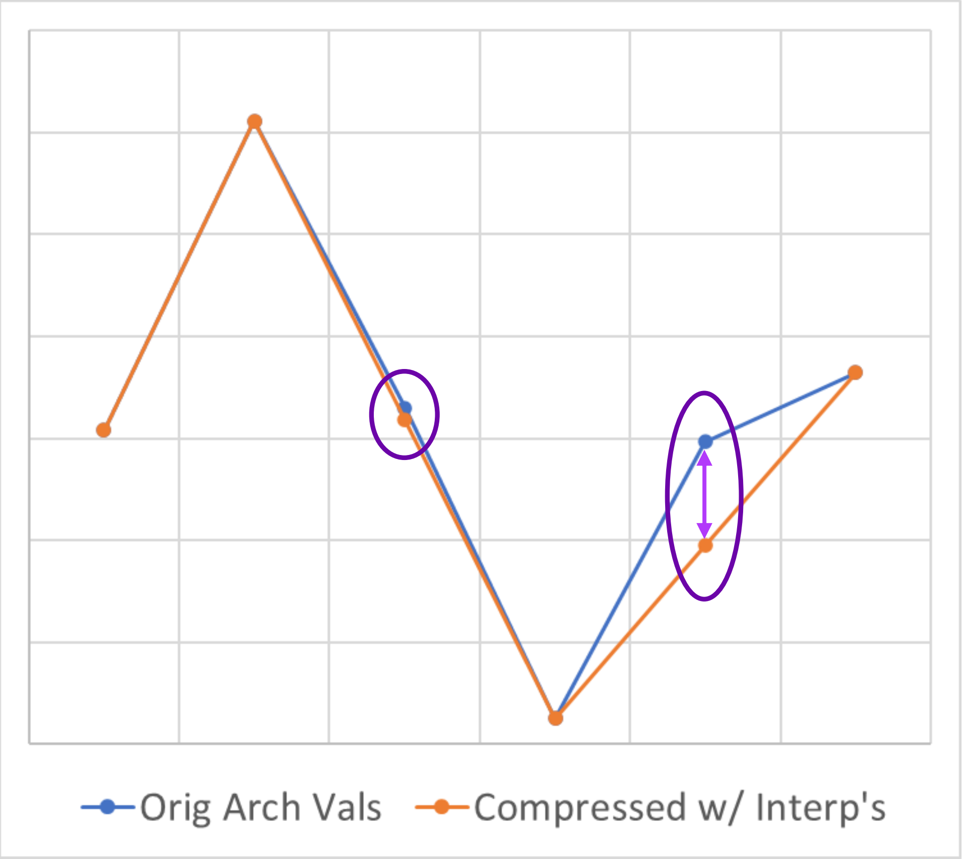
- Analyze selection of commonly used high frequency tags using Excel to mimic exception and compression algorithms.
- Compare deviations from low-compression data to instrument precision.

Results

- **Data density can be greatly reduced without loss of precision.**
- **Analysis backfill times are greatly reduced.**

Exception/Compression Analysis Methods

- This study: Excel workbook that mimics exc/comp
  - Paste archive data from production system
  - Enter desired exception & compression settings
  - Run macros to see predicted snapshot & archive values
  - Calculate KPIs:
    - Percentage of data compressed
    - Maximum delta between original & compressed



- Other methods:
  - Parallel tags with exception/compression applied
  - Partner products

Study Results:

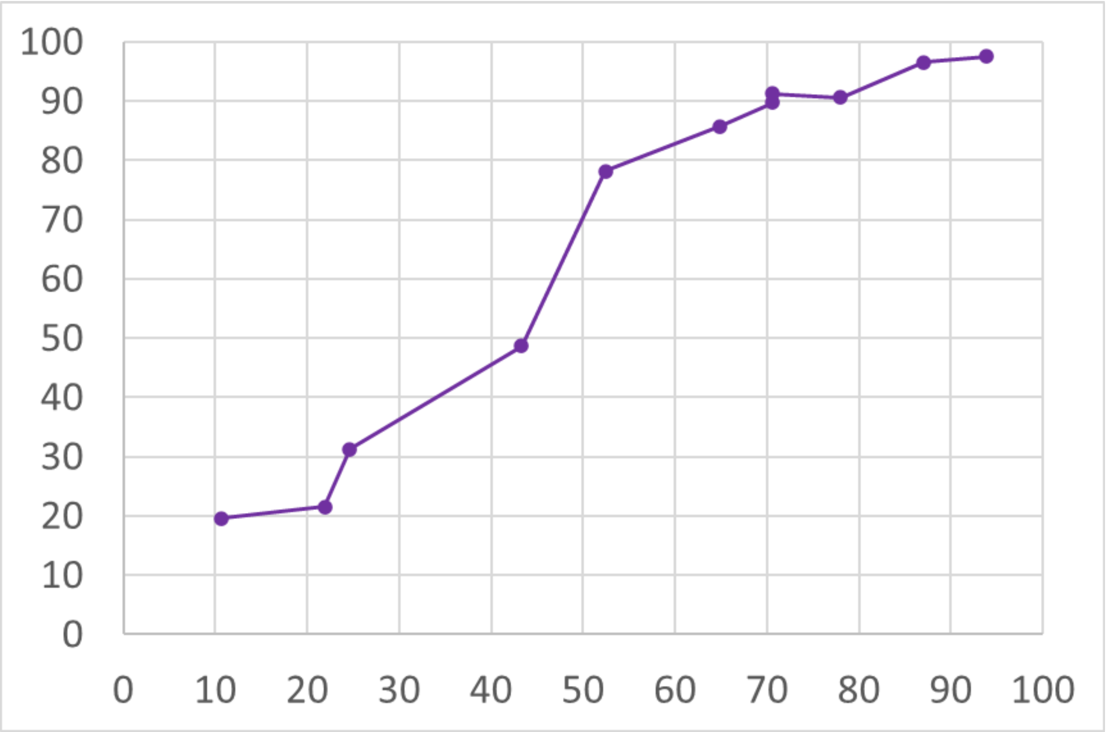
- Modest exception and compression settings were used.
- All tags achieved a **reduction in data density**, most by 25% or more.
- Half of tags met or surpassed the suggested minimum compression ratio of 3:1.
- All tags had **Max Deltas below the measurement precision**.

Measurement UoM	Original Event Count	Compressed Event Count	% Compressed	Measurement Precision	Max Delta
ppm	198,621	198,238	0.2%	0.1-1	0.064
%	44,641	39,872	11%	0.059	0.0165
bbl/h	153,161	135,434	12%	0.1-0.5	0.03
%	89,281	69,750	22%	0.3	0.032
%	178,495	134,636	25%	0.066	0.033
%	89,133	50,521	43%	0.01	0.005
g/mol	89,281	42,504	52%	0.01	0.006
Btu/scf	43,560	15,304	**65%**	7	2.566
Octane #	38,844	11,437	**71%**	0.2	0.055
Octane #	38,844	11,438	**71%**	0.2	0.055
psig	44,641	9,807	**78%**	0.05	0.009
ppm	89,281	11,514	**87%**	0.0004	0.00002
%	89,216	5,538	**94%**	0.01	0.0002
psig	3,157,788	145,938	**95%**	0.02-0.05	0.022

AVEVA

Study Results: Analysis Service Backfill

- Tags from study compared for backfill of analyses
  - Mixture of simple and complex calculations: If-Then-Else, TagAvg, etc.
  - Backfill approximately one month of data
- Increased compression correlated with decreased backfill time (as expected).
- Even minimal compression of 11% still led to 20% decrease in backfill time.



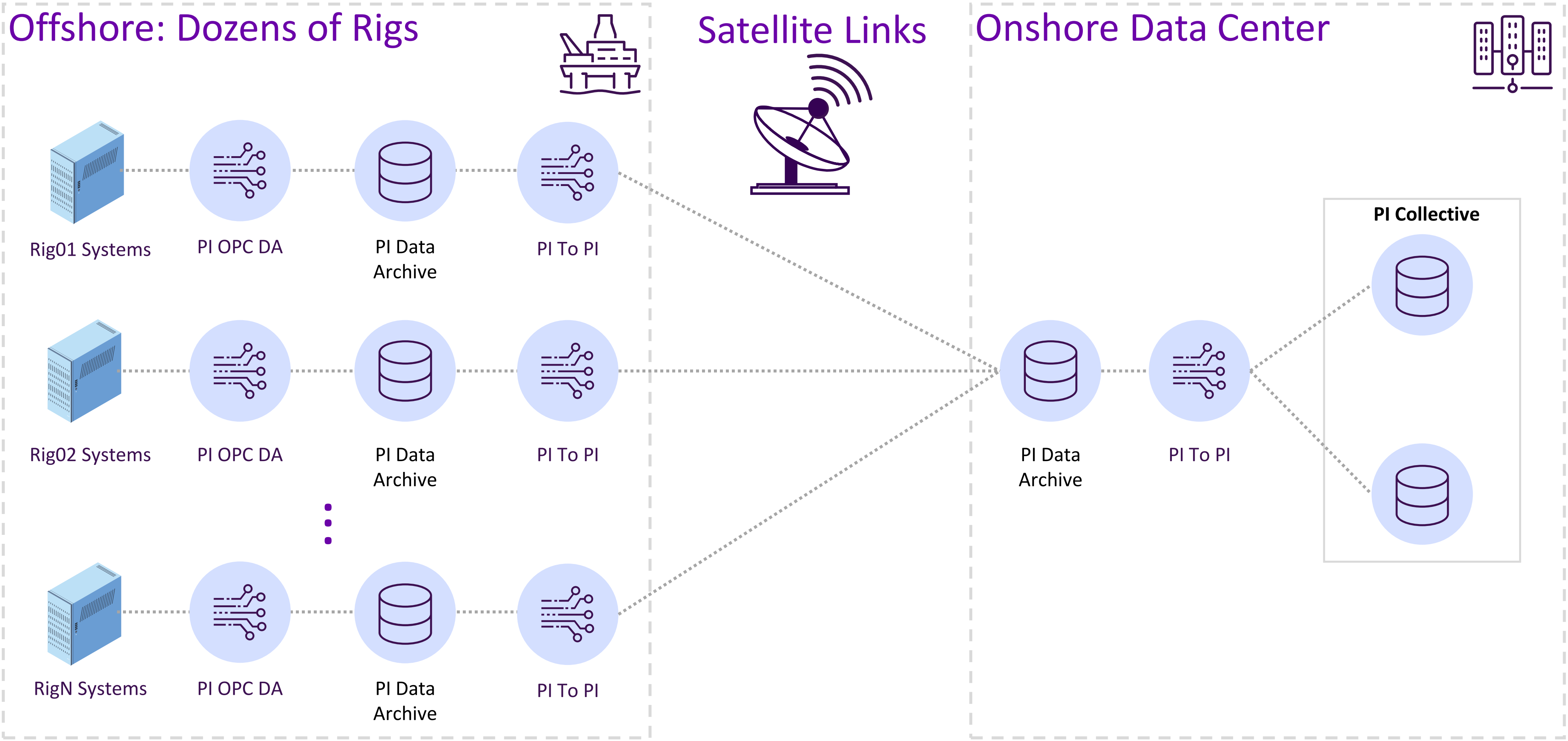
y-axis: % Decrease in Backfill Time

x-axis: % Compression

AVEVA

Customer Example: Offshore Oil And Gas

Customer PI System Architecture Diagram



Offshore Oil and Gas | USA

Drilling operator seeks performance gains through better use of data filtering.

Challenges

- >87% of tags use no exception or compression.
- Onshore Data Archives experience periodic instability.
- A federated PI Server architecture onshore is not desirable.
- Upgrades to satellite network are cost prohibitive.
- Customer plans to add rigs that will increase tag count by ~15%.

Solution

- Categorize tags and document current settings.
- Determine new settings based on instrument precision and SME input.
- Apply the settings to test tags on a pilot rig to measure the effects.

Results

- **~94% reduction in archived events during pilot study**
- **Customer plans to rollout to all rigs**

Tag Filter Tuning Strategy

Step 1: Categorize tags

- Dimension 1: Tag Criticality
  - Critical: high fidelity for contract or compliance requirement
  - Non-critical: all others

Critical	Non-Critical
1.3%	98.7%

- Dimension 2: Data Type
  - Analog: measurement signals, e.g., temperature, pressure, flow
  - Digital: status tags, e.g., motor on/off, valve open/closed

Analog	Digital
37%	63%

- Dimension 3: Unit of Measure (analog tags only)
  - Use reference documents to find instrument precision
  - Use tag engineering units as a proxy for sensor type

- Set exc/comp based on instrument precision for tag's UOM
- Validate settings with SMEs

AVEVA

Example for Non-Critical Analog Tag: Temperature

Identify units of measurement

- Tag Attributes:
  - Engineering Units
- AF Attribute Properties:
  - Default UOM
  - Source Units

Quantity	Unit	BPCS (HMI) Display
Mass	kilogram, tonne	kg, t
Molecular Weight	grams per mol	g/mol
Molecular Weight: used on Flares	Molecular Weight	Mw (to match P&ID if used)
pH	pH	pH
Power	Mega Watts, kilowatts,	MW, kW,
Reactive Power	Megavars, kilovars,	MVAR, kVAR
Pressure –Gauge	kiloPascal	kPa
Pressure - Absolute	kiloPascal Absolute	kPaa
Pressure – Steam over 5000 kPa	MegaPascal	MPa
Speed – Rotational	Revolutions per minute	rpm
Speed - pumpjack	Strokes per minute	spm
Speed, velocity	Meters/ sec, millimeters/ sec	m/s, mm/s
Sound	decible	dBA
Tank Inventory rate	Actual cubic meters/ hour	Am^3/h
Temperature	Celsius	°C
Time (t)	Hour, minute, second	hr, min, sec
Valve Opening	0%-100% (0% = Closed, 100% = Open)	%
Vibration displacement	Mils peak (mil pk)	Vendor Specific (as long as metric & consistent across the project)
Vibration acceleration (a)	g-force (g)	Vendor Specific (as long as metric & consistent across the project)
Viscosity - Dynamic	centistokes	cS
Viscosity - Kinematic	centipoise	cP
Volume – Gross, pumpable	Actual cubic meters	Am^3
Volume – Standard, corrected	Standard cubic meters	Sm^3
Voltage	kiloVolts, Volts	kV, V
Weight	kilogram, gram	kg, g

Quantity	Unit	BPCS (HMI) Display
Temperature	Celsius	°C

Example for Non-Critical Analog Tag: Temperature

Identify instrument spec's

- Instrument precision from periodic calibration documentation

- SMEs to ask:
  - I&C Engineers
  - Process Engineers

Instrument/Loop Type	GxP/HSE Calibration Tolerance Limit	GxP Critical	HSE Critical	System Calibration Tolerance Limit	System Critical	Non-Critical
Differential Pressure Transmitter (electronic ≤ 100 Pa)	± 1.5 Pa	12M	12M	± 3 Pa	3Y	N/A
Differential Pressure Transmitter (electronic pressure cell ≤ 5 bar)	± 0.02 bar	12M	12M	± 0.04 bar	3Y	N/A
Differential Pressure Transmitter (electronic pressure cell ≤ 10 bar)	± 0.03 bar	12M	12M	± 0.06 bar	3Y	N/A
Pressure Switch (≤ 5 bar)	± 0.05 bar	N/A	2Y	± 0.1 bar	3Y	N/A
Flow Transmitter (mass flow, MID for fluids)	± 1% of reading	12M	12M	± 2% of reading	3Y	N/A
Flow Transmitter (vortex, orifice plates with DP measurement)	± 2% of reading	12M	12M	± 4% of reading	3Y	N/A
Flow Transmitter (thermal mass flow for gasses)	± 1.5% of reading if flow > 20% of FS ± 3% of reading if flow > 7% of FS	12M	12M	± 3% of FS	3Y	N/A
Flow Transmitter (mass flow for gasses)	± 2% of reading	12M	12M	± 4% of reading	3Y	N/A
Level Switch		N/A	2Y		3Y	N/A
Level Transmitter (guided radar)	± 5 mm	12M	12M	± 10 mm	3Y	N/A
Speed Transmitter	± 1 rpm	2Y	2Y	± 2 rpm	3Y	N/A
Temperature Transmitter (RTD)	± 1 °C	12M	12M	± 2 °C	3Y	N/A
Temperature Transmitter (RTD) Room Monitoring	± 1 °C	12M	12M	± 2 °C	3Y	N/A
Weight Cell (vessels) ≤ 50 kg	± 0.5% of reading	12M	12M	± 1% of reading	3Y	N/A
Weight Cell (vessels) ≤ 400 kg	± 0.5% of reading	12M	12M	± 1% of reading	3Y	N/A
Weight Cell (vessels) ≤ 1000 kg	± 1% of reading	12M	12M	± 2% of reading	3Y	N/A
Weight Cell (platform based) ≤ 150 kg	± 0.5% of reading	12M	12M	± 1% of reading	3Y	N/A
Weight Cell (platform based) 150 kg < W ≤ 1500 kg	± 1% of reading	12M	12M	± 2% of reading	3Y	N/A
Weight Cell (platform based) > 1500 kg	± 2% of reading	12M	12M	± 4% of reading	3Y	N/A
Pressure Relief Valve	± 2% of SP	N/A	2Y	N/A	N/A	N/A
Moisture Transmitter	± 2% rH	12M	12M	± 4% rH	3Y	N/A

Instrument/Loop Type	GxP/HSE Calibration Tolerance Limit	GxP/HSE Critical	System Calibration Tolerance Limit	System Critical	Non-Critical
Temperature Transmitter (RTD)	± 1 °C	12M	± 2 °C	3Y	N/A

Example for Non-Critical Analog Tag: Temperature

Build master table for tag settings

- Match instrument precision to tag units of measure.
- Set CompDev <= Instrument precision
- Set ExcDev = ½ CompDev
- Set CompMax, ExcMax, Scan Class according to update frequency requirements

Measurement	Eng. Units	HMI Display	Comp Dev	Comp Max	Exc Dev	Exc Max	Scan Rate (sec)
Temperature	Celsius	C	1	28800	0.5	600	10

Measurement	Eng. Units	HMI Display	Comp Dev	Comp Max	Exc Dev	Exc Max	Scan Rate (sec)
pH	pH	pH	0.1	28800	0.05	600	5
Power	Mega Watts, kilowatts,	MW, kW,	0.2	28800	0.1	600	10
Current	Amperes	A	1	28800	0.5	600	10
Voltage	kiloVolts, Volts	kV, V	2	28800	1	600	10
Pressure	Pounds per Square In or Ounces per Square In	Psi or Oz/sqin	0.5	28800	0.25	600	5
Speed – Rotational	Revolutions per minute	rpm	2	28800	1	600	30
Speed - pumpjack	Strokes per minute	spm	2	28800	1	600	30
Speed, velocity	Feet per second	ft/s	1	28800	0.5	600	5
Sound	Decibels	dBA	2	28800	1	600	10
Tank Inventory rate	See Flow rate		0.5	28800	0.25	600	5
Temperature	Fahrenheit	F	0.5	28800	0.25	600	10
Temperature	Celsius	C	1	28800	0.5	600	10
Valve Opening	0%-100% (0% = Closed, 100% = Open)	%	0	28800	0.1	600	5
Vibration displacement	Mils peak (mil pk)	Vendor Specific	0.2	28800	0.1	600	10
Vibration acceleration (a)	g-force (g)	Vendor Specific	0	28800	0.1	600	10
Volume – Gross, pumpable	Barrels gallons cubic ft	bbl g cuf	0.2	28800	0.1	600	5
Volume – Standard, corrected	Standard cubic feet	scuf	0.2	28800	0.1	600	5
Digital	Digital Status	Status (On, Off)	0	86400	0	28800	1

Pilot Study Results

- 70 tags covering 58 UOMs and 5 digitals

- Before: ~87% of tags with no exception or compression
- After: **~98% of tags using better exc/comp settings**
  - Non-Critical Analog: CompDevPercent ranging from 0.1 to 2
  - Non-Critical Analog: ExcDevPercent set to ½ of CompDevPercent

- Exception Alone: **~70% decrease in data volume sent over the wire**
- Exception & Compression: **~94% decrease in data stored in the onshore Data Archive**

- **Customer is satisfied with fidelity of filtered data and plans to extend to all tags on pilot rig**

Wrapping Up

Conclusions and Suggestions

Conclusions:

- Exception and Compression can be applied to enable better PI System performance
- Significant decreases in data density can be achieved while keeping precision loss below instrument precision

Suggestions:

- For non-critical tags, use at least minimal settings:
  - **Enable compression**: (**Compessing = 1**) & set **CompDev = 0**
  - **Enable exception**: **ExcDev = 0** & **ExcMax > scan class frequency**
- Use available methods to test stronger Deviation values based on instrument precision:
  - Parallel test tags
  - Partner products
  - Homegrown tools (e.g., Excel)
- Set ExcDev = ½ CompDev

AVEVA

Brent Bregenzer

Staff Systems Engineer

- AVEVA
- Brent.Bregenzer@aveva.com

Special Thanks!
Kyle Lam, Sr. Software Developer
Daniel Davalillo, Staff Systems Engineer
Ales Soudek, Principal Pre-Sales Engineer

Questions?

Please wait for the microphone.

State your name and company.

Please remember to…

Navigate to this session in the mobile app to complete the survey.

Thank you!

AVEVA

This presentation may include predictions, estimates, intentions, beliefs and other statements that are or may be construed as being forward-looking. While these forward-looking statements represent our current judgment on what the future holds, they are subject to risks and uncertainties that could result in actual outcomes differing materially from those projected in these statements. No statement contained herein constitutes a commitment by AVEVA to perform any particular action or to deliver any particular product or product features. Readers are cautioned not to place undue reliance on these forward-looking statements, which reflect our opinions only as of the date of this presentation.

The Company shall not be obliged to disclose any revision to these forward-looking statements to reflect events or circumstances occurring after the date on which they are made or to reflect the occurrence of future events.

linkedin.com/company/aveva

@avevagroup

ABOUT AVEVA

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.

Over 20,000 enterprises in over 100 countries rely on AVEVA to help them deliver life's essentials: safe and reliable energy, food, medicines, infrastructure and more. By connecting people with trusted information and AI-enriched insights, AVEVA enables teams to engineer efficiently and optimize operations, driving growth and sustainability.

Named as one of the world's most innovative companies, AVEVA supports customers with open solutions and the expertise of more than 6,400 employees, 5,000 partners and 5,700 certified developers. The company is headquartered in Cambridge, UK.

Learn more at www.aveva.com

AVEVA