

Modernizing PI SQL For The Future

Bodo Bachmann
Kelsey Duffy

Your Speakers Today



- Bodo Bachmann
- Team Leader, Software Development
- bodo@osisoft.com



- Kelsey Duffy
- Sr Product Support Engineer
- kduffy@osisoft.com

Why SQL for the PI System

- Allows Real Time Data to mesh with relational, Line of Business (LOB) data
- Compatibility with Applications
 - OLEDB, ODBC, and JDBC support
- Maximizes the project resources you already have:
 - SQL Database Administrators
 - Web Developers
 - LOB App Developers

Why SQL for the PI System

- Some data will never live in SQL (streams)
- Some data will never live in the PI System (financial costing)
- We've optimized how we merge relational structures and their relationships to assets with streaming data in the PI System

Four Generations

1° : SQL Subsystem (PI ODBC Client)

2° : PI OLEDB Provider / PI OLEDB Enterprise

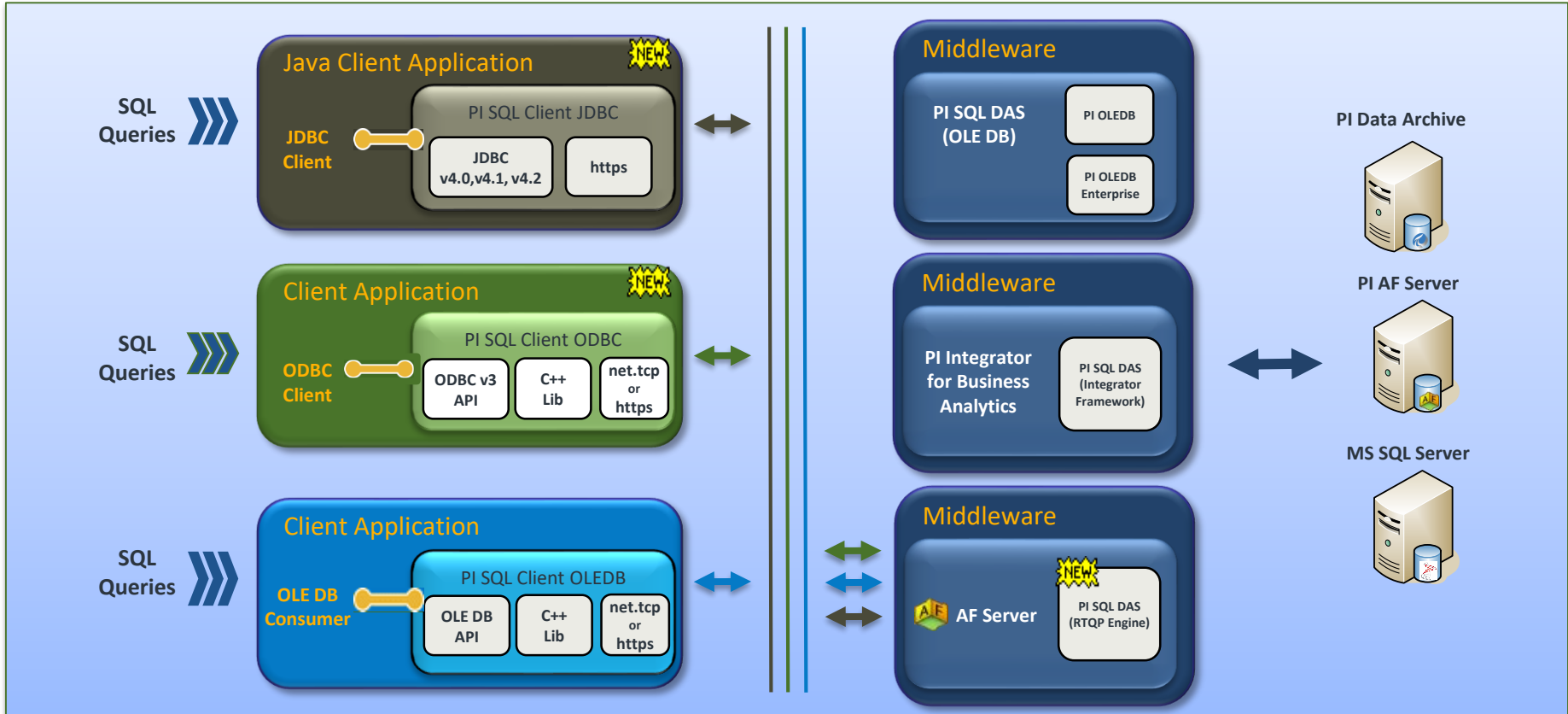
3° : PI JDBC, PI ODBC using PI SQL DAS

4° : RTQP Engine (PI SQL Client)

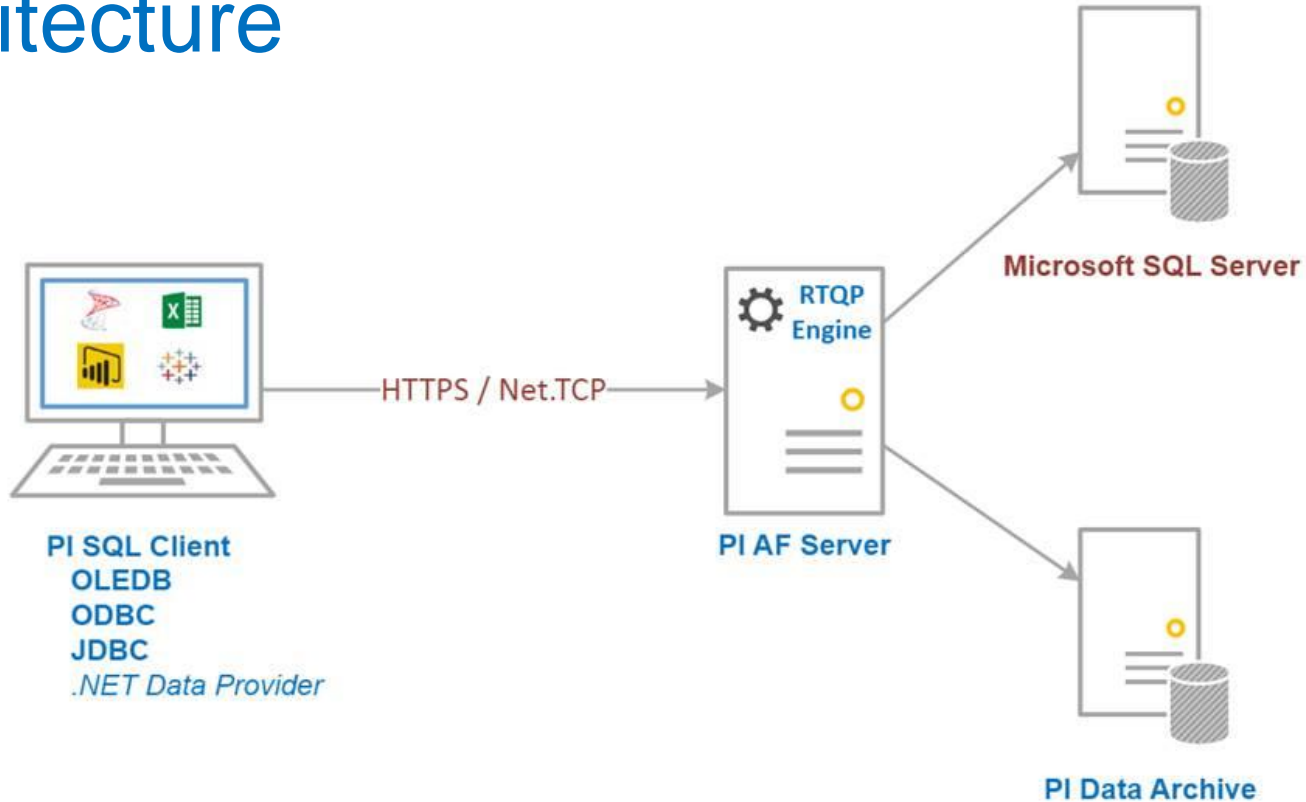
Next Generation Development Goals

- Performance and scalability
- Review data model
 - Reduce query complexity
 - What are top use cases (use customer feedback)
 - Address known issues (e.g. timestep data type, PI time literals)
- Infrastructure to support multiple standards and thin clients
- Works across WAN and different time zones
- Review security and authentication

PI SQL Client Architecture



Architecture

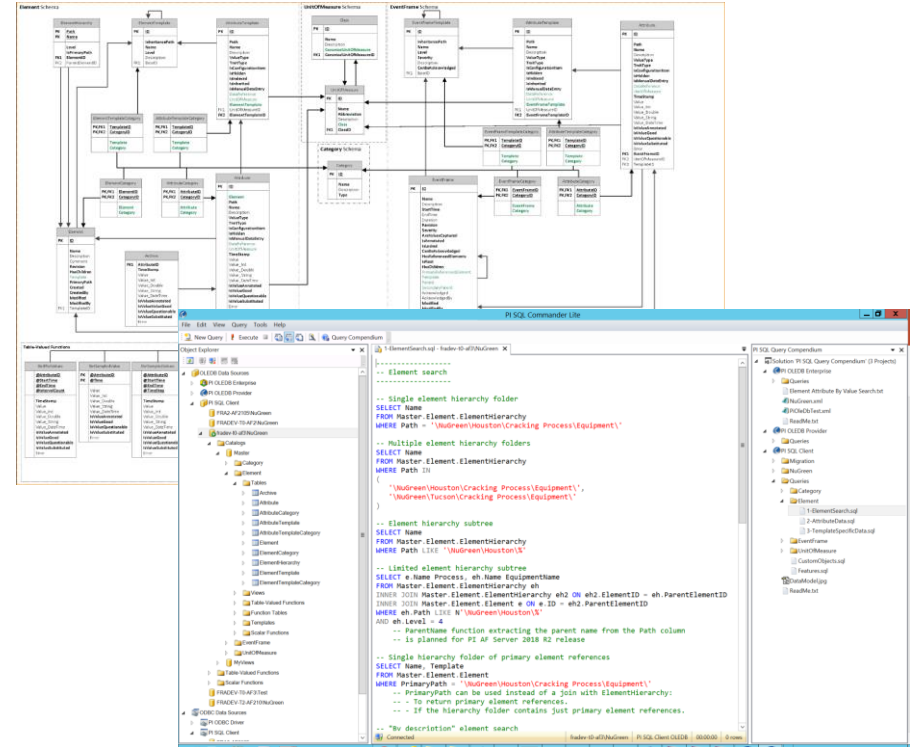


RTQP Engine – A Learned Technology

- **Deployment**
- **Working with different internal data sources**
- **Issue of Data References**
- **Memory Management / Intermediate Results**
- **Optimization**
- **Streaming**
- **Security**

RTQP Engine: Data Model

- Entity-Relationship Model
- Connection = AF Database
- Master Catalog
- Elements and Event Frames
- Attributes and Data
- Categories and Templates
- Template based Table-Valued Functions (*New!*)
- Denormalization
- Navigation Columns
- Multiple Value columns



Simplified Queries

Denormalization



Column Name	Data Type	Nullability
ID	Guid	not null
Name	String(2000)	not null
Description	String(2000)	null
Comment	String(2000)	null
Revision	Int32	not null
HasChildren	Boolean	not null
PrimaryPath	String(2000)	not null
Template	String(2000)	null
Created	DateTime	not null
CreatedBy	String(2000)	not null
Modified	DateTime	not null
ModifiedBy	String(2000)	not null
TemplateID	Guid	null

```
SELECT eh.Path + eh.Name Element, et.Name Template
FROM NuGreen.Asset.Element e
LEFT OUTER JOIN NuGreen.Asset.ElementTemplate et
  ON et.ID = e.ElementTemplateID
INNER JOIN NuGreen.Asset.ElementHierarchy eh
  ON eh.ElementID = e.ID
WHERE et.Name IN ('Boiler', 'Heater')
```



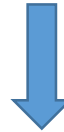
```
SELECT e.PrimaryPath + e.Name, e.Template
FROM Master.Element.Element e
WHERE e.Template IN ('Boiler', 'Heater')
```

Simplified Queries

Extension

Column Name	Data Type	Nullability
ID	Guid	not null
Path	String(2000)	not null
Name	String(2000)	not null
Description	String(2000)	null
ValueType	String(2000)	not null
TraitType	String(2000)	not null
IsConfigurationItem	Boolean	not null
IsHidden	Boolean	not null
IsManualDataEntry	Boolean	not null
DataReference	String(2000)	null
UnitOfMeasure	String(2000)	null
ValueTimeStamp	DateTime	not null
Value	Variant	null
Value_Int	Int64	null
Value_Double	Double	null
Value_String	String(2000)	null
Value_DateTime	DateTime	null
ValueStatus	Int32	not null
IsValueAnnotated	Boolean	not null
IsValueGood	Boolean	not null
IsValueQuestionable	Boolean	not null
IsValueSubstituted	Boolean	not null
ValueError	String(2000)	null
TemplateID	Guid	null
ElementID	Guid	not null

```
SELECT eh.Path + eh.Name Element, et.Name Template, ea.Name Attribute, s.Time, s.Value
FROM NuGreen.Asset.Element e
LEFT OUTER JOIN NuGreen.Asset.ElementTemplate et ON et.ID = e.ElementTemplateID
INNER JOIN NuGreen.Asset.ElementHierarchy eh ON e.ID = eh.ElementID
INNER JOIN NuGreen.Asset.ElementAttribute ea ON eh.ElementID = ea.ElementID
INNER JOIN NuGreen.Data.Snapshot s ON ea.ID = s.ElementAttributeID
WHERE et.Name IN ('Boiler', 'Heater')
AND eh.Path = N'\NuGreen\Houston\Cracking Process\Equipment\'
ORDER BY 1
```



```
SELECT e.PrimaryPath + e.Name Element, e.Template, ea.Name Attribute,
ea.ValueTimeStamp, ea.Value
FROM Master.Element.Element e
INNER JOIN Master.Element.Attribute ea ON e.ID = ea.ElementID
WHERE e.Template IN ('Boiler', 'Heater')
AND e.PrimaryPath = N'\NuGreen\Houston\Cracking Process\Equipment\'
ORDER BY 1
```

RTQP Engine: Custom Objects

- Views
- Custom Table-Valued Functions
- Function Tables for Table-Valued Functions
- Custom Functions

```
-- Create a custom catalog
CREATE CATALOG Test

-- Create a custom schema
CREATE SCHEMA Test.Test

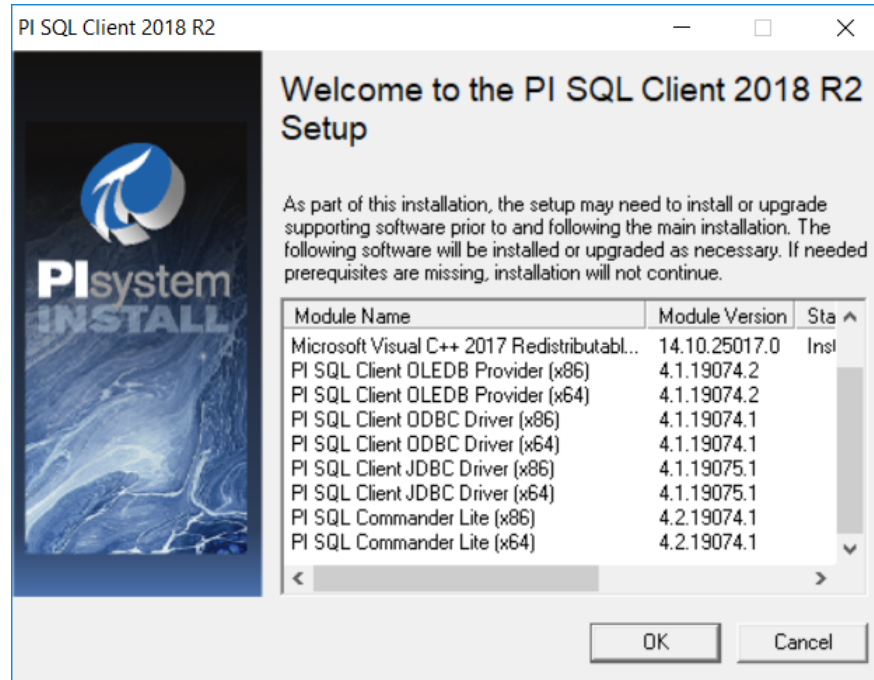
-- Create a custom view
CREATE VIEW Test.Test.HoustonElement
AS
SELECT *
FROM Master.Element.Element
WHERE PrimaryPath LIKE '\NuGreen\Houston\%'

-- Create a custom table-valued function as a parameterized query
-- (all parameters must be used in WHERE clause column equalities)
CREATE FUNCTION Test.Test.YesterdayEventFrame(@Unit String)
AS
SELECT ef.Name, ef.StartTime, ef.Duration, sv.Value ProcessFeedrate
FROM Master.EventFrame.EventFrame ef
INNER JOIN Master.Element.Attribute a ON a.ElementID = ef.PrimaryReferencedElementID
CROSS APPLY Master.Element.GetSampledValue(a.ID, ef.EndTime) sv
WHERE ef.PrimaryReferencedElement = @Unit
AND a.Name = 'Process Feedrate'
```

SQL Clients

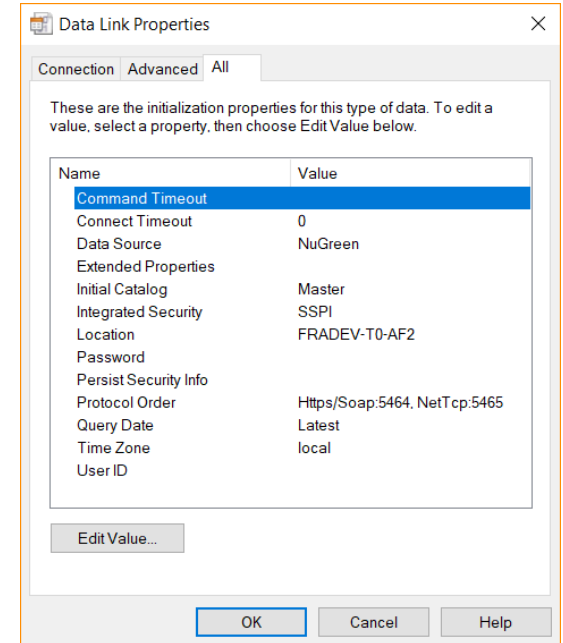
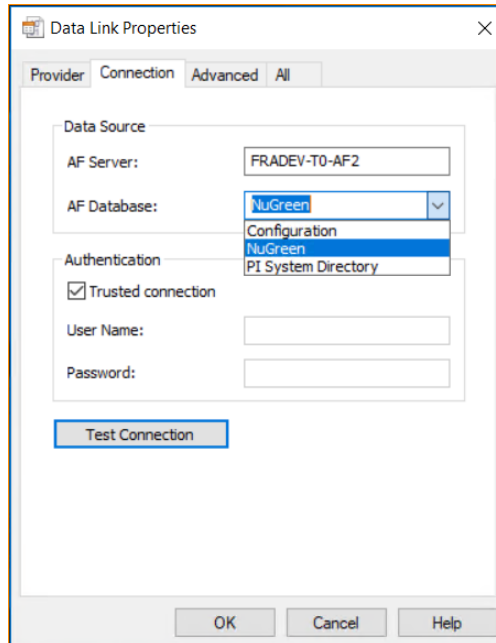
PI SQL Client 2018 R2

- No AF SDK dependency
- ODBC added
- JDBC added



Connection and Connection Options

- AF Database names can be browsed when **PI Web API Core Services** are configured
- Time Zone support
- Query Date



PI SQL Client: OLE DB Provider

- SQL Server integration (SSRS, SSIS, etc.)
- BizTalk
- SAP Crystal Reports
- ADO.NET, ASP.NET

PI SQL Client: ODBC Driver

- Oracle integration
- BI Tools, e.g. Tibco, Spotfire, Power BI
- Crystal Reports
- ADO.NET, ASP.NET

PI SQL Client: JDBC Driver

- Pure Java
- Https only

The screenshot shows the DbVisualizer Free 9.5.6 interface. The main window displays a table with the following columns: Id, TimeStamp_Local, Environment, Environmental Target, Feedrate, Plant, Process, and Quality. The table contains 18 rows of data, representing various process parameters over time.

Id	TimeStamp_Local	Environment	Environmental Target	Feedrate	Plant	Process	Quality
1	2015-01-01 00:00:00	49.275543212890625	100.0	49.27554	Tucson	Distilling Plant	49.275543212890625
2	2015-01-01 00:01:00	49.67314529418945	100.0	49.67315	Tucson	Distilling Plant	49.67314529418945
3	2015-01-01 00:02:00	50.070743560791016	100.0	50.07074	Tucson	Distilling Plant	50.070743560791016
4	2015-01-01 00:03:00	50.46934542095944	100.0	50.46935	Tucson	Distilling Plant	50.46934542095944
5	2015-01-01 00:04:00	50.8659477238867	100.0	50.86595	Tucson	Distilling Plant	50.8659477238867
6	2015-01-01 00:05:00	51.2635490466875	100.0	51.26355	Tucson	Distilling Plant	51.2635490466875
7	2015-01-01 00:06:00	51.66114807128906	100.0	51.66115	Tucson	Distilling Plant	51.66114807128906
8	2015-01-01 00:07:00	52.05875015258769	100.0	52.05875	Tucson	Distilling Plant	52.05875015258769
9	2015-01-01 00:08:00	52.4563522388672	100.0	52.45635	Tucson	Distilling Plant	52.4563522388672
10	2015-01-01 00:09:00	52.85395431518555	100.0	52.85395	Tucson	Distilling Plant	52.85395431518555
11	2015-01-01 00:10:00	53.25155258178711	100.0	53.25155	Tucson	Distilling Plant	53.25155258178711
12	2015-01-01 00:11:00	53.64915466308594	100.0	53.64915	Tucson	Distilling Plant	53.64915466308594
13	2015-01-01 00:12:00	54.046756744884766	100.0	54.04676	Tucson	Distilling Plant	54.046756744884766
14	2015-01-01 00:13:00	54.444358825605594	100.0	54.44436	Tucson	Distilling Plant	54.444358825605594
15	2015-01-01 00:14:00	54.841957092285156	100.0	54.84196	Tucson	Distilling Plant	54.841957092285156
16	2015-01-01 00:15:00	55.239559173583984	100.0	55.23956	Tucson	Distilling Plant	55.239559173583984
17	2015-01-01 00:16:00	55.63716125488281	100.0	55.63716	Tucson	Distilling Plant	55.63716125488281
18	2015-01-01 00:17:00	56.034759521484375	100.0	56.03476	Tucson	Distilling Plant	56.034759521484375

PI SQL Client: PI SQL Commander

- Browse Data Model and Functions
- Compendium
- Code/keyboard pre-completion
(it might also be known as IntelliSense™®☺)

Sample Queries and Performance

The screenshot displays the PI SQL Commander Lite interface. On the left is the Object Explorer showing a tree view of data sources under 'OLEDB Data Sources' and 'PI OLEDB Provider'. The main window shows two queries and their results.

Query 2: Query2.sql - FRADEV-T2-AF210*

```
SELECT top 3000 e.Name, sSP.ValueStr "Service Point", sY.ValueDb1 "Y", sX.ValueDb1 "X"
FROM Element e
INNER JOIN ElementAttribute eaSP ON eaSP.ElementID = e.ID
INNER JOIN ElementAttribute eaX ON eaX.ElementID = e.ID
INNER JOIN ElementAttribute eaY ON eaY.ElementID = e.ID
INNER JOIN Data_Snapshot sSP ON sSP.ElementAttributeID = eaSP.ID
INNER JOIN Data_Snapshot sX ON sX.ElementAttributeID = eaX.ID
INNER JOIN Data_Snapshot sY ON sY.ElementAttributeID = eaY.ID
INNER JOIN ElementTemplate et ON et.ID = e.ElementTemplateID
WHERE eaSP.Name = 'ServicePointID'
AND eaX.Name = 'X'
AND eaY.Name = 'Y'
AND sX.ValueDb1 BETWEEN 2210000. AND 2220000.
AND sY.ValueDb1 > 390000. AND sY.ValueDb1 < 400000.
AND et.Name = 'SilverSpringMeter'
ORDER BY Y DESC, Name -- North to South
```

Results for Query 2:

Name	Service Point	Y	X
1 SilverSpring_NP_ab00dd10027f	SPE_ab00dd10027f	399999.364297941	2213255.1212611
2 SilverSpring_NP_ab00dd100040	SPE_ab00dd100040	399998.395467848	2213695.82871303
3 SilverSpring_NP_ab00dd1002b4	SPE_ab00dd1002b4	399995.923031852	2215560.89486477

Query 3: Query3.sql - FRADEV-T2-AF210\PIFD24L*

```
SELECT top 3000 e.Name, eaSP.Value_String "Service Point", eaY.Value_Double "Y", eaX.Value_Double "X"
FROM Element e
INNER JOIN ElementAttribute eaSP ON eaSP.ElementID = e.ID
INNER JOIN ElementAttribute eaX ON eaX.ElementID = e.ID
INNER JOIN ElementAttribute eaY ON eaY.ElementID = e.ID
WHERE eaSP.Name = 'ServicePointID'
AND eaX.Name = 'X'
AND eaY.Name = 'Y'
AND eaX.Value_Double BETWEEN 2210000. AND 2220000.
AND eaY.Value_Double > 390000. AND eaY.Value_Double < 400000.
AND e.Template = 'SilverSpringMeter'
ORDER BY Y DESC, Name -- North to South
```

Results for Query 3:

Name	Service Point	Y	X
1 SilverSpring_NP_ab00dd10027f	SPE_ab00dd10027f	399999.364297941	2213255.1212611
2 SilverSpring_NP_ab00dd100040	SPE_ab00dd100040	399998.395467848	2213695.82871303
3 SilverSpring_NP_ab00dd1002b4	SPE_ab00dd1002b4	399995.923031852	2215560.89486477
4 SilverSpring_NP_ab00dd10013e	SPE_ab00dd10013e	399992.44567661	2215416.38399895
5 SilverSpring_NP_ab00dd1002e9	SPE_ab00dd1002e9	399992.336096764	2215277.20087835

Future

- Locale property:
 - e.g. '01-Dec-2019' vs N'01-Dez-2019'
- Data Archive tables (PI tags vs AF attributes)
- INSERT/UPDATE/DELETE event frames
- INSERT/UPDATE/DELETE tags/attribute values



<https://feedback.osisoft.com/>

DEMO

Exploring PI SQL Client functionality in PI SQL Commander
Microsoft SQL Server – PI SQL Client Remote Connection

Further Resources

- PI SQL Online Course
 - <https://learning.osisoft.com/series/developer/exposing-pi-data-with-the-pi-sql-framework#en-language>
 - Videos, exercises with solution guides, further resources
- Earlier Presentations
 - <https://www.osisoft.com/about-osisoft/presentations/>
- PI SQL Data Access Technologies
 - <https://pisquare.osisoft.com/community/developers-club/pi-sql-data-access-technologies>

Questions?

Please wait for
the **microphone**

State your
name & company



Please remember to...

Complete Survey!

Navigate to this session in
mobile agenda for survey

An advertisement for the OSISOFT PIWorld app. The background is a dark blue gradient with a subtle pattern. On the left, the text "TO DOWNLOAD APP, SEARCH OSISOFT" is written in white, bold, sans-serif font. Below this text are two black buttons: "Download on the App Store" with the Apple logo and "GET IT ON Google Play" with the Google Play logo. On the right, a smartphone is shown vertically, displaying the app's logo (a stylized white atom) and the text "OSISOFT PIWorld" on a green screen.

謝謝 KEA LEBOHA
 TAPADH LEIBH 고맙습니다
 БАЯРЛАЛАА MISAOTRA ANAO
 DZIĘKUJĘ CI NGIYABONGA TEŞEKKÜR EDERIM GRACIES OBRIGADO شكرا SALAMAT
 DANKIE TERIMA KASIH DANKON TANK TAPADH LEAT
 KÖSZÖNÖM SPASIBO MULȚUMESC
 PAKMET CIZGE OSIssoft.
 GO RAIBH MAITH AGAT PI World
 БЛАГОДАРЯ GRACIAS HVALA FAAFETAI
 ТИ БЛАГОДАРАМ MAHADSANID HVALA ESKERRIK ASKO
 TAK DANKE MAHALO IĀ 'ŌE HVALA ХВАЛА ВАМ
 RAHMAT MERCI TEŞEKKÜR EDERIM
 HATUR NUHUN DANK JE EΥΧΑΡΙΣΤΩ GRATIAS TIBI GRAZIE
 GRAZZI ПAKKA PĒR ДЯКУЙ DI OU MÈSI
 PAXMAT САГА FALEMINDERIT ありがとうございます ŏAKUJEM
 SIPAS JI WERE TERIMA KASIH MATUR NUWUN
 CẢM ƠN BẠN UA TSAUG RAU KOJ
 WAZVIITA ТИ БЛАГОДАРАМ
 СИПОС