OPC Data Logger Case Study

How Unifi used the OPC Data Logger as part of their data logging strategy

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Table of Contents

Introduction

The following is a case study of how Brad Bright of Unifi used the OPC Data Logger to solve his data logging needs.

Intended Audience

This document is intended for people who need to log OPC data to a database, plain and simple.

This document assumes no prior database experience.

Purpose of this document

This document is intended to provoke design decisions prior to implementation.

This document is intended to help facilitate the easiest possible OPC Data Logger configuration, while leveraging maximum database efficiency which will result in:

- Less data being logged
- More accurate data being logged
- Maximum reporting capabilities.

This document will outline a simple data logging scenario along with step-by-step instructions that will accomplish a solution.

Data Logging Scenario

Brad had a need to log data to an ORACLE database for later analysis. Brad outlined the following requirements:

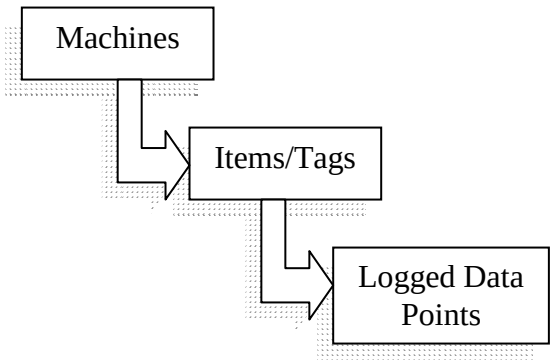
1. Approx. 30 devices required their data to be logged.
2. Each device has approx. 30 items that needed to be logged.
3. All data, from all devices needed to be collected 4 times per day.
4. The logged data can be analyzed later (not in real time)
5. Would like to see the data in a tabular report, i.e. showing the data between time-frames.
6. Ability to see & exclude any questionable/bad data during a specific time-frame.

Data Design

Brad realized that his needs were such that he could end-up with large and complex configuration settings that could be confusing to other users, so Brad started out by designing his database applying widely adopted database principles and best practices including data-normalization and the use of Stored Procedures to maximize his data efficiency as well as maximizing his Oracle database performance.

Data Normalization - Separating Data into Multiple Tables

The first step is to identify and normalize the data.[1]



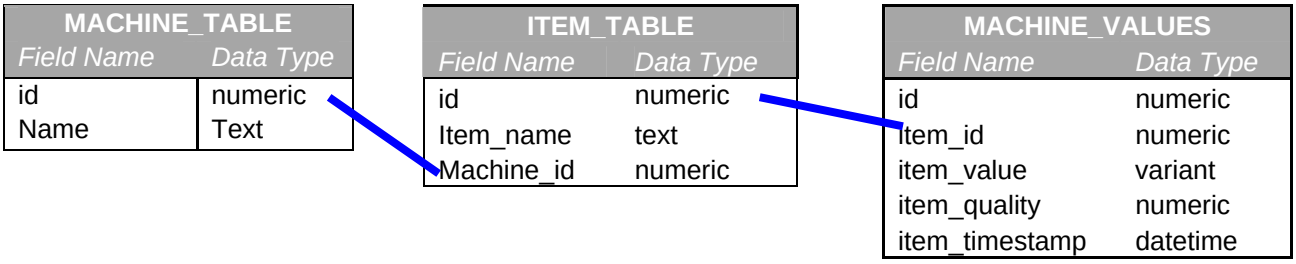
In this case, Brad separated the data into 3 respective areas:

- Machines – to store information about each machines whose data is being logged
- The Items/Tags – which will be related to the Machines
- The logged data points – and we will relate them to the Items

[1] Database normalization is not in the scope of this document.

Data Table Design

In this simple design, Brad opted to separate the logged values from the underlying items themselves. Here is a look at these simple tables:



MACHINE_TABLE	
Field Name	*Data Type*
id	numeric
Name	Text

ITEM_TABLE	
Field Name	*Data Type*
id	numeric
Item_name	text
Machine_id	numeric

MACHINE_VALUES	
Field Name	*Data Type*
id	numeric
Item_id	numeric
item_value	variant
item_quality	numeric
item_timestamp	datetime

In this design, the values could be logged to the MACHINE_VALUES table without having to log the name of the item for each value logged, which would save space in the database. Furthermore, because of the direct relationship between the value and the item, much more efficient database queries will be possible.

How will data be stored?

First, the machines and items tables had to be pre-populated. The machine table stores information about the machines:

MACHINE_TABLE	
Id	*Item_Name*
1	Machine 1
2	Machine 2
3	Machine 3

Also, the ITEM_TABLE had to be populated before we begin logging. For example:

ITEM_TABLE	
Id	*Item_Name*
1	Channel1.Device1.Tag1
2	Channel1.Device1.Tag2
3	Channel1.Device1.Tag3

Once the MACHINE_TABLE and ITEM_TABE database tables contained the data, the OPC Data Logger could now log the values into the MACHINE_VALUES as follows:

MACHINE_VALUES				
Id	*Item_Id*	*Item_Value*	*Item_Quality*	*Item_Timestamp*
1	1	10	192	1/1/2008 12:01:01
2	1	20	192	1/1/2008 12:01:01
3	2	30	192	1/1/2008 12:01:01
4	1	40	192	1/1/2008 12:01:01
5	1	50	192	1/1/2008 12:01:01
6	3	60	192	1/1/2008 12:01:01

Note: This time the name of the item is NOT being logged (yellow column) but its index within the other/related table is being logged instead.

Configuring the OPC Data Logger

Configuration Process

Before configuring the OPC Data Logger, Brad already configured the database with the previously documented tables, and the MACHINE_TABLE and ITEM_TABLE were pre-populated with the data.

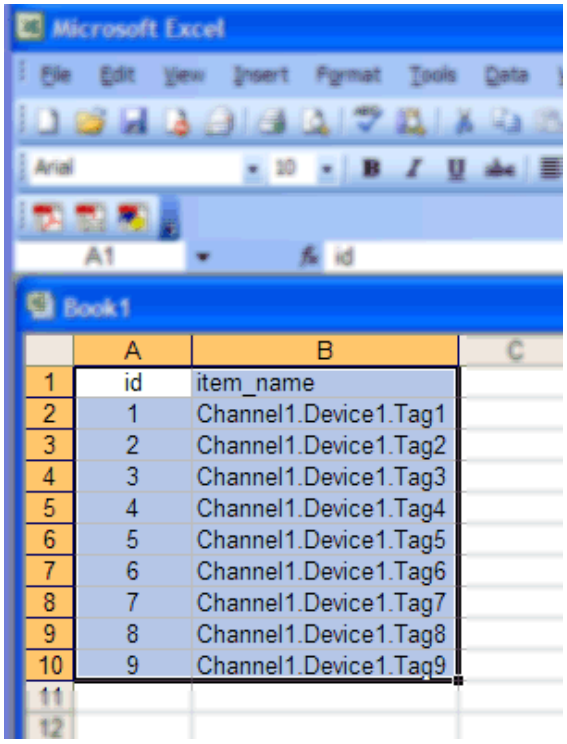
Because Brad already had the names of the items configured within his TOPServer OPC Server, he simply exported them to a *.CSV file and then opened file within Excel. Brad then modified the data so as to be able to import the items straight into the database, for example:

item_name	machine_id
Channel1.Device1.Tag1	1
Channel1.Device1.Tag2	1
Channel1.Device1.Tag3	1
Channel1.Device1.Tag4	2
Channel1.Device1.Tag5	2
Channel1.Device1.Tag6	2
Channel1.Device1.Tag7	3
Channel1.Device1.Tag8	3
Channel1.Device1.Tag9	3

Brad then further configure the data such that he was able to import this *.CSV file straight into the OPC Data Logger, eliminating the need for him having to manually configure the items.

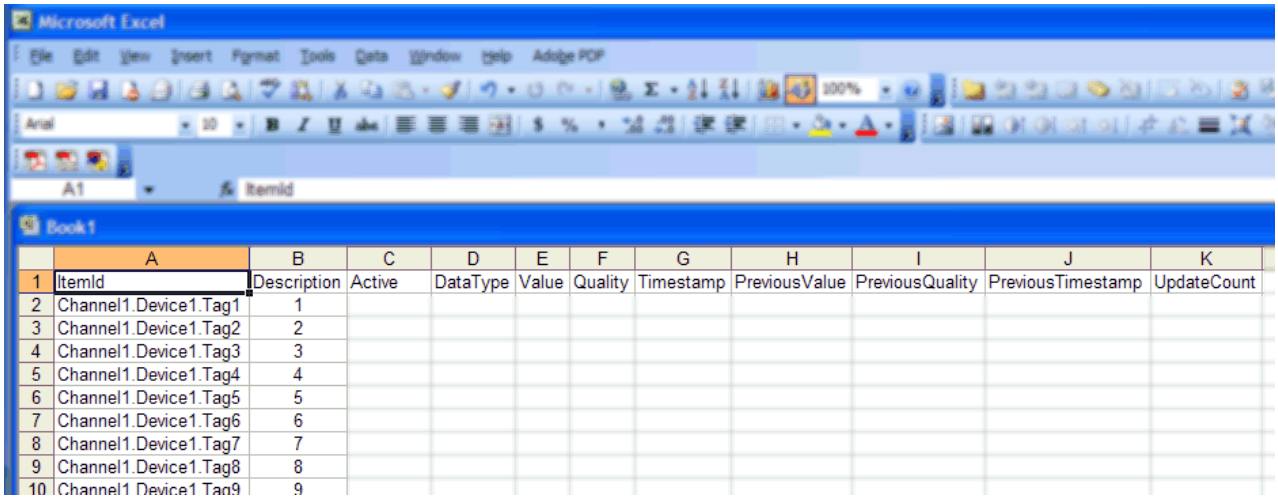
Modifying the items data within Excel

Next, Brad modified the items table within Excel that were previously used to import into database.



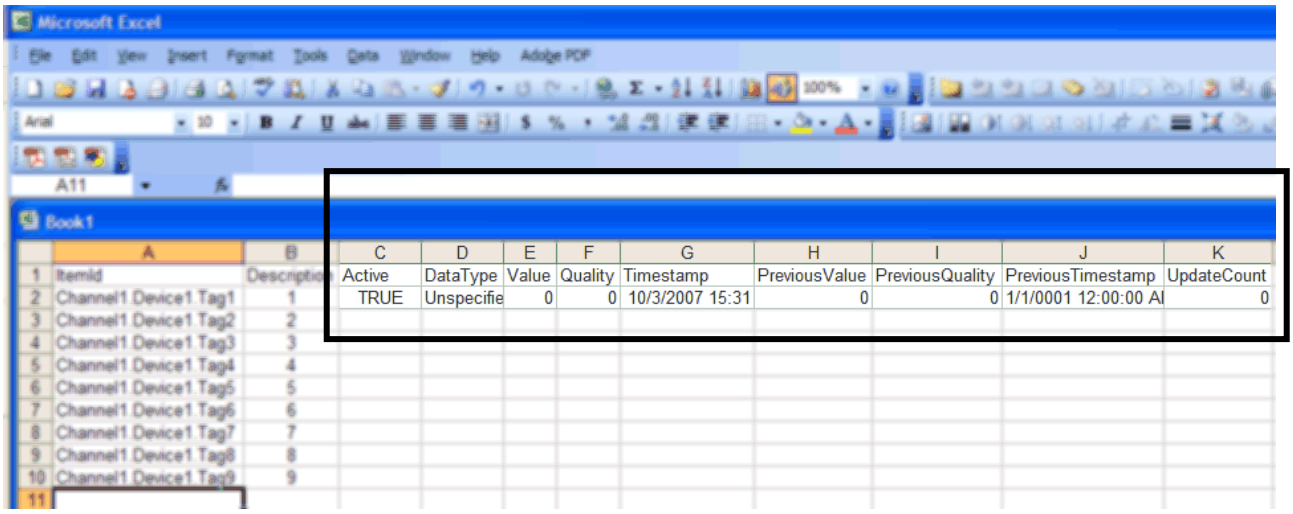
	A	B	C
1	id	item_name	
2	1	Channel1.Device1.Tag1	
3	2	Channel1.Device1.Tag2	
4	3	Channel1.Device1.Tag3	
5	4	Channel1.Device1.Tag4	
6	5	Channel1.Device1.Tag5	
7	6	Channel1.Device1.Tag6	
8	7	Channel1.Device1.Tag7	
9	8	Channel1.Device1.Tag8	
10	9	Channel1.Device1.Tag9	
11			
12			

In order to import this data into the OPC Data Logger, Brad needed to modify the data by first adding the extra columns needed. Also, in order to tie the relationship between the data being logged and the items table within the database, Brad opted to store the **Machine_Id** inside the Item **Description** column for each item.



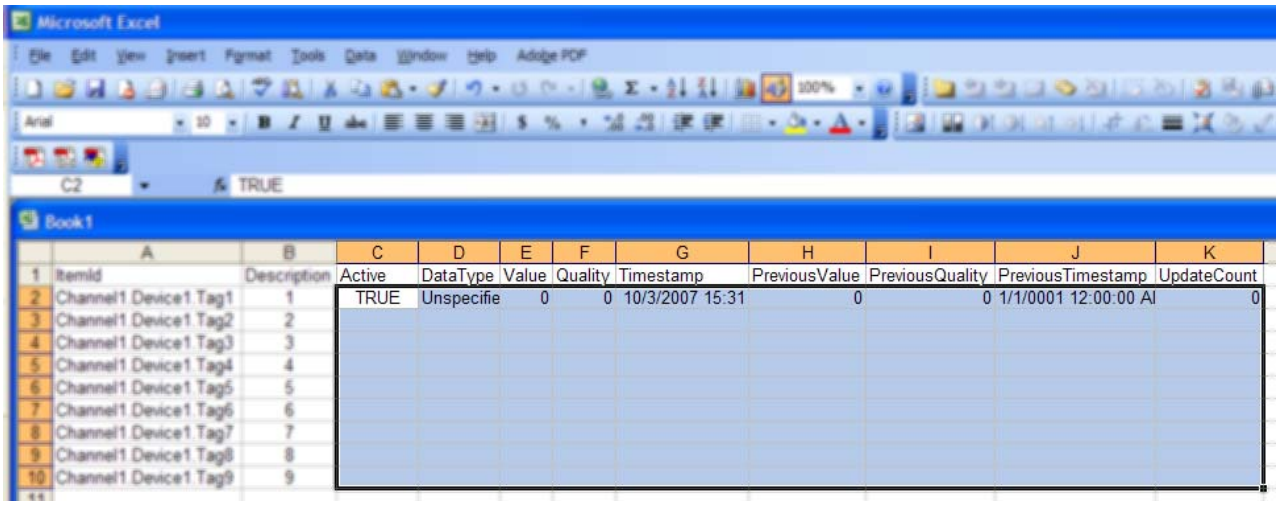
	A	B	C	D	E	F	G	H	I	J	K
1	ItemId	Description	Active	DataType	Value	Quality	Timestamp	PreviousValue	PreviousQuality	PreviousTimestamp	UpdateCount
2	Channel1.Device1.Tag1	1									
3	Channel1.Device1.Tag2	2									
4	Channel1.Device1.Tag3	3									
5	Channel1.Device1.Tag4	4									
6	Channel1.Device1.Tag5	5									
7	Channel1.Device1.Tag6	6									
8	Channel1.Device1.Tag7	7									
9	Channel1.Device1.Tag8	8									
10	Channel1.Device1.Tag9	9									

Next, Brad had to fill-in the empty cell values for the first row:



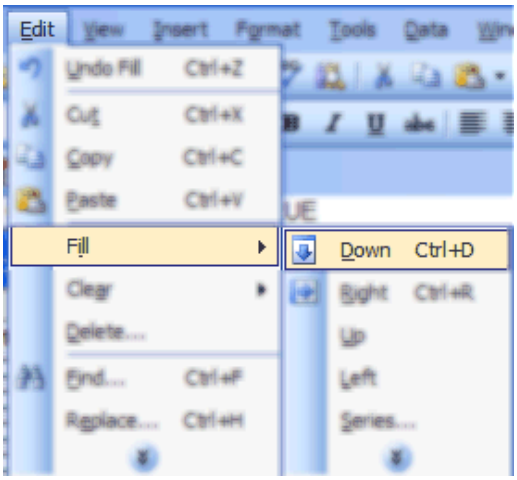
	A	B	C	D	E	F	G	H	I	J	K
1	ItemId	Description	Active	DataType	Value	Quality	Timestamp	PreviousValue	PreviousQuality	PreviousTimestamp	UpdateCount
2	Channel1.Device1.Tag1	1	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
3	Channel1.Device1.Tag2	2									
4	Channel1.Device1.Tag3	3									
5	Channel1.Device1.Tag4	4									
6	Channel1.Device1.Tag5	5									
7	Channel1.Device1.Tag6	6									
8	Channel1.Device1.Tag7	7									
9	Channel1.Device1.Tag8	8									
10	Channel1.Device1.Tag9	9									
11											

Once the first row contained some default values, the remaining empty rows needed to be configured also. This was done quickly and easily by using the **Fill-down** option within Excel. The first key was to select the entire range of data that was added, in this example cell **C2** to **K2**. But, also to expand this range so that it covers the blank cells beneath this range as shown below:

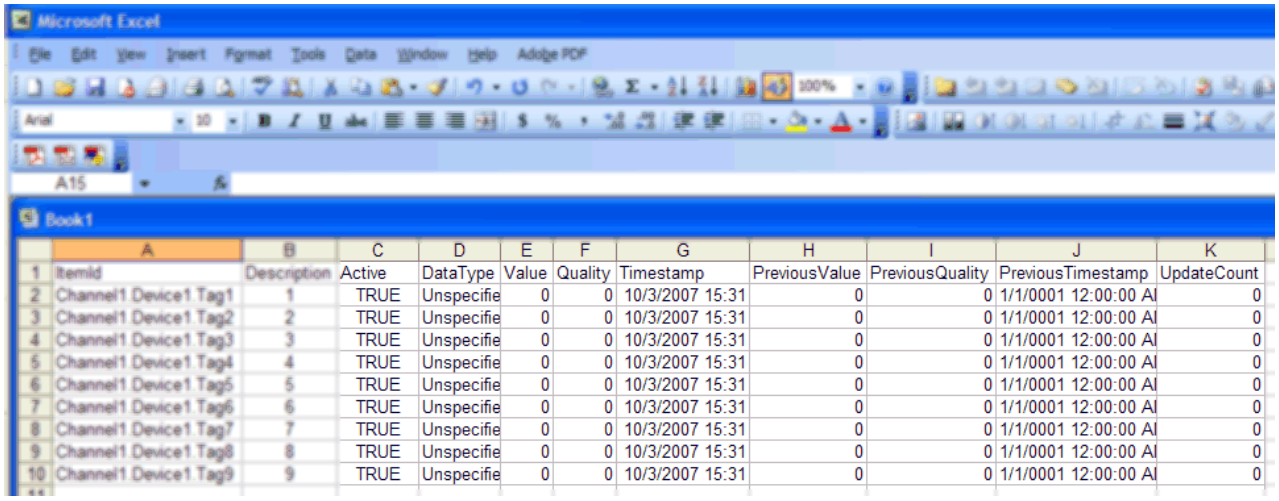


	A	B	C	D	E	F	G	H	I	J	K
1	ItemId	Description	Active	DataType	Value	Quality	Timestamp	PreviousValue	PreviousQuality	PreviousTimestamp	UpdateCount
2	Channel1.Device1.Tag1	1	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
3	Channel1.Device1.Tag2	2									
4	Channel1.Device1.Tag3	3									
5	Channel1.Device1.Tag4	4									
6	Channel1.Device1.Tag5	5									
7	Channel1.Device1.Tag6	6									
8	Channel1.Device1.Tag7	7									
9	Channel1.Device1.Tag8	8									
10	Channel1.Device1.Tag9	9									

Next, Brad chose the **Fill > Down** option:



The values were then copied onto each row as shown here:

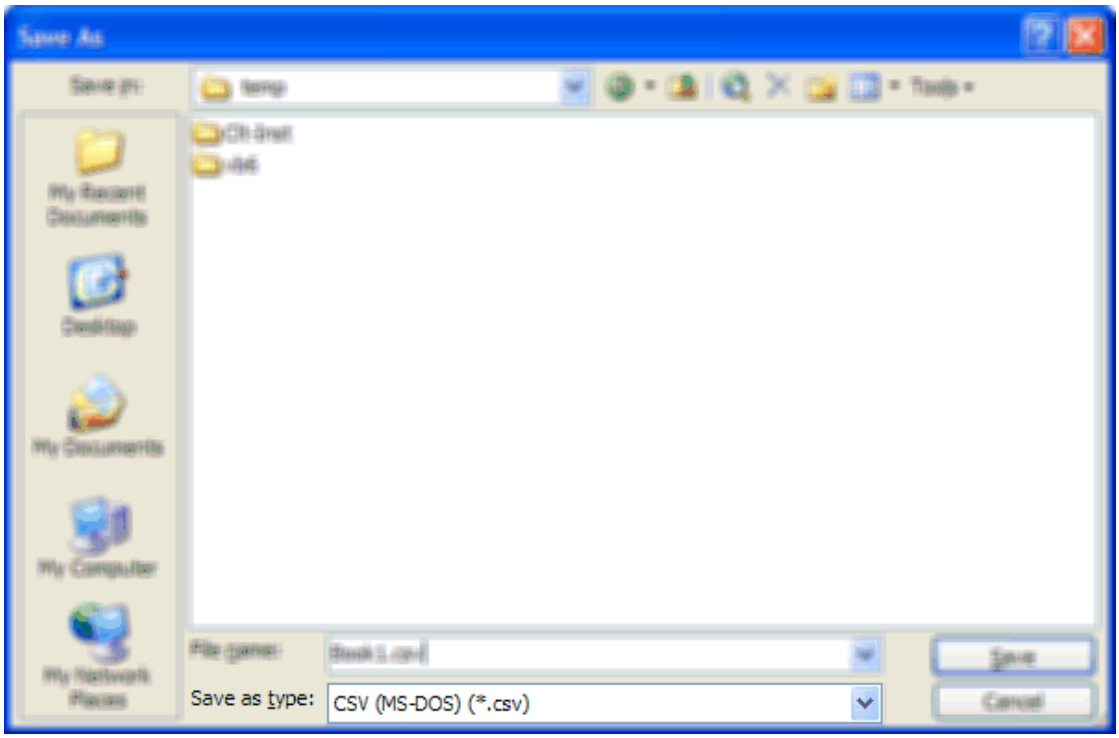


Microsoft Excel

Book1

	A	B	C	D	E	F	G	H	I	J	K
1	ItemId	Description	Active	DataType	Value	Quality	Timestamp	PreviousValue	PreviousQuality	PreviousTimestamp	UpdateCount
2	Channel1.Device1.Tag1	1	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
3	Channel1.Device1.Tag2	2	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
4	Channel1.Device1.Tag3	3	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
5	Channel1.Device1.Tag4	4	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
6	Channel1.Device1.Tag5	5	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
7	Channel1.Device1.Tag6	6	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
8	Channel1.Device1.Tag7	7	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
9	Channel1.Device1.Tag8	8	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0
10	Channel1.Device1.Tag9	9	TRUE	Unspecifie	0	0	10/3/2007 15:31	0	0	1/1/0001 12:00:00 AI	0

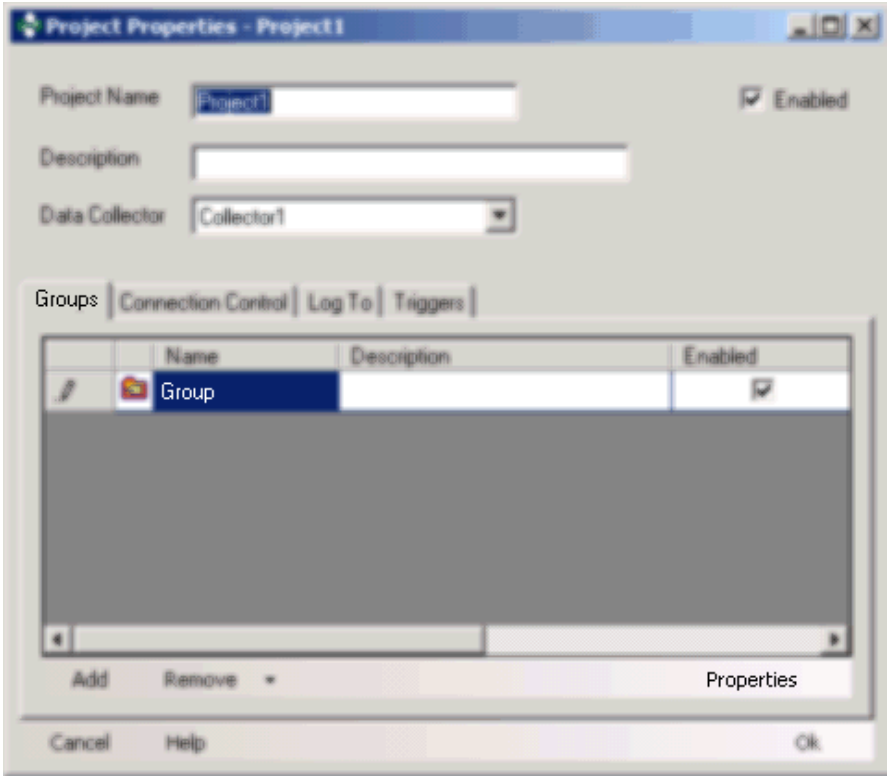
Brad then saved this sheet as a *.CSV file by simply choosing **FILE** -> **SAVE AS** and then picking *.CSV as shown here:



Importing the items into the OPC Data Logger

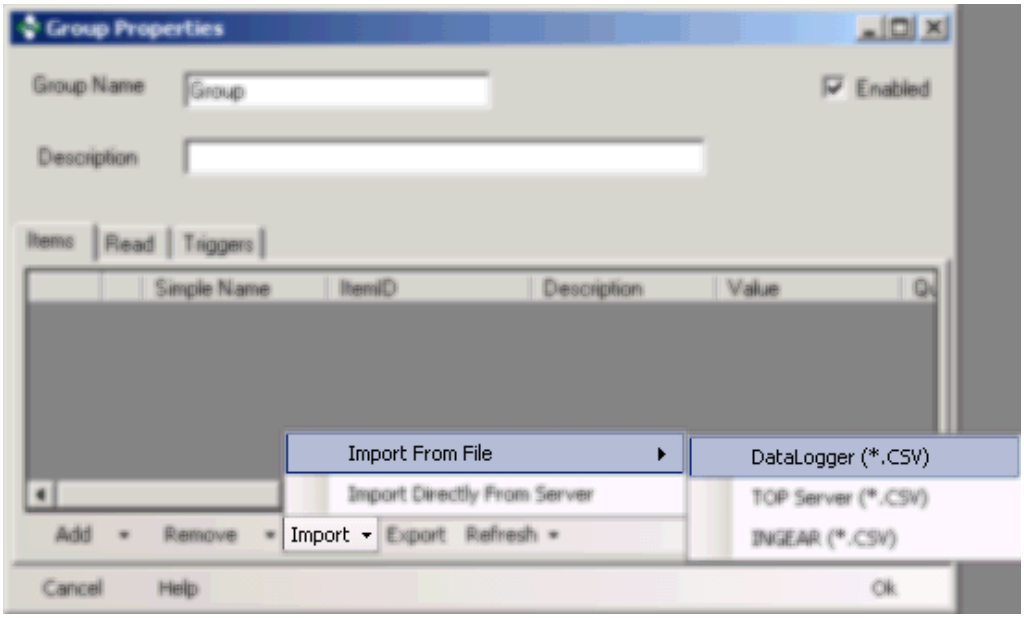
Once the items were defined within the *.CSV file, Brad then used the Item Import feature to add these items to the OPC Data Logger configuration:

1. Opened the OPC Data Logger, then opened the Project containing the group being modified.



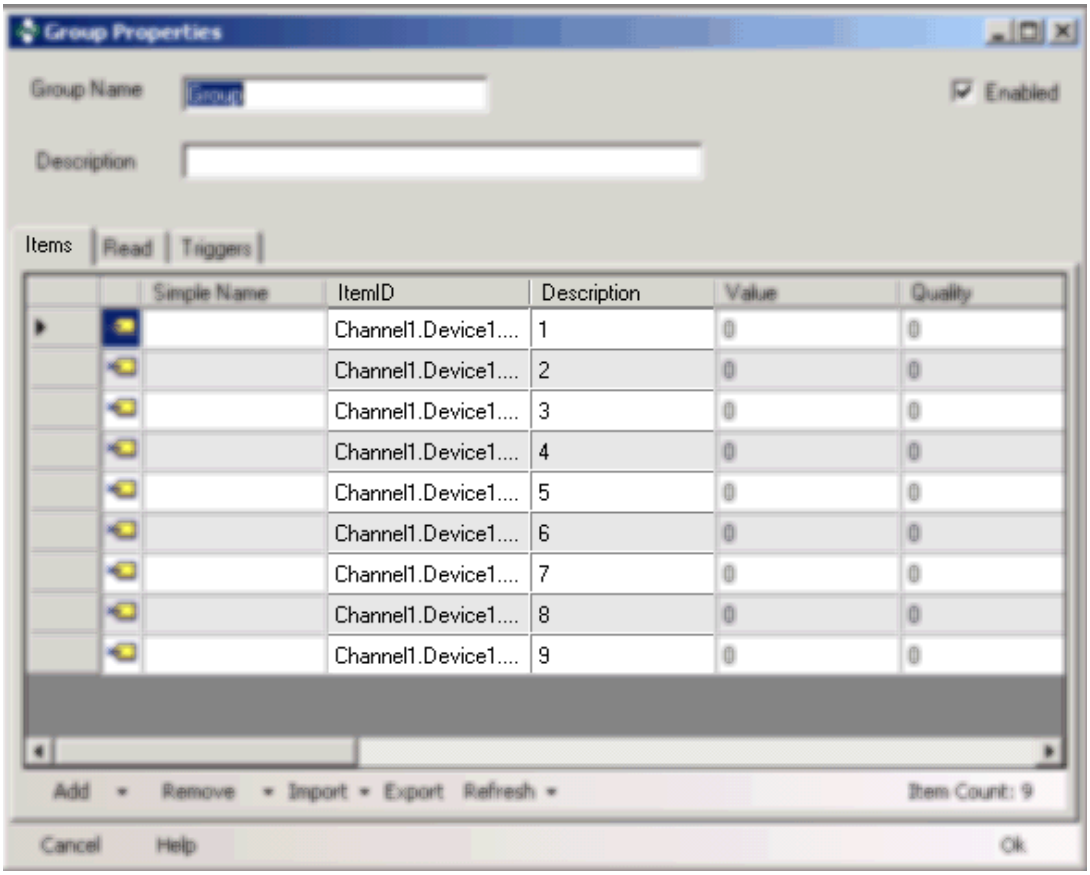
2. Highlight (or add) the group, and then open its **Properties**.

3. Clicked on the **Items** tab and then opened the **Import** option at the bottom of the window, choosing the **Import From File** sub-menu finally clicking on the **DataLogger (*.CSV)** option:



4. A dialog prompted for the file to import:

5. The items were then imported:

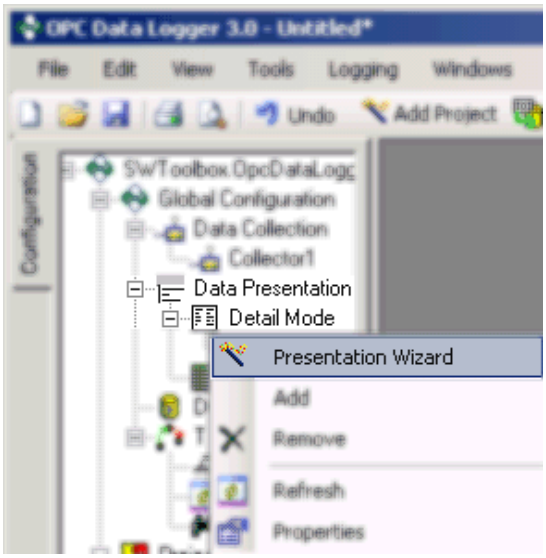


Note: That Item's id in the database is stored within the **Description** column.

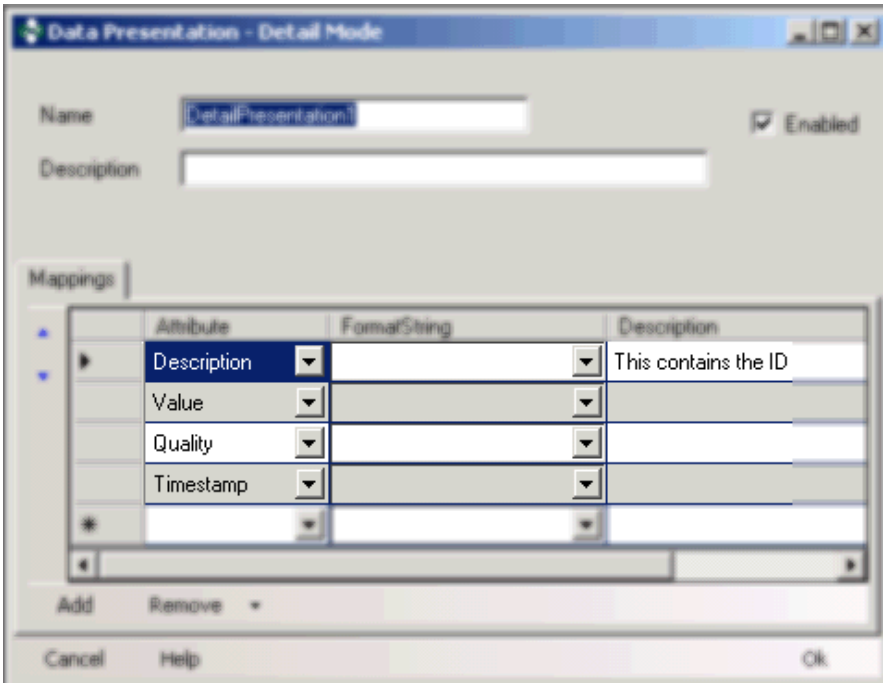
Configuring a Detail mode presentation formatter

Brad then configured just one detail mode formatter needed to correctly log the items (including the reference to the Item ID).

1. Created a new Detail mode presentation by simply right-clicking on the **Detail Mode** icon in the main application tree-view:



2. Configured the detail mode to resemble the following:

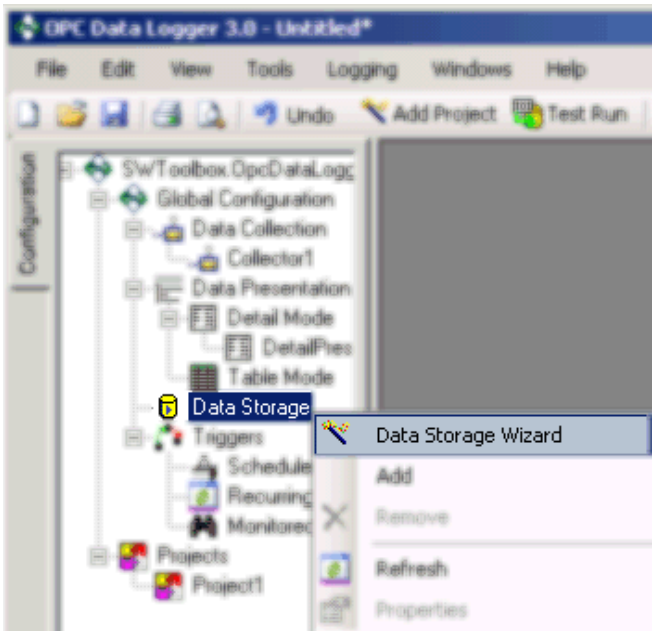


3. Clicked **OK** to save and close this window.

Connecting to the Database

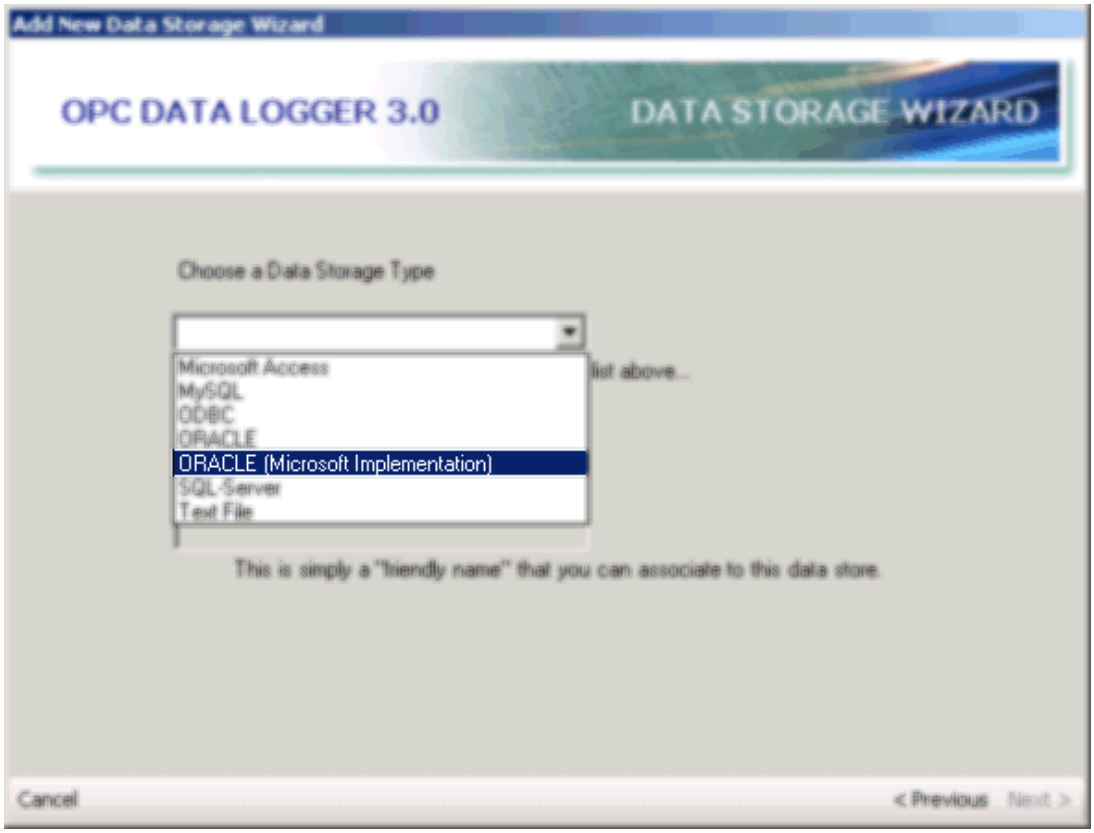
Now, the database had been configured, the items had been imported into the database and OPC Data Logger, and defined the Detail mode presentation. Brad was able to complete the configuration process by binding the detail-mode formatter to the database table. Once this was done, data can be logged.

1. Right-click on the **Data Storage** node within the treeview and choose the **Data Storage Wizard**:



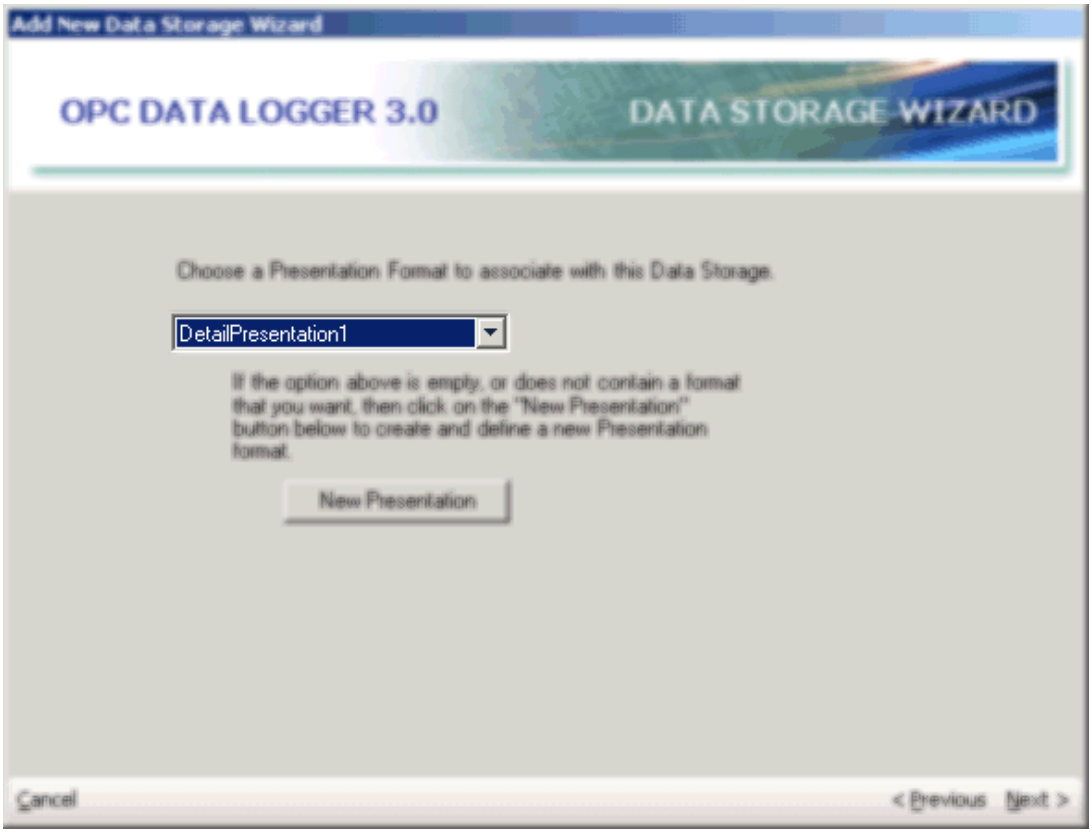
2. The wizard will begin. Press **Next** to bypass the welcome screen.

3. Next, the ORACLE database type was chosen from the list.



Then click the **Next** button.

4. Pick the Detail presentation that was previously created:



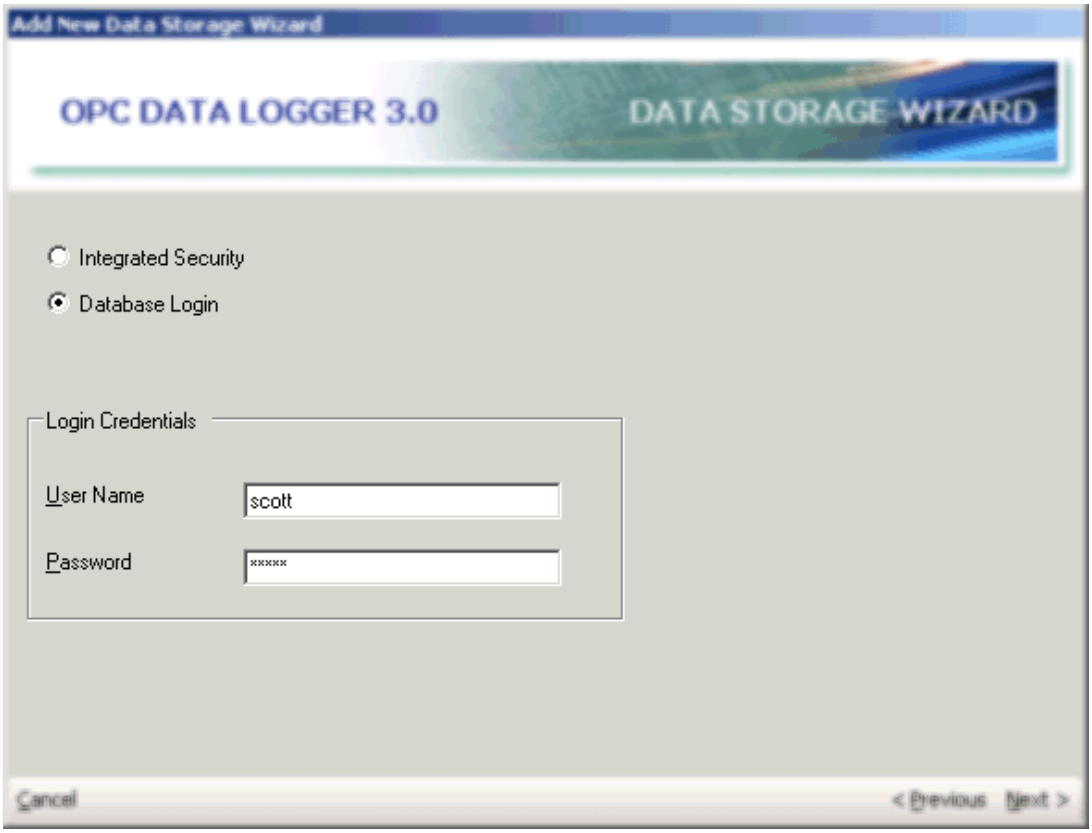
Then click the **Next** button.

5. In the case of connecting to an ORACLE database, the following window will be displayed requiring the entry of a valid Service Name.

   (This does not apply to any other type of database.)

Simply click the **Next** button to proceed.

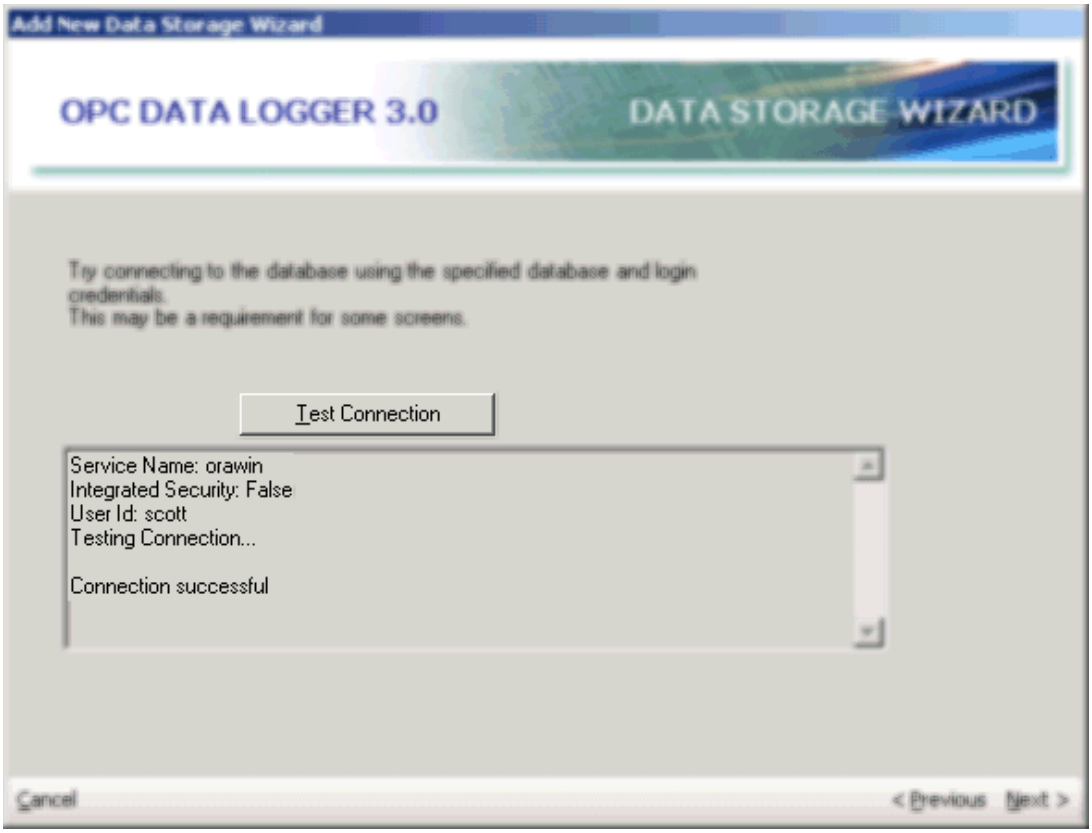
6. Specify how to log into the database.



In this case we will be using the **scott\tiger** default account installed by Oracle.

Click the **NEXT** button.

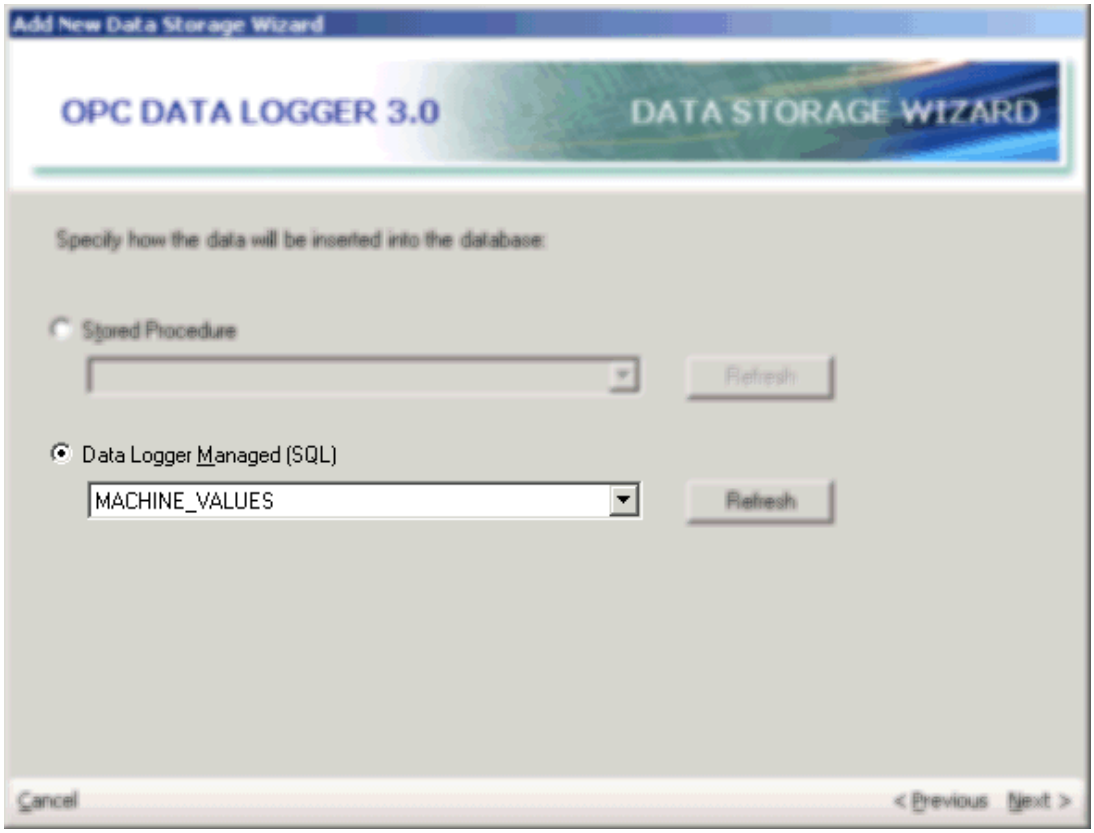
7. Test your database configuration:



It is important that the test is successful for the wizard to proceed.

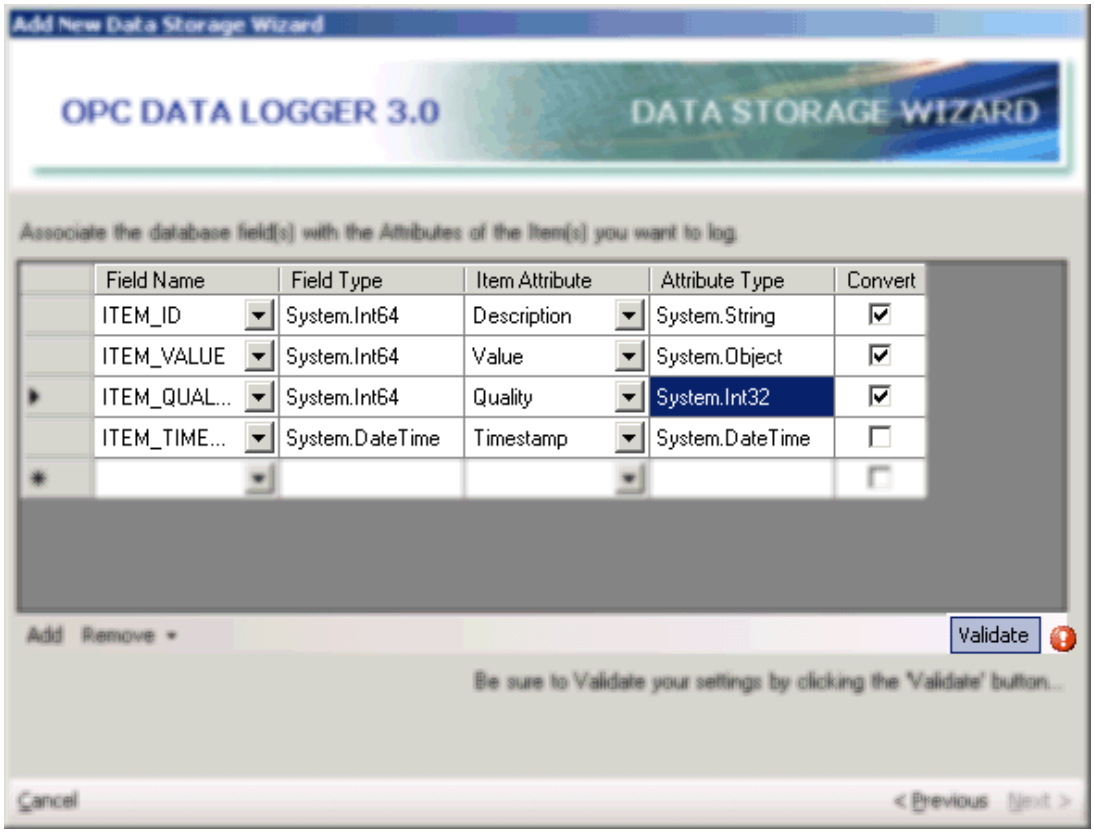
Click the **Next** button to continue.

8. Now to pick MACHINE_VALUES table from the list of available tables, because this is the table where data will be logged:



Click the **Next** button to continue.

9. Now to configure the bindings, that is, the relationship between the item values within the OPC Data Logger and the fields within the selected table.



You must click the **Validate** button to verify that your configuration is valid.

Press the **Next** button to proceed.

10. The wizard will summarize what you have just done, simply click the **Finish** button and then save your OPC Data Logger configuration.

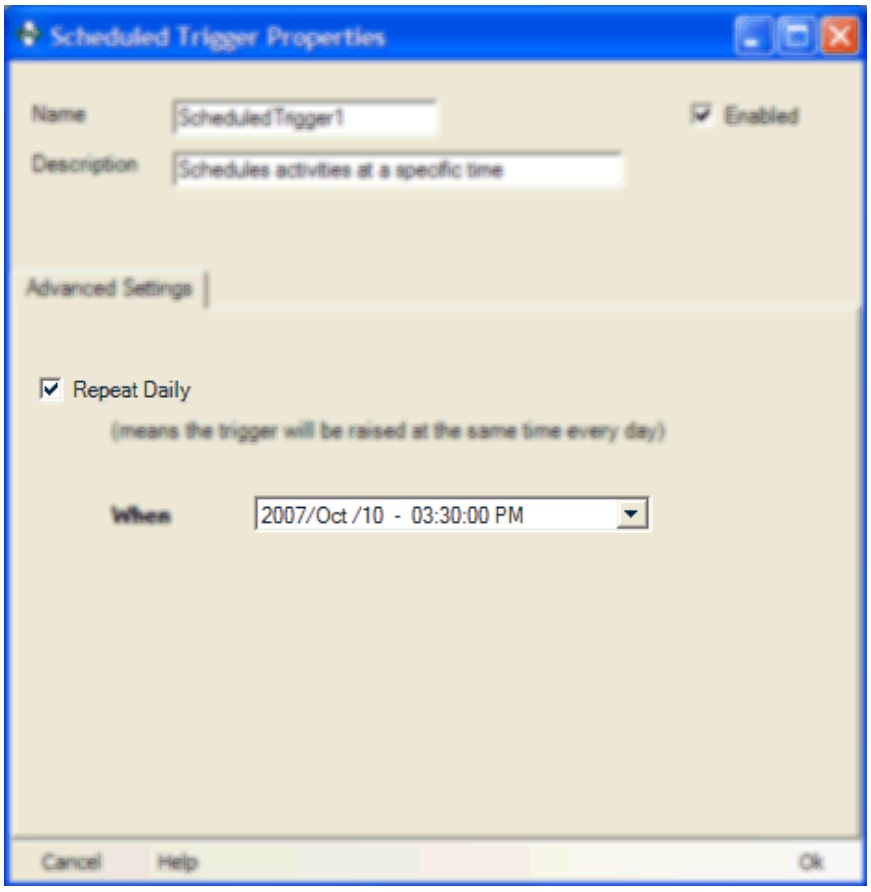
Collecting the data 4 times a day

The OPC Data Logger required 2 configuration steps in order to log data 4 times a day:

1. Setting up Triggers
2. Configuring the group to read based on the triggers

Step 1 Configuring the Triggers

Brad needed to log data 4 times a day, at specific times of the day. The other choice could have been to log every 6 hours. Because strict times were going to be used, a **Scheduled Trigger** was created for each time of the day a reading needed to be made. Here's an example of a scheduled trigger scheduled to execute at 3:30 pm.



3 other triggers were created, 1 for each of the other times of the day.

Step 2 Configuring the Group to use the Triggers

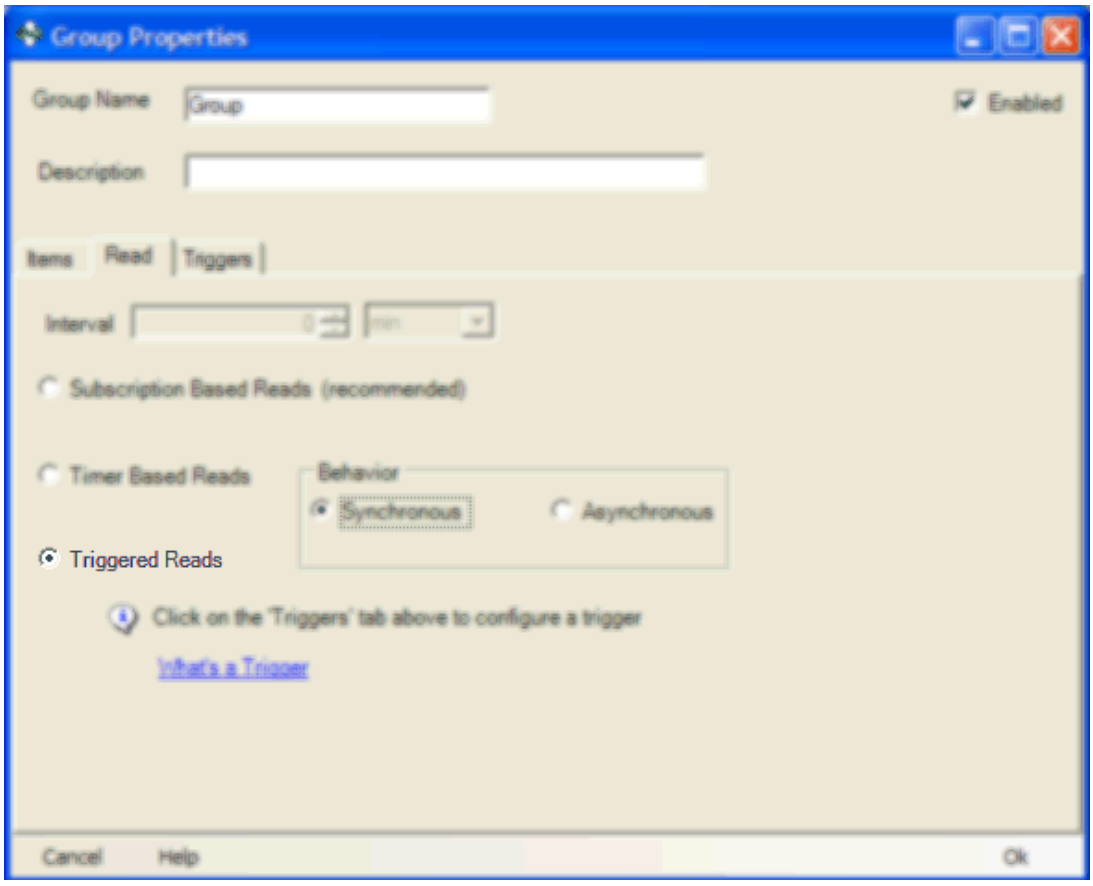
Now that the triggers had been setup, the next step was to configure the GROUP to use them. This also was a 2-step configuration:

1. Specify that triggers initiate when to read the items.

2. Specify which triggers will cause the reading to take place.

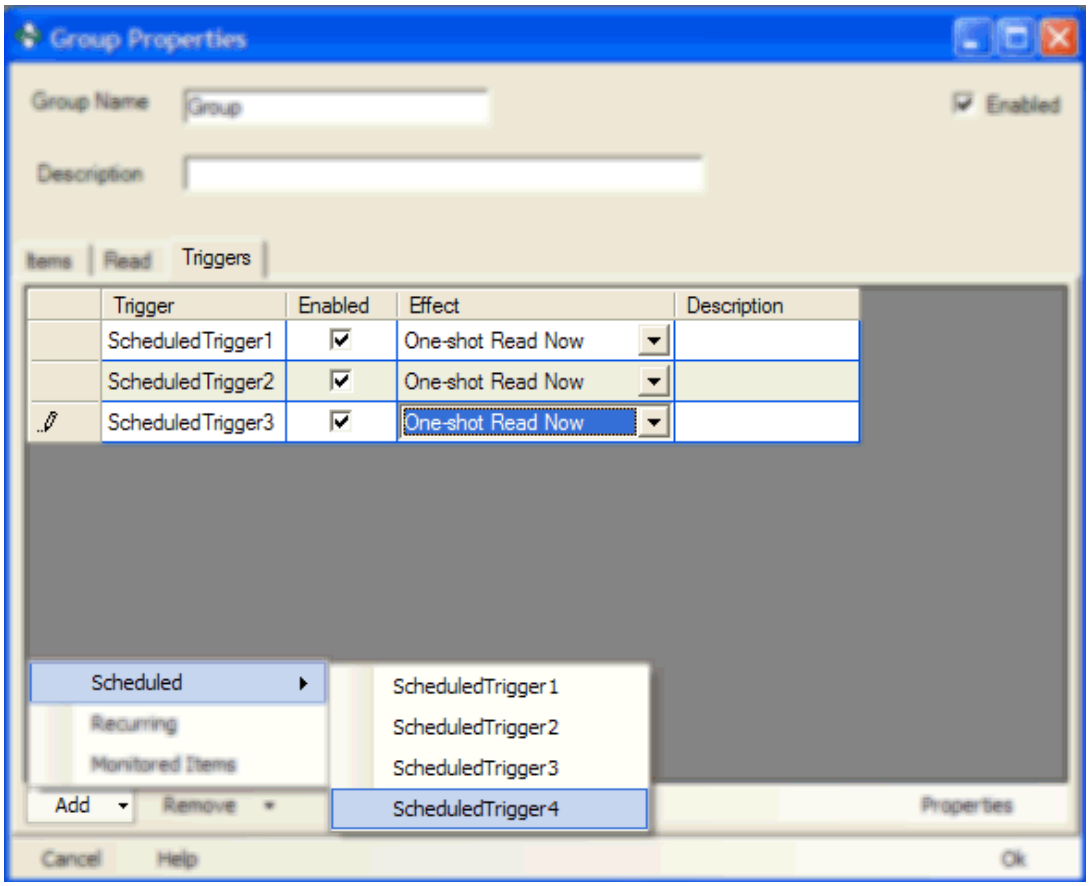
Step 1 – Specifying the reading to take place when a trigger is raised.

Open the group properties and click on the **Read** tab. Click the **Triggered Reads** option:



Step 2 – Specifying which triggers to observe

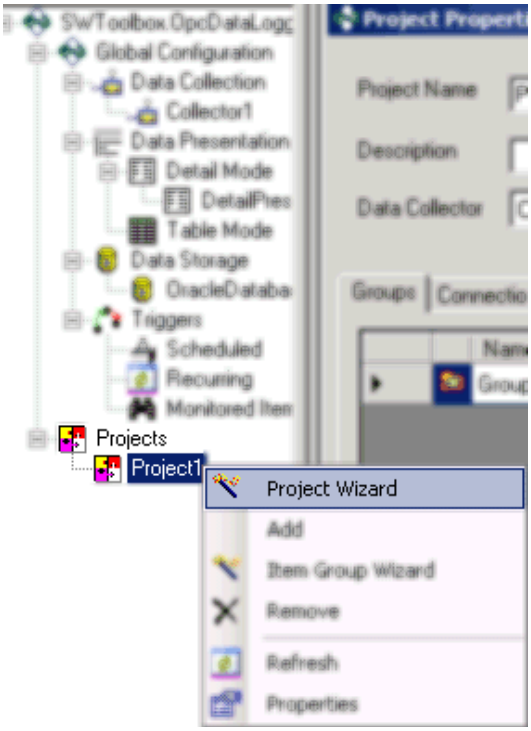
Within the Group property pages, click the **Triggers** tab and then add the scheduled triggers previously defined. Each trigger was specified to execute the **One-shot Read Now** within the **Effect** column:



Last Step – Connecting the Data Collection to the Data Storage

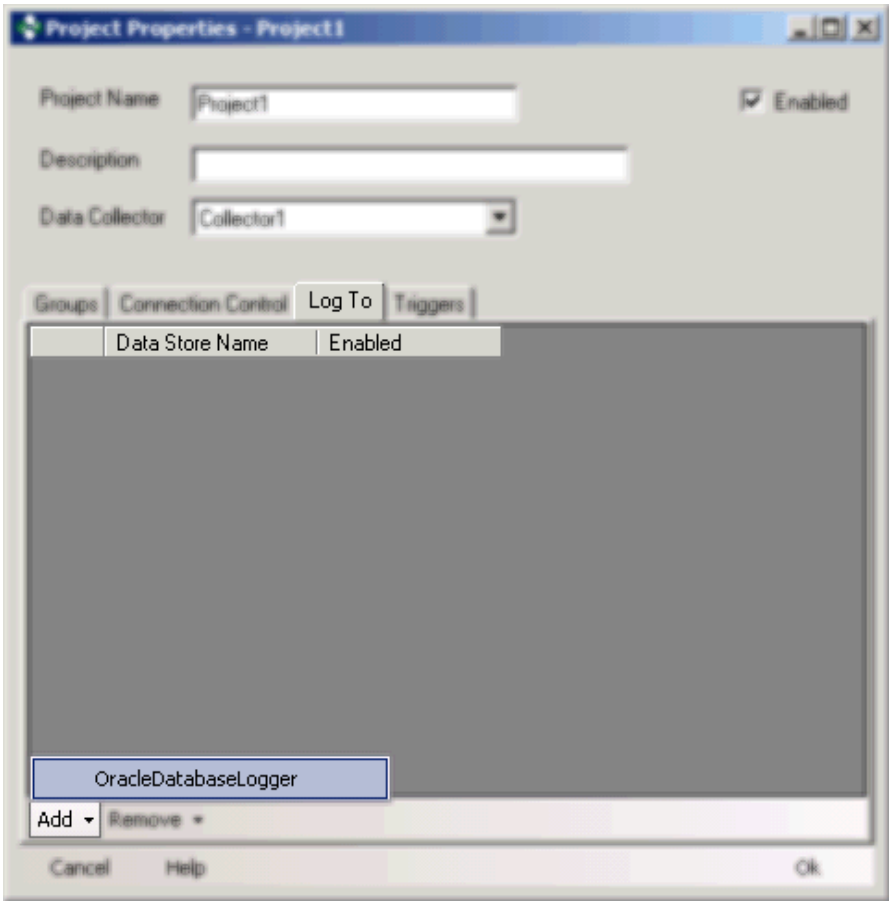
Now that the data collection has been defined, the items added, presentation format defined, and the database connection defined, the last step is to bring it all together.

1. Open or create a new **Project** under the **Projects** node in the OPC Data Logger tree-view:



TIP: Whenever you are creating a new project, use the **Project Wizard** as it dramatically simplifies the configuration process and ensures the configuration is valid and correct.

2. Open the **Project** properties window and click on the **Log To** tab.



At the bottom of the window click on the **Add** button, and you will see the available data stores available, in this case we have our only Oracle database storage component called *OracleDatabaseLogger*.

Click **OK** to save and close the screen.

That's it! Brad was now ready to log data.

Further Optimization – Stored Procedures vs SQL Injection

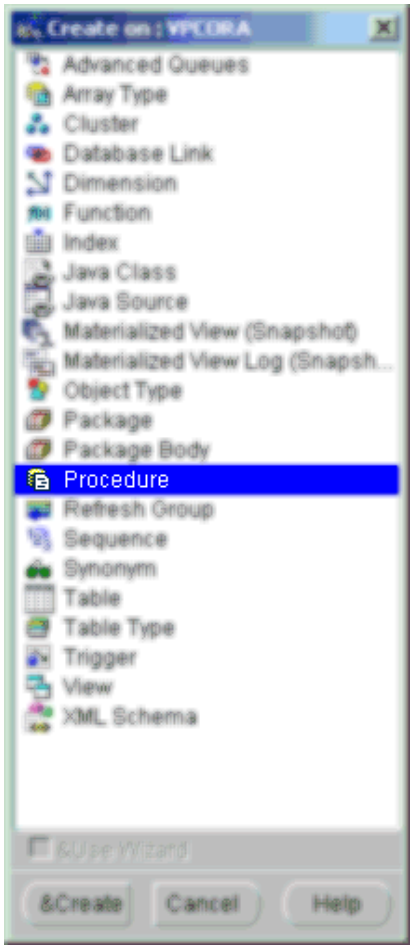
So far, Brad used direct SQL injection to log the data to the MACHINE_VALUES table *See step 8 on Page 24. This is not optimal*. Brad knew that this is a slower method of logging data because it meant the OPC Data Logger was sending SQL statement to the database,which then must be parsed and validated by the database server prior to compilation and final execution. This would happen every time data would be sent to the database.

The obvious step was to avoid the parsing/compilation needed by the database server each time data was being logged. This can was accomplished by creating a **Stored Procedure**.

Stored Procedure

A stored procedure is a module that is compiled and ran within the database engine itself.

The stored procedure (sproc) was created using the Wizard tool within the Oracle Enterprise Manager:


Create on : VPCORA
Advanced Queues
Array Type
Cluster
Database Link
Dimension
Function
Index
Java Class
Java Source
Materialized View (Snapshot)
Materialized View Log (Snapsh...
Object Type
Package
Package Body
Procedure
Refresh Group
Sequence
Synonym
Table
Table Type
Trigger
View
XML Schema
&Type Wizard
&Create
Cancel
Help

Selecting the **Procedure** option and then hitting the **&Create** button opened a dialog where you could specify a name for the sproc and the actual SQL statement itself, as in:

Name: Insert_Machine_Values

SQL:

```
(
 item_id in  numeric,
 item_value in numeric,
 item_quality in numeric,
 item_timestamp in date
)
as
begin
INSERT INTO "SCOTT"."MACHINE_VALUES" (
    "ITEM_ID",
    "ITEM_VALUE",
    "ITEM_QUALITY",
    "ITEM_TIMESTAMP" )
VALUES (
    item_id,
    item_value,
    item_quality,
    TO_DATE(item_timestamp, 'dd-Mon-yyyy HH:MI:SS AM')  )

end;
```

***Note**: The text with the yellow-background represents the arguments that are required by this sproc.*

Example Reports

To complete this case-study, we will take a look at some example SQL Queries that could be used for reporting.

NOTE: The following examples are purely for educational purposes and do not reflect those used by Brad or Unifi.

NOTE: The following SQL queries were creating against an ORACLE 10i database server; consequently, the exact syntax may not be compatible with other database engines.

Retrieving values logged for an item between a date-range

```
select
  scott.machine_tags.tagname,
  scott.machine_values.item_value,
  scott.machine_values.item_quality,
  scott.machine_values.item_timestamp
from
  scott.machine_values, scott.machine_tags
where
  scott.machine_values.item_id = scott.machine_tags.tag_id
  and
  scott.machine_tags.tagname like 'channel1.device1.tag1'

;
```

This produces the following output:

```
TAGNAME                                 ITEM_VALUE ITEM_QUALITY ITEM_TIME
--------------------------------------- ---------- ------------ ---------
channel1.device1.tag1                           10          192 01-JAN-08
channel1.device1.tag1                           20          192 01-JAN-08
channel1.device1.tag1                           30            0 01-JAN-08
```


Retrieving a count of logged values for all items between a date-range

```
select
  scott.machine_tags.tagname,
  scott.machine_values.item_timestamp,
  count (*)
from
  scott.machine_values,
  scott.machine_tags
where
  scott.machine_values.item_id = scott.machine_tags.tag_id
  and
  scott.machine_values.item_timestamp
    between TO_DATE('1-JAN-2008 12:00:00 AM', 'dd-Mon-yyyy HH:MI:SS AM')
      and   TO_DATE('1-FEB-2008 12:00:00 AM', 'dd-Mon-yyyy HH:MI:SS AM')
group by
  scott.machine_tags.tagname,
  scott.machine_values.item_timestamp
;
```

This produces the following output:

```
TAGNAME                                  ITEM_TIME   COUNT(*)
---------------------------------------- --------- ----------
channel1.device1.tag1                    01-JAN-08          3
channel1.device1.tag2                    01-JAN-08          2
channel1.device1.tag3                    01-JAN-08          1
```