Using Informix TimeSeries and the Internet of Things

Mike Walker

mike@advancedatatools.com

Advanced DataTools

Internet of Things (IoT) Webcasts

1. Introduction to Informix and the Internet of Things – May 26th
2. **Using Informix TimeSeries and the Internet of Things**
3. Running an Informix Database Server on an ARM Computer – June 23rd
4. The Basics of Getting Up and Running with Informix – July 28th

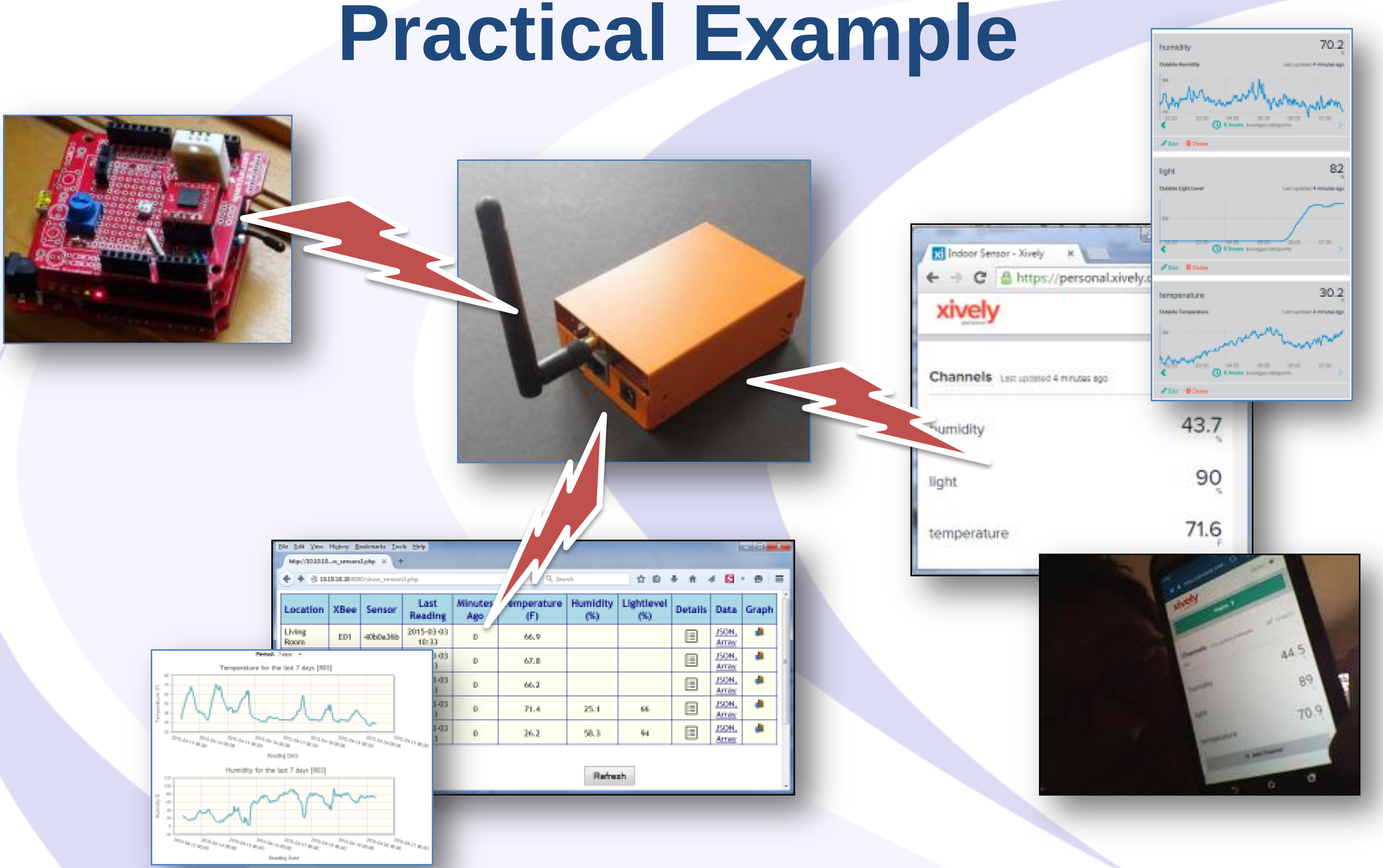
Using Informix TimeSeries and the Internet of Things

- Summary of IoT, capturing sensor data and using ARM computer as a smart gateway
- TimeSeries – what is it?
- How to set up a simple, regular TimeSeries
- Creating a TimeSeries for sensor data
- Virtual Table Interface and expression-based VTI
- Example of displaying sensor data on a web page
- Publishing sensor data to the cloud
- View data in the cloud
- Using APIs to pull data from the cloud
- Demonstration of using APIs to display sensor data and graphs on a website

Internet of Things (IoT)

- Connecting together the Physical and Digital World
- Built around sensors and smart gateways
- Consumer Examples of “smart” devices:
  - Thermostats
  - Door Locks
  - Lightbulbs,
  - Etc.

Practical Example



Indoor Sensor - Xively

https://personal.xively.c

xively

Channels Last updated 4 minutes ago

humidity 43.7 %

light 90 %

temperature 71.6 F

humidity 70.2 %
Outside Humidity — Last updated 4 minutes ago

light 82 %
Outside Light Level — Last updated 4 minutes ago

temperature 30.2 F
Outside Temperature — Last updated 4 minutes ago

xively

Channels

humidity 44.5

light 89

temperature 70.9

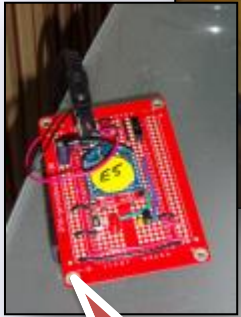
Location	XBee	Sensor	Last Reading	Minutes Ago	Temperature (F)	Humidity (%)	Lightlevel (%)	Details	Data	Graph
Living Room	ED1	40b0a36b	2015-03-03 10:33	0	66.9			☰	JSON, Array	▮
[illegible]	[illegible]	[illegible]	[illegible]	0	67.8			☰	JSON, Array	▮
[illegible]	[illegible]	[illegible]	[illegible]	0	66.2			☰	JSON, Array	▮
[illegible]	[illegible]	[illegible]	[illegible]	0	71.4	25.1	66	☰	JSON, Array	▮
[illegible]	[illegible]	[illegible]	[illegible]	0	26.2	58.3	94	☰	JSON, Array	▮

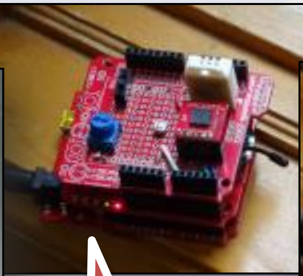
Refresh

File Edit View History Bookmarks Tools Help
Period: 7 days
Temperature for the last 7 days [RED]
Reading Date
Humidity for the last 7 days [RED]
Reading Date
Edit
Delete
6 hours

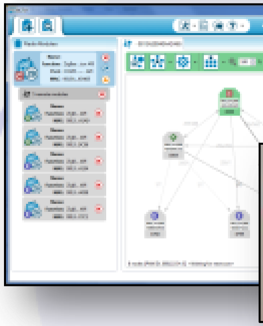
Sensor Data and Gateway

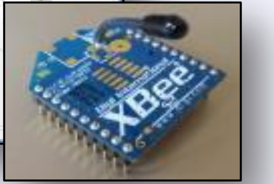
Sensors



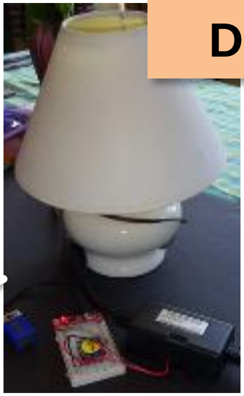


XBee Radios Mesh Network





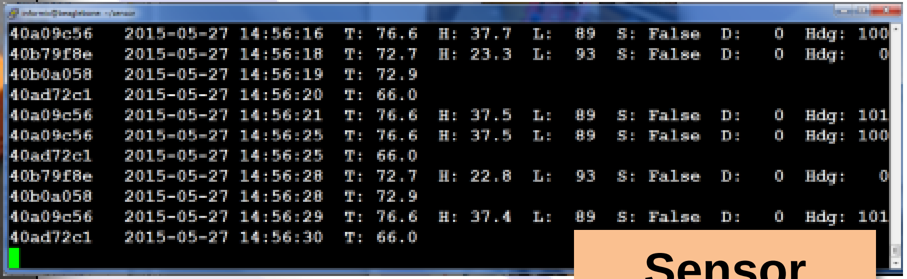
Control Devices



Smart Gateway

Informix

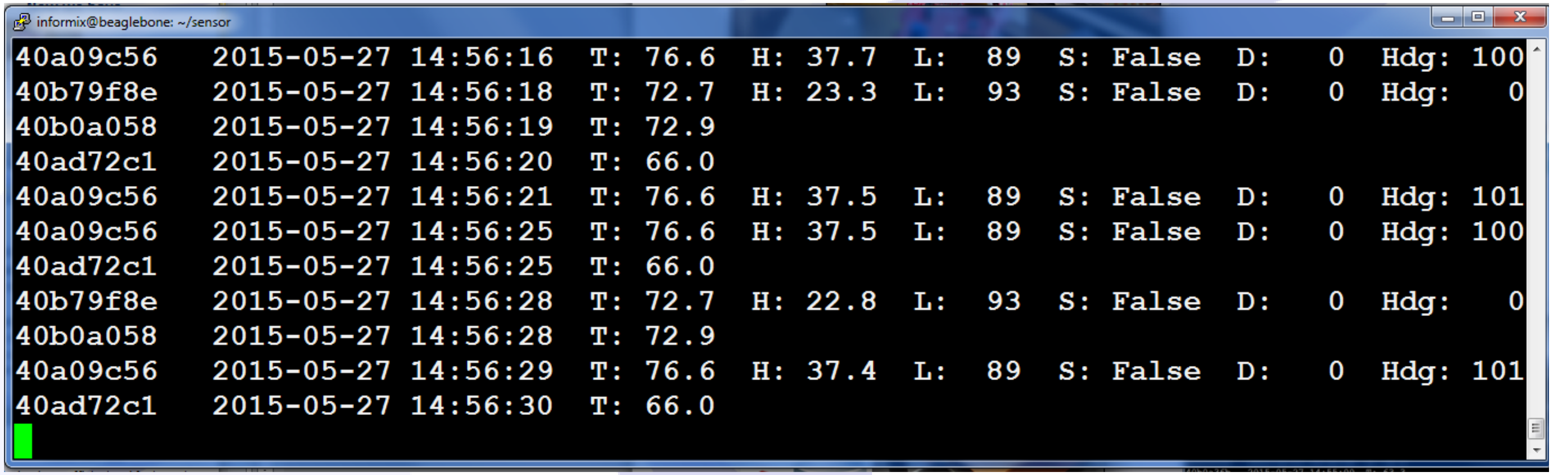
beaglebone



```
40a09c56    2015-05-27 14:56:16  T: 76.6  H: 37.7  L:  89  S: False  D:   0  Hdg: 100
40b79f8e    2015-05-27 14:56:18  T: 72.7  H: 23.3  L:  93  S: False  D:   0  Hdg:   0
40b0a058    2015-05-27 14:56:19  T: 72.9
40ad72c1    2015-05-27 14:56:20  T: 66.0
40a09c56    2015-05-27 14:56:21  T: 76.6  H: 37.5  L:  89  S: False  D:   0  Hdg: 101
40a09c56    2015-05-27 14:56:25  T: 76.6  H: 37.5  L:  89  S: False  D:   0  Hdg: 100
40ad72c1    2015-05-27 14:56:25  T: 66.0
40b79f8e    2015-05-27 14:56:28  T: 72.7  H: 22.8  L:  93  S: False  D:   0  Hdg:   0
40b0a058    2015-05-27 14:56:28  T: 72.9
40a09c56    2015-05-27 14:56:29  T: 76.6  H: 37.4  L:  89  S: False  D:   0  Hdg: 101
40ad72c1    2015-05-27 14:56:30  T: 66.0
```

Sensor Readings

Sensor Data on Gateway



```
40a09c56   2015-05-27 14:56:16  T: 76.6  H: 37.7  L:  89  S: False  D:   0  Hdg: 100
40b79f8e   2015-05-27 14:56:18  T: 72.7  H: 23.3  L:  93  S: False  D:   0  Hdg:   0
40b0a058   2015-05-27 14:56:19  T: 72.9
40ad72c1   2015-05-27 14:56:20  T: 66.0
40a09c56   2015-05-27 14:56:21  T: 76.6  H: 37.5  L:  89  S: False  D:   0  Hdg: 101
40a09c56   2015-05-27 14:56:25  T: 76.6  H: 37.5  L:  89  S: False  D:   0  Hdg: 100
40ad72c1   2015-05-27 14:56:25  T: 66.0
40b79f8e   2015-05-27 14:56:28  T: 72.7  H: 22.8  L:  93  S: False  D:   0  Hdg:   0
40b0a058   2015-05-27 14:56:28  T: 72.9
40a09c56   2015-05-27 14:56:29  T: 76.6  H: 37.4  L:  89  S: False  D:   0  Hdg: 101
40ad72c1   2015-05-27 14:56:30  T: 66.0
```

- What are we going to do with this data?
- Store it in the database…using TimeSeries
  - Keep a history
  - Local analytics
  - Values accessible from multiple applications

IoT…The Problem with Data

- The Internet of Things – tens of billions of devices, each generating many data points over time

- Storing the data efficiently is important
  - Fast saving
  - Fast retrieval
  - Maximize storage efficiency

Lots of Data!

By mid-2014, 50 million Smart Meters had been installed in the US *(IEI Report, September 2014)*

	Number of Data Points in 1 Year		
Number of Meters	**Read 1 x day**	**Read 1 x hour**	**Read 1 x 15 mins**
50,000,000	18,250,000,000	438,000,000,000	1,752,000,000,000

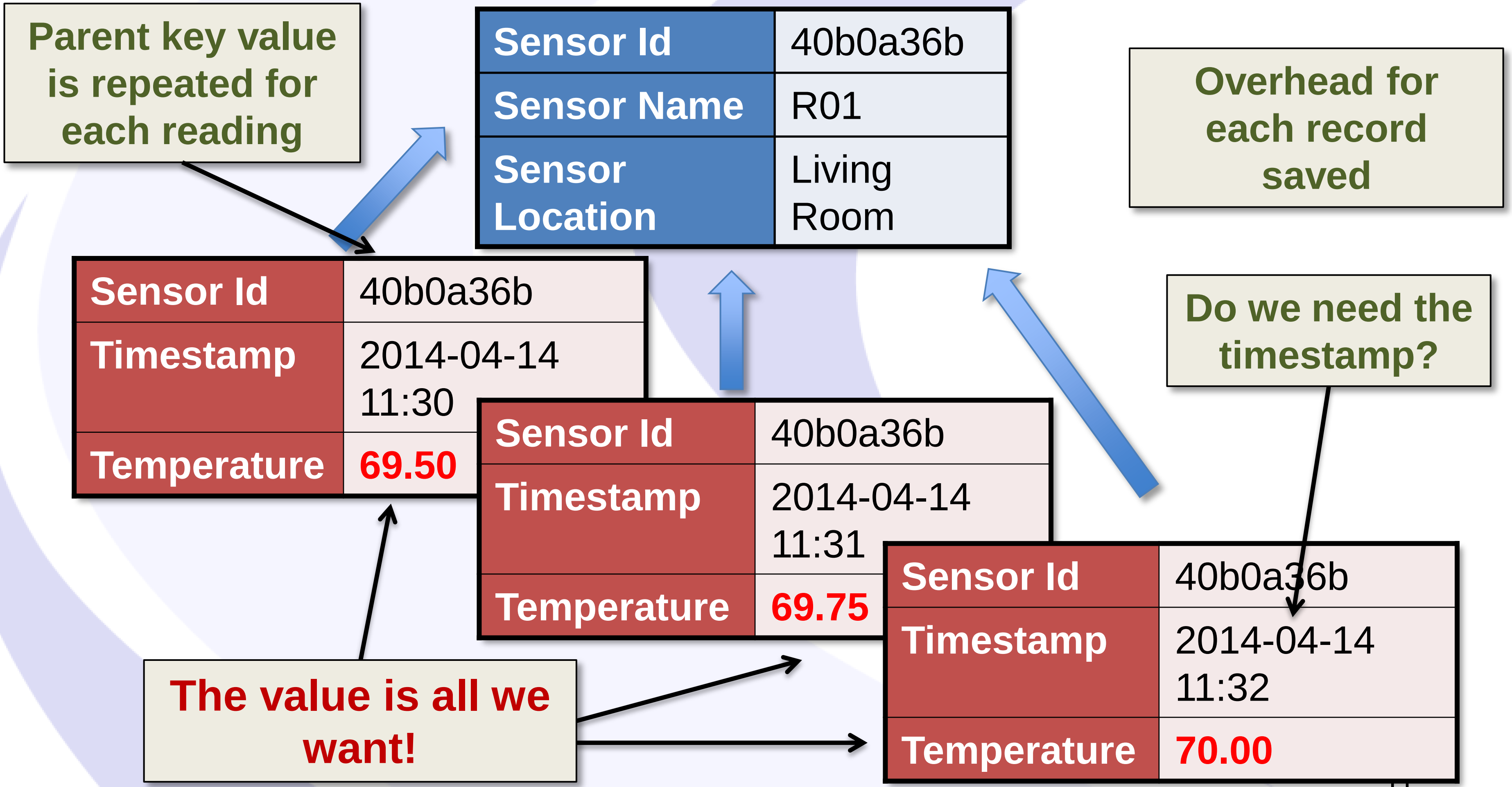
A single utility company with 5 million meters will still generate over 175 billion readings each year if read every 15 minutes

TimeSeries

- TimeSeries is an efficient and fast way to store and access datapoints that have a time component
- Stores the data elements in columnar form
- Consider our sensor data:
  - Simple data elements (temperature, humidity, etc)
  - Readings arrive at regular intervals with timestamps
- TimeSeries is included with **ALL** editions of Informix – it is ***not*** an add-on

Sensor Data

Traditional Relational Model



Parent key value is repeated for each reading

Sensor Id	40b0a36b
Sensor Name	R01
Sensor Location	Living Room

Overhead for each record saved

Sensor Id	40b0a36b
Timestamp	2014-04-14 11:30
Temperature	69.50

Sensor Id	40b0a36b
Timestamp	2014-04-14 11:31
Temperature	69.75

Do we need the timestamp?

Sensor Id	40b0a36b
Timestamp	2014-04-14 11:32
Temperature	70.00

The value is all we want!

Sensor Data

TimeSeries Model

– Store all of the readings in the *SAME* record

– Append them to the TimeSeries ***column***

Sensor Id	40b0a36b
Sensor Name	R01
Sensor Location	Living Room
Temperature	**69.50, 69.75, 70.00, …**

TimeSeries Column

– With a **regular** timestamp, if we know the start time of readings, we can work out the timestamp of any reading by its offset.

What does a TimeSeries Look Like?

The values are stored in a *single column*

```
sensor_id        40b79f8e
xbee_name        R03
sensor_location  Arduino Sensor 2
sensor_data      origin(2015-01-18 18:30:00.00000), calendar(ts_1min), containe
                 r(sensor_container), threshold(0), regular, [NULL, NULL, NULL,
                  NULL, NULL, NULL, NULL, NULL, NULL, (66.6  ,38.7  ,67    ), (
                 65.3  ,40.2  ,67    ), (63.9  ,42.2  ,67    ), (63.3  ,42.7  ,
                 66    ), (62.6  ,43.7  ,67    ), (62.1  ,45.0  ,66    ), (61.5
                   ,45.6  ,66    ), (61.2  ,46.6  ,67    ), (60.8  ,47.1  ,67
                   ), (60.3  ,48.1  ,67    ), (60.1  ,48.1  ,67    ), (59.7  ,4
                 8.2  ,67    ), (59.5  ,49.2  ,67    ), (59.4  ,48.7  ,67    ),
                 ...
```

Consider our utility company with 5 million smart meters…
They will only have 5 million records in their “meter” table, regardless of how many “readings” they store

Creating a TimeSeries

1. Create a Calendar Pattern
   – Defines valid time intervals for timeseries data
2. Create a Calendar Table, referencing the Pattern
   – Defines a calendar based on start date/time & pattern
3. Create a Row Type to store the timeseries
4. Create a Container for the TimeSeries data, referencing the Row Type
   – Specifies where the timeseries data is stored
5. Create a Table with a TimeSeries column, using the Row Type

Creating a TimeSeries – 1: Calendar Pattern

Defines valid time intervals for TimeSeries data

Example:

To store employee hours over a week that is only Mon-Fri, the pattern would be defined as:

```
INSERT INTO CalendarPatterns
VALUES('workweek_day',
        '{1 off, 5 on, 1 off}, day');
```

Assuming the calendar will begin on a Sunday

Creating a TimeSeries – 2: Calendar Table

The calendar uses the supplied pattern and a start date to know what are valid entries and to define the format of the stored data

Example:

```
INSERT INTO CalendarTable
      (c_name, c_calendar)
VALUES ('weekcal',
        'startdate(2014-04-13 00:00:00.00000),
         pattstart(2014-04-13 00:00:00.00000),
         pattname(workweek_day)');
```

Needs to be a Sunday to match the pattern

Creating a TimeSeries – 3: Row Type

Row that will be used to store the timestamp and data elements for that timestamp

Example:

```
create row type hours_worked(
 timestamp datetime year to fraction(5),
 num_hours decimal(4,2)
);
```

Must have this level of precision

This is what we want to store

Creating a TimeSeries – 4: Container

Specify where the TimeSeries rows are to be stored

Example:

```
execute procedure TSContainerCreate
('hours_container',
 'datadbs',
 'hours_worked',
 0, 0);
```

DBSpace

Row Type

Creating a TimeSeries – 5: Table

Table containing the Row Type to store the TimeSeries

Example:

```
create table emp_hours_worked (
   empid integer,
   emp_hours TimeSeries(hours_worked)
);
```

Row Type

Creating a TimeSeries – New Record

Create the TimeSeries when insert the record

Example:

```
insert into emp_hours_worked values (
   1,
   TSCreate('weekcal',
  '2014-04-13 00:00:00.00000', 0, 0, 0,
  'hours_container')
);
```

Calendar

Container

This is a **REGULAR** TimeSeries [use TSCreateIrr for **irregular**]

Creating a TimeSeries – New Record

Empty TimeSeries record – what does it look like?

```
empid      1
emp_hours
   origin(2014-04-14 00:00:00.00000),
   calendar(weekcal),
   container(hours_container),
   threshold(0), regular, []
```

Start date got bumped forward because it was created on a non-work day

No TS data yet

Creating a TimeSeries – Insert Data

We **UPDATE** the row to add TimeSeries data, because we are *modifying* the TimeSeries column

```
update emp_hours_worked
set emp_hours = PutElem(emp_hours,
row("2014-04-14 00:00:00",8)::hours_worked)
where empid = 1;
```

Monday

The time is of no relevance in this example as the calendar pattern uses a unit of DAY

```
update emp_hours_worked
set emp_hours = PutElem(emp_hours,
row("2014-04-18 17:00:00",8.25)::hours_worked)
where empid = 1;
```

Friday

Creating a TimeSeries – Insert Data

The Calendar will prevent timestamps that don’t match the pattern

```
update emp_hours_worked
set emp_hours = PutElem(emp_hours,
row("2014-04-19 17:00:00",7.50)::hours_worked)
where empid = 1;
#             ^
#(UTSBB) - Timestamp 2014-04-19 17:00:00.00000 is not a valid day in calendar.
#
```

Saturday

Creating a TimeSeries

Reviewing the TimeSeries data

```
update emp_hours_worked
set emp_hours = PutElem(emp_hours,
row("2014-04-21 17:00:00", 7.75)::hours_worked)
where empid = 1;
```

Monday

One value stored for each valid day of the Calendar

```
empid       1
emp_hours
  origin(2014-04-14 00:00:00.00000),
  calendar(weekcal), container(hours_container),
  threshold(0), regular,
  [(8.00   ), NULL, NULL, NULL, (8.25   ), (7.75   )]
```

Mon Tue Wed Thu Fri Mon

Creating a TimeSeries for Sensor Data

Create the structures to store the sensor information and TimeSeries

[Not creating a Calendar in this example – instead use a predefined one when create the timeseries]

#1 – Row Type

```
create row type sensor_reading(
   timestamp datetime year to fraction(5),
   temperature decimal(4,1),
   humidity decimal(4,1),
   lightlevel smallint
);
```

Creating a TimeSeries for Sensor Data

#2 – Table

```
create table sensor(
   sensor_id           char(8),
   xbee_name           char(3),
   sensor_location     char(20),
   sensor_data TimeSeries(sensor_reading)
);
```

Row Type

Creating a TimeSeries for Sensor Data

#3 – Container

```
execute procedure TSContainerCreate
('sensor_container',
 'sensordbs',
 'sensor_reading',
 0,
 0);
```

Creating a TimeSeries for Sensor Data

Create the records for the sensors – one for each sensor

```
insert into sensor values (
   "40b79f8e",
   "R03",
   "Arduino Sensor 2",
   TSCreate(
      'ts_1min',
      '2015-01-18 18:30:00.00000',
      0, 0, 0,
      'sensor_container'));
```

Predefined calendar – new value each minute

Creating a TimeSeries for Sensor Data

Update the appropriate sensor record with a new value

```
update sensor
set sensor_data =
   PutElem(sensor_data,
           row("2015-01-18 18:30:00.00000",
               78.1, 45.5, 70)::sensor_reading)
where xbee_name = "R03";
```

In the demonstration, I use a python script on the Beaglebone to read the data received at the Controller XBee radio and, at regular intervals, save it to the Informix database

Viewing TimeSeries Sensor Data

Query the table

```
select *
from sensor
where xbee_name matches "R03";
```

The values are stored in a *single column*

```
sensor_id        40b79f8e
xbee_name        R03
sensor_location  Arduino Sensor 2
sensor_data      origin(2015-01-18 18:30:00.00000), calendar(ts_1min), containe
                 r(sensor_container), threshold(0), regular, [NULL, NULL, NULL,
                  NULL, NULL, NULL, NULL, NULL, NULL, (66.6  ,38.7  ,67    ), (
                 65.3  ,40.2  ,67    ), (63.9  ,42.2  ,67    ), (63.3  ,42.7  ,
                 66    ), (62.6  ,43.7  ,67    ), (62.1  ,45.0  ,66    ), (61.5
                   ,45.6  ,66    ), (61.2  ,46.6  ,67    ), (60.8  ,47.1  ,67
                   ), (60.3  ,48.1  ,67    ), (60.1  ,48.1  ,67    ), (59.7  ,4
                 8.2  ,67    ), (59.5  ,49.2  ,67    ), (59.4  ,48.7  ,67    ),
                 ...
```

Viewing TimeSeries Sensor Data

Query values for a timestamp

```
select
   sensor_id,
   xbee_name,
   GetElem(sensor_data, '2015-01-18 18:40:00') as readings
from sensor
where xbee_name matches "R03";
```

The values are returned as the custom type

```
sensor_id  40b79f8e
xbee_name  R03
readings   ROW('2015-01-18 18:40:00.00000',65.3  ,40.2  ,67    )
```

Virtual Table Interface

Using a Virtual Table Interface (VTI) simplifies the use of TimeSeries data by displaying the data in a ***relational*** format

– Each TimeSeries element can be treated as a “row” of data through the VTI

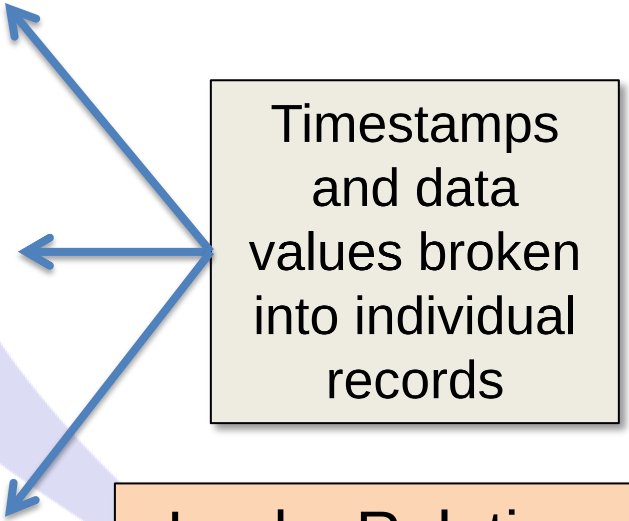
```
execute procedure tscreatevirtualtab(
    'sensor_vti',
    'sensor');
```

VTI to create

TimeSeries table to create the VTI on

Querying the VTI

```
select *
from sensor_vti
where sensor_location = "Arduino Sensor 2"

sensor_id        40b79f8e
xbee_name        R03
sensor_location  Arduino Sensor 2
timestamp        2015-01-18 18:39:00.00000
temperature      66.6
humidity         38.7
lightlevel       67

sensor_id        40b79f8e
xbee_name        R03
sensor_location  Arduino Sensor 2
timestamp        2015-01-18 18:40:00.00000
temperature      65.3
humidity         40.2
lightlevel       67

sensor_id        40b79f8e
xbee_name        R03
sensor_location  Arduino Sensor 2
timestamp        2015-01-18 18:41:00.00000
temperature      63.9
humidity         42.2
lightlevel       67
```



Timestamps and data values broken into individual records

Looks Relational!

Querying the VTI

Read values for a single timestamp using a regular WHERE clause:

```
select
   sensor_id,
   xbee_name,
   timestamp::datetime year to minute as when,
   temperature as temp,
   humidity as humid,
   lightlevel as light
from sensor_vti
where xbee_name matches "R03"
  and timestamp = "2015-01-18 18:40:00";
```

```
sensor_id xbee_name when                temp  humid  light
40b79f8e  R03       2015-01-18 18:40    65.3   40.2      6
```

Expression-Based VTI

Create a VTI based off an *expression*

Example: Can use this to simplify the averaging of our sensor data

```
execute procedure tscreateexpressionvirtualtab(
'sensor_hourly_vti',
'sensor',
'AggregateBy(
"avg($temperature),avg($humidity),avg($lightlevel)",
"ts_1hour", sensor_data,0)',
'sensor_reading',
1,
'sensor_data'
);
```

Using a different Calendar

Querying the Expression-Based VTI

```
select *
from sensor_hourly_vti
where sensor_location = "Arduino Sensor 2"

sensor_id          40b79f8e
xbee_name          R03
sensor_location    Arduino Sensor 2
timestamp          2015-01-18 18:00:00.00000
temperature        60.9
humidity           46.8
lightlevel         66

sensor_id          40b79f8e
xbee_name          R03
sensor_location    Arduino Sensor 2
timestamp          2015-01-18 19:00:00.00000
temperature        57.2
humidity           50.9
lightlevel         66

sensor_id          40b79f8e
xbee_name          R03
sensor_location    Arduino Sensor 2
timestamp          2015-01-18 20:00:00.00000
temperature        57.0
humidity           49.0
lightlevel         66
```

Now see ***one*** timestamp **each hour** and values are ***averaged***

TimeSeries Row Type

- Our Row Type allows us to store three values:
  - Temperature
  - Humidity
  - Light Level
- Some sensors just send temperature
- Lots of NULL values in the TimeSeries

```
 ... (69.6  ,NULL,NULL), (69.1  ,NULL,NULL), (69.8  ,N
ULL,NULL), (69.6  ,NULL,NULL), (69.6  ,NULL,NULL), (69.6  ,NUL
L,NULL), (69.6  ,NULL,NULL), (69.6  ,NULL,NULL), (69.6  ,NULL,
NULL), (69.6  ,NULL,NULL), (69.8  ,NULL,NULL), (69.1  ,NULL,NU
LL), (69.8  ,NULL,NULL), (69.8  ,NULL,NULL), (69.8  ,NULL,NULL
), (69.8  ,NULL,NULL), (70.0  ,NULL,NULL), (70.0  ,NULL,NULL),
 (70.0  ,NULL,NULL), (70.0  ,NULL,NULL), (70.0  ,NULL,NULL),
...
```

TimeSeries Data

- Good use case for JSON
  - Key-value pairs. Example:

    { {"temperature":"70.2"}, {"humidity":"45.0"} }

  - Only store the elements that are received
  - Can add new sensors easily, e.g.

    {"volume":"22"}

  - Informix 12.10.xC4 supports JSON data in TimeSeries

Display the Sensor Data

Query to show the latest value for each sensor, with the timestamp and data values as separate fields:

```
select
       trim(rtab.sensor_location)::char(15) sensor_location,
       rtab.xbee_name,
       rtab.sensor_id,
       rtab.lastval.timestamp::datetime year to minute last_reading,
       rtab.lastval.temperature temp,
       rtab.lastval.humidity humid,
       rtab.lastval.lightlevel light
from
   (select sensor_id,
          xbee_name,
          sensor_location,
          GetLastElem(sensor_data) lastval
    from sensor) as rtab
order by rtab.xbee_name;
```

Display the Sensor Data

The latest values for each sensor

```
sensor_location xbee_name sensor_id last_reading       temp  humid  light

Living Room     E01       40b0a36b  2015-03-01 21:22   67.5
Dining Room     E03       40b0a058  2015-03-01 21:22   69.1
Secret Bunker   E05       40ad72c1  2015-03-01 21:22   68.5
Arduino Sensor  R01       40a09c56  2015-03-01 21:23   71.2   25.3      4
Arduino Sensor  R03       40b79f8e  2015-03-01 21:22   25.9   55.5      6

5 row(s) retrieved.
```

Display the Sensor Data

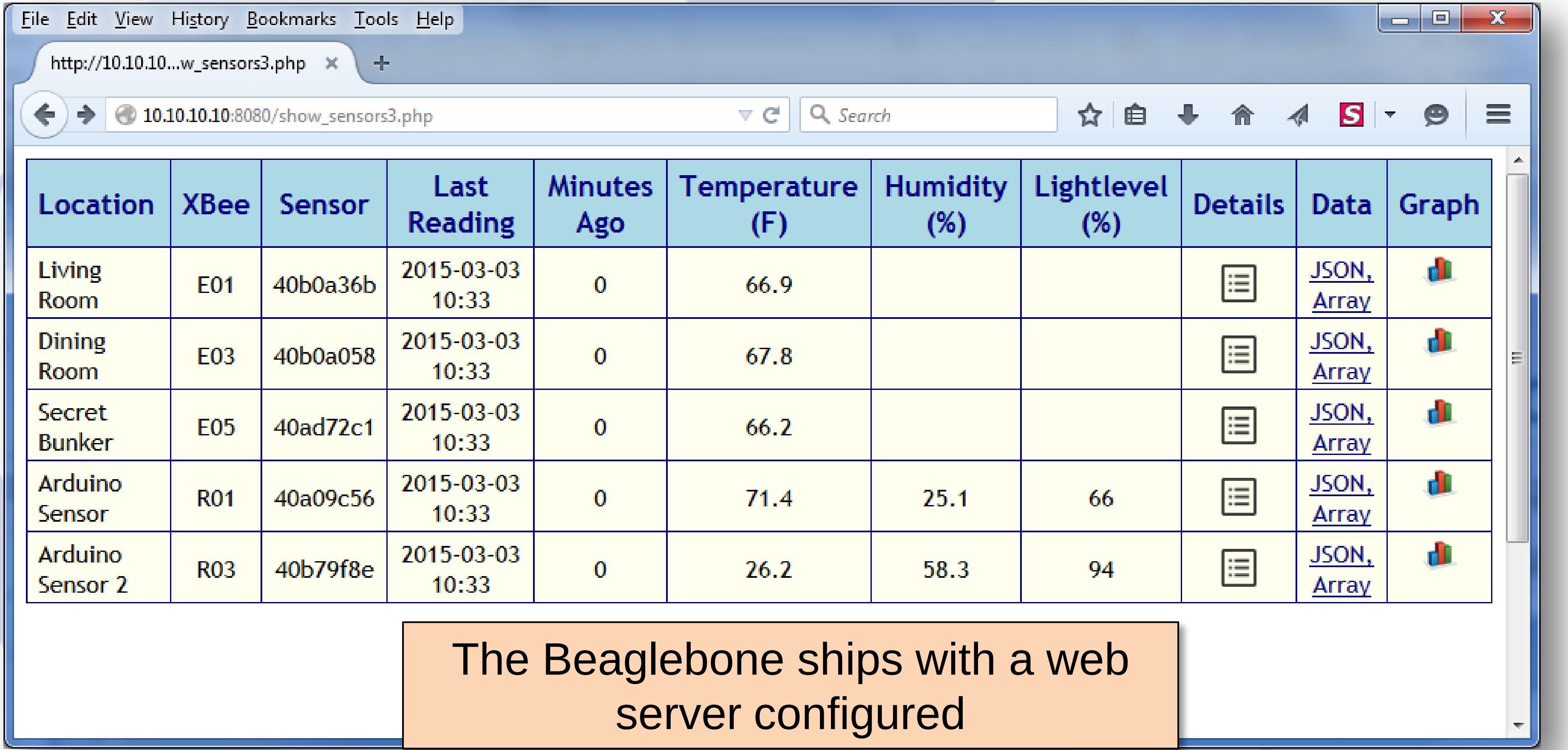
Put this query into PHP…

```
$dbh = connectdb();

$sqlline = "
select
       trim(rtab.sensor_location) sensor_location,
       rtab.xbee_name,
       rtab.sensor_id,
       rtab.lastval.timestamp::datetime year to minute last_reading,
       rtab.lastval.humidity humidity,
       rtab.lastval.lightlevel lightlevel,
       (current - rtab.lastval.timestamp)::interval minute(9) to minute
minutes_ago,
       rtab.lastval.temperature
from
(select sensor_id,
       xbee_name,
       sensor_location,
       GetLastElem(sensor_data) lastval
from sensor) as rtab
where rtab.lastval.timestamp > current - 2 units day
order by rtab.xbee_name;";

$sth = $dbh->prepare($sqlline);
$sth->execute(array());
```

Advanced DataTools

Display the Sensor Data

Execute the query in a PHP script and format the results in HTML to see all the sensors and values



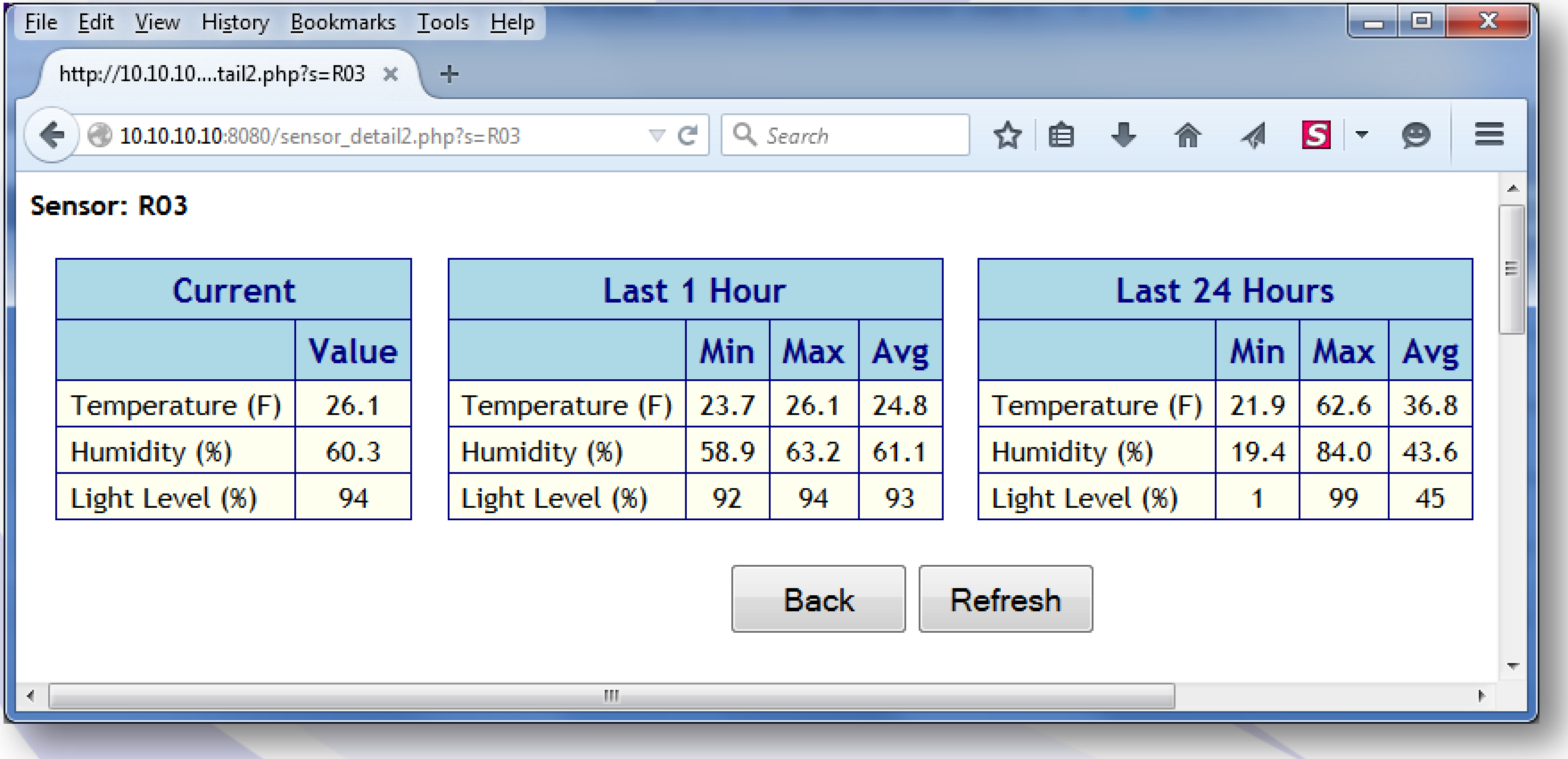
File Edit View History Bookmarks Tools Help
http://10.10.10...w_sensors3.php
10.10.10.10:8080/show_sensors3.php
Search

Location	XBee	Sensor	Last Reading	Minutes Ago	Temperature (F)	Humidity (%)	Lightlevel (%)	Details	Data	Graph
Living Room	E01	40b0a36b	2015-03-03 10:33	0	66.9			☰	JSON, Array	📊
Dining Room	E03	40b0a058	2015-03-03 10:33	0	67.8			☰	JSON, Array	📊
Secret Bunker	E05	40ad72c1	2015-03-03 10:33	0	66.2			☰	JSON, Array	📊
Arduino Sensor	R01	40a09c56	2015-03-03 10:33	0	71.4	25.1	66	☰	JSON, Array	📊
Arduino Sensor 2	R03	40b79f8e	2015-03-03 10:33	0	26.2	58.3	94	☰	JSON, Array	📊

The Beaglebone ships with a web server configured

Display the Sensor Data

Run queries against the TimeSeries sensor data and display…


File Edit View History Bookmarks Tools Help
http://10.10.10....tail2.php?s=R03
10.10.10.10:8080/sensor_detail2.php?s=R03
Search

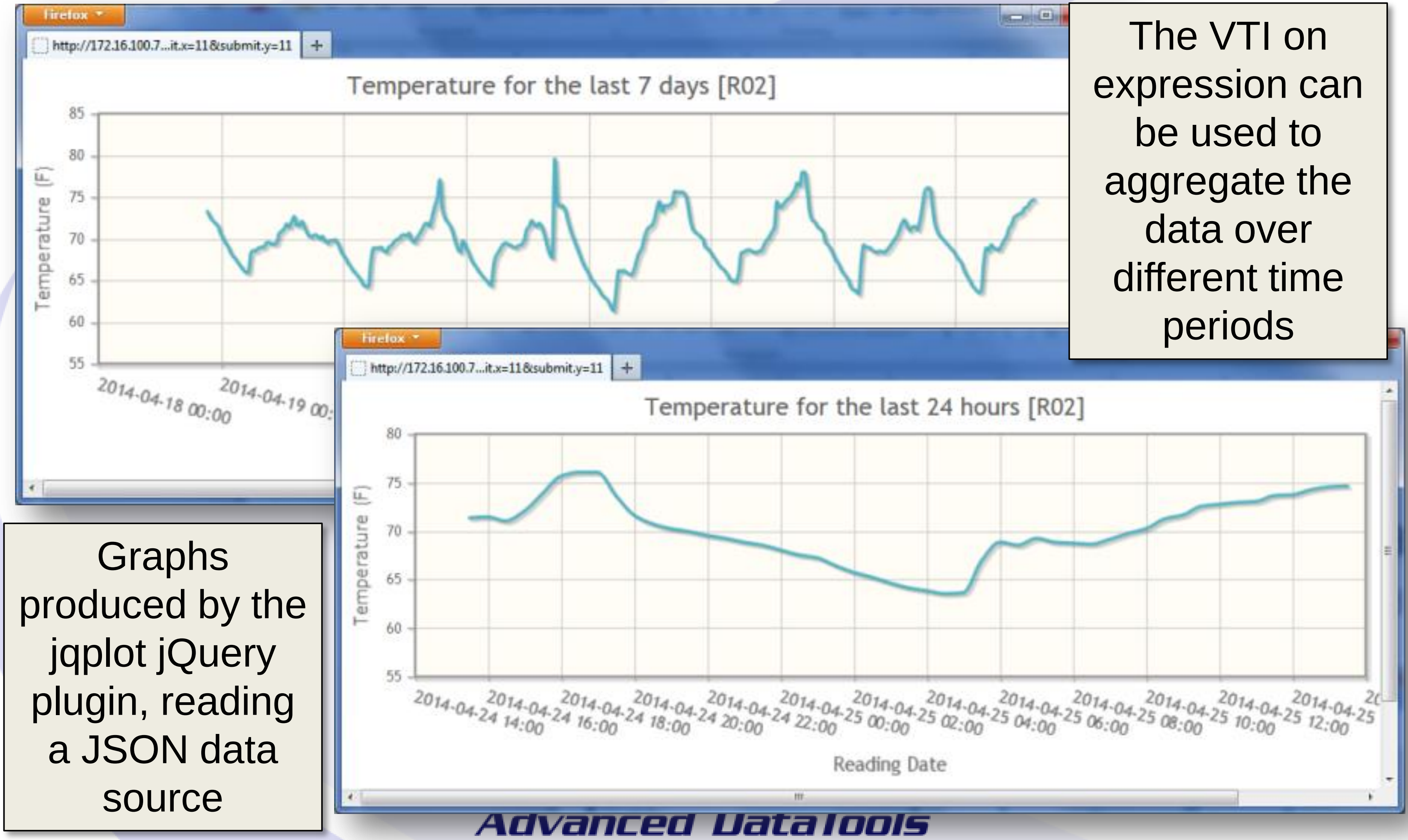
Sensor: R03

Current	
	Value
Temperature (F)	26.1
Humidity (%)	60.3
Light Level (%)	94

Last 1 Hour			
	Min	Max	Avg
Temperature (F)	23.7	26.1	24.8
Humidity (%)	58.9	63.2	61.1
Light Level (%)	92	94	93

Last 24 Hours			
	Min	Max	Avg
Temperature (F)	21.9	62.6	36.8
Humidity (%)	19.4	84.0	43.6
Light Level (%)	1	99	45

Graph using Array of TimeSeries Values



The VTI on expression can be used to aggregate the data over different time periods

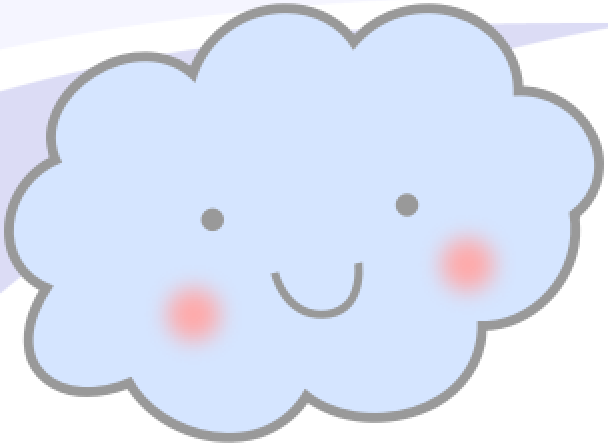
Graphs produced by the jqplot jQuery plugin, reading a JSON data source

Outside the Box

- The TimeSeries data is stored on the Smart Gateway
- The queries run locally…
- The web pages are served locally...

But this is the Internet of Things… I want to view my data from anywhere…and on my fancy smartphone!!

Publishing the Sensor Data to the Cloud



- Use one of several sites that allow data to be posted to a remote server
- Information can be retrieved from the site and viewed anywhere
- Site provides APIs to post data and view data
- Can also set triggers, view location, etc

Publishing the Sensor Data

Example with xively.com in Python

```
import xively
.
api = xively.XivelyAPIClient("qPy5…0")
feed = api.feeds.get(818865217)
.
now = datetime.datetime.utcnow()
feed.datastreams = [
xively.Datastream(id='temp', current_value=sensor[f]['temp'], at=now),
xively.Datastream(id='light',current_value=sensor[f]['light'], at=now),
xively.Datastream(id='humidity', current_value=sensor[f]['humidity'],
at=now),
xively.Datastream(id='dial', current_value=sensor[f]['dial'], at=now),
xively.Datastream(id='switch', current_value=switchpos, at=now),
xively.Datastream(id='heading', current_value=sensor[f]['heading'], at=now),
                    ]
feed.update()
```

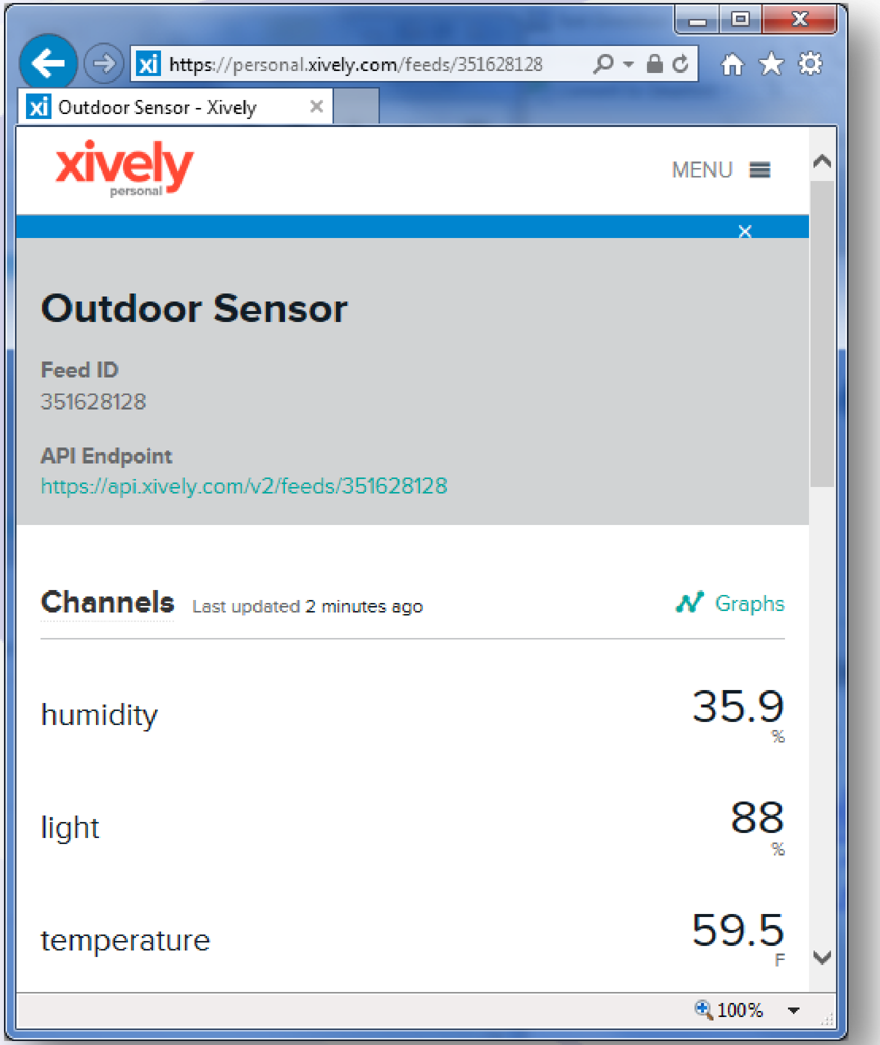
PUT using JSON

```
{
  "datastreams": [
    {
      "id": "temperature",
      "datapoints": [
        {
          "at": "2015-03-01T20:20:00-07:00",
          "value": "71.6"
        },
        {
          "at": "2015-03-01T20:21:00-07:00",
          "value": "71.6"
        }
      ]
    },
    {
      "id": "humidity",
      "datapoints": [
        {
          "at": "2015-03-01T20:20:00-07:00",
          "value": "26.1"
        },
        {
          "at": "2015-03-01T20:21:00-07:00",
          "value": "26.0"
        }
      ]
    },
    {
      "id": "light",
      "datapoints": [
        {
          "at": "2015-03-01T20:20:00-07:00",
          "value": "5"
        },
        {
          "at": "2015-03-01T20:21:00-07:00",
          "value": "5"
        }
      ]
    }
  ],
  "version": "1.0.0"
}
```

Viewing the Sensor Data on the Web

Immediately view the data on a webpage:

https://personal.xively.com/feeds/351628128



Outdoor Sensor

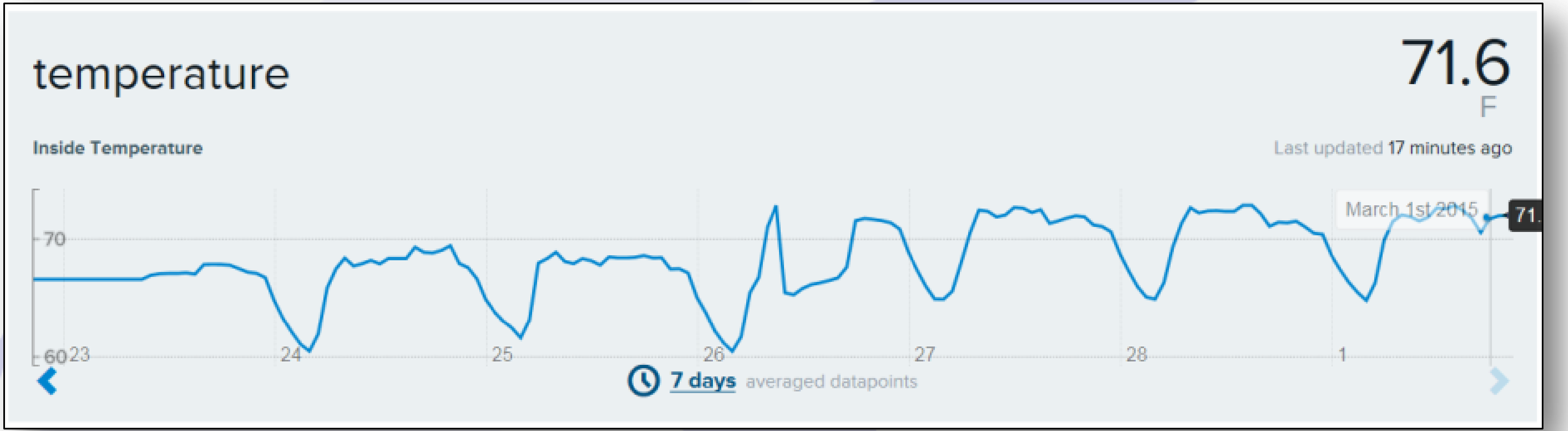
Feed ID
351628128

API Endpoint
https://api.xively.com/v2/feeds/351628128

Channels Last updated 2 minutes ago

humidity	35.9 %
light	88 %
temperature	59.5 F

Viewing the Sensor Data on the Web



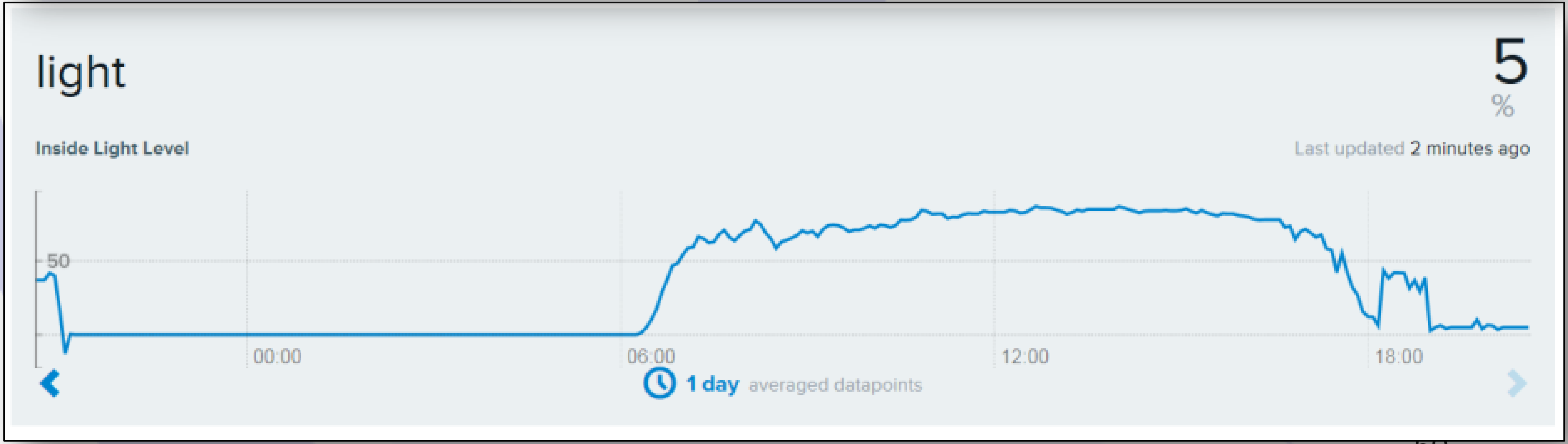
temperature

71.6
F

Inside Temperature

Last updated **17 minutes ago**

7 days averaged datapoints



light

5
%

Inside Light Level

Last updated **2 minutes ago**

1 day averaged datapoints

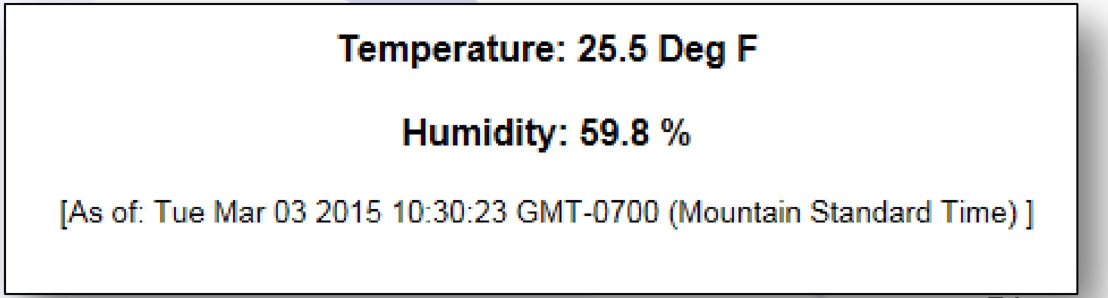
Use APIs to Pull Data from Cloud

http://api.xively.com/v2/feeds/351628128.json?&key=n1AqEZak5r7Hbj2q75vTTsRrnJjHTuOan8oLTrCAf7LAyqVz

Returns a JSON object containing the current values of each datastream.

```
{"id":351628128,"title":"Outdoor Sensor","private":"false","feed":"https://api.xively.com/v2/feeds/351628128.json","auto_feed_url":"https://api.xively.com/v2/feeds/351628128.json","status":"live","updated":"2015-03-04T00:20:10.055886Z","created":"2015-01-27T18:52:29.627560Z","creator":"https://xively.com/users/mikeeew","version":"1.0.0","datastreams":[{"id":"humidity","current_value":"57.4","at":"2015-03-04T00:19:00.000000Z","max_value":"96.4","min_value":"0.0","tags":["Outside Humidity"],"unit":{"symbol":"%","label":"Percent"}},{"id":"light","current_value":"82","at":"2015-03-04T00:19:00.000000Z","max_value":"100.0","min_value":"1.0","tags":["Outside Light Level"],"unit":{"symbol":"%","label":"Percentage of Max"}},{"id":"temperature","current_value":"23.2","at":"2015-03-04T00:19:00.000000Z","max_value":"88.3","min_value":"-1.5","tags":["Outside Temperature"],"unit":{"symbol":"F","label":"Degrees F"}}],"product_id":"6qbhiTM74LELhDvwuZ4H","device_serial":"MK4GFWRYW9EN"}
```

Display on a web page:



Temperature: 25.5 Deg F

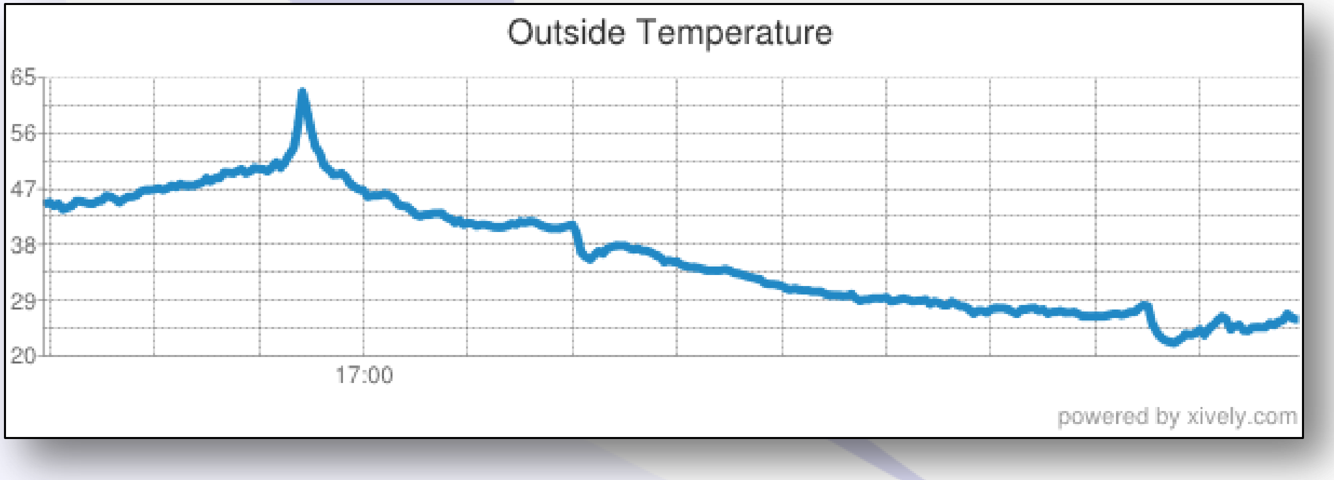
Humidity: 59.8 %

[As of: Tue Mar 03 2015 10:30:23 GMT-0700 (Mountain Standard Time)]

Use APIs to Pull Data from Cloud

https://api.xively.com/v2/feeds/351628128/datastreams/temperature.png?duration=24hours&limit=1000&c=2188c5&g=true&s=4&b=true&t=Outside%20Temperature&w=600&h=200&timezone=Mountain%20Time%20%28US%20%26%20Canada%29

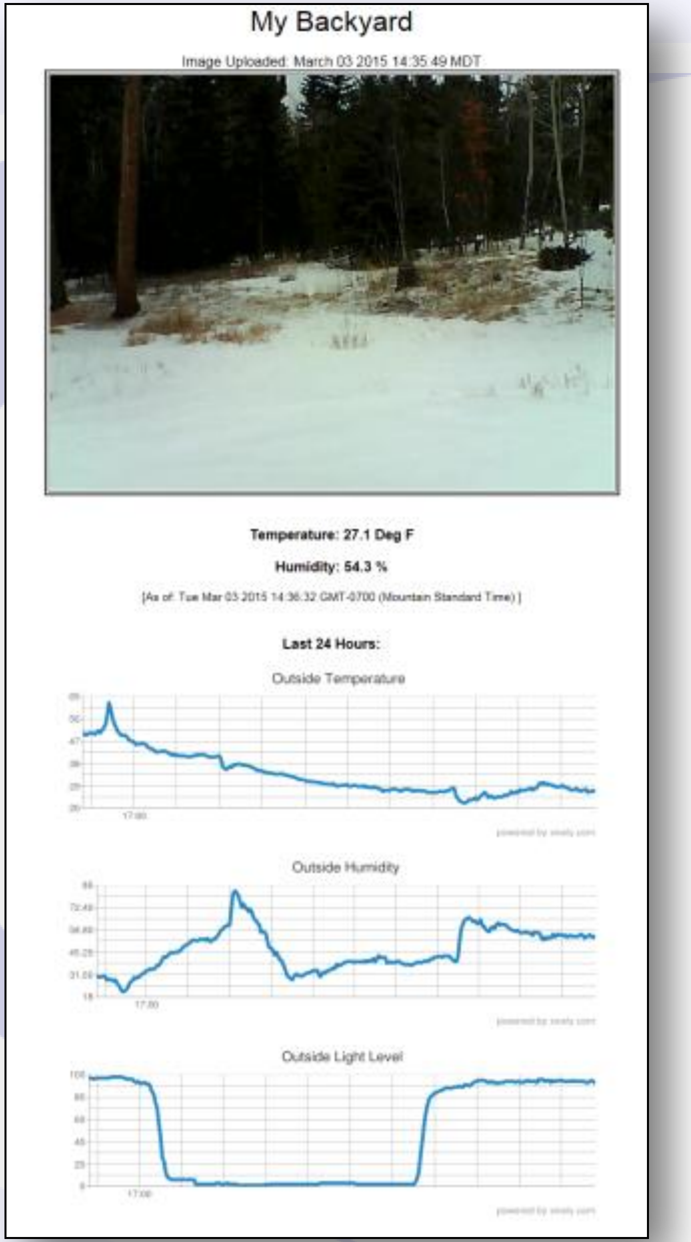
Returns a PNG graph of the “temperature” datastream:



Use the APIs on a Webpage

View from anywhere!

http://mybackyard.altervista.org



My Backyard

Image Uploaded: March 03 2015 14:35:49 MDT

Temperature: 27.1 Deg F

Humidity: 54.3 %

[As of: Tue Mar 03 2015 14:36:32 GMT-0700 (Mountain Standard Time)]

Last 24 Hours:

IBM Internet of Things Foundation

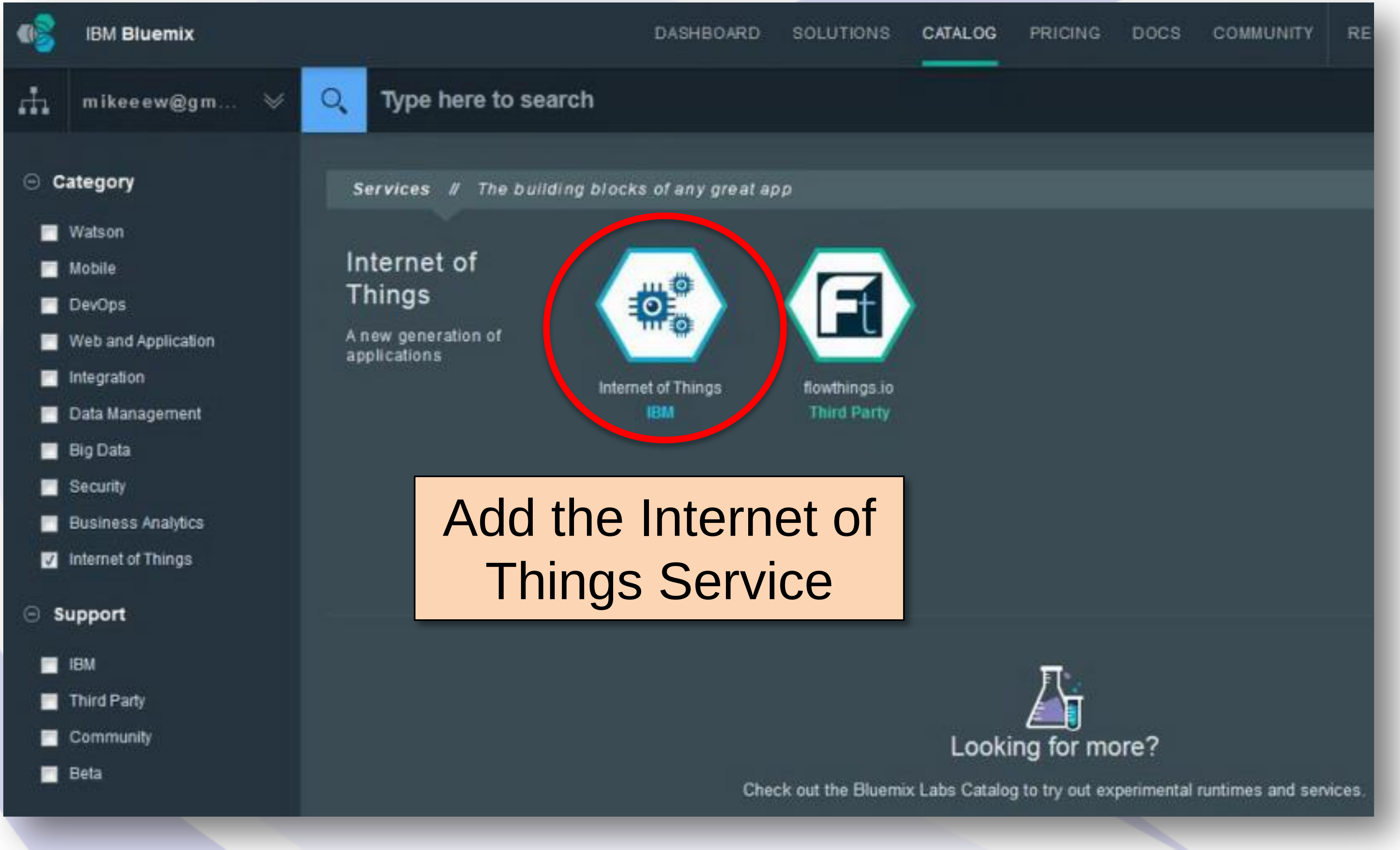
- IBM have created their own, cloud-hosted service for IoT
- Part of the IBM Bluemix platform
- Uses Informix TimeSeries

Bluemix

- Cloud based services
- Pick and choose what you want

Advanced DataTools

Bluemix - IoT



IBM Bluemix

DASHBOARD SOLUTIONS CATALOG PRICING DOCS COMMUNITY RE

mikeeew@gm...

Type here to search

Category

- □ Watson
- □ Mobile
- □ DevOps
- □ Web and Application
- □ Integration
- □ Data Management
- □ Big Data
- □ Security
- □ Business Analytics
- ☑ Internet of Things

Support

- □ IBM
- □ Third Party
- □ Community
- □ Beta

Services // The building blocks of any great app

Internet of Things

A new generation of applications

Internet of Things
IBM

flowthings.io
Third Party

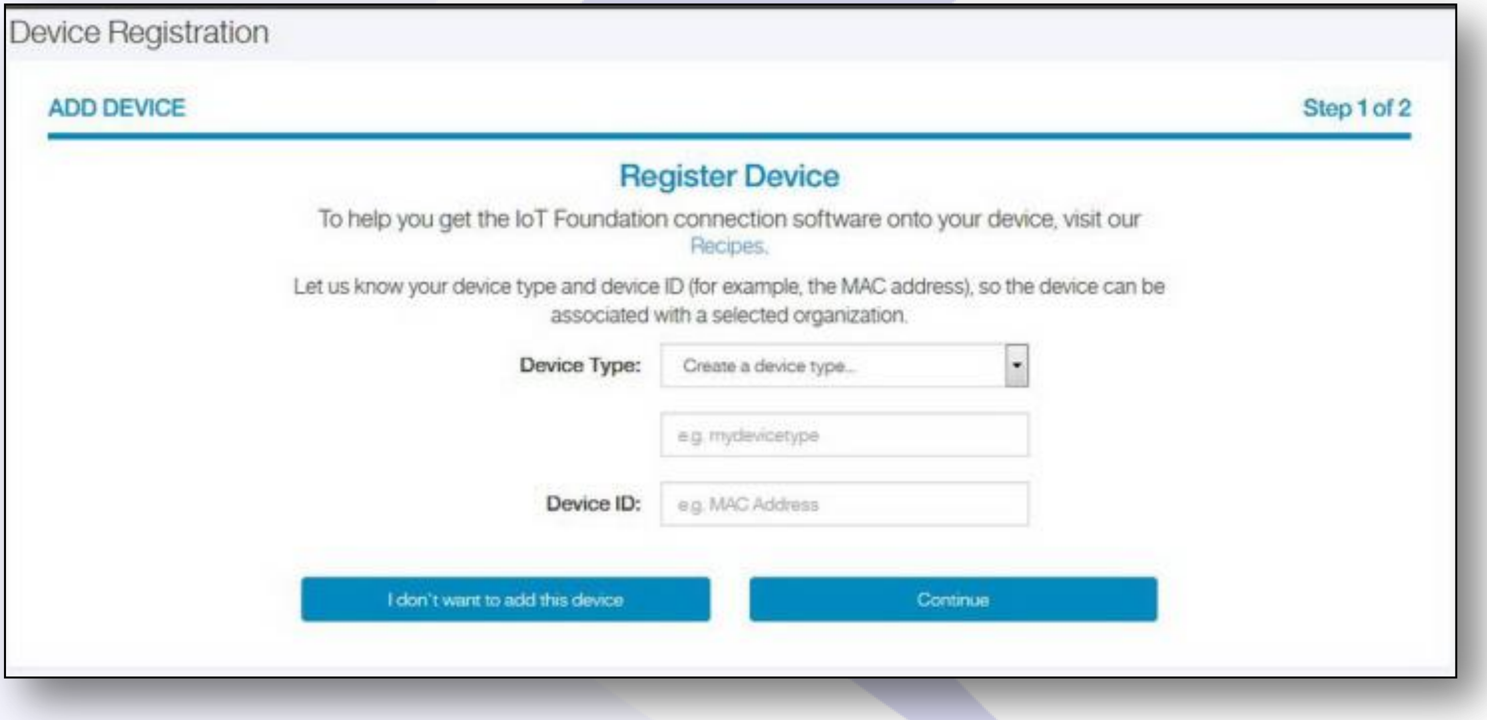
Looking for more?

Check out the Bluemix Labs Catalog to try out experimental runtimes and services.

Add the Internet of Things Service

Internet of Things Foundation

- Register a Device



Device Registration

ADD DEVICE

Step 1 of 2

Register Device

To help you get the IoT Foundation connection software onto your device, visit our Recipes.

Let us know your device type and device ID (for example, the MAC address), so the device can be associated with a selected organization.

Device Type: Create a device type...

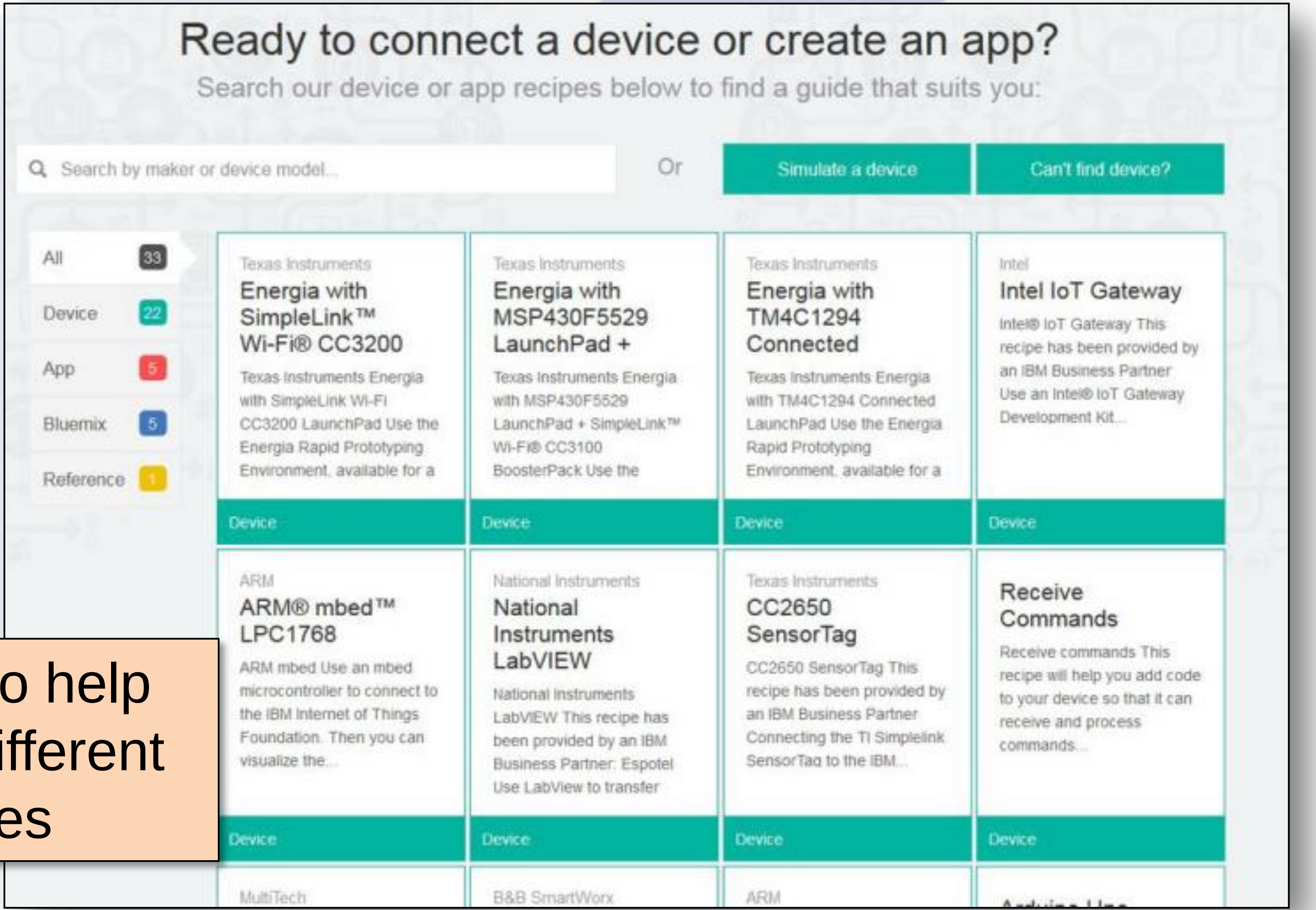
e.g. mydevicetype

Device ID: e.g. MAC Address

- Use MQTT protocol to send messages to IoTF in the cloud

Internet of Things Foundation

https://developer.ibm.com/iotfoundation/



Ready to connect a device or create an app?

Search our device or app recipes below to find a guide that suits you:

Search by maker or device model... Or **Simulate a device** **Can't find device?**

All	33
Device	22
App	5
Bluemix	5
Reference	1

Texas Instruments
Energia with SimpleLink™ Wi-Fi® CC3200
Texas Instruments Energia with SimpleLink Wi-Fi CC3200 LaunchPad Use the Energia Rapid Prototyping Environment, available for a
Device

Texas Instruments
Energia with MSP430F5529 LaunchPad +
Texas Instruments Energia with MSP430F5529 LaunchPad + SimpleLink™ Wi-Fi® CC3100 BoosterPack Use the
Device

Texas Instruments
Energia with TM4C1294 Connected
Texas Instruments Energia with TM4C1294 Connected LaunchPad Use the Energia Rapid Prototyping Environment, available for a
Device

Intel
Intel IoT Gateway
Intel® IoT Gateway This recipe has been provided by an IBM Business Partner Use an Intel® IoT Gateway Development Kit...
Device

ARM
ARM® mbed™ LPC1768
ARM mbed Use an mbed microcontroller to connect to the IBM Internet of Things Foundation. Then you can visualize the...
Device

National Instruments
National Instruments LabVIEW
National Instruments LabVIEW This recipe has been provided by an IBM Business Partner: Espotel Use LabView to transfer
Device

Texas Instruments
CC2650 SensorTag
CC2650 SensorTag This recipe has been provided by an IBM Business Partner Connecting the TI Simplelink SensorTag to the IBM...
Device

Receive Commands
Receive commands This recipe will help you add code to your device so that it can receive and process commands...
Device

MultiTech

B&B SmartWorx

ARM

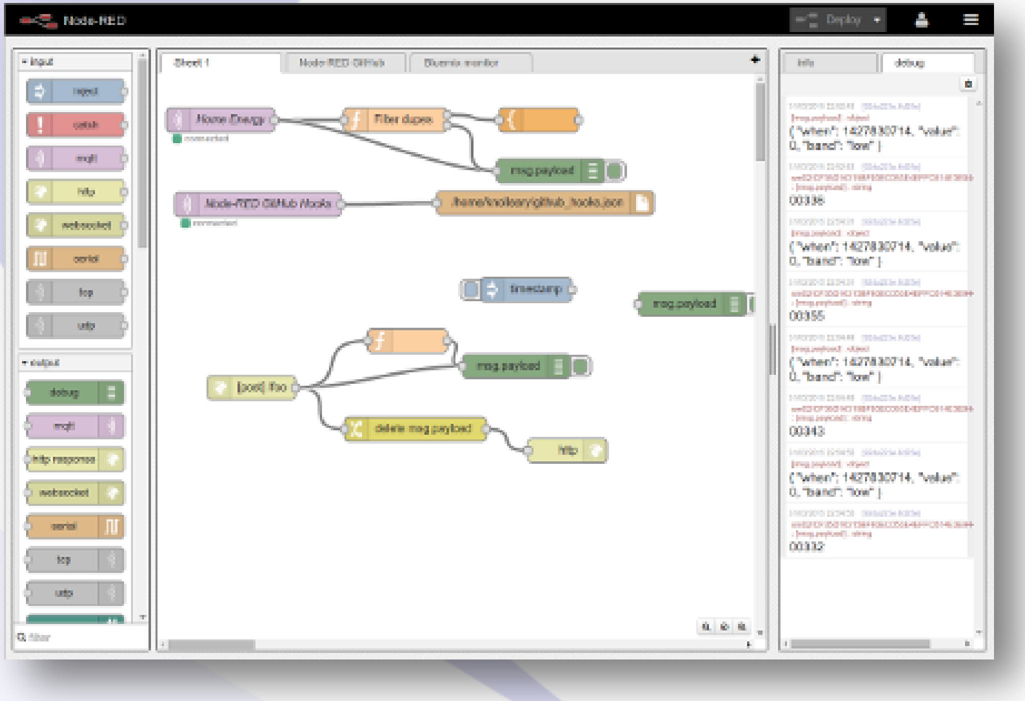
Arduino Uno

Recipes to help connect different devices

Node-RED

http://nodered.org/

- Create “flows” using a browser
- Choose and configure different events and outputs
- Uses node.js
- Can run on Raspberry Pi and Beaglebone



```
{ "when": 1427830714, "value": 0, "band": "low" }
00338
{ "when": 1427830714, "value": 0, "band": "low" }
00355
{ "when": 1427830714, "value": 0, "band": "low" }
00343
{ "when": 1427830714, "value": 0, "band": "low" }
00332
```

Links

Solving Business Problems with Informix TimeSeries RedBook:

http://www.redbooks.ibm.com/redbooks/pdfs/sg248021.pdf

TimeSeries Data User's Guide:

http://www-01.ibm.com/support/knowledgecenter/SSGU8G_12.1.0/com.ibm.tms.doc/tms.htm

IoT on Bluemix:

https://console.ng.bluemix.net/solutions/iot

Docker – Informix Container:

https://registry.hub.docker.com/u/ibmcom/informix-innovator-c/

Next Webcast

Running an Informix Database Server on an ARM Computer – June 23rd, 2 PM EDT

Thomas Beebe

Since IBM released Informix for the ARM platform, it has become a marriage of two great technologies: the small, fast, low-power, affordable solution of ARM chips paired with the high-performance, low-footprint, low-maintenance, and high-stability of the Informix database engine.

This presentation will cover the features and benefits of running Informix on ARM, how to begin working with it, and what hardware can be used. This isn't just for hardware developers; anyone who tinkers with hardware, IoT, or could use more portable and flexible computing can benefit from the pairing of ARM and Informix.

Questions?

Mike Walker

mike@advancedatatools.com