# Introduction to Informix and the Internet of Things Mike Walker mike@advancedatatools.com



# Internet of Things (IoT) Webcasts

- 1. Introduction to Informix and the Internet of Things
- Using Informix TimeSeries and the Internet of Things – June 2<sup>nd</sup>
- 3. Running an Informix Database Server on an ARM Computer June 23<sup>rd</sup>
- Installing and Configuring Informix on an ARM Computer – July 28<sup>th</sup>

# Introduction to Informix and the Internet of Things

- Brief overview of what IoT is
- IBM & IoT
- Demonstration of sensor data and IoT
- Overview of an IoT solution how the pieces fit together
- Microcontrollers connect to the physical world
- Example of reading a temperature sensor using an Arduino
- Use an ARM-based computer as a low-power, low-cost gateway
- Brief overview of installing Informix on a Beaglebone Black
- Wireless communication to/from ARM gateway using XBee radios
- Receiving sensor data at the gateway

# Internet of Things (IoT)

 Connecting together the Physical and Digital World

 Network of objects, exchanging information

# **Internet of Things - Examples**

- Smart Meters
  - Real time power usage monitoring
- Virgin Atlantic
  - Use internet connected sensors on engines, flaps, landing gear, etc. Can generate 0.5 TB from a single flight (Computerworld UK)
- DisneyWorld
  - MagicBand : check into hotel room, buy lunch, go through the turnstiles at the amusement parks.
     Disney can collect data on visitor movement (ZDNet)

# Internet of Things – Consumer Examples



- Lightbulbs
- Thermostat
- Garage Door Controller
- Door Lock
- Power Strip
- Wall Switch
- Propane Tank Gauge
- Piggybank

All connected...and all accessible with a smartphone

# Internet of Things (IoT)

Nearly 26 billion devices on the Internet of Things by 2020

Gartner, Inc

More than 30 billion devices will be wirelessly connected to the Internet of Things (Internet of Everything) by 2020

ABI Research

# Why do we Care?

- Monitoring and control of all sorts of things
- Interaction through smartphones/tablets anywhere in the world
- Enormous amounts of data

# **IBM and IoT**

- Informix is IBM's database of choice for Internet of Things implementations
  - Informix TimeSeries
    - Very efficient storage of large volumes of sensor data
  - Informix on ARM and Intel Quark
    - Run Informix on a small footprint, cheap hardware
  - Partnerships
    - Example: Informix available as part of the Intel Gateway developer SDK
  - Informix Docker image available
    - Try out Informix quickly and easily
- Internet of Things Foundation
  - Cloud based repository for storing IoT data
- Node-RED
  - Configure flows and events through a browser





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## That's the WHAT...

## Now the HOW...

# SensorsSensors for everythingElectricity<br/>UsageControl of the sensorsControl of the sensorsContro



Moisture



Reader

Barometric Pressure

## Temperature

# **Get Things Talking**



# **Technologies**



# Where to Start?

## How do I go from this:



## To this:



# **Microcontroller Boards**

- Electronics board with a microcontroller
- Can bridge the gap between the physical world around you and computers
- Input and Output pins
  - Read values from the environment
  - Turn things on and off
- Programmable

# **Microcontroller Boards**

## Intel Edison

## TI LaunchPad

## Beaglebone Black



## Pickaxe





## Raspberry Pi



## and many more... Advanced DataTools

# Arduino

- Electronics board & microcontroller
- Cheap (\$10-45 depending on version)
- Programming language (based on Wiring)
- Arduino is Open Source/Open Hardware
- Many different varieties and clones

# **Arduino**



# Arduino – Open Hardware

## **Arduino Uno R3**



## **Sparkfun Redboard**



# Arduino – Connect to the Physical



# **Arduino Programming**

- Program the Arduino from a PC using the Arduino IDE
- Free Download: <a href="http://www.arduino.cc/en/Main/Software">http://www.arduino.cc/en/Main/Software</a>
- Available for:
  - Windows
  - Mac
  - Linux

		Search the Arduino Website 🔍
Home Buy Download	Products - Learning - Forum Support - Blog	LOG IN SIGN UP
Download	the Arduino Softw	are
$\bigcirc \bigcirc$	ARDUINO 1.6.4 The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board. Refer to the Cetting Started page for Installation instructions.	Windows Installer Windows 2IP file for non admin install Mac OS X 10.7 Lion or newer Linux 32 bits Linux 64 bits Release Notes Source Code Checksums

# **Arduino Programming**

## Upload "sketch" (Arduino program) via a USB cable



# **Arduino INPUT/OUTPUT**

```
void setup() {
    // declare the LED pins
as outputs
    pinMode(3,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(5,OUTPUT);
    pinMode(6,OUTPUT);
```

// declare the switch
pin as an input
 pinMode(2,INPUT);

}



# **Arduino Temperature Sensor**



TempSensor	Arduino 1.0.	5
------------	--------------	---

File Edit Sketch Tools Help

#### 🗎 🛨 🛨 Ξ $\checkmark$

TempSensor

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Sketch

//TMP36 Pin Variables		
int sensorPin = 0; //the analog pin the TMP36's Vout (sense) pin is connected to	COM0	
//the resolution is 10 mV / degree centigrade with a	E COIVIS	
//500 mV offset to allow for negative temperatures		
/*		Se
* setup() - this function runs once when you turn your Arduino on		
* We initialize the serial connection with the computer	0.71 00105	
*/	21.29 degrees C	
void setup()	70 32 degrees F	
{	70.52 degrees r	
Serial.begin(9600); //Start the serial connection with the computer		
//to view the result open the serial monitor	0 73 volts	
Vold 100p() // run over and over again	23.24 degrees C	
{ //atting the velters reading from the tennerstore concer	73.84 degrees F	
<pre>int reading - enclogRead(sencorPin);</pre>		
// converting that reading to voltage for 3 30 and vino use 3 3		
float voltage = reading \$ 5.0:	0.74 volts	
voltare /= 1024.0:	22 72 degrade C	
// print out the voltage	23.75 degrees C	
<pre>Serial.print(voltage); Serial.println(" volts");</pre>	74.71 degrees F	
// now print out the temperature		
<pre>float temperatureC = (voltage - 0.5) * 100 ; //converting from 10 mv per degree wit 50</pre>		
//to degrees ((voltage - 500mV) times 100)	0.73 volts	
<pre>Serial.print(temperatureC); Serial.println(" degrees C");</pre>	22.75 degrees C	
// now convert to Fahrenheit		
<pre>float temperatureF = (temperatureC * 9.0 / 5.0) + 32.0;</pre>	72.96 degrees F	
<pre>Serial.print(temperatureF); Serial.println(" degrees F");</pre>		
<pre>delay(1000); //waiting a second</pre>	0.72	
}	U.72 VOIUS	Output
	22.27 degrees C	
	72 08 degrees F	
	72.00 degrees r	
	Autoscroll	Newline - 9600 baud

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Send

# Step it up!

- Can expand the Arduino through "shields"
- Add more capabilities WiFi, Bluetooth, etc ...or more sensors





# **Next Step**

- Now we've got a way read sensor information in a way we can understand it
- We can also drive devices in the same way and interact with the environment – actuators, lights, etc.
- To make this really useful, we want to put all this together so we can make better decisions, keep a history, publish the data and *do stuff!*
- Need a controller...a hub/gateway

# **Smart Gateway**

- Somewhere to collect data, store data, make decisions, trigger other actions and publish data
- Hardware depends on application

# Controller

For home automation, a small Raspberry Pi, or Beaglebone Black is an ideal solution

- Run linux
- Small Footprint
- Low power
- Cheap (\$35-55)
- Can run a database





# **Beaglebone Black**

## Rev C (latest version) - \$55

- ARM Cortex-A8 (ARMv7)
- 512MB RAM
- 4GB internal flash storage
- Expand storage with microSD card
- Ethernet
- HDMI
- No built in WiFi, no Bluetooth
- Requires 5V power (can be powered via USB)
- Now ships with Debian Linux installed
- Capable of running a full version of Informix!





# **Beaglebone – Setup**

- Ready out of the box
  - Connect via USB and ssh into it
- Additional steps:
  - Flash Beaglebone with the latest version of Debian from a microSD card
  - Configure microSD card for additional storage
  - Set up networking (WiFi requires dongle)
  - Update packages
  - Set up user accounts

# Why Install a Gateway Database?

- Maintain a history
- Advanced local reporting
- Make more informed decisions locally
- Don't need to wait to get information from the cloud
- Don't need to rely on an Internet connection

# Why Informix?

- Over a 20 year history
- Full support from IBM
- Enterprise class database software
- Reliable & Robust
- Scalable
- Performance
- Ease of administration
- Features
  - High Availability/DR
  - Full NoSQL support built in JSON & BSON data types, MongoDB APIs
  - Many, many more...

# Why Informix for IoT?

For all the same reasons, and...

- Informix TimeSeries
  - Store large volumes of sensor data very efficiently
- Easily Embeddable
  - No administration DBA free
  - Remote management through SQL
- Runs on low-cost hardware
  - Full version no loss of features
  - Small footprint disk and memory
  - OEM licensing options

# **Beaglebone – Informix Install**

## Download Informix for ARM from IBM website

	Name	Version	Туре	Release date	Size	Operating system	
1.	IBM Informix Dynamic Server Developer Edition (Informix Developer Edition for Linux Quark 32 (DK 50))	12.10UC4DE	Released product	30 Jan 2015	1kb	Linux	
	Exceptional, low maintenance online transaction processing (OLTP) data server for enterprise and workgroup computing.			Quar	·k, e	e.g. Intel (	Galileo
2.	IBM Informix Dynamic Server Developer Edition (Informix Developer Edition for Linux ARM v6 32	12.10UC4DE	Released product	05 Jan 2015	1kb	Linux	
	(Raspberry PI)) Exceptional, low maintenance online transaction processing (OLTP) data server for enterprise and			ARM	/6, e	e.g. Rasp	berry Pi
	workgroup computing.						
3.	IBM Informix Dynamic Server Developer Edition (Informix Developer Edition for Linux ARM v7 32)	12.10UC4DE	Released product	07 Jul 2014	1kb	Linux	
	Exceptional, low maintenance online transaction processing (OLTP) data server for enterprise and workgroup computing.			ARM	v7, o Ras	e.g. Beag pberry P	lebone, i 2

# **Beaglebone – Informix Install**

- Install the ksh package
- Upgrade java
- Copy the Informix tar file to the Beaglebone
- Unpack the tar file
- Run ./ids\_install
- Perform the normal (simple!) Informix install

informix@beaglebone:~\$ onstat -
IBM Informix Dynamic Server Version 12.10.UC4DE On-Line Up 1 days 09:34:46 58544 Kbytes
informix@beaglebone:~\$

# Beaglebone – OAT Run OAT against Beaglebone instance Configure/monitor Informix from a desktop

Same     Annu	OpenAdmin Tool							Server: sheldon_top#172-16.100.147				• • • •
Note         Note <t< th=""><th>Search Q</th><th>Actions</th><th>Information</th><th></th><th></th><th>Time Series 8</th><th>lubtypes</th><th>۲</th><th>Containers</th><th></th><th></th><th>۲</th></t<>	Search Q	Actions	Information			Time Series 8	lubtypes	۲	Containers			۲
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# **Informix Install - Docker Container**



 Informix is available as a Docker Container for simple setup

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

- Innovator-C Edition
  - Free to use
  - Limited to 1-core, 2 GB memory
- Informix database products:

http://www-03.ibm.com/software/products/en/informix-family

## Now we have...

- Arduino reading sensor data
- Beaglebone, ARM-based, Linux computer, running an Informix database

 Want to wirelessly connect the Arduino to the hub

# Send/Receive Information Wirelessly

- Many options:
  - WiFi/Low Power WiFi
  - Cellular
  - Bluetooth Low Energy (Bluetooth Smart)
  - Other wireless protocols
    - ZigBee
    - Z-Wave

# Send/Receive Information Wirelessly

- ZigBee
  - IEEE 802.15.4 Standard
  - Personal Area Network
  - Low power
  - Mesh Capable
- Zigbee implementation with XBee radios



## **XBee Radios**



## Need an XBee module on each sensor

## Need an XBee module on the hub



# **XBee Radios**

- Configure the modules to talk to each other
  - Can use AT commands in a terminal window
  - Set a PAN ID
     (like a network name)
  - Simple to set up each XBee to echo output to the other (transparent/command mode)

ſ	🚱 Serial - COM4		
	+++OK	*	
4	atsh		
	13A200		
	atsl		
	40B0A154		
	atid2001		
	OK		
	atwr		
	OK		
		Ŧ	

Use API mode for more advanced applications

# **XBee Radios - Configuration**

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Modem Parameter Profile Remote Configuration Vers	ions
PC Settings Range Test Terminal Modem Configuration	
Modem Parameter and Firmware Parameter View Profile	Versions
Read Write Restore Clear Screen Save	Download new
Always Update Firmware Show Defaults Load	versions
Modem: XBEE Function Set	Version
XB24-ZB ZIGBEE ROUTER AT	✓ 22A7 ✓
	<u>^</u>
E (2001) ID - PAN ID	
	E
🖥 (0) ZS - ZigBee Stack Profile	
📓 (FF) NJ - Node Join Time	
UINW - Network Watchdog Timeout	
- I (0) JN - Join Notification	
🔓 (2001) OP - Operating PAN ID	
📮 (D8D9) OI - Operating 16-bit PAN ID	
L C NC - Number of Bemeining Children	
🔤 🔚 (13A200) SH - Serial Number High	
40B0A154) SL - Serial Number Low	
A57CJ MY - 16-bit Network Address	
- 0) DL - Destination Address Low	
O NI - Node Identifier	-
Head parametersUK	

9600 8-N-1 FLOW:NONE XB24-ZB Ver:22A7

COM4

# X-CTU

Interface to configure all the XBee parameters and basic troubleshooting

# **XBee Network**

 Define an XBee as one of Coordinator, Router or End Point

## - Coordinator:

Destination/Root node [connected to the gateway]

## – Router:

- Usually always on
- Can connect to any other node

## – End Device:

- May sleep to save power
- Can connect to any router or coordinator

# **XBee Network**

- Routers will pass on traffic from End Device, allowing End Points to be situated further away
- Routers will store messages for End Points and deliver when they wake up



# **XBee Mesh Network**

- XBees will automatically re-route traffic if nodes are unavailable
- All done without any additional programming



# **XBee Network, with the new XCTU**



# **XBee Network, with the new XCTU**

SC XCTU			
	ו 🖹 🙊 ?•	🔅 🖳 🠇	
Radio Modules	Radio Configuration [ - 0013A20040AD	072C1]	
Name: Function: ZigBee Coordinator API Port: COM5 - 9600/8/N/1/N - API MAC: 0013A20040A4D465	<ul> <li>SB Stop Bits</li> </ul>		
2 5 remote modules	D7 DI07 Configuration	CTS flow control [1]	
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MAC: 0013A20040B0A1A9	AP API Enable	2 API enabping (2)	۲
Name: Function: TinBee Bouter API	() AO API Output Mode	Native [0]	۲
MAC: 0013A20040A09C56	<ul> <li>Sleep Modes</li> <li>Configure low power options for end device</li> </ul>	e5	
Name: Function: ZigBee End Device API	SM Sleep Mode	Cyclic Sleep [4]	۲
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		-	5

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# **XBee Communication**

Libraries for Arduino, python, C, etc to give programmatic control of the XBee

## Arduino – Sensor (Send)

#include <XBee.h>
XBee xbee = XBee();
XBeeAddress64 addr64 = XBeeAddress64(0x0000000,
0x0000000);

Populate a "payload": ZBTxRequest zbTx = ZBTxRequest(addr64, payload, sizeof(payload)); xbee.send(zbTx);

# XBee Communication Python – Gateway (Receive)

from xbee import ZigBee PORT = '/dev/ttyUSB0' BAUD\_RATE = 9600 ser = serial.Serial(PORT, BAUD\_RATE) xbee = ZigBee(ser,escaped=True)

. . .

response = xbee.wait\_read\_frame()
Parse response, e.g.
sa = hex(response['source\_addr\_long'][4:])

# **XBees & Sending Simple Data**

- XBee can be configured to send the analog value on a particular pin
  - Allows us just to connect it to a simple sensor and send the voltage reading back to base
- Can also configure it to sleep for a set period

Sleep Wake Up Send value on pin

# **XBees & Sending Simple Data**

- The sleep allows us to save power
- Can run on batteries
- NOT always on best for an End Device
- Simple setup do not need an Arduino



# **Wireless Sensor Network**









# **Wireless Sensor Network**



# **Putting it together**

# Add a Coordinator XBee to the Beaglebone using a "cape" (could also use USB or wire directly to the headers)



# **Receive Data from Remote Sensors**

# On the gateway (Beaglebone), read the data packets from the XBees

40ad72c1       2015-03-01       11:44:30       T: 66.7         40a09c56       2015-03-01       11:44:31       T: 72.5       H: 24.6       L: 83       S: True       D: 61       Hdg: 72         40b0a058       2015-03-01       11:44:33       T: 66.2
40a09c56       2015-03-01 11:44:31       T: 72.5       H: 24.6       L: 83       S: True       D: 61       Hdg: 72         40b0a058       2015-03-01 11:44:33       T: 66.2         40ad72c1       2015-03-01 11:44:35       T: 66.7         40a09c56       2015-03-01 11:44:36       T: 72.5       H: 24.5       L: 83       S: True       D: 61       Hdg: 72         40b79f8e       2015-03-01 11:44:36       T: 39.7       H: 39.8       L: 95       S: False       D: 0       Hdg: 0         40ad72c1       2015-03-01 11:44:40       T: 66.7
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40a09c56 2015-03-01 11:44:45 T: 72.5 H: 24.2 L: 83 S: True D: 61 Hdg: 72
40ad72c1 2015-03-01 11:44:45 T: 66.7
40b79f8e 2015-03-01 11:44:46 T: 39.7 H: 39.9 L: 95 S: False D: 0 Hdg: 0

# **Doing Something**

• We now have data from multiple sensors streaming to our base station

- Can trigger alerts - emails, texts, etc

– Can trigger other actions...

# **Turning a Switch On/Off**

Remotely set a pin on the XBee to Low/High

```
# D0=Digital Pin 0
# parameter: 4=Low, 5=High
xbee.remote_at(
dest_addr_long='\x00\x13\xa2\x00\x40\xb3\x42\xbb',
command='D0',
parameter='\x05')
```

Use to control a relay to power a device

# Turning a Switch On/Off Pin high/low can control a relay to power a device





# Now we have...

- Data from sensors (Arduino and "simple")
- ARM based, Linux gateway, running Informix
- Sensor data sent/received wirelessly
- What are we going to do with this data?
  - Store it in the database...using TimeSeries
    - Keep a history
    - Values accessible from multiple applications
  - Push to the cloud
    - Access from anywhere

# **Next Webcast**

# Using Informix TimeSeries and the Internet of Things – June 2<sup>nd</sup>

- 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
- Example of using APIs to display sensor data and graphs on a website

# WAIUG

## **Next Meeting**

Free Informix Technical Workshop New Features and Multi-tenancy – June 25 2015

# **Questions?**

# Mike Walker mike@advancedatatools.com