# Scripps Ocean Acidification Real-Time (SOAR) Monitoring Project using OSDT Android SensorPod

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# What are some of the big issues?

Climate change:

- Ocean acidification
- Temperature increases
- Variability in weather dynamics

Food and water security and sanitation:

- Threats to the food chain by long-term processes
- Disasters caused by combination of poor planning, poor execution, and poor timing, e.g., floods, typhoons, fires, nuclear accidents,…

Many problems are a combination of bad decisions and unfortunate circumstances. Maybe we can help…

# Open Source DataTurbine Initiative: Why? How? Who?

– Challenge: How to develop technologies and design systems that will enable timely data collection to inform rational decisions and policies?

– Mission of the Open Source DataTurbine Initiative:

*To Empower the Scientific Community with Streaming Data Cyberinfrastructure for Environmental Monitoring.*

OPEN SOURCE DATA TURBINE INITIATIVE

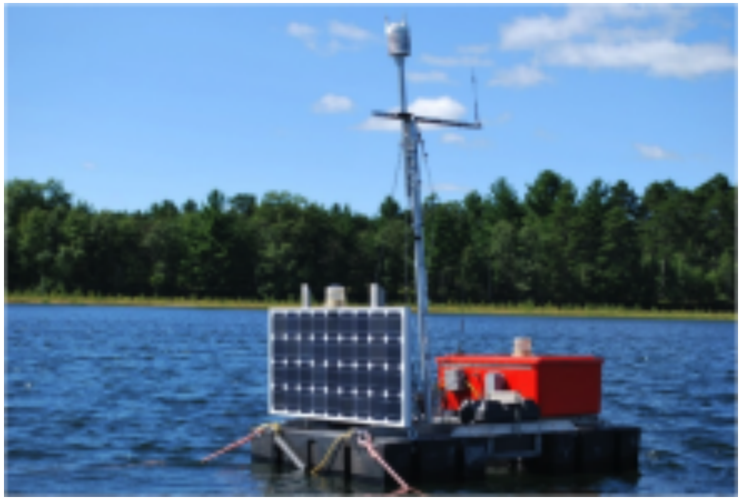
Empowering the Scientific Community with Streaming Data Middleware

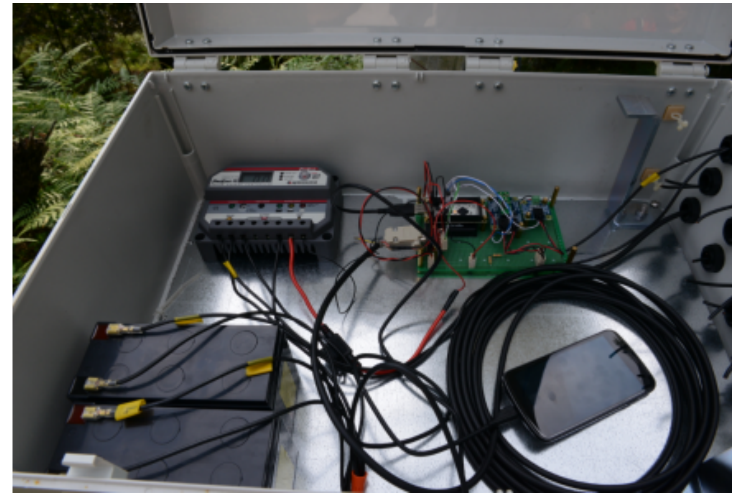
# Open Source DataTurbine Initiative

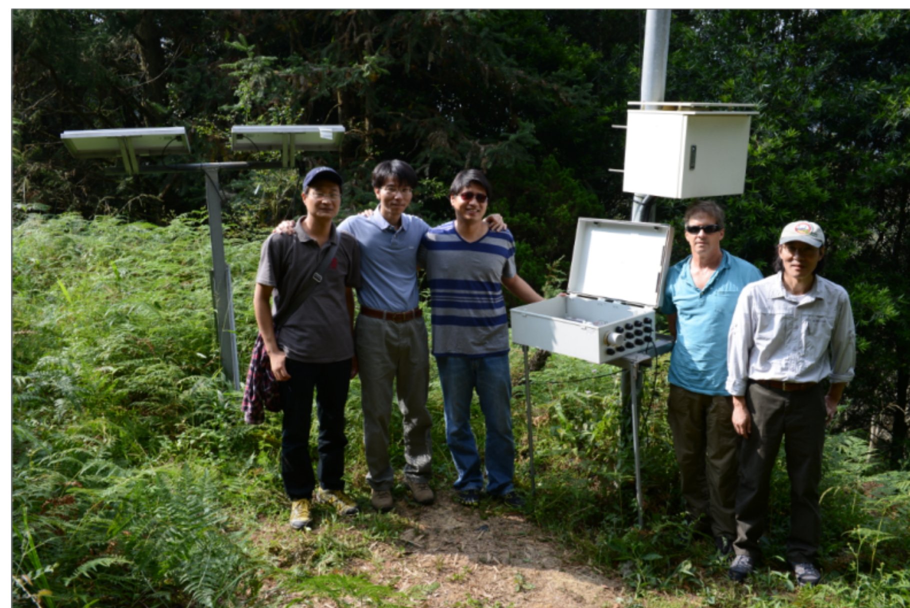
***What do we do?***

- Software development and publishing:
  - DataTurbine middleware for streaming data applications
- OSDT Android SensorPod:
  - Smart controller (gateway note/cluster head) for wireless sensor networks
- Cloud computing:
  - Virtualization of services for data, analytics, and decision support
- Systems design and applications development:
  - End-to-end (sensors to user) cyberinfrastructure that is scalable, robust, efficient, and affordable.

# Collaborations and Applications







# What is Ocean Acidification?

Ocean Acidification (OA):

- man-made process of increasing in acidity of the ocean body
- result of increasing amount of carbon dioxide dissolving into the ocean water

Effects of OA:

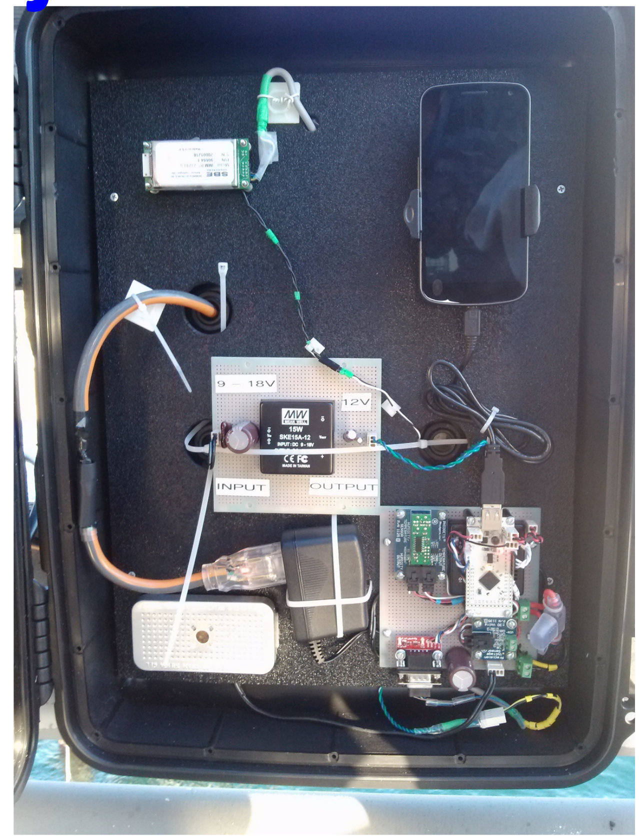
- can act like osteoporosis for marine organisms
  - ones that build shells or have external skeletons such as mussels, oysters, clams, coral, and many others.

# Scripps Ocean Acidification Real-Time (SOAR) Monitoring Project

- Motivation:
  - Currently the scientific community does not know much about OA in coastal regions, most data collection has been done in open waters.
- Launched SOAR Monitoring Project in March 2013
- Collaboration between Cyberinfrastructure lab in Qualcomm Insititute and the Smith Lab at Scripps Institute of Oceanography
- Employed SensorPod to set up a deployment at Scripps Pier to establish a long term OA monitoring program.
- The Scripps deployment has the potential for becoming an industry standard for coastal pH monitoring.

# OSDT Android SensorPod at SOAR Monitoring Project

- Custom hardware and software that integrates:
  - Sensors
  - Smart Phones
  - Networks: wired and wireless, cellular, Wi-Fi, satellite
  - Clouds (OSDC, Amazon EC2)

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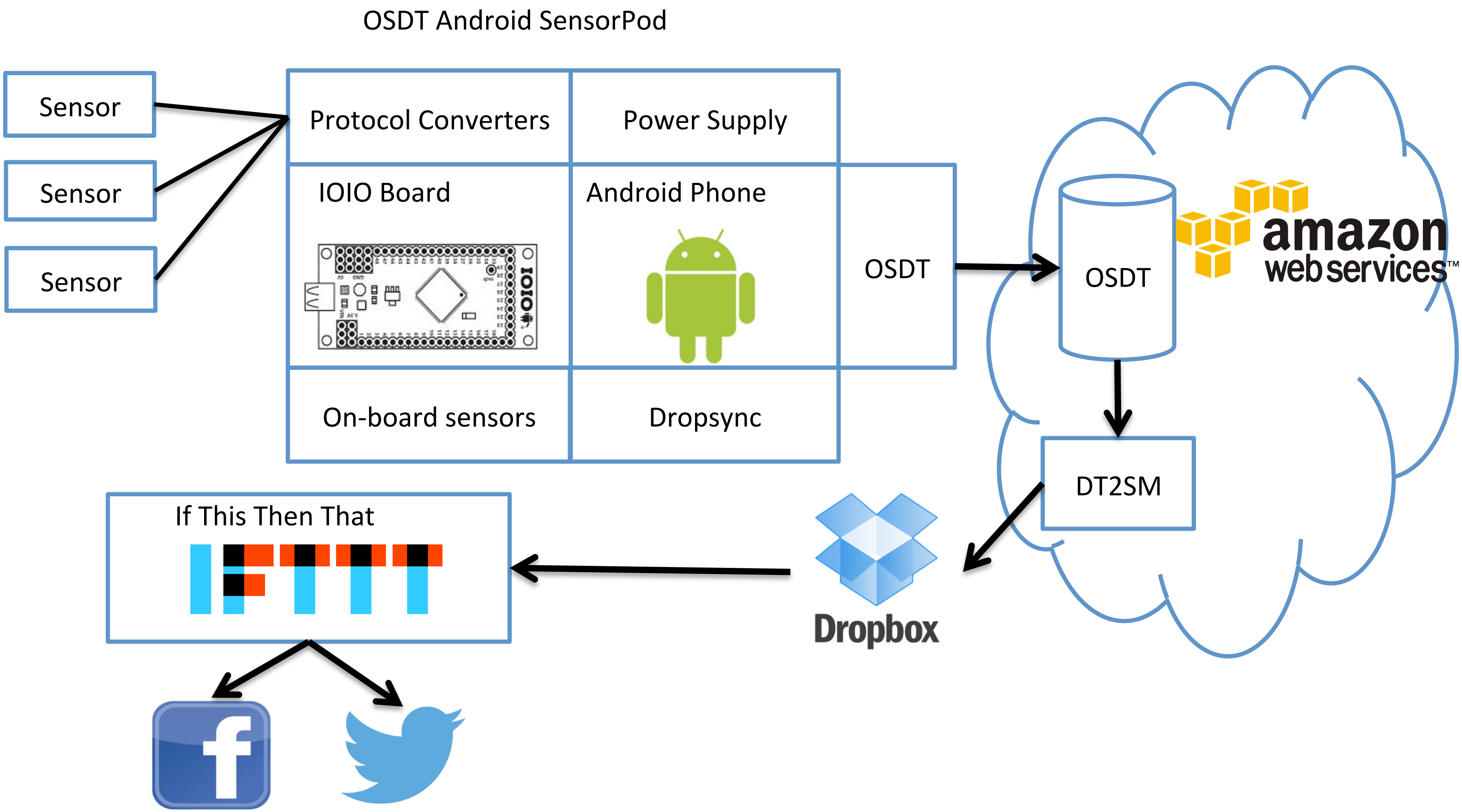
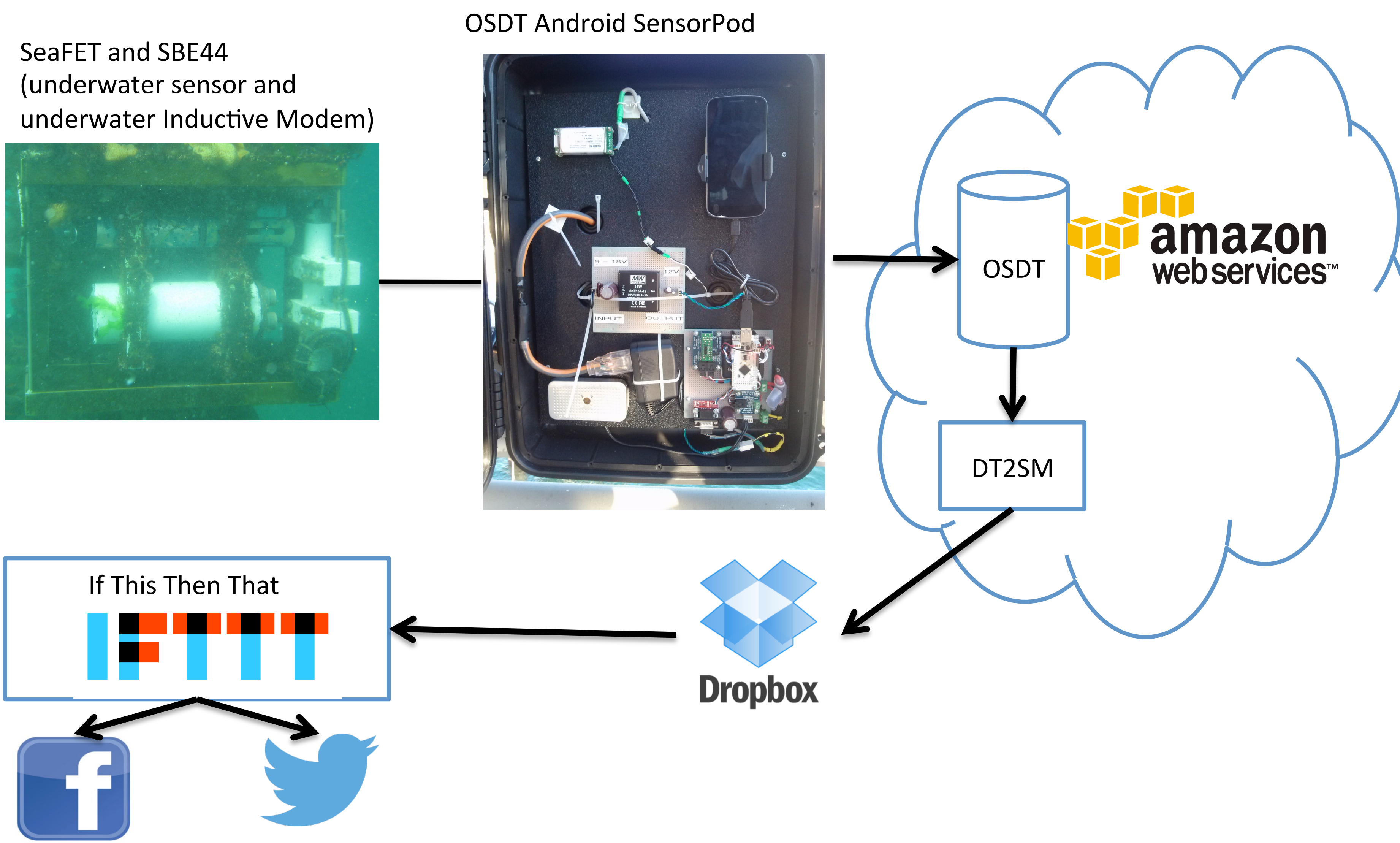
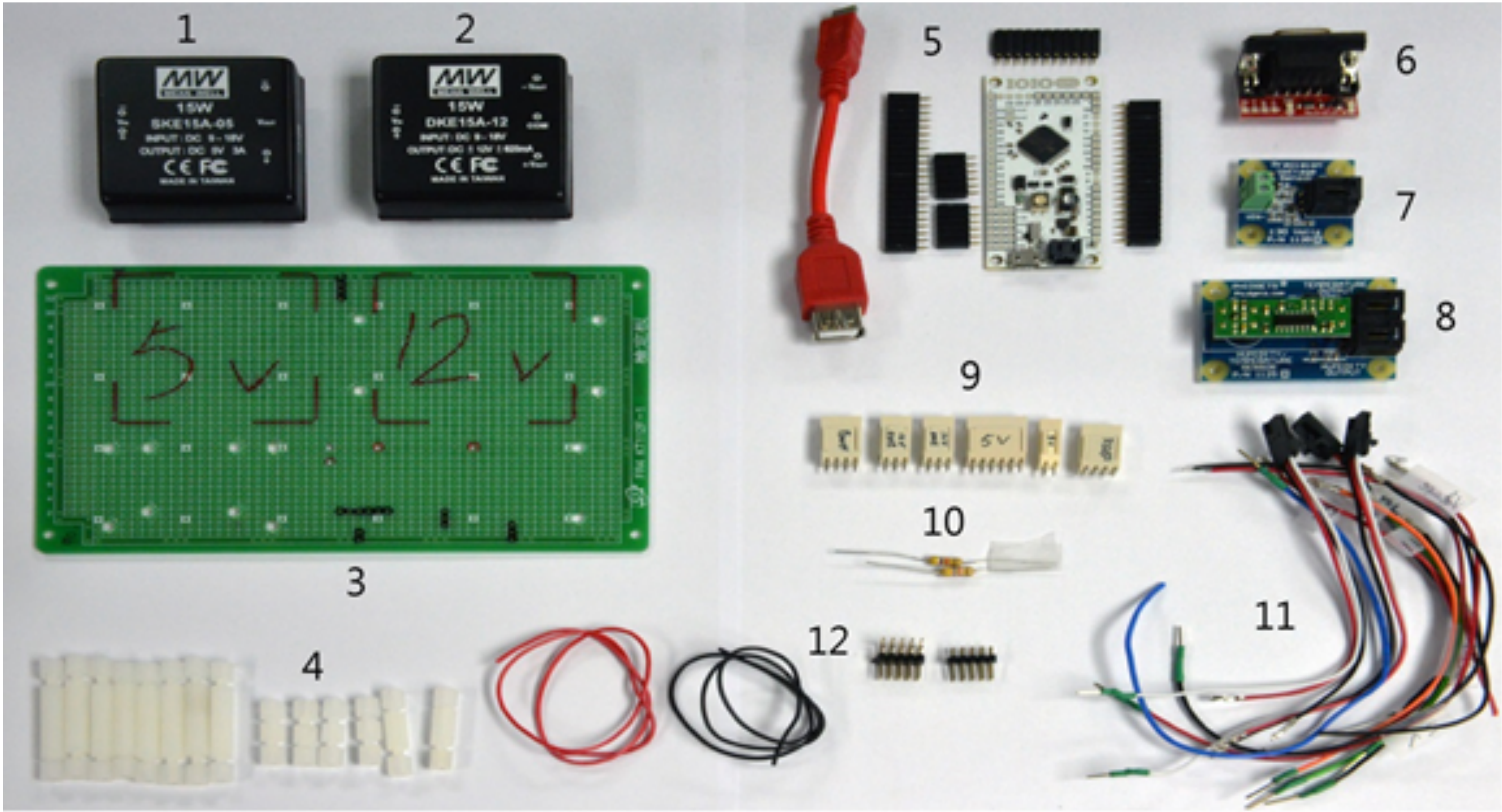
# OSDT Android SensorPod System Architecture



# SensorPod System at Scripps Pier



# OSDT Android SensorPod Kit

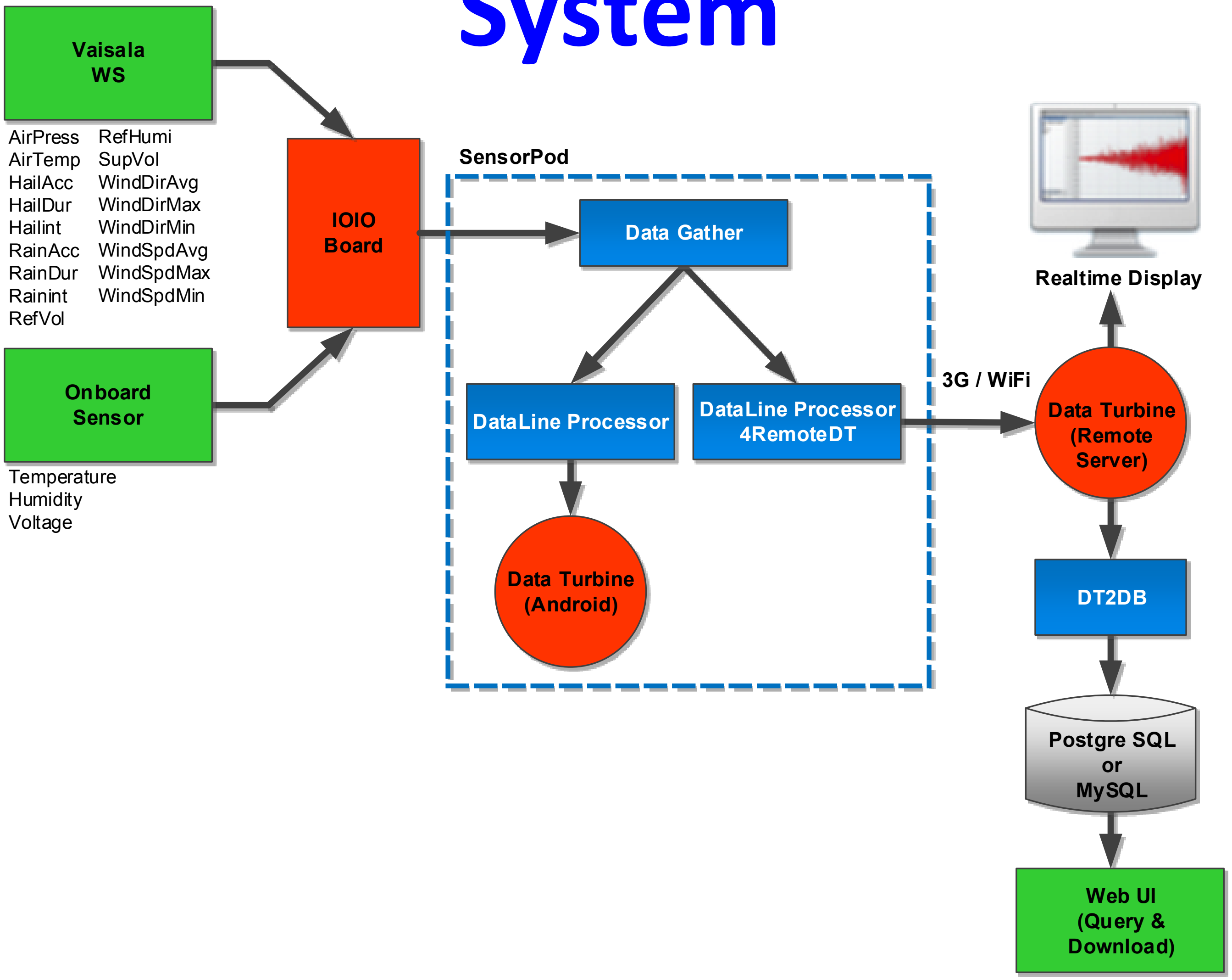



1. 5V voltage regulator
2. 12V voltage regulator
3. Perf board
4. Plastic hex-screw pillar
5. IOIO board and pin-socket connector
6. RS232 shifter
7. Voltage sensor
8. Humidity/temperature sensor
9. 2-pin, 3-pin, 4-pin, and 6-pin power connectors
10. Resistors as a voltage divider for decreasing humidity sensor output voltage
11. Sensor signal wire
12. Wire and pin for soldering power and ground connections beneath perf board

# SensorPod Kit?

- What is SensorPod kit?
  - Packaging of SensorPod components that can be assembled to produce a functional SensorPod system
  - Designed to be relatively quick and easy to assemble from common and inexpensive Commercial Off-The-Shelf (COTS) components with detailed assembly instructions
- Why did we build a kit?
  - Allows the scientists to build and deploy an infrastructure tailored to their needs
  - Frees site managers and research programs from proprietary components - avoids commercial and vendor lock-in

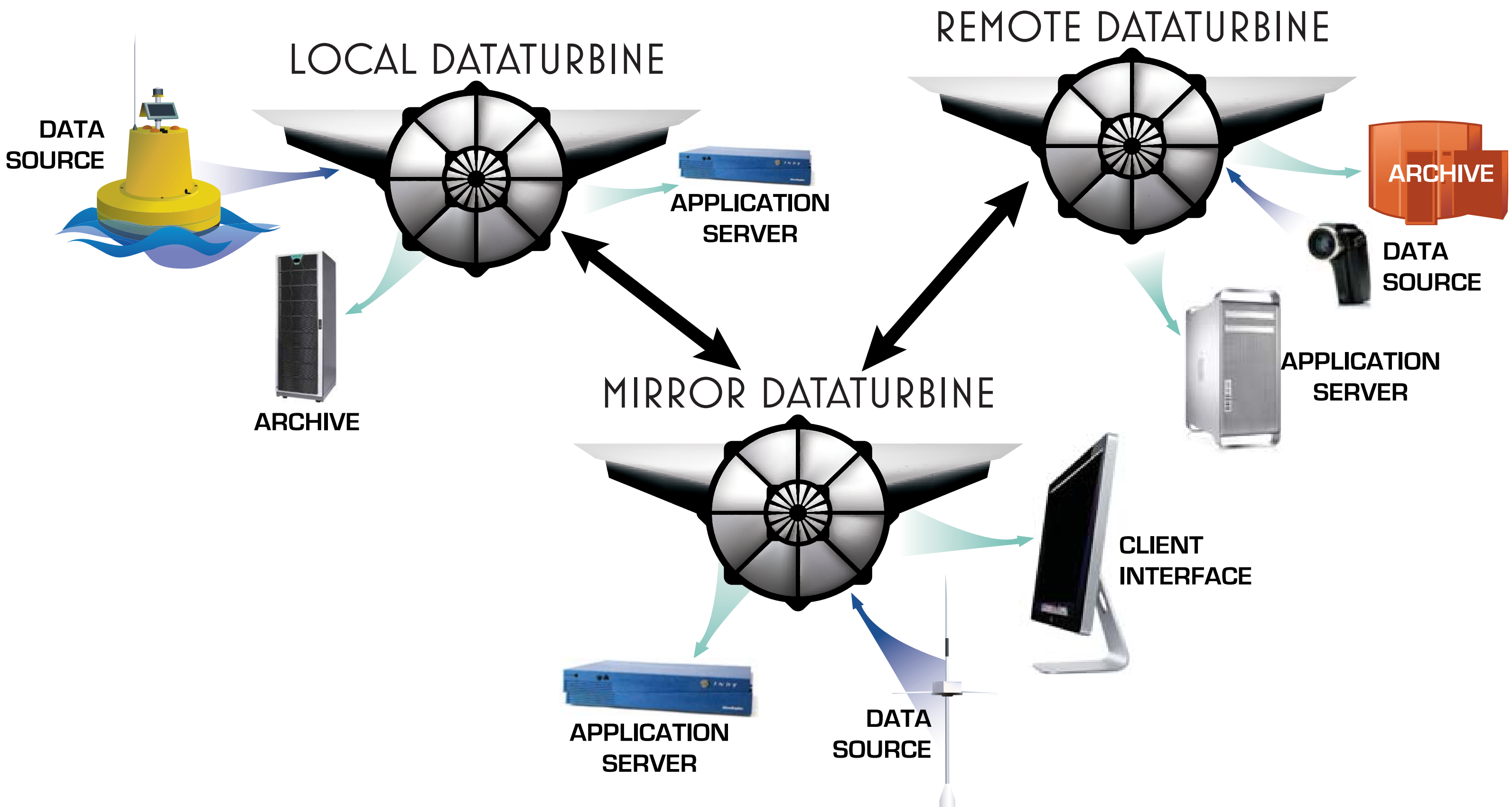
# Typical Data Flow in SensorPod System



# DataTurbine in a Nutshell

- R*obust real-time streaming data engine*
- Stream live data from experiments, labs, web cams and even Java enabled cell phones
- Acts as a "*black box*" to which applications and devices send and receive data
- Scalable – runs on everything from embedded devices to supercomputers
- Open source and freely available
  - www.dataturbine.org

# DataTurbine Middleware




DataTurbine middleware integrates the disparate elements of complex distributed real-time applications.

# Design Goals of SensorPod

- Flexible
- Robust
- Efficient

# Flexible

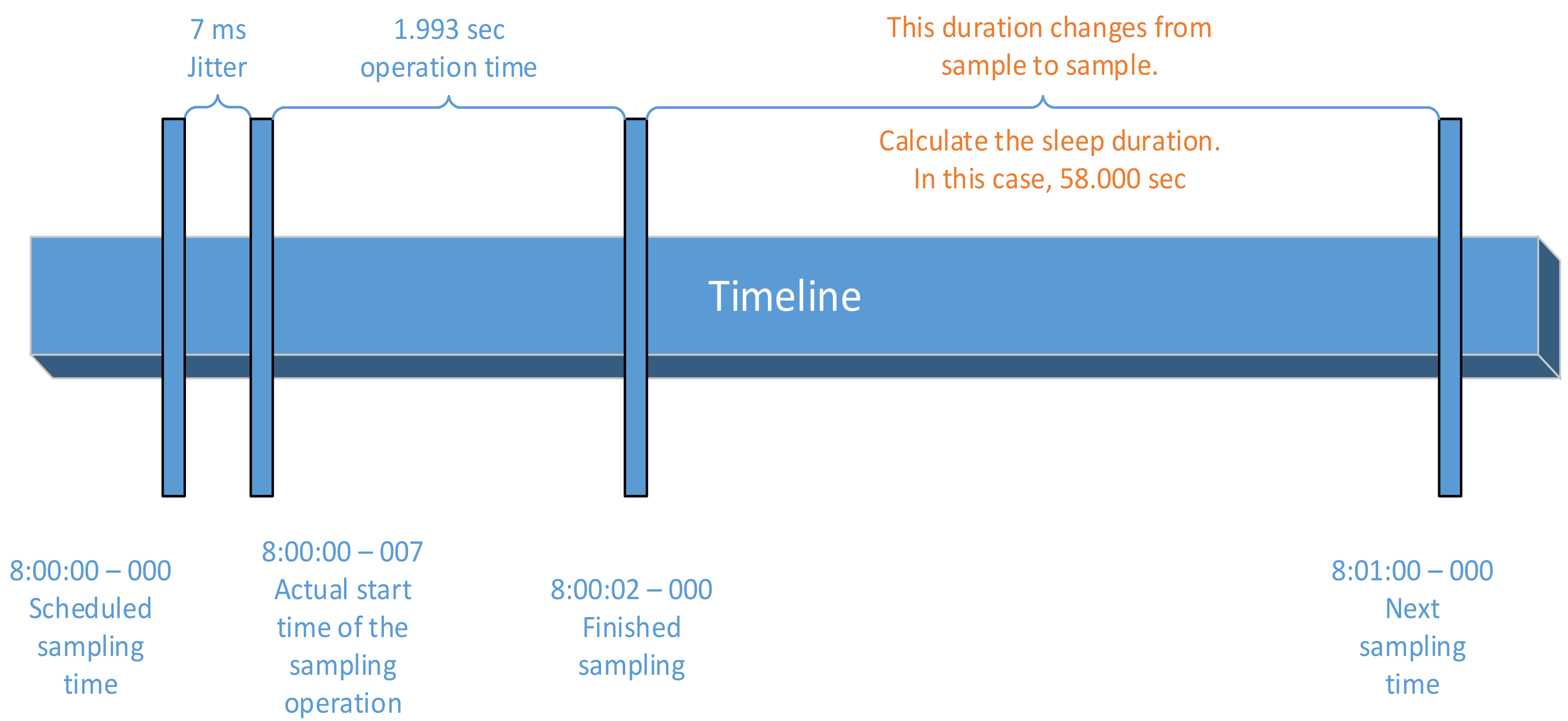
- Supports various data center scenarios:
  - distributed, centralized, and cloud data management models.
- Provides an abstraction to sensors
  - no standard to communicate with sensors.
    - The manufacturers typically offer their sensors with a set of commands with some specific corresponding responses for their digital sensors.
  - abstraction in the configuration file
    - Determine the expected timing window.
    - Add and remove the sensors easily.

# Flexible

- Customized sampling time for each sensor.
  - Supports strict timing schedule for each sensor.
    - The mean jitter has been around 7 ms.  The max jitter time was 9 ms.
    - The multi-threaded applications are controlling the sensors, and sensors can sample at specified time – same or different.

# Efficient

- Maintain precise sampling time
- Minimize the jitter
  - Foreground service to support the strict timing constraints.
  - Calculates the sleep time based on its next sampling time, instead of busy waiting.



# Efficient

- Modular design in both HW and SW
  - Choose HW/SW modules
    - Examples - no satellite in WI, SIO or Taiwan, no local ODST service in the phone
    - Note: trade-off exists - energy-efficient voltage regulator vs. linear voltage regulator

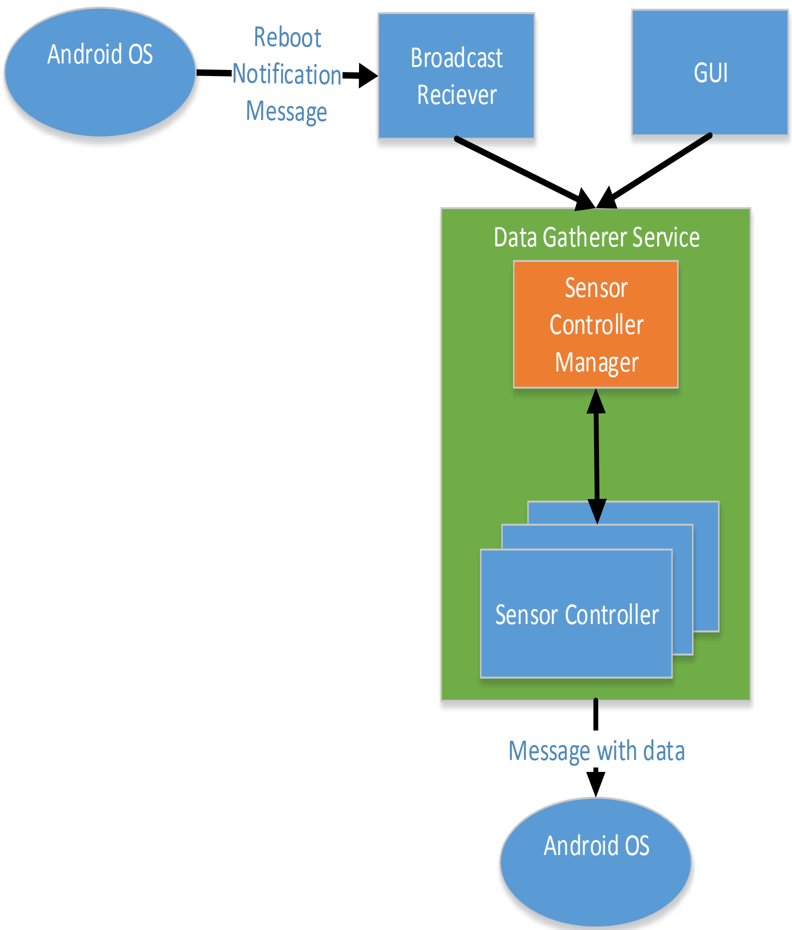
- Management of multi-threaded application
  - Handle error and recover from it at appropriate levels.
  - Avoid the escalation of an error.

# Robust

- Operate autonomously for months.
  - Monitors the system itself
  - Handles unknown or unexpected failure
    - Each SW module is a multi-threaded program implemented in the hierarchical fashion.
      - The top level thread is a manager thread keeping track of the spawned working threads.
      - Manager thread handles errors, kills and restarts the working threads at an appropriate level.
      - If the working threads get an exception or fails, the master threads keeps the handles onto those threads and cleans them up before restarting.

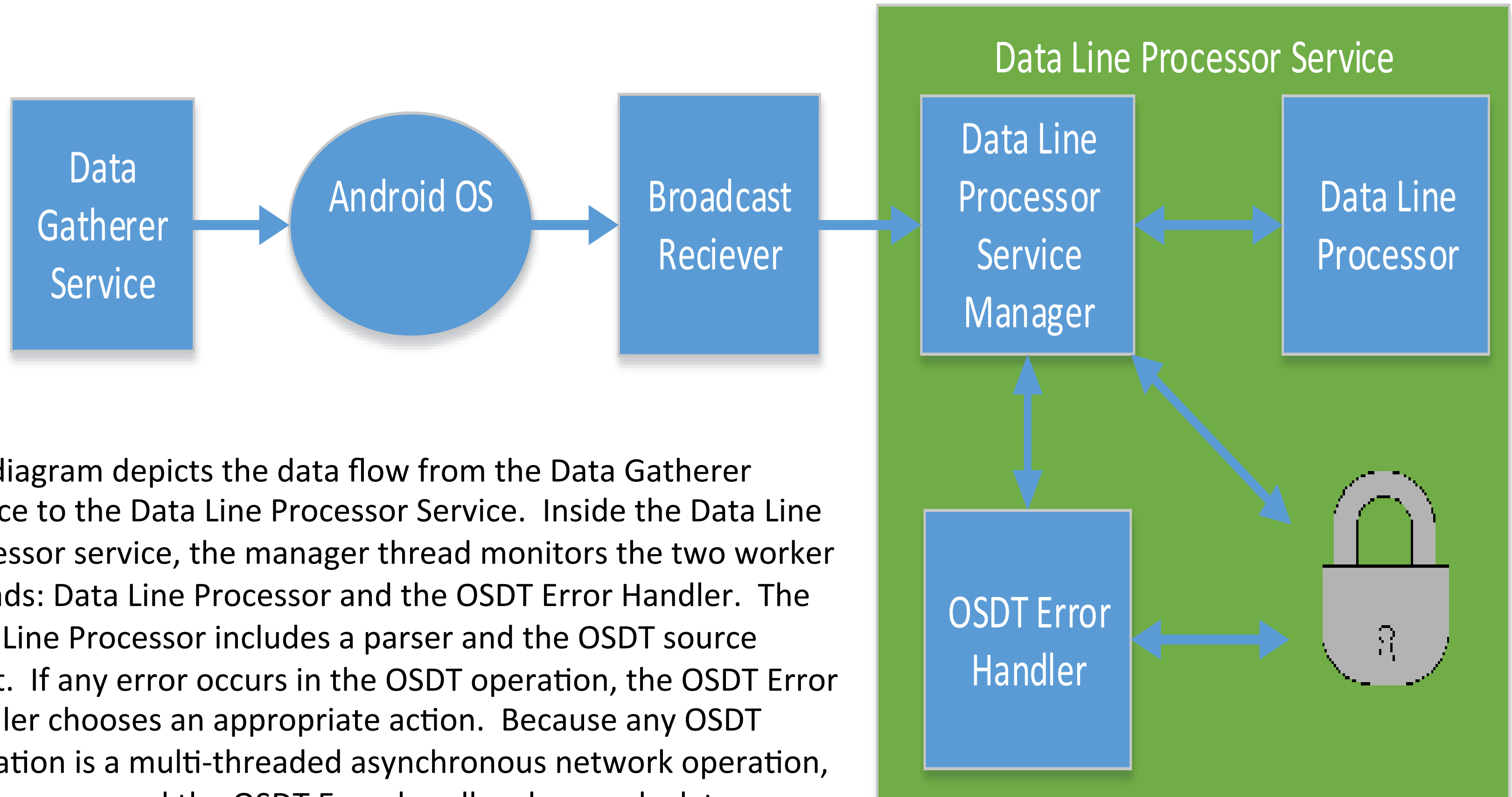
# Robust

- Automatic restart logic for unexpected reboot.




The Android OS sends out a reboot notification broadcast message after it reboots. Broadcast receiver is an abstract Android OS class. A subclass of this Broadcast receiver is implemented to receive the reboot notification message for the Data Gatherer Service. Upon receiving the message, it starts the Data Gatherer Service. The diagram shows that a user can also start the service through the GUI.

# Robust



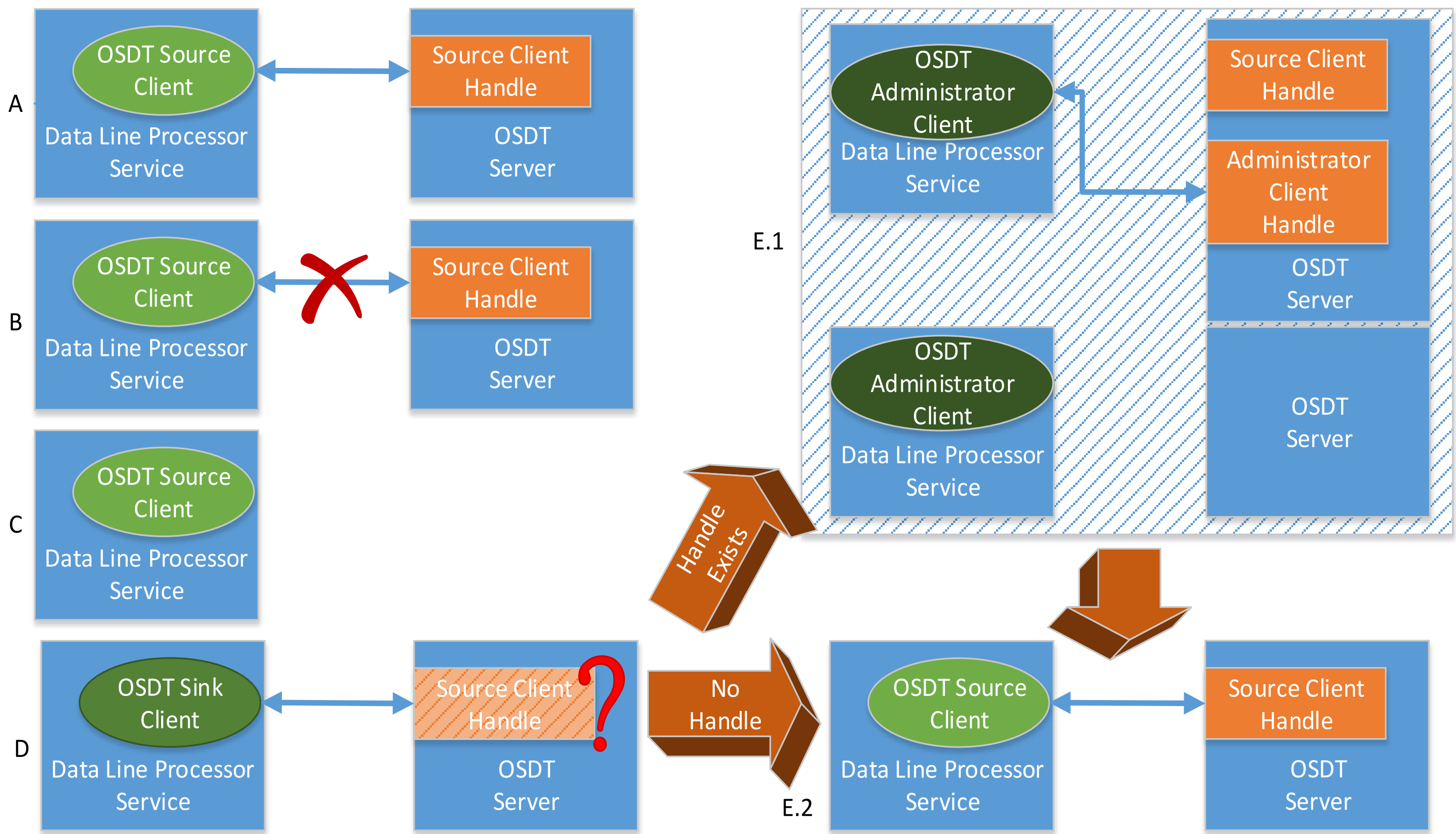

The diagram depicts the data flow from the Data Gatherer Service to the Data Line Processor Service. Inside the Data Line Processor service, the manager thread monitors the two worker threads: Data Line Processor and the OSDT Error Handler. The Data Line Processor includes a parser and the OSDT source client. If any error occurs in the OSDT operation, the OSDT Error Handler chooses an appropriate action. Because any OSDT operation is a multi-threaded asynchronous network operation, the manager and the OSDT Error handler shares a lock to coordinate its activities.

# Robust

- Withstand transient communication outages.

# Robust

- The diagram below shows how the OSDT Error Handler module implements the network recovery mechanism steps.



# Demonstration

- Demonstrate SOAR Monitoring Project facebook page.

# Acknowledgement

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