Managing Sensor Network Configuration and Metadata In Ocean Observatories Using Instrument Pucks

Kent L. HEADLEY, Thomas C. O’REILLY, Michael RISI, Lance McBRIDE, Dan DAVIS, Duane EDGINGTON,
May 10, 2007
Acknowledgements

SIAM Engineering
- Thomas C. O’Reilly
- Michael Risi
- Daniel Davis
- Duane Edgington

MOOS Engineering
- Lance McBride
- Wayne Radochonsky
- Timothy Meese
- Mark Chaffey

SSDS Engineering
- Kevin Gomes
- John Graybeal

Science Collaborators
- Francisco Chavez
- John Ryan

Operations Collaborators
- Mike Kelley
- Mark “Zorba” Pickerill

External Collaborators
- Nortek
- Seabird Electronics
- WetLabs

Technical Support
- Support Engineering
- Technical Support Group

Sponsors
David and Lucille Packard Foundation
Overview

• New Ocean Observatories: Context for Instrument Pucks
  • MBARI Ocean Observing System (MOOS)
  • Software Infrastructure and Applications for MOOS (SIAM)

• Challenges Faced by New Ocean Observatories

• Instrument Pucks

• Results and Status
MOOS: Context for Instrument Pucks

• “Monterey Ocean Observing System”

• Development program of observatory technologies and systems integrated with multiple field deployments and science experiments

• Aim is for the technologies and systems to be adopted by community observatory programs, e.g. OOI

• System concepts
  • Buoy based observatories
  • Cabled observatories

• MOOS Sub-Systems/Technologies
  • Software Infrastructure and Applications (SIAM)
  • Shore Side Data System (SSDS)
  • MOOS Mooring/MOOS Mooring Controller (MMC)
  • AUV’s/AUV docking
  • Vertical profiling
MOOS Mooring

- Moored network of benthic, midwater, and surface nodes
- Instruments can be accessed in near-realtime over satellite or RF link
- Power (50-100 W) and data (10 Mbit/sec) to the seafloor
- 4000 meter depth
- 10 km Benthic runs
- Support for AUV docking
MOOS Sensors

- Commercial off-the-shelf (COTS)
- Custom-made
- > 100 candidates for MOOS
- Many different software protocols
- Existing instrumentation (mostly serial)
  - RS-232
  - RS-485
  - analog

Spectroradiometer

Fluorometer

Acoustic Doppler Current Profiler
SIAM

- “Software Infrastructure and Applications for MOOS”
- *Deployed* and *Operations* subsystems of MOOS moored network
- Provides and enables
  - data collection
  - resource and configuration management
  - metadata handling
  - maintenance
  - instrument configuration, command and control
  - archiving data/metadata
SIAM Operations Subsystem

Operations workstation

Portal host

TCP/IP

wire/fiber

Shore network

Radio

TCP/IP

Moored network

SIAM Deployed Subsystem

Mooring node

Benthic node

Benthic node

TCP/IP

wire/fiber

MOOS network
Key Elements of SIAM

• **Plug and Work Configuration**
  – Instrument Pucks

• **Deployed subsystem**
  – Host-node application frameworks
  – Host-node applications

• **Operations subsystem**
  – Shore side applications

• **Portal software**
  – links *deployed* and *operations* subsystems
  – manages communications, bandwidth
With Greater Capabilities…

• Great variety of instrumentation
• Highly integrated data collection
• Cooperation between a variety of platforms (AUV, ROV, Moorings)
• Adaptive sampling
• Event detection
• Wider Coverage (Surface to Seafloor)

Come New Challenges…

• Platform Configuration Management
• Metadata Management
• Diverse Software Protocols
• Operational Scalability
• Power Management
• Intermittent, Low-Bandwidth Telemetry Links
The Configuration Headache

• Many steps required for a device to join a platform:
  – Plug device into host port
  – Install device software, configuration files, metadata
  – Modify host’s configuration file (port #, baud rate, etc)
  – Note change of data collection context and associate metadata with new data stream

• Time-consuming, tedious, and error-prone
• Does not scale well

Pete Strutton, 1998, Equatorial Pacific
Metadata System Requirements

Metadata needed to:

– Interpret scientific data from sensors
  • Rigorously captures context of scientific measurements

– Describe sensors, instruments, platforms, and communication links in a deployment

– System infrastructure data support
  • Support the real time operation of the system, including monitoring and diagnostics
Why is This a Difficult Problem?

- Power constraints
- Intermittent network
- Harsh physical/electrical environment
- Many legacy instruments
  - Commercial off-the-shelf and custom made
  - Diverse protocols, few interface standards
- Need to describe and distinguish individual instruments
The *Plug-and-Work* Solution...

- Physically plug device into host serial port
- Instrument service is (almost) *automatically* retrieved from instrument puck
- Metadata are *automatically* inserted into the archiving data stream when relevant changes occur
- Distributed software makes device services and metadata accessible to users and other observatory nodes
Instrument Puck Concept

- Consists of non-volatile memory and a simple protocol to access the contents
- An instrument puck is closely coupled to a specific instrument, always travels with its instrument
- Puck contains unique ID, instrument service code and metadata
- Host retrieves instrument service code and metadata from puck when the instrument/puck is plugged in to host node
What Information is Stored in the Puck?

- Depends on application…
- Instrument ID and metadata
  - Instrument type, default settings, owner, etc…
- Instrument service code
  - Downloaded and executed on node when instrument is plugged in
Node manager

Instrument service

New sensor

Platform Configuration

Operator Initiates Scan

Plug in new sensor
Node manager

Instrument service

Instrument service

Instrument service

Network

Platform Configuration

Scanner starts instrument service

Service joins network
What is Inside a Puck?

- 7.32 MHz MSP430 microprocessor
  - 48 Kbytes flash for puck firmware
  - 2 Kbytes RAM
- MAX3160 Serial Transceiver
- 1 MB SPI flash (configurable) for instrument service code and metadata
Puck Specifications

- Supports RS-232 or RS-485 up to 115 Kbps (and possibly greater)
- 1 MB flash (configurable) for instrument service code and metadata
  - Typical Instrument Service code is 10-15 Kbytes
  - Typical metadata size TBD
- Power consumption (0.40 W quiescent / 1.06 W during I/O) currently driven by COTS isolated power supply; target is 0.030/1.00 W)
- 4000 m housing
- 28 cm x 3.3 cm O.D.
- 5-wire interface
Plug in new sensor
Operator initiates scan
Puck contents retrieved
Puck enters pass through mode
Instrument service controls sensor
PUCK Enabled Instruments

• Same principle of operation

• Latest protocol enables seamless transfer between PUCK and instrument mode via software control

• Clear operational advantages over hardware implementations
Why Not Other Instrument Interface Standards?

• Easy for instrument manufacturers to adopt
  – requires little hardware change to integrate into existing products
  – small, lightweight, low power
  – inexpensive
  – uses common serial protocols already used by many manufacturers

• Puck is a general solution
  – independent of controller hardware/software
  – uses no proprietary standards

• SIAM/Puck architecture supports simple cabling infrastructure (5 wire interface)

• Lack financial incentive for instrument manufacturers to adopt new protocols

• No demand from science users for other interface standards
Activities and Milestones

- MTM-1 Deployment: Winter 2002
- Puck Prototype Hardware: Spring-Summer 2003
- AOSN Deployment: Summer 2003
- CIMT Deployment: Summer 2004
- MTM-2 Deployment Autumn 2003
- MTM-3 Autumn 2005
- MOOS Science Experiment: Summer 2006 Autumn 2006
Recent PUCK Activities

- PUCK Protocol v 1.3 developed with Nortek, Seabird and WetLabs
- Hardware implementation at v 1.2
- Instruments deployed as part of MOOS Science Experiment
- Interoperability demonstration at JavaOne conference with Agilent and USF NetBeams project
- Currently writing proposal for OOI Coastal Global Scale Nodes Implementing Organization
Closing Remarks

• Close binding of metadata and configuration information to their data sources improves system scalability

• Instrument pucks perform this data-binding function, enabling plug-and-work behavior and automated configuration management and automatic metadata handling

• Instrument pucks can be used in cable-to-shore or moored ocean observatories; their usefulness is independent of the location of system intelligence (remote or on-shore)

• Instrument pucks use existing protocols to leverage large existing instrument base and standards used widely by the oceanographic community
Thank You
NOAA/UCSC project to develop coastal observatory infrastructure

Chavez/Edgington - MBARI PM/Engineering lead

SIAM to develop plug-and-work sensors for MOOS mooring controller

Benchtop demo in August, 2003 with M1 instrument suite
Technical Approach to System

- Object oriented modular approach in software, hardware, and metadata
- Use distributed object, client-server, smart network, software framework
- Use instrument-puck interface between instrument and software infrastructure host
- Use XML to represent metadata and bind metadata to instrument through its puck
SIAM Deployed Deliverables

- Node networking
- Time-keeping
- Instrument control
- Data acquisition
- Metadata management
- Autonomous event response
- Plug-and-work: sensor pucks
SIAM Operations Deliverables

- Utilities for
  - System integration
  - Deployment
  - Maintenance
- Shoreside portal gateway
- Instrument user interfaces
Helping Platforms Manage Themselves

Every Challenge

• Operational Scalability
• Platform Configuration Management
• Metadata Management

Has A Solution

• Self Configuring Networks
• Binding Instruments with their Metadata
• Automatic Response to Dynamic Metadata
• Focus on Infrastructure that Provides Facilities for Automation and Cooperation
MOOS Mooring

- Wireless comms to shore
- Power (20-100 W) and data (10 Mbit/sec) to the seafloor
- 4000 meter depth
- 10 km Benthic runs
- Support for AUV docking
Device Discovery

Node

Network

Node manager

Instrument service

Puck

Flash

Micro

New Sensor

Operator initiates scan

Plug in new sensor
Puck Operation During Device Discovery

Plug in New Sensor

Turn On Power
Puck Operation During Device Discovery

Plug in New Sensor
Retrieve Puck Contents
Turn On Power
Enter Puck Mode
Puck Operation During Device Discovery

Plug in New Sensor
Turn On Power
Enter Puck Mode
Retrieve Puck Contents
Enter Pass Through Mode
Service Connects to Instrument