Secure Data Transfer Using OpenDOF

LCE-EU

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Overview

- Why?
- The OpenDOF Project
  - Object, topology, and security models
- Data collection and manipulation
- Persisting data

Why?

- Data is everywhere, often needs to be centralized
- Often too much data, aggregation closer to the source is beneficial
- Data model should be preserved until the last possible moment
- Network topologies are messy
- Security cannot be ignored

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What is OpenDOF ?

- Open source collaborative project, hosted at https://opendof.org
- Initial contribution by Panasonic, representing over 10 years of development in the IoT space
- No license required, free for commercial use
- Everything you see today is open source and free to use (except JSON Studio)

What is OpenDOF ?

- OpenDOF = Open source specifications and product-ready implementations
  - Object model
  - Topology and connectivity support
  - Security model
- DOF = **D**istributed **O**bject **F**ramework
  - Distributed in terms of object model and network
  - Object-based from the ground up
  - Framework for building applications

OBJECT MODEL

OpenDOF Object Model

- Object
  - A set of uniquely identified capabilities and data
  - Bound to an Object Identifier (OID)
  - Similar to objects in programming languages
  - Different in that the implementation can be distributed over a network

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OpenDOF Object Model

- Interface
  - A defined set of items
    - Properties
    - Methods
    - Events
    - Exceptions
  - Bound to an Interface Identifier (IID)
  - Repository for definitions
    - https://interface.opendof.org

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OpenDOF Identifiers

- Global meaning, optional registration
  - Class determines registration requirements
- Unique data based on class
- Optional attributes based on class
- Specifics determined by context

[3:user@opendof.org] (object, class 3, email)

[2:{d0 67 e5 43 f8 ff}] (object, class 2, MAC address)

[2:{01 07}] (interface, class 2, binary)

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Bindings and Items

- **Bindings** are OID plus IID
- **Items** are Bindings plus item identifier
- Operations require either a binding or an item

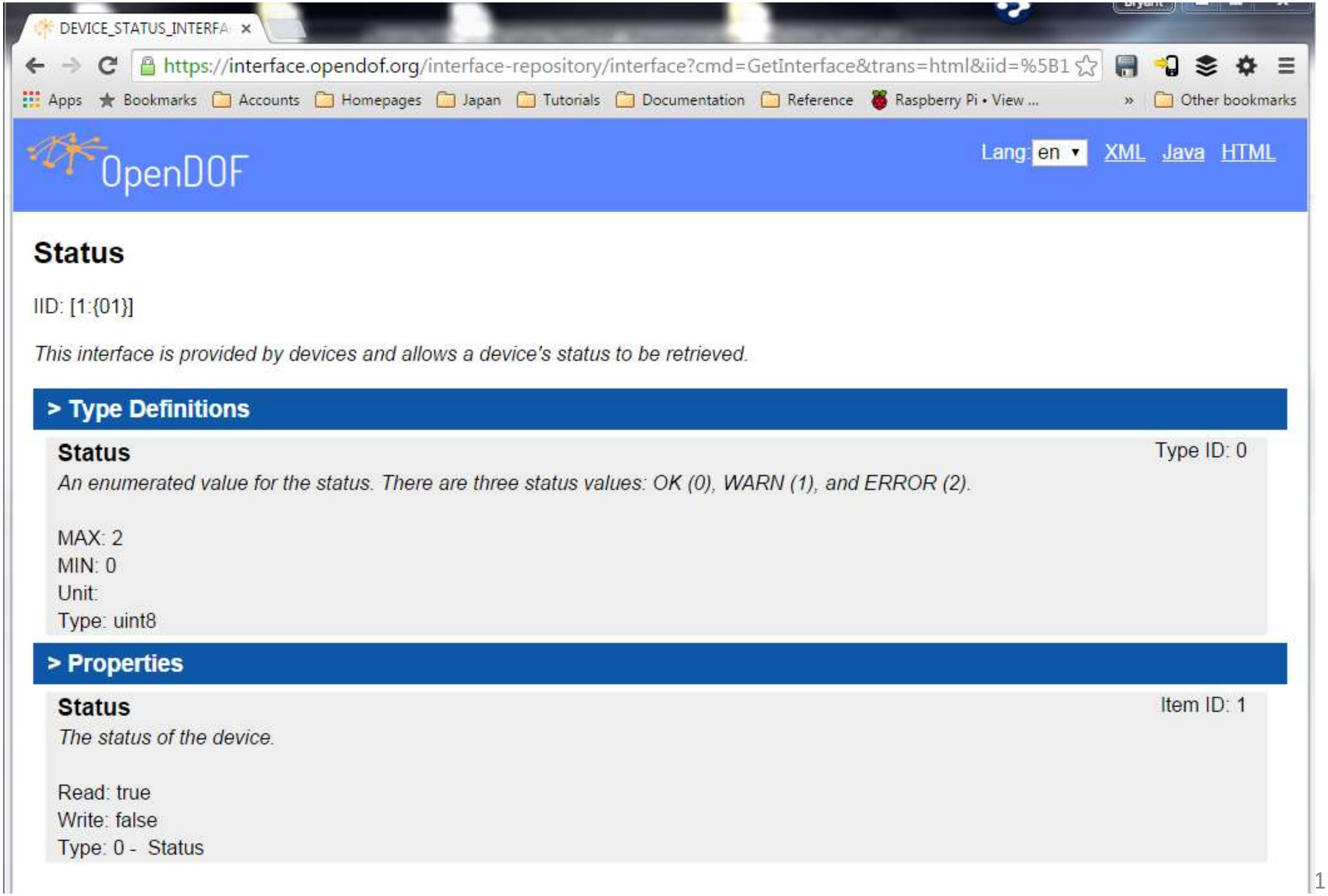
Item 1 of the Status interface of my computer

`DOFObjectID` is [2:{d0 67 e5 43 f8 ff}] (computer MAC address)

`DOFInterfaceID` is [1:{01}] (registered for a ‘status’ interface)

Item identfier is 1 (the item as identified in the interface)

Shareable Interfaces



Status

IID: [1:{01}]

This interface is provided by devices and allows a device's status to be retrieved.

> Type Definitions

Status Type ID: 0

An enumerated value for the status. There are three status values: OK (0), WARN (1), and ERROR (2).

MAX: 2
MIN: 0
Unit:
Type: uint8

> Properties

Status Item ID: 1

The status of the device.

Read: true
Write: false
Type: 0 - Status

Data Transfer Object Model

- Includes
  - Time series data using value sets
  - Events
  - Topology
  - Messages
- We will only be focusing on time series data

TOPOLOGY AND CONNECTIVITY

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DOF

- The DOF is the basis for all communication
- A DOF may route traffic to another DOF
- The following connectivity components may be created from a DOF
  - DOFSystem
  - DOFConnection
  - DOFServer

`DOFSystem`

- Typically the source and destination of operations
- Creates and uses `DOFObject` to represent distributed objects
- `DOFObject` and `DOFSystem` provide the primary API used by application developers

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DOFConnection & DOFServer

- A DOFConnection connects to a DOFServer
- A DOFServer accepts inbound connections
- Once connected, traffic is bidirectional
- The DOF will automatically manage routing of operations as needed
- Any topology is allowed, including redundant links and loops

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Data Transfer Topology

- Data is provided by a **Source**
- Data is consumed by a **Sink**
- Sources and Sinks are hierarchical
- There may be intermediate nodes that are both a Source and a Sink
- Intermediate nodes may do data reduction (aggregation like min/max/average)

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SECURITY MODEL

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Identity

- An identity is a unique persona associated with a secret and permissions
- Identities represent
  - A specialized `DOFObjectID` used as the identifier
  - Secrets (key or password)
  - Granted Permissions

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Domain

- Domain is a managed set of identities
- Security-related information is stored in the domain
- Each domain has a unique identifier
- An Authentication Server (AS) verifies and distributes information about a domain

Permissions

- Permissions allow applications to send and receive operations and data
- Each interaction typically requires two permissions
  - Permission for the request
  - Permission for the response

`DOFCredentials`

- `DOFCredentials` are a combination of a domain, identity, and secret
- `DOFCredentials` can be assigned to a connectivity component
- Communication between connectivity components is limited to the associated permissions

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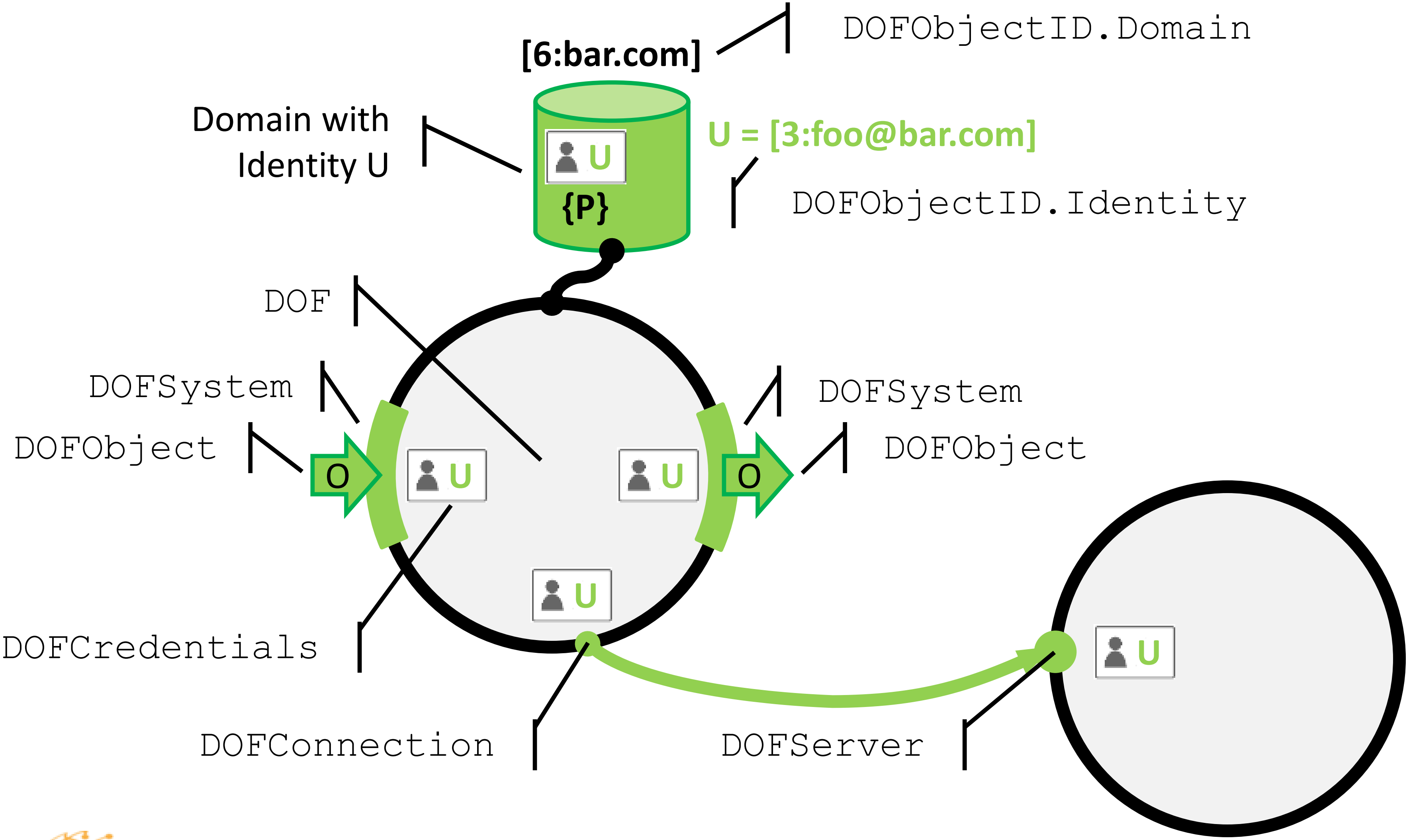
Summary



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DATA TRANSFER

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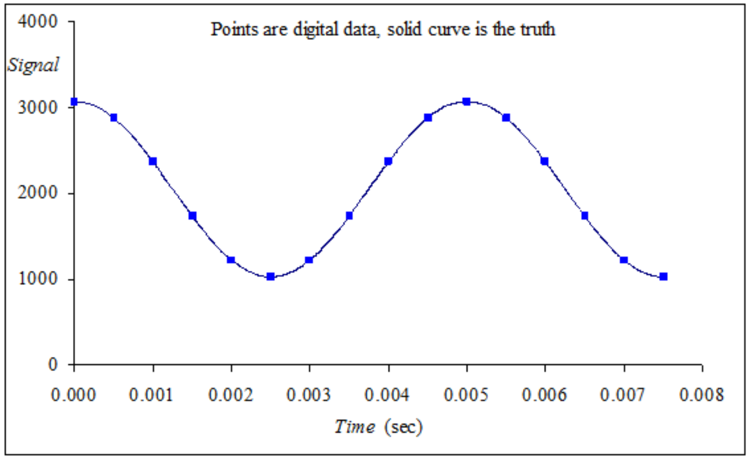
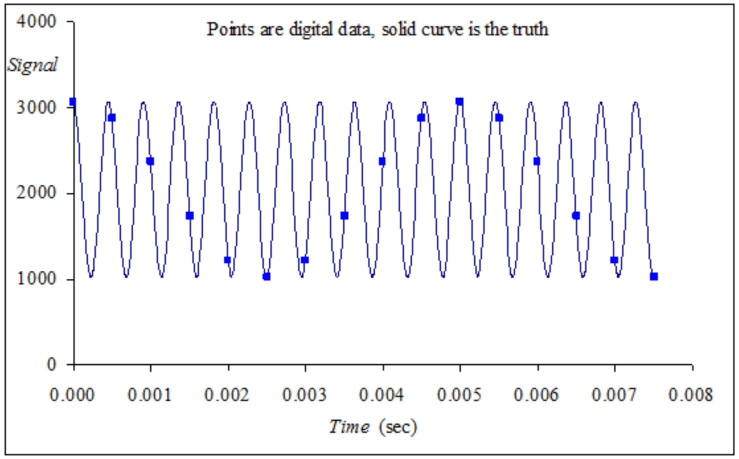
Time-Series Data

- Time-series data is data collected periodically with each sample representing a period
- Time quantum represents the period (slice) of time the data was gathered or aggregated





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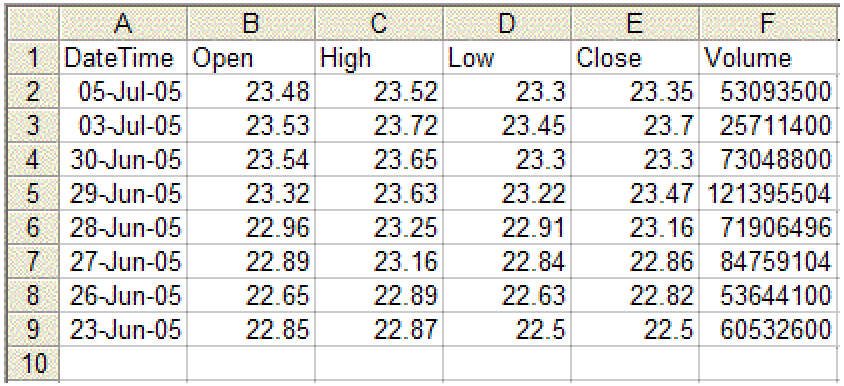
ValueSet

- Used for bulk transfer of time-series data
- *Similar* to a spreadsheet
- Self-contained
- Compresses well



	A	B	C	D	E	F
1	DateTime	Open	High	Low	Close	Volume
2	05-Jul-05	23.48	23.52	23.3	23.35	53093500
3	03-Jul-05	23.53	23.72	23.45	23.7	25711400
4	30-Jun-05	23.54	23.65	23.3	23.3	73048800
5	29-Jun-05	23.32	23.63	23.22	23.47	121395504
6	28-Jun-05	22.96	23.25	22.91	23.16	71906496
7	27-Jun-05	22.89	23.16	22.84	22.86	84759104
8	26-Jun-05	22.65	22.89	22.63	22.82	53644100
9	23-Jun-05	22.85	22.87	22.5	22.5	60532600
10						

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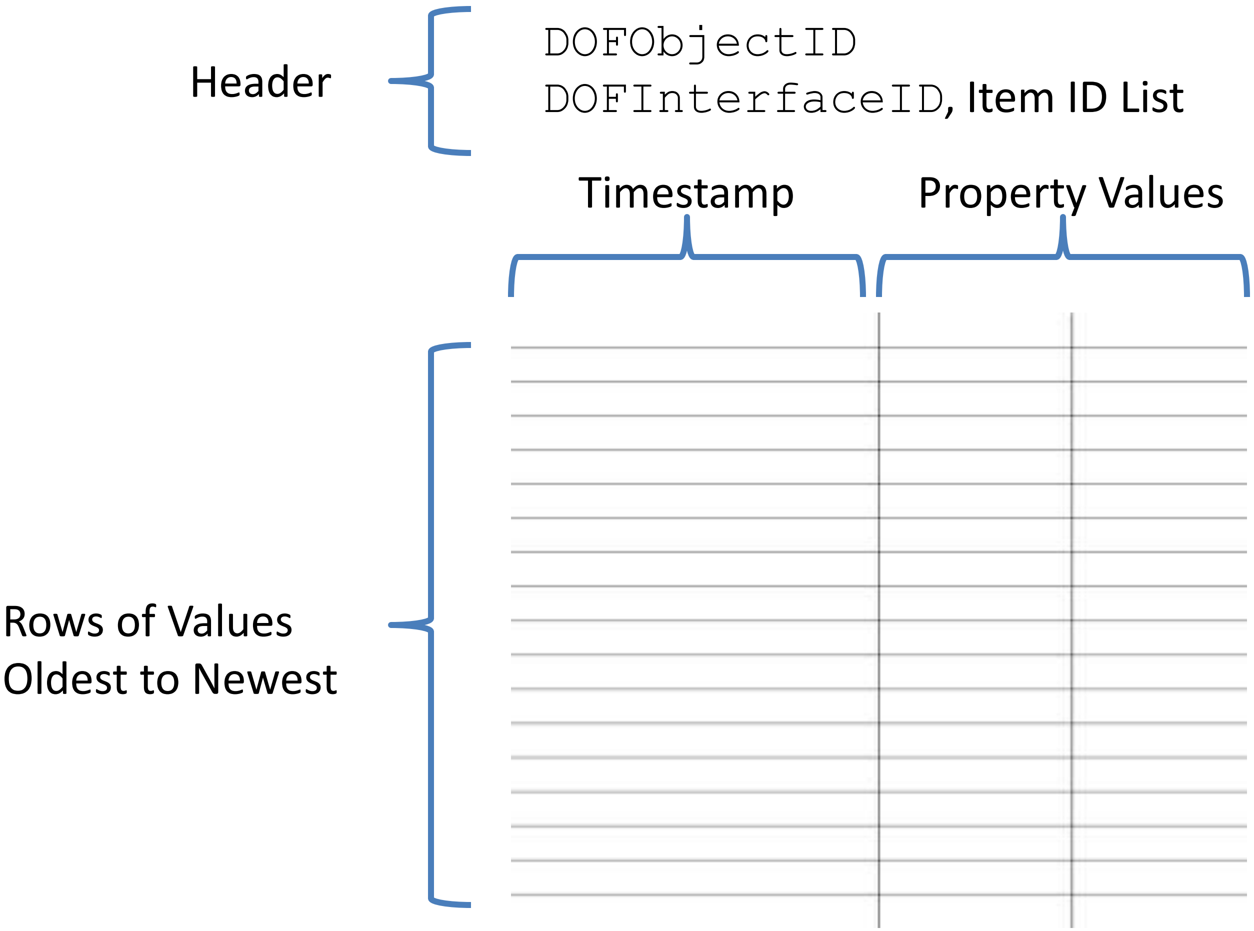
ValueSet Contents



Header

DOFObjectID
DOFInterfaceID, Item ID List

Timestamp

Property Values

Rows of Values
Oldest to Newest

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`ValueSet` Header Contents

- Specifies the source object identifier
- Specifies each included property
  - Interface ID
  - Item ID
  - Type information
  - Aggregation Method (e.g., Min)
- Specifies the source parent and position

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`ValueSet.Row` Contents

- Timestamp for data in the row
- Data values for the properties
- A sample count for each value
- Flag for missing data

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Data Collection and Delivery Rates

- Each value set can contain data collected over a long period of time
- High data collection rates increase accuracy but also increase data size
- Low data delivery rates increase compressibility but also increases latency
- Each application needs to determine the appropriate balance

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DEMONSTRATION AND Q&A

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Example Source

```
@Override
public void persistValueSet( Sink sink, DOFObjectID source,
                             ValueSet valueSet ) {
 DOFObjectID deviceID = valueSet.getDeviceID();
 Date firstTime = valueSet.getFirstTime();
 Date lastTime = valueSet.getLastTime();
 DOFObjectID parentID = valueSet.getParentID();
 Integer topologyPosition = valueSet.getPosition();
 int quantum = valueSet.getTimeQuantum();
 ValueSet filteredValueSet = valueSet.filter( definition );
 if ( filteredValueSet != null ) {
  for ( ValueSet.Row row : valueSet.getRows() ) {
   // Process values in the row
  }
 }
}
```

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Demonstration

- Replay historical weather data from NOAA
- Local source and sink, but fully cloud-capable
- Data persisted locally to MongoDB
- Analytics with JSON Studio from jStudio
  - Commercial software

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Q&A

Feedback is appreciated, email **admin@opendof.org**

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Glossary

Authentication Server (AS) – A specialized server that represents a Domain and manages OpenDOF security

Binding – The combination of a DOFObjectID and a DOFInterfaceID, respresenting the name of functionality in the network

Domain – A collection of Identities representing security configuration

DOF – Distributed Object Framework, both the name of a class and a technology

DOFConnection – A class that represents a connection between two DOFs

DOFCredentials – A class that represents the combination of a domain, identity, and secret

DOFInterface – A class that represents the definition of functionality provided by an Object

DOFInterfaceID – A class that represents the unique identifier for each Interface

DOFObject – A class that represents an Object

DOFObjectID – A class that represents the unique identifier for each Object

DOFServer – A class that represents the ability of a DOF to accept inbound connections

DOFSystem – A class that represents the association of a DOFObject to a DOF

Glossary

Identity – A unique persona used in security configuration that represents a user or device with its associated permissions

Interface – Defined functionality provided by an Object

Interface Identifier – A unique identifier that represents an Interface

Item – Individual features of an Interface such as Properties and methods

JSON – An unstructured data representation associated with JavaScript but used more widely

Object – A defined set of functionality provided by Interfaces and bound to an Object Identfier

Object Identifier – A unique identifier that represents an Object

OpenDOF – An open-source project that provides implementation and specifications of the distributed object framework

Property – A Interface Item that represents data

Sink – The consumer of ValueSets in the OpenDOF data transfer libraries

Source – The creator and provider of ValueSets in the OpenDOF data transfer libraries

Value Set – A collection of time-series data associated with an Object over a given time period

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