Using the Gateway Exchange Protocol

Tutorial Session 2

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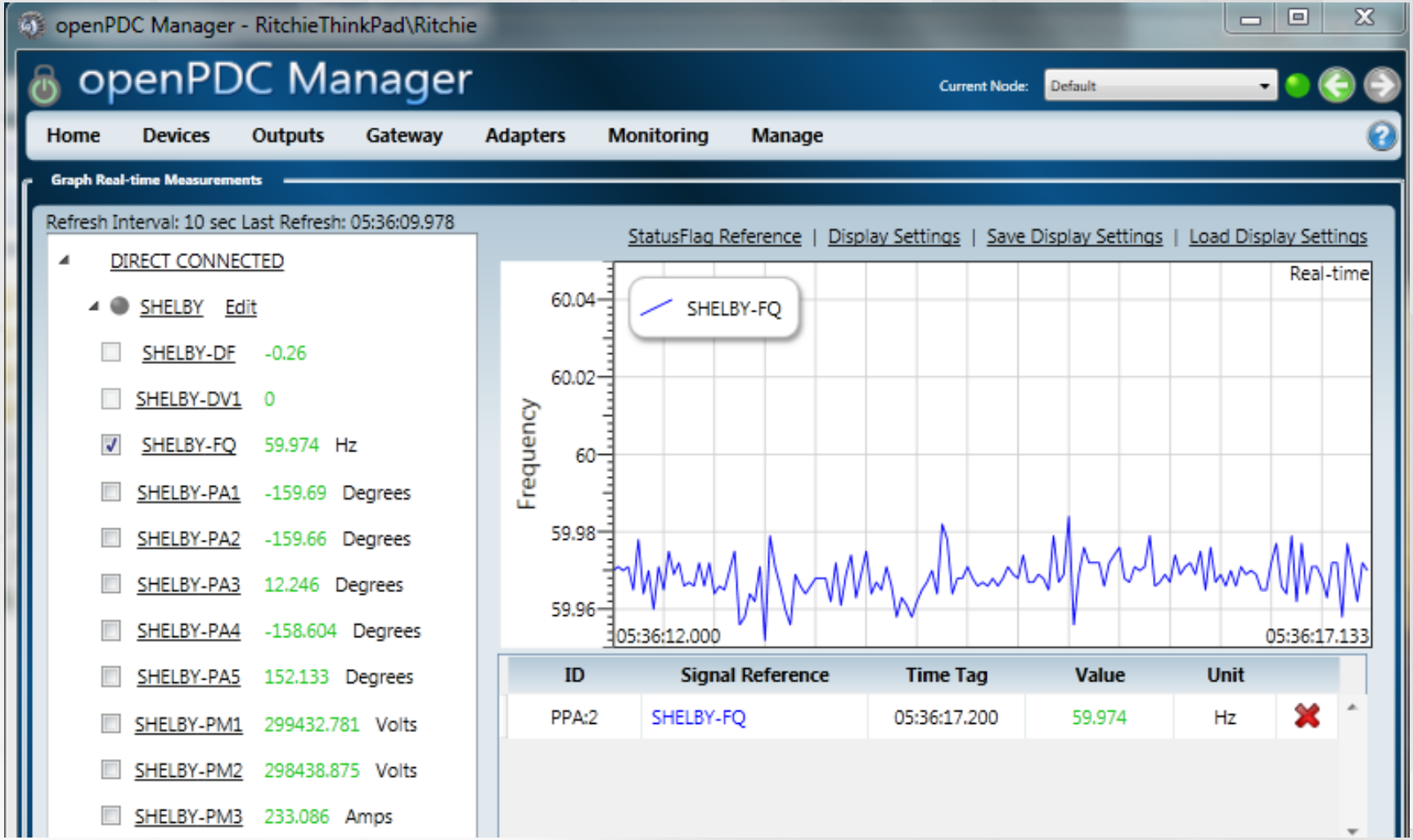
Subscribing to Measurements



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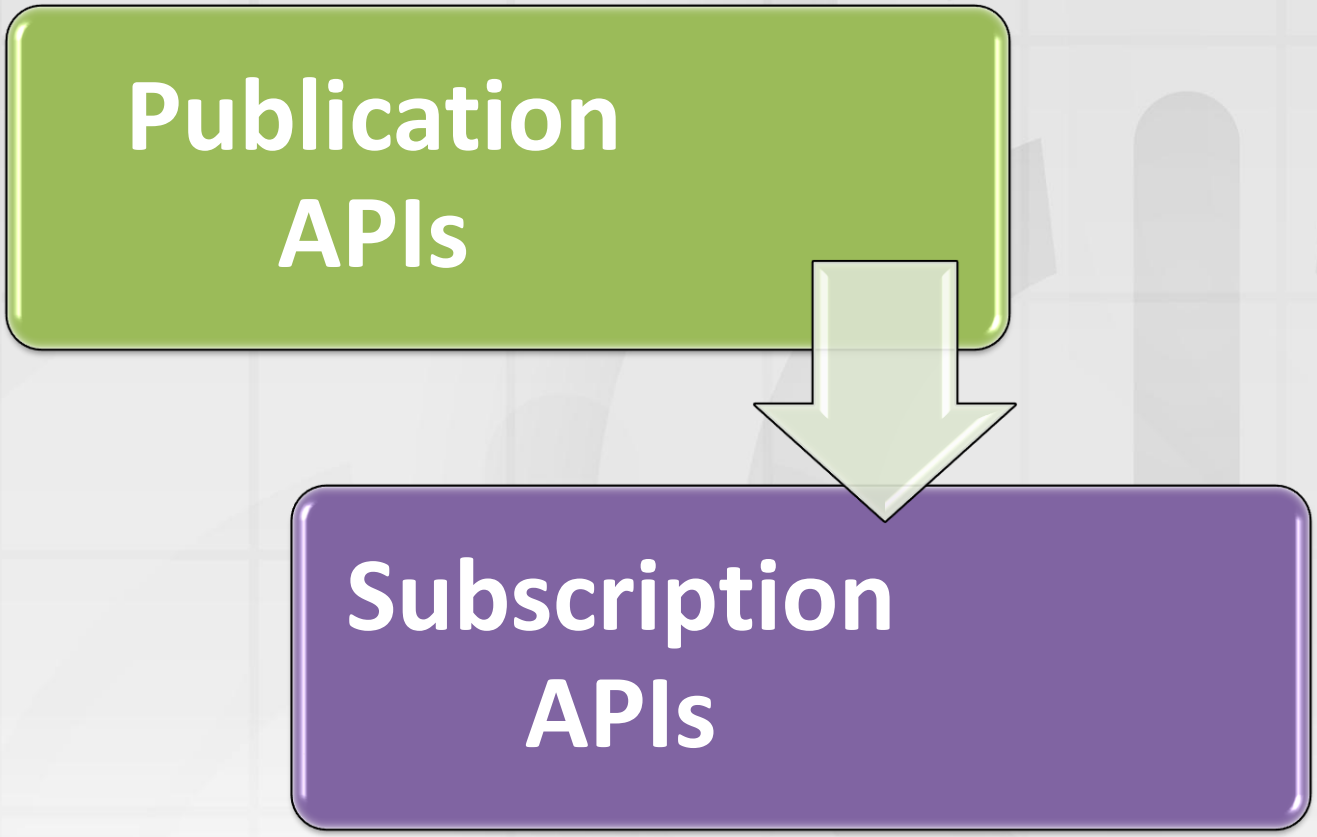
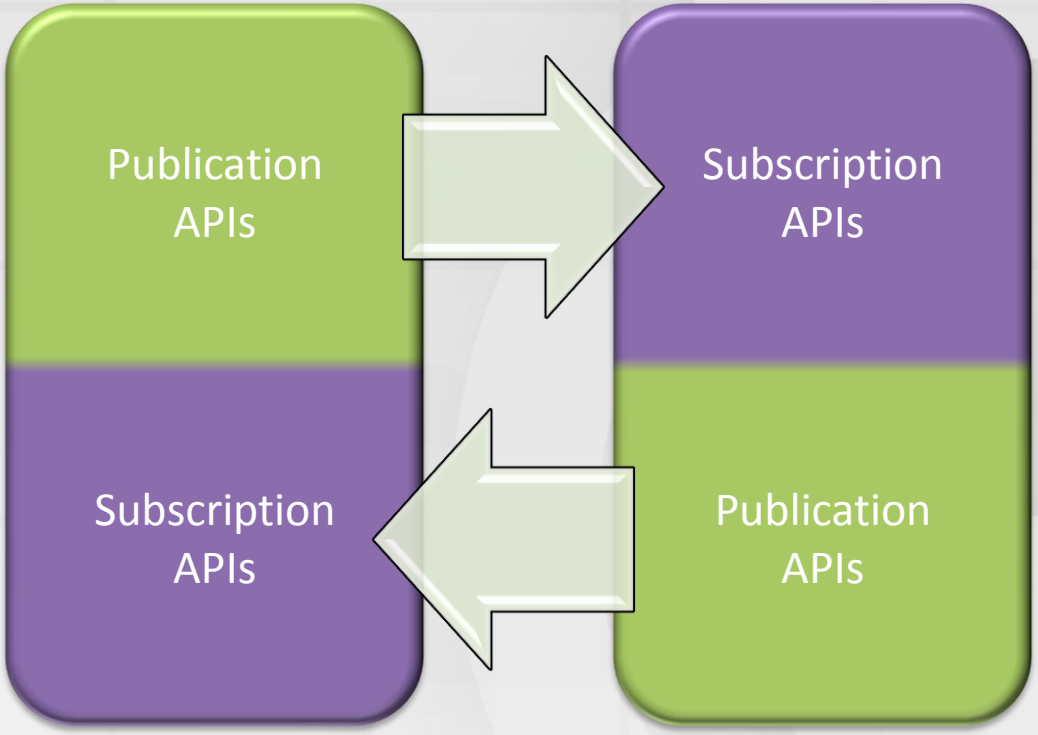
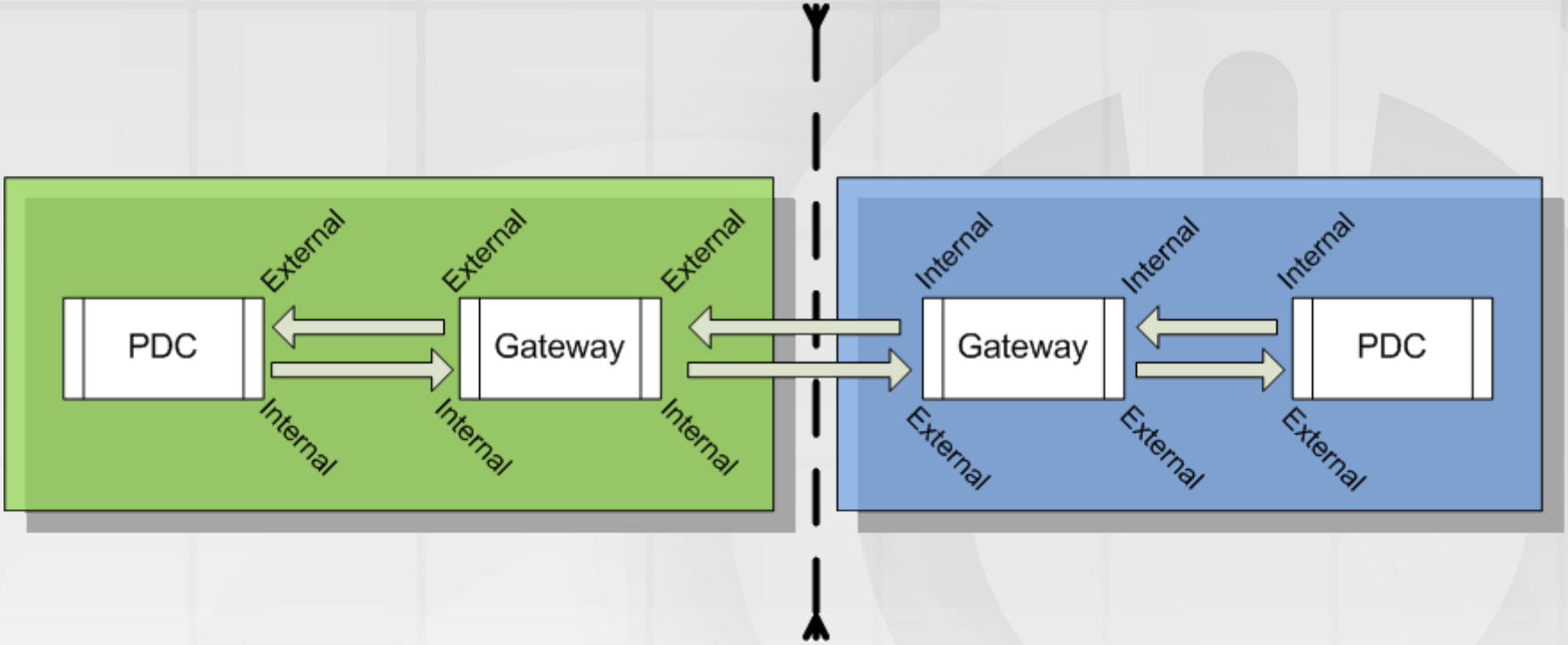
Primary Data Flow



Primary Data Flow (cont.)



Internal/External



Gateway Exchange Protocol (GEP)

- GEP is an extremely simple, small and fast wire format than can be used to exchange data points without a fixed predefined configuration – that is:
  - Points arriving in one data packet can be different than those arriving in another data packet. This can be due to each point having a different delivery schedule – or a dynamic schedule (e.g., alarms).
- GEP is a signal level publish/subscribe protocol with two available channels:
  - ***Command Channel (TCP)***
  - ***Data Channel (UDP or TCP)***

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Synchrophasor Data Protocol Comparisons

	IEEE C37.118	IEC 61850	GEP
Deployment Zones *Today*	Substation Control Center Inter-company	Substation Control Center	Control Center Inter-company
Preconfigured Data Packet Format	Yes	Yes – but client definable	No
Security Options	No	Yes	Yes
Signal Level Publish / Subscribe	No	Yes – but not dynamic	Yes

Example Interoperability Layers

Utility Layer	Example	Challenges
Inter-Reliability Coordinator	GEP	• High Volume at Low Latency • Dynamic Configuration
Inter-Operating Center	GEP IEEE C37.118	• Configuration Management
Control Center	GEP IEEE C37.118	• System Integration
Device / Substation	IEEE C37.118 IEC 61850	• Device interoperability • Device performance

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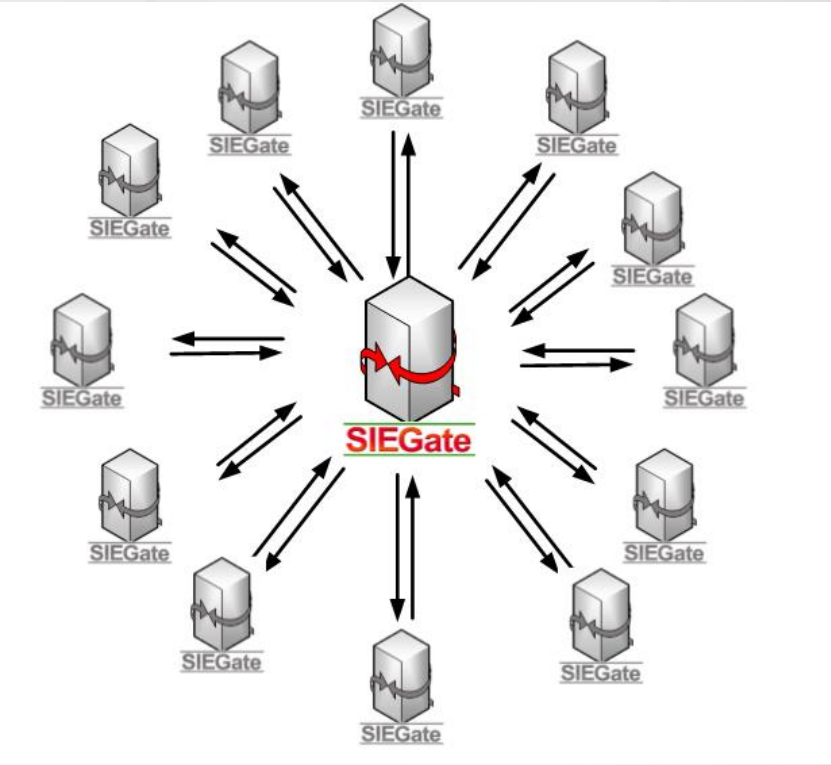
What are the requirements?

- GEP must move a *continually variable* set of points at low latency – to be successful, around 1 million points per second.



- 1 million assumes 12 associations and 100 PMUs (in and out)
  = ~ 0.5 M points in / sec
  ~ 0.5 M points out / sec
- As of SIEGate 1.0 and openPDC 2.0, over 3,350,000 measurements per second can be accommodated.

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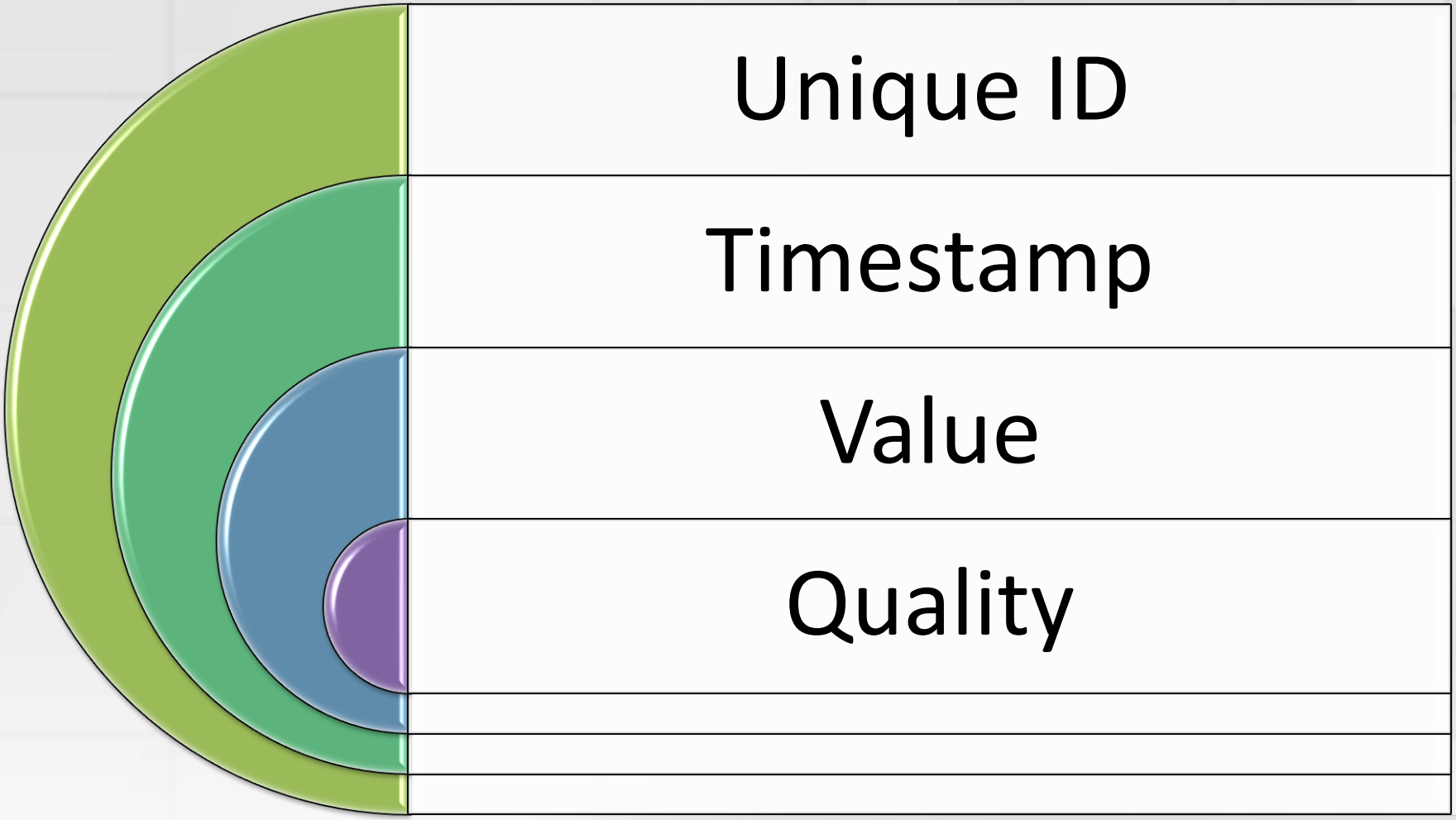
Moving Measurement Data



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Simple Optimizable Structure

- Measurement data is well structured and can be safely condensed into a simple data structure (per signal):
  - 16-bit ID (established at connection)
  - Time (condensed where possible)
  - Value (32-bit real number)
  - Flags
- A highly effective lossless data compression is optionally enabled for the time-series data:
  - Implements an Xor based back-tracking compression algorithm to remove repeating bytes

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Buffer Block

- Buffer block measurements define a block of data, rather than a simple measurement value
- GEP can transmit buffer blocks to transfer serialized data in chunks
- SIEGate uses buffer blocks for file-based transfers through GEP

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Options for Connecting with GEP

- To get data “into” an application you can use GEP using a variety of API options:
  - C++
  - Java
  - .NET
  - Mono.NET
  - Unity 3D

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GEP Security Modes

- Transport Layer Security Mode
  - TCP command channel is secured using TLS – certificates exchanged out of band
  - Optional UDP data channel is secured using rotating keys exchanged over TLS command channel
  - Measurement access restricted on a per subscriber basis
- Gateway-to-Gateway Security Mode
  - TCP command channel is secured using symmetric AES encryption – keys exchanged out of band
  - Optional UDP data channel is secured using rotating keys exchanged over encrypted command channel
  - Measurement access restricted on a per subscriber basis
- Internal Access Mode (No Encryption)
  - Data transferred openly (ideal for internal connections or VPN transfers when connection is already encrypted)
  - Measurement access is unrestricted

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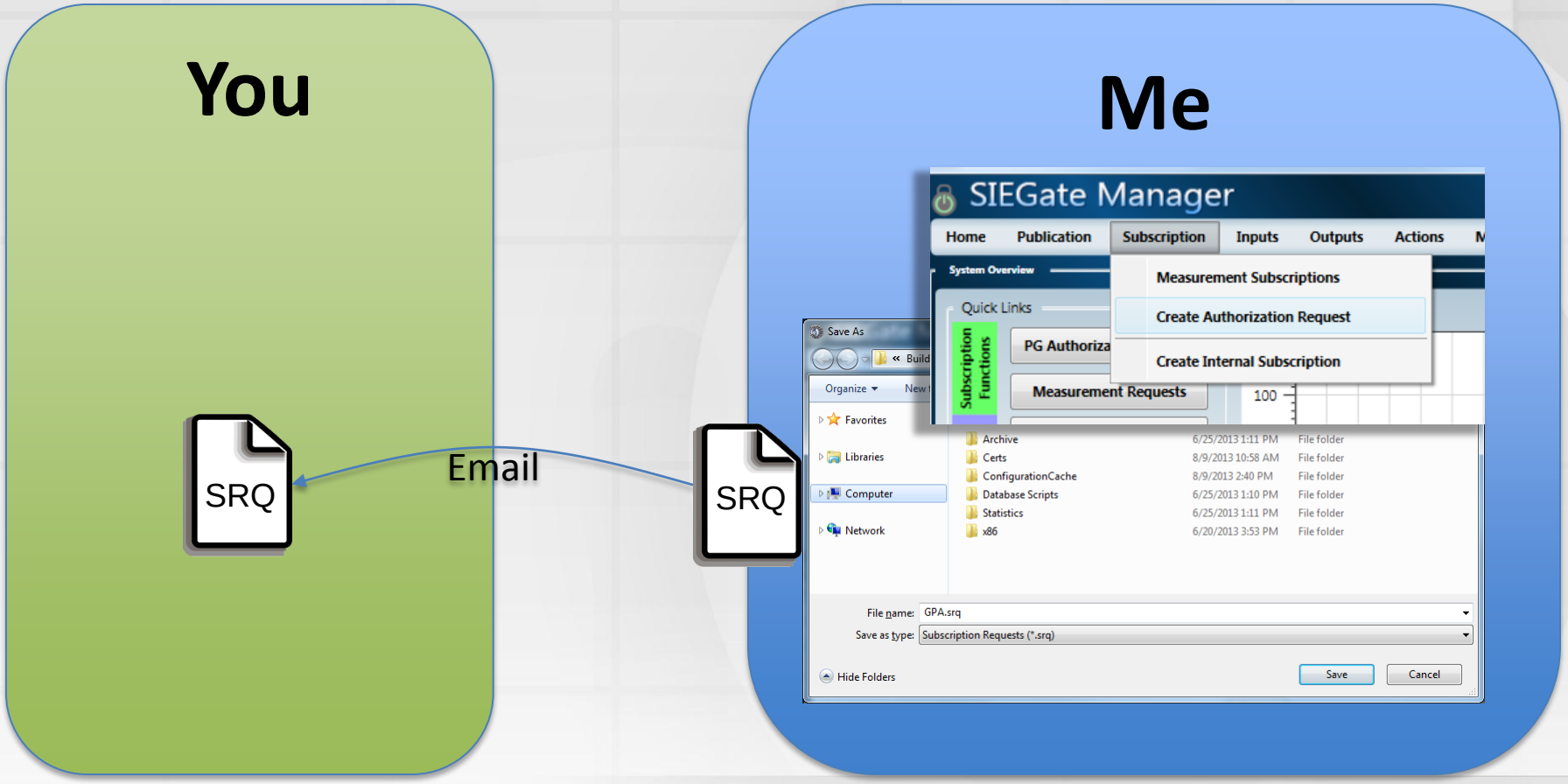
Steps to Exchange Data

1. **Subscriber creates an authorization request**
   - Generates an SRQ file
   - Send the SRQ file out-of-band (email, thumb drive, CD, etc.)
2. **Publisher imports SRQ file**
   - Authorizes subscriber to connect, but still cannot subscribe
3. **Publisher authorizes subscriber to subscribe to measurements**
   - Publisher can control which measurements that subscriber can see
4. **Subscriber subscribes to measurements**
   - Subscriber can control which measurements that subscriber needs to see

Subscriber Creates an Authorization Request



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Publisher Imports SRQ File

You

Publisher Authorizes Subscriber to Subscribe to Measurements

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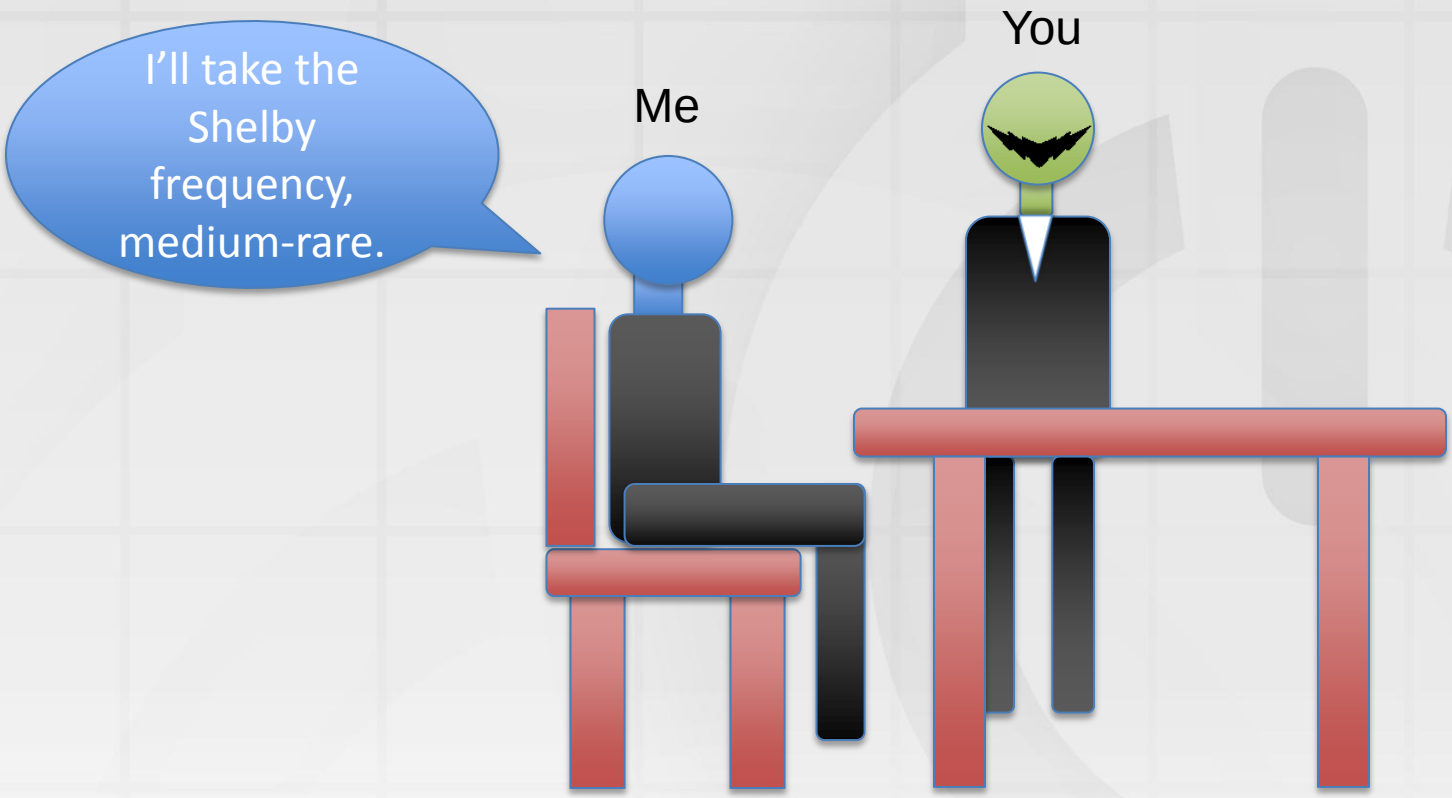
Subscriber Subscribes to Measurements



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DataPublisher API Usage

Purpose:
SEND

- **Attach to publisher events**
- **Initialize publisher**
- **Start publisher**
- **Queue new measurements for processing**

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Example DataPublisher API Code

```
namespace DataPublisherTest
{
    class Program
    {
        static DataPublisher publisher = new DataPublisher();
        static Ticks lastDisplayTime;
        static object displayLock = new object();

        static void Main(string[] args)
        {
            // Attach to publisher events
            publisher.StatusMessage += publisher_StatusMessage;
            publisher.ProcessException += publisher_ProcessException;
            publisher.ClientConnected += publisher_ClientConnected;

            // Initialize publisher
            publisher.Name = "dataPublisher";
            publisher.UseBaseTimeOffsets = true;
            publisher.Initialize();

            // Start publisher
            publisher.Start();

            ThreadPool.QueueUserWorkItem(ProcessMeasurements);
```


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DataSubscriber API Usage

Purpose:
Receive

- **Attach to subscriber events**
- **Set up subscription info objects**
- **Initialize subscriber**
- **Start subscriber connection cycle**
- **Handle new measurement data**

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Example DataSubscriber API Code

```
static void Main(string[] args)
{
    if (args.Length < 2)
    {
        Console.Error.WriteLine("Error: requires two command line arguments");
        Console.Error.WriteLine("       1. hostname of publisher");
        Console.Error.WriteLine("       2. port used to initiate connection");
        return;
    }

    // Set up subscription info object
    unsynchronizedInfo.FilterExpression = "FILTER ActiveMeasurements WHERE SignalID LIKE '%'";

    // Attach to subscriber events
    subscriber.StatusMessage += subscriber_StatusMessage;
    subscriber.ProcessException += subscriber_ProcessException;
    subscriber.ConnectionEstablished += subscriber_ConnectionEstablished;
    subscriber.ConnectionTerminated += subscriber_ConnectionTerminated;
    subscriber.NewMeasurements += subscriber_NewMeasurements;

    // Initialize subscriber
    subscriber.OperationalModes |= OperationalModes.UseCommonSerializationFormat |
        OperationalModes.CompressMetadata |
        OperationalModes.CompressSignalIndexCache |
        OperationalModes.CompressPayloadData;

    subscriber.ConnectionString = string.Format("server={0}:{1}", args[0], args[1]);
    subscriber.Initialize();

    // Start subscriber connection cycle
    subscriber.Start();
```


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Live Demos

- *Subscribing from a .NET C# application*
- *Subscribing from a C++ application (Linux)*
- *Subscribing from a Java application*
- *Subscribing from the Unity platform*

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