Towards a Unified Monitoring and Performance Analysis System for the Grid

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AURORA

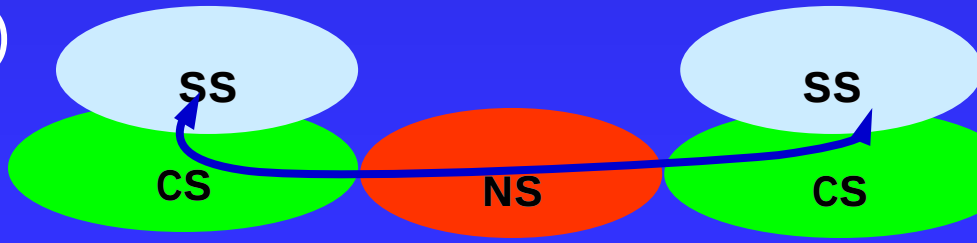
APART

Outline

- Grid in our view
- SCALEA-G Architecture
- Sensor and Sensor Manager Service
- Instrumentation
- Data Subscription and Query
- Prototype
- Summary

Grid Services

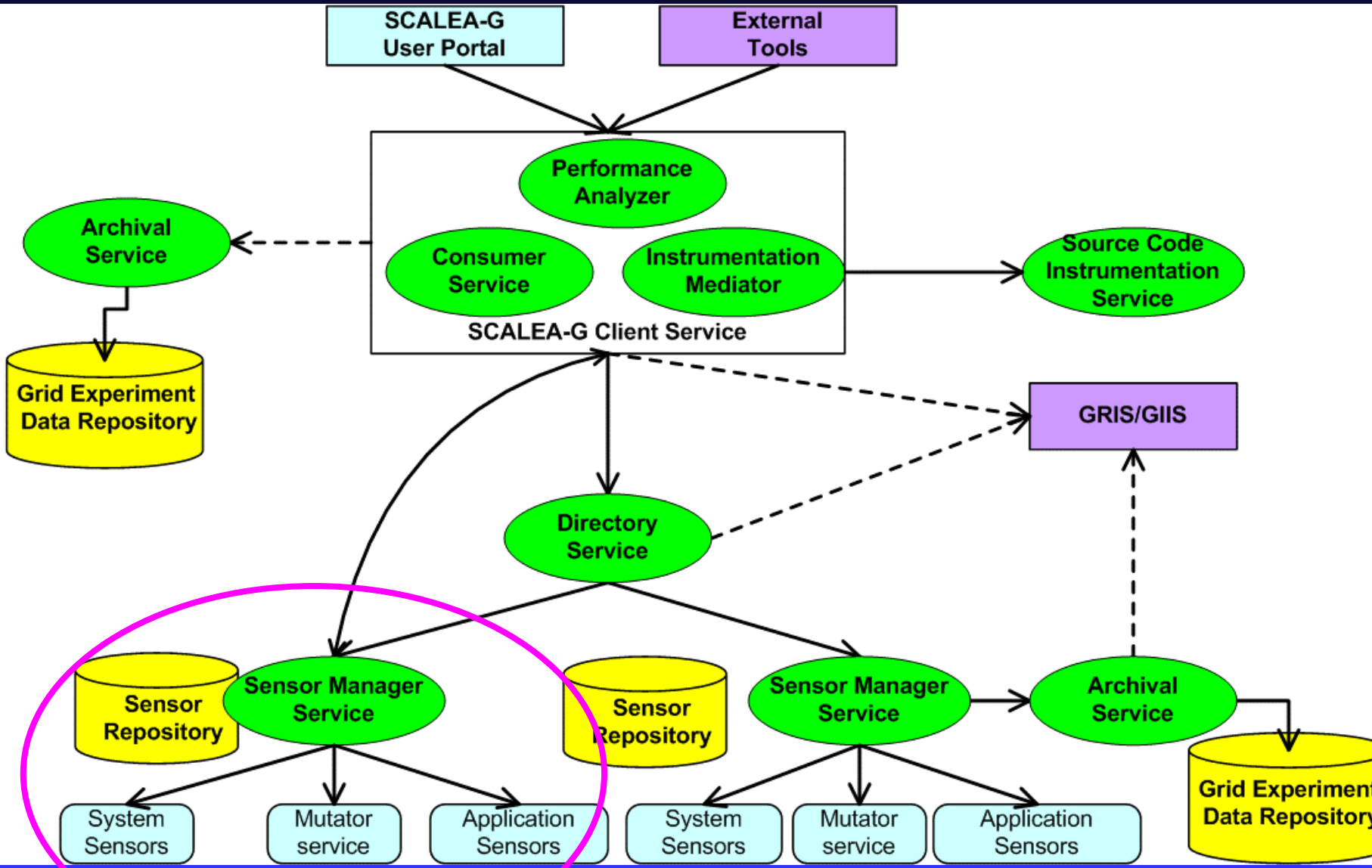
- Grid systems
  - Collection of grid services
- Grid services
  - Web service that provides a set of well-defined interfaces (e.g. addressed discovery, dynamic service creation, lifetime management, notification, manageability) and that follows specific conventions (e.g. addressed naming, upgrading) in the Grid.
- Types of Grid services
  - Computational services(CS). E.g. computational hosts
  - Network services (NS). E.g. network connections
  - Software services (SS)



SCALEA & SCALEA-G

- SCALEA
  - Performance Instrumentation, Measurement, Analysis and Visualization for Parallel Applications
  - Main focus: Fortran OpenMP/MPI on Clusters
- SCALEA-G (SCALEA Grid-enabled)
  - Unified system of monitoring and performance analysis for Grid Services
    - Computational services, network services and software services
    - Based on GMA (Grid Monitoring Architecture) and OGSA (Open Grid Service Architecture)
  - Providing meaningful performance data to external tools/software

SCALEA-G Architecture



Combining GMA and OGSA

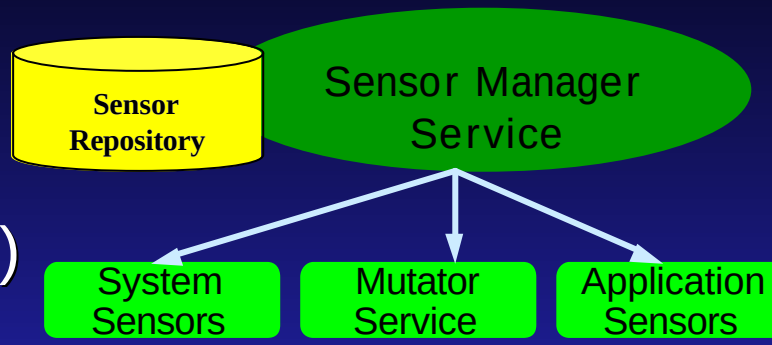
- Support both push (via subscribe) and pull (via query) model.
- Control operations: to control activities, to register information, to subscribe and query data.
  - Based on Grid services operations
- Data Channel: to deliver real subscribed data, results of requests
  - Use a separate data stream connection.
- All are implemented as OGSA-Enabled Grid services
  - Deployed on different sites & shared by multiple users
  - Used by different external tools

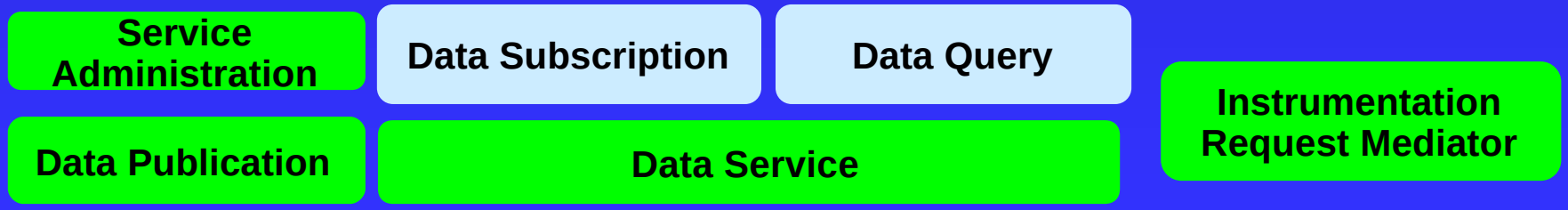
Directory Service and Archival Service

- SCALEA-G Directory Service
  - Store information about Sensor Managers, sensors, properties of data provided by sensor instances, consumers
  - Employ a relational database (PostgreSQL)
- Archival Service
  - Extension of SCALEA Experiment Repository
    - Raw data provided by sensor instances
    - Analyzed data provided by analysis services
- Open problem:
  - Data is organized in distributed manner
  - Data has to be represented in a semantic way so that external tools/software can easily and automatically use the data: ontology?

SCALEA-G Sensor Manager Service

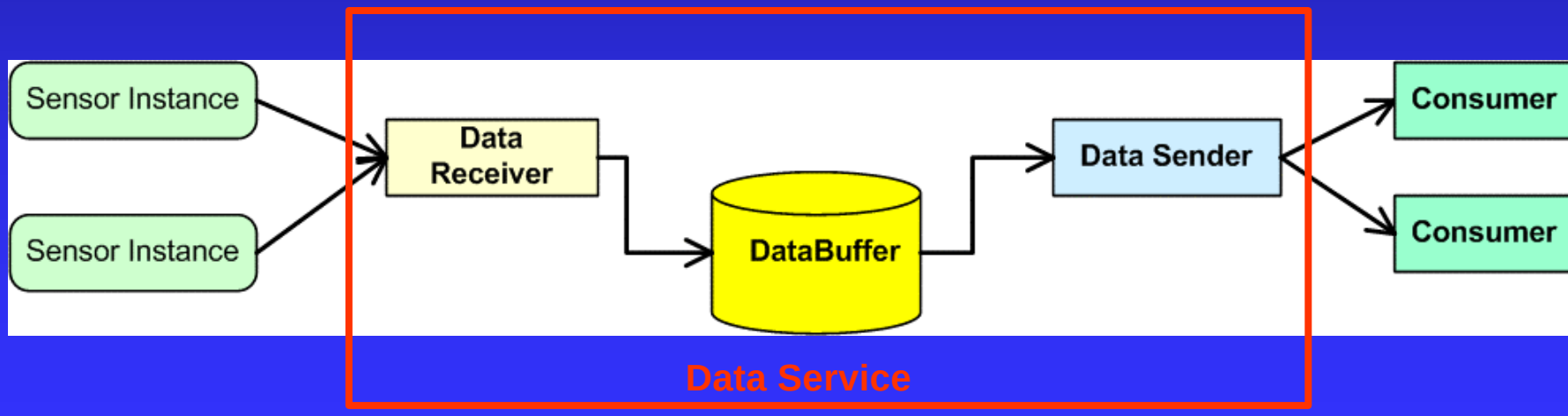
- Components
  - Service Administration
  - Data Subscription (push model)
  - Data Query (pull model)
  - Data Publication (publish data)
  - Instrumentation Request Mediator
  - Data Service





Sensor Manager Service: Data Service

- Data delivery is carried out via Data Service
- Data is cached and filtered at Sensor Manager Service (SMS)
- There is only one connection from SMS to consumer



Sensors

A sensor is a component that performs measurements

- Classification
  - System sensors are used to monitor Grid computational services and Network services
  - Application sensors are specific codes embedded in Grid software services to measure execution behaviors of code regions, to monitor events of these services, etc.
- Static and dynamic properties
  - Unique sensor identifier
  - Public XML Schema for measurements
  - Lifetime (start, end)
  - ...

System Sensors & Sensor Repository

- System sensors
  - Monitor computational services and network services
    - Networks link, hard disks, memory usage, CPU availability
  - Exploit existing tools: extracts information from existing providers, e.g. MDS, NWS
  - Network metrics
    - Based on work of Grid Network Measurements Working Group (http://www-didc.lbl.gov/NMWG/)
    - Close to applications, e.g path metrics at transport layer (TCP, TSL), application protocol (HTTP, SOAP)
- Sensor repository
  - Collection of system sensors, add-on ability
  - Represented in XML
  - System sensors can be invoked by Sensor Manager Services

Sensor Name	Monitored Object	Description
host.cpu.used	host	The average, over the last minute, of the amount of time that processors of this system were not idle
host.predict.cpu.used	Host	The prediction of CPU usage
host.mem.used	Host	Ratio of used memory
host.predict.mem.used	Host	The prediction of memory used ratio
host.system.loadagv	Host	System Load average
path.bandwidth.capacity.TCP	Network	TCP bandwidth capacity
path.predict.bandwidth.capacity.TCP	Network	Prediction of TCP bandwidth
path.delay.oneWay	Network	One way delay for IP packet
path.delay.roundTrip	Network	Round trip delay for IP packet
path.delay.roundtrip.TCP	Network	Round trip delay for TCP packet

The same work should be done for high-level network metrics e.g. (SOAP, HTTP)

Sensor Repository

```
<sensor name="host.mem.used">
    <impl>scaleag.sm.sensor.Mem</impl>
    <desc>Measure ratio used memory of a host</desc>

    <properties>
      <![CDATA[
        <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
         ...
         <xsd:element name="sensordata" type="SensorData"/>
            <xsd:complexType name="SensorData">
             <xsd:sequence>
               <xsd:element name="hostname"  type="xsd:string"/>
               <xsd:element name="eventtime" type="xsd:dateTime"/>
               <xsd:element name="availmem"  type="xsd:double"/>
               <xsd:element name="usedmem"   type="xsd:double"/>
            </xsd:sequence>
          <xsd:attribute name="name" type="xsd:string"/>
       </xsd:complexType>
       </xsd:schema>
         ]>]]>

     </properties>
    <params>
          <param name="Interval" desc="second“ dataType="int"/>
     </params>
</sensor>
```

Application Sensors

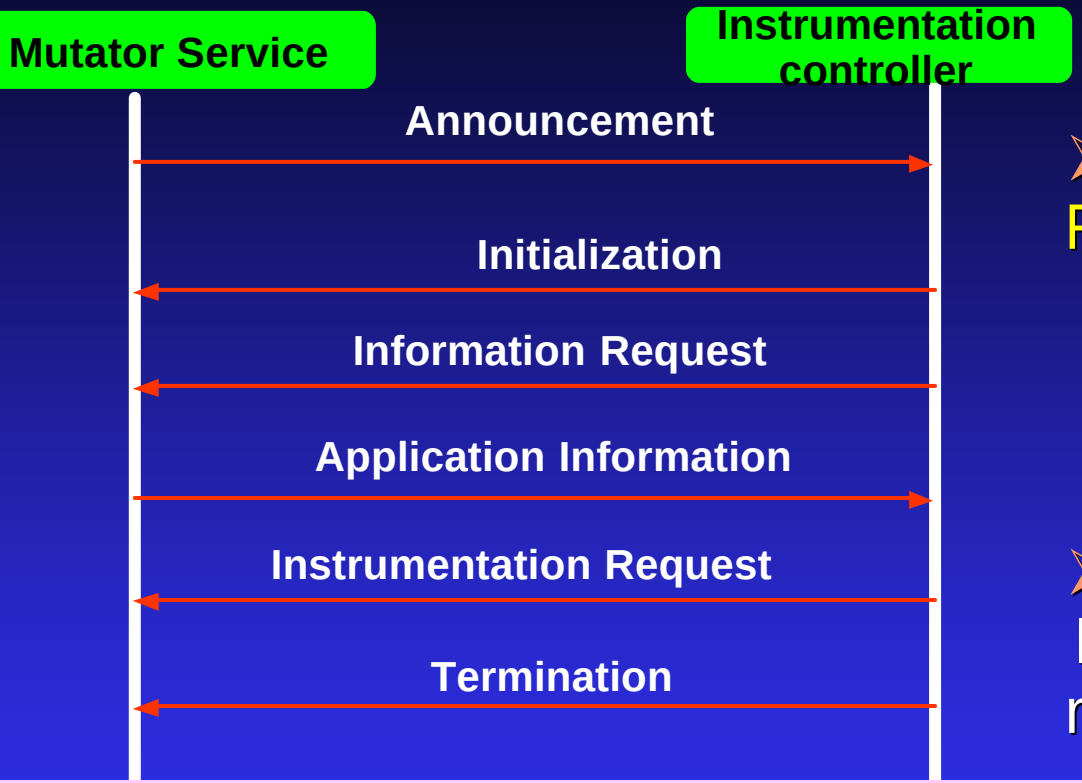
- How sensors are embedded into software services
  - Source code/byte code instrumentation service
    - Fortran (Source code), Java (byte code)
    - Investigate ARM (Application Request Management) standard for Grid service
  - Dynamic instrumentation :
    - Mutator service is created by application process
      - Created by user process
      - Number of mutators is controlled by user (via function calls, environment variables)
    - Mutator service runs as a separate service
      - Used by multiple users
      - One instance per node per user
- Data collected online
  - Profiling & tracing data
  - XML representation
  - Low level and high level metrics

Application Sensor Data

```
<sensordata name="app.trace">
    <coderegion> … </coderegion>

    <processingunit> … </processingunit>
    <events>
            <event eventname="FOO_CALL">
                <eventtime>106156729528</eventtime>
                <eventdata attrname="CALLEE"
                                attrvalue="ServiceB/FOO"/>
            </event>
    </events>
 </sensordata>
```

```
<sensordata name="app.prof">
    <coderegion> … </coderegion>

    <processingunit> … </processingunit>      <metrics>
      <metric name="CTIME"  value="8.0962703E7"/>
      <metric name="WTIME"  value="2.61909657E8" />
     </metrics>

  </sensordata>
```

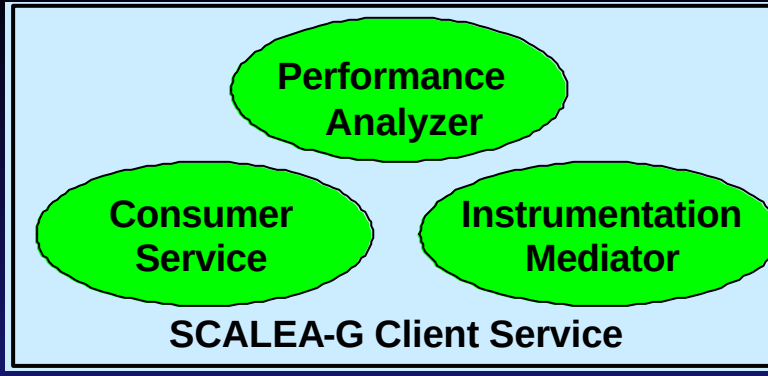
Dynamic Instrumentation Request



- Instrumentation Request Language (IRL)
  - XML based
  - C++/Java based on Xercers XML library
- Any tool that supports IRL can work with mutator service

```
<?xml version="1.0" ?>
<irl>
    <request name="instrument">
      <processingunit computationalNode="gescher" … />
      <task coderegions="MPI_Reduce" metrics="WTIME,L2_TCA" />
    </request>
 </irl>
```

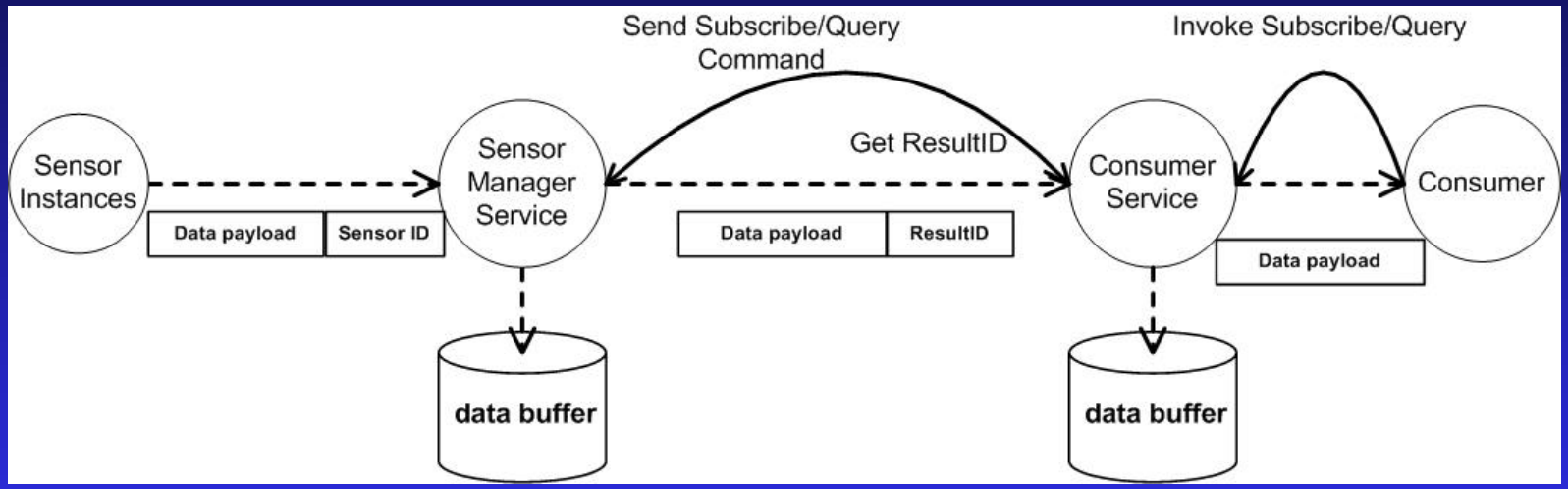
SCALEA-G Client Service



- Consumer Service
  - Control activities of sensor manager services and sensors
  - Register information to directory service
  - Subscribe/unsubscribe and query data
- Instrumentation Mediator: Act as intermediary agent in communicating between users/tools with
  - Source Code Instrumentation Service (based on SCALEA Instrumentation Service)
  - Dynamic instrumentation service
- Performance Analyzer
  - Analyze collected data provided by Consumer Service and provide the result to the user

Data Subscription and Query

- Message Propagation uses simply tunnel protocol

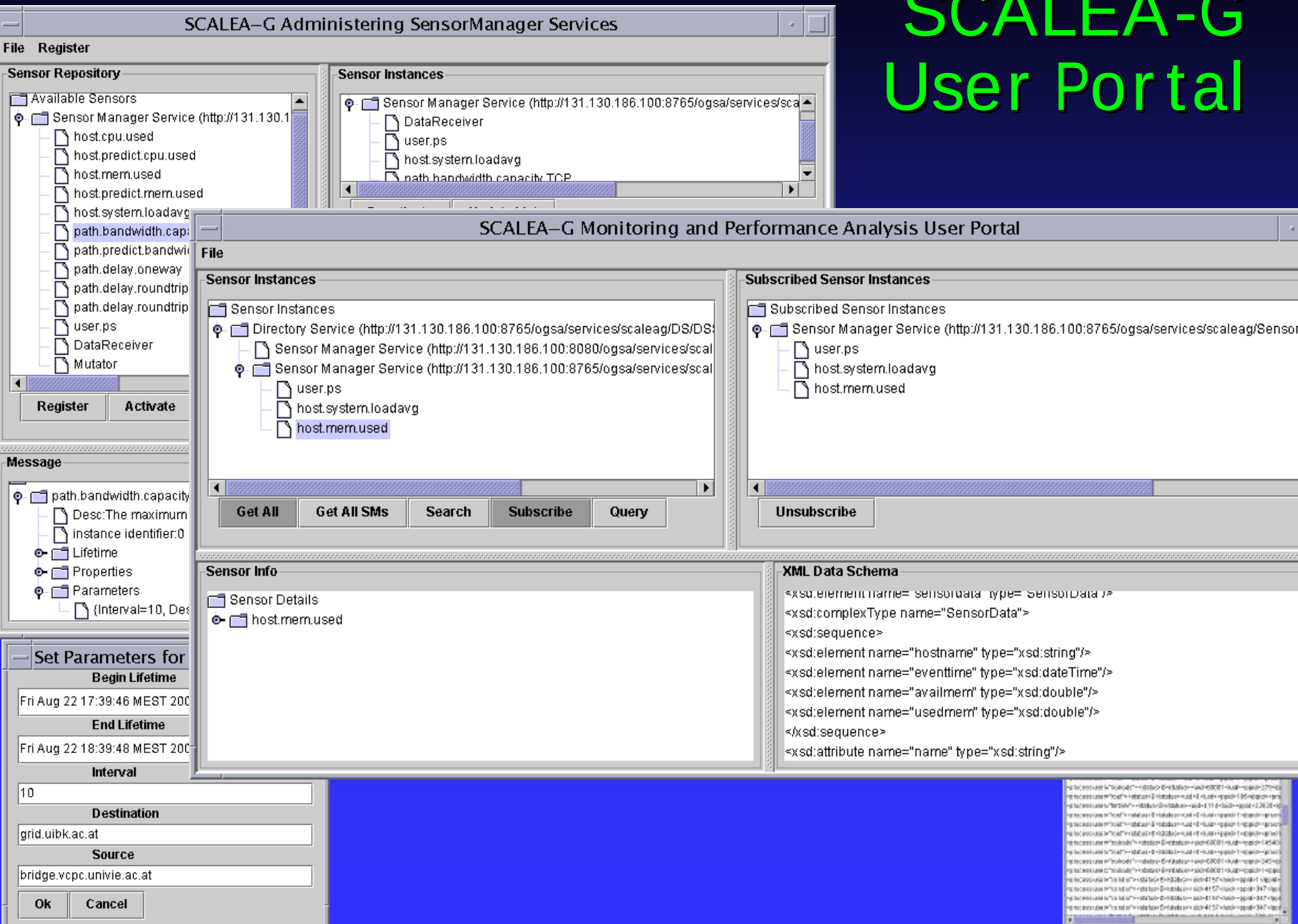


- Pull and Push Request
  - Consumer has XML Schema specifying data provided by sensors
  - Consumer builds Pull/Push request in XML based XPath/XQuery

Security Issues

- Authentication & Authorization
  - Performed in several actions such as registration, subscription, control of activities
  - Carried out by GSI (Globus) with user's X.509 certificate
- Shared SCALEA-G services
  - The administration can define access control list which maps user information to data types/tasks which the user is allowed to access.
- Subscription/Query data collected by application sensors
  - Only the user who invokes the application is allowed
  - Sensor Manager Service records the information about the user who wants to subscribe/query data and the one who invokes applications

SCALEA-G User Portal



Summary

- Design of SCALEA-G
- Current status
  - Finishing the implementation of basic infrastructure
  - Very premature prototype
- Future works
  - Refine and improve design
  - Work on full imlementation
  - Study representation of monitoring and performance data in Grids.