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J. Salowey  
Tableau Software  
L. Lorenzin  
C. Kahn  
Pulse Secure  
S. Pope  
S. Appala  
A. Woland  
N. Cam-Winget, Ed.  
Cisco Systems  
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XMPP Protocol Extensions for Use in SACM Information Transport  
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## Abstract

This document defines a transport protocol for use with the Security Automation and Continuous Monitoring (SACM) Architecture.

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## [1.](#) Introduction

This document describes the extensions made to Extensible Messaging and Presence Protocol (XMPP) [[RFC6120](#)] that enables use of XMPP as a transport protocol for collecting and distributing security telemetry information between and among network platforms, endpoints, and most any network connected device. Proposed use of this transport protocol is for serving use-cases outlined by the Security Automation and Continuous Monitoring (SACM) working group with the IETF.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [[RFC2119](#)].

Many of the terms used in this document are defined in [\[I-D.ietf-sacm-terminology\]](#) and new ones referenced in this draft.

This document is being discussed on the [sacm@ietf.org](mailto:sacm@ietf.org) mailing list.

## [1.1.](#) Glossary of Terms

AAA

Authentication, Authorization and Accounting.

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CA

Certification Authority.

Capability Provider

Providers who are capable of sharing information on XMPP-Grid.

CMDB

Configuration Management Database.

IDS

Intrusion Detection System.

IPS

Intrusion Prevention System.

JID

Jabber Identifier, native address of an XMPP entity.

MDM

Mobile Device Management.

NAC

Network Admission Control.

PDP

Policy Decision Point.

PEP

Policy Enforcement Point.

Presence

XMPP-Grid node availability and online status on XMPP-Grid.

Publisher

A capability provider sharing content information to other devices participating on XMPP-Grid.

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SIEM

Security Information and Event Management.

Subscriber

A device participating in XMPP-Grid and subscribing or consuming information published by Publishers on XMPP-Grid.

Sub-Topics

Topic created by XMPP-Grid Controller under a capability provider's topic based on message filter criteria expressed by subscribers.

Topics

Contextual information channel created on XMPP-Grid where a published message by the Publisher will be propagated by XMPP in real-time to a set of subscribed devices.

VoIP

Voice over IP.

## XMPP-Grid

Set of standards-based XMPP messages with extensions, intended for use as a transport and communications protocol framework between devices forming an information grid for serving SACM use-cases.

## XMPP-Grid Controller

Centralized component of XMPP-Grid responsible for managing all control plane operations.

## XMPP-Grid Connection Agent

XMPP-Grid client library that a XMPP-Grid node implements to connect and exchange information with other vendor devices on XMPP-Grid.

## XMPP-Grid Node

Platform or device that implements XMPP-Grid Connection Agent to connect to XMPP-Grid and share or consume security data.

### [1.2.](#) What is XMPP-Grid?

XMPP-Grid is a set of standards-based XMPP messages with extensions. It is intended for use as a transport and communications protocol framework for devices that interconnect with each other, forming an information grid for serving SACM use-cases.

XMPP-Grid enables secure, bi-directional multi-vendor exchange of contextual information between IT infrastructure platforms such as security monitoring and detection systems, network policy platforms, asset and configuration management, identity and access management platforms. XMPP-Grid can serve to exchange any contextual security information, the relevance and scope for SACM is to use XMPP-Grid to exchange Posture Assessment Information; thus this draft shall use the terms interchangeably. XMPP-Grid is built on top of XMPP

[[RFC6120](#)], [[RFC6121](#)] which is an open IETF standard messaging routing protocol used in commercial platforms such as Google Voice, Jabber IM, Microsoft Messenger, AOL IM and a variety of IoT and XML message routing services. XMPP is also being considered as a means to transport IODEF [[RFC5070](#)]. XMPP-Grid is designed for orchestration of data sharing between security platforms on a many-to-many basis for millions of end systems.

XMPP-Grid provides a security data sharing framework that enables multiple vendors to integrate to XMPP-Grid once, then both share and consume data bi-directionally with many IT infrastructure platforms and applications from a single consistent framework akin to a network-wide information bus. This reduces the need to develop to explicit, multiple platform-specific interfaces, thereby increasing the breadth of platforms that can interface and share security data. XMPP-Grid is also configurable thereby enabling partners to share only security data they want to share and consume only information relevant to their platform or use-case and to customize information shared without revising the interfaces. XMPP-Grid is data-agnostic enabling it to operate with virtually any data type or information model, but does offer optional interoperability with the Interface for Metadata Access Points (IF-MAP) [[IF-MAP](#)] or with IODEF, which are commonly used information repositories for security data sharing.

### [1.3](#). Overview of XMPP-Grid

XMPP-Grid employs publish/subscribe/query operations brokered by a controller, which enforces access control in the system. This architecture controls what platforms can connect to the "grid" to share ("publish") and/or consume ("subscribe" or "query") contextual information ("Topics") (described in [Section 3.3](#) and 3.5) such as security data needed to support SACM use-cases. The control of publish/subscribe/query operations is architecturally distinct from

the actual sharing of the contextual information. Control functions are split into a logical control plane, whereas information exchange is considered a logical data plane. This separation enables scalability and customizability.

XMPP-Grid defines an infrastructure protocol that hides the nuances of the XMPP data plane protocol and makes the information sharing models extensible with simple intuitive interfaces. XMPP-Grid Nodes

connect to the Grid using the XMPP-Grid Protocol. The XMPP-Grid Protocol makes use of the XMPP transport protocol and introduces an application layer protocol leveraging XML and XMPP extensions to define the protocol.

The components of XMPP-Grid are:

- o XMPP-Grid Controller (Controller): The Controller manages the control plane of XMPP-Grid operations. As such it authenticates and authorizes platforms connecting to the data exchange grid and controls whether or not they can publish, subscribe or query Topics of security data.
- o XMPP-Grid Connection Agent (Connection Agent): The Connection Agent enables the adopting Node to communicate with the Controller and other vendor platforms that have adopted XMPP-Grid. Through this communication privileges of the connecting platform-- authorization to connect, publish, subscribe, query--are established. The Connection Agent is typically implemented as a client library.
- o XMPP-Grid Node (Node): A Node is a platform that has implemented the Connection Agent so that it can connect to an XMPP-Grid deployment to share and/or consume security data.
- o Data Repository: This is the source of security data available on the Grid and may be a network security platform, management console, endpoint, etc. XMPP-Grid does not mandate a specific information model, but instead remains open to transport structured or unstructured data. Data may be supplied by the security platform itself or by an external information repository.
- o Topic: An XMPP-Grid Topic defines a type of security data that a platform wants to share with other platform(s).

The operations carried out by XMPP-Grid to exchange security data are:

- o Grid Connect: This is a Controller operation that authenticates a Node that has implemented the Connection Agent to establish a

connection with the XMPP-Grid. Once authenticated, authorization



policies on the Controller establish a Node's privileges on the XMPP-Grid such as the right to undertake publish, subscribe or query operations explained below.

- o Publish Topic: Security information is made available when a XMPP-Grid enabled platform "publishes" a "Topic". This operation is authorized by the Controller and communicated to the connecting platform via the Connection Agent.
- o Topic Discovery: Nodes on a XMPP-Grid discover Topics of security data relevant to them by searching the Topic directory available within the XMPP-Grid deployment. The Controller maintains such a Topic directory for every instance of XMPP-Grid.
- o Subscribe to Topic: A Node seeking to consume security information "subscribes" to a Topic that provides the security information it seeks to serve its use-case. This operation has its authorization checked by the Controller and communicated with the connecting platform via the Connection Agent.
- o Query: This operation enables a Node to request a specific set of security data regarding a specific asset (such as a specific user endpoint) or bulk output history from a Topic over a specific span of time. Such queries can be carried out node-to-node or by querying a central data repository. Query structure is adaptable to match the information model in use.

XMPP-Grid is used to exchange security context data between systems on a 1-to-1, 1-to-many, or many-to-many basis. Security data shared between these systems may use pre-negotiated non-standard/native data formats or may utilize an optional common information repository with a standardized data format, as may be specified by SACM. XMPP-Grid is data format agnostic and accommodates transport of whatever format the end systems agree upon.

XMPP-Grid can operate in the following deployment architectures:

- o Broker-Flow: An XMPP-Grid control plane brokers the authorization and redirects the Topic subscriber to Topic publisher directly. In this architecture, the Controller only manages the connection; the security data flow is directly between Nodes using data formats negotiated out-of-band.
- o Centralized Data-Flow: An XMPP-Grid maintains the data within its optional centralized database. In this architecture, the Controller provides a common information structure for use in

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formatting and storing security context data, such as IF-MAP, and directly responds to Node publish and Subscribe requests.

- o Proxy-Flow: An XMPP-Grid is acting as proxy, collecting the data from the publisher(s) and presenting it to the subscriber directly. This is used for ad-hoc queries.

Within the deployment architecture, XMPP-Grid may be used in any combination of the following data exchange modes. The flexibility afforded by the different modes enables security information to be exchanged between systems in the method most suitable for serving a given use-case.

- o Continuous Topic update stream: This mode delivers in real-time any data published to a Topic to the Nodes that are subscribed to that Topic.
- o Directed query: This mode enables Nodes to request a specific set of security information regarding a specific asset, such as a specific user endpoint.
- o Bulk historic data query: This mode enables Nodes to request transfer of past output from a Topic over a specific span of time.

#### [1.4.](#) Benefits of XMPP-Grid

Benefits of XMPP-Grid can be summarized on two fronts: 1) end-user benefits, 2) benefits for adopting vendors.

Benefits for end-users deploying security services based on XMPP-Grid security context information sharing capabilities are derived from the results that come with standardization including:

- o Consolidating relevant security event data from multiple systems to the "right console at the right time".
- o Cross-vendor interoperability out-of-the-box, when using a standard data format.
- o Coordinated security response across multiple products from multiple vendors, ranging from endpoint security to AAA, NAC, IDS/IPS, Data Loss Prevention, firewalls to infrastructure such as SIEM, CMDB, physical access control systems.
- o Customer product choice and flexibility. No need to buy all security products from one vendor.

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Adopting XMPP-Grid security data sharing capabilities provides a number of benefits for adopting vendors, especially when compared to proprietary interfaces, such as:

- o Integrate the XMPP-Grid Connection Agent once to interface with many platforms, simultaneously by subscribing or publishing relevant security data
- o Security information shared is configurable (via Topics) based on relevance to specific use-cases and platforms
- o Only sharing relevant data enables both publishing and subscribing platforms to scale their security data sharing by eliminating excess, irrelevant data
- o Integrated authorization and security ensures only appropriate XMPP-Grid operations are executed by permitted platforms
- o Ability to share security data in native or structured formats enables data model flexibility for adopting vendors
- o Flexibility, adaptability to evolve to address new use cases over time. Utilize data-agnostic transport protocol or the extensible schema that allows for easy support for vendor-specific data.

#### [1.5.](#) Example Workflow

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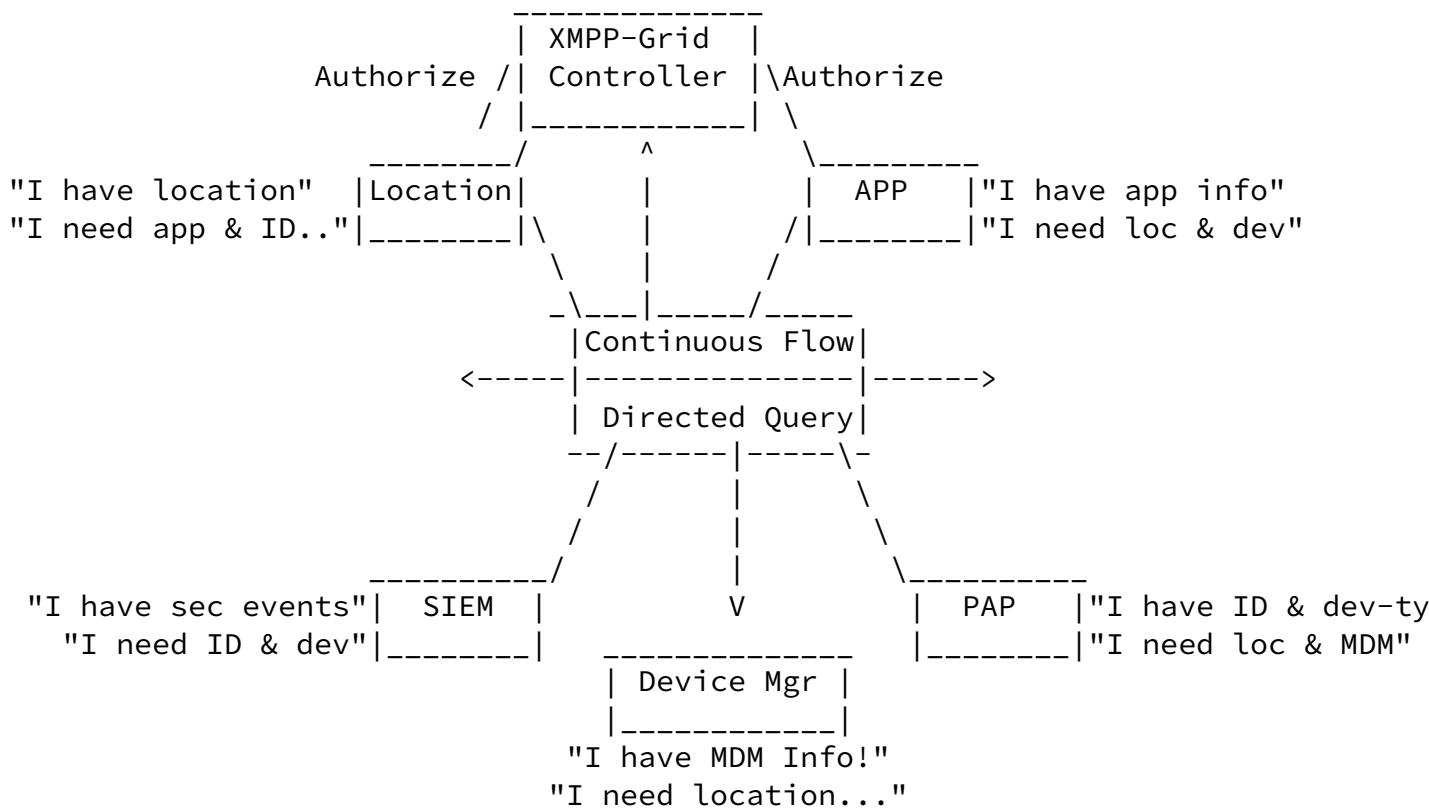


Figure 1: Typical XMPP-Grid Workflow

- a. XMPP-Grid Controller establishes a grid for platforms wanting to exchange security data.
- b. A platform (Node) with a source of security data requests connection to the Grid.

- c. Controller authenticates and establishes authorized privileges (e.g. privilege to publish and/or subscribe to security data Topics) for the requesting Node.
- d. Node may either publish a security data Topic, subscribe to a security data Topic, query a Node or Topic, or any combination of these operations.
- e. Publishing Nodes unicast Topic updates to the Grid in real-time. The Grid handles replication and distribution of the Topic to subscribing Nodes. A Node may publish multiple Topics, thereby allowing for customized relevance of the security data shared.
- f. Subscribing Nodes receive continuous real-time stream of updates to the Topic to which they are subscribed.

- g. Any Node on the Grid may subscribe to any Topics published to the Grid (as permitted by authorization policy), thereby allowing for one-to-one, one-to-many and many-to-many meshed security data sharing between Nodes.

## 2. Applicability of XMPP-Grid to SACM Use Cases

This section discusses the applicability of XMPP-Grid to the usage scenarios defined in [[I-D.ietf-sacm-use-cases](#)].

Within the SACM use-cases, the working group has outlined four use-cases and seven usage-scenarios. XMPP-Grid is applicable to each one of the use-cases and usage-scenarios by following one of the three main logical flows of XMPP-Grid as outlined in [section 1.1.1](#). The three flows are summarized here:

- o Broker-Flow: XMPP-Grid brokers the authorization and redirects the Topic subscriber to Topic publisher directly.
- o Centralized Data-Flow: XMPP-Grid is maintaining the data within its optional centralized database.
- o Proxy-Flow: XMPP-Grid is acting as proxy, collecting the data from the publisher(s) and presenting it to the subscriber directly. This is used for ad-hoc queries.

Each of the seven defined usage-scenarios is listed below, along with a summary of how XMPP-Grid is applicable to each use-case.

It is important to note that XMPP-Grid is data model agnostic, and may use any information model to structure data between systems. The most common standardized security information model deployed currently is IF-MAP, which XMPP-Grid interoperates with today.

## [2.1.](#) Applicability of XMPP-Grid to SACM Usage Scenarios

### [2.1.1.](#) SACM Definition and Publication of Automatable Configuration Checklists

XMPP-Grid is fully applicable to the usage-scenario 2.2.1 as defined within the SACM use-cases document. As a vendor creates a new guide, they would publish an entry describing the existence of the checklist to the applicable Topic within XMPP-Grid. For the purposes of this explanation, the Topic name will be "Guide".

Grid Nodes who are subscribed to the Topic, will receive the notification of the Topic update. In response or on-demand, the Node will query XMPP-Grid in order to initiate the downloading of the new

guide(s). The Grid Controller authorizes the download and proceeds to retrieve the guide(s) from the publisher, and transfers that download to the subscriber.

Similarly, when an administrator publishes a new checklist, they would publish an entry describing the existence of the checklist to the applicable Topic within XMPP-Grid. For the purposes of this explanation, the Topic name will be "Checklist".

Grid Nodes who are subscribed to the Topic, will receive the notification of the Topic update. In response or on-demand, the participating entity will query XMPP-Grid in order to initiate the downloading of the new checklist(s). The Grid Controller authorizes the download and proceeds to retrieve the checklist(s) from the publisher, and transfers that download to the subscriber. This is an example of XMPP-Grid in Proxy-Flow mode.

### [2.1.2.](#) SACM Automated Checklist Verification

An Endpoint Management System (EMS) publishes a Topic to XMPP-Grid defining itself as an owner of Endpoint Data. Other network services that are interested in endpoint data may subscribe to the Topic on Endpoint Data, which is authorized by the XMPP-Grid.

A Baseline Service is subscribed to the Endpoint Data Topic, and has a need for that updated endpoint data. The Baseline Service (subscriber) requests the data from the XMPP-Grid, which authorizes the retrieval and informs the subscriber of the existence of data on the EMS directly. In this instance, the data transfer has been authorized and occurs directly between the subscriber and the EMS.

The subscriber has now created new checklists and published the information to the checklist Topic in XMPP-Grid. A PDP is subscribed to the Checklist Topic, and is notified of the new checklists. The PDP requests the data from the XMPP-Grid, which in-turn authorizes the download and brokers the direct communication between the Baseline Service and the PDP Directly.

This usage scenario is an example of XMPP-Grid in the Broker-Flow. It is also showing that single entities may act as both publisher and subscriber with the XMPP-Grid simultaneously.

#### [2.1.3.](#) SACM Detection of Posture Deviations

A user disables the firewall on a managed endpoint, which in-turn sends a notice to its managing Compliance Service. The Compliance Service publishes an alert to the "Alert Topic" in XMPP-Grid. There is an Assessment Service, which subscribes to the Alert Topic, and is

therefore notified of the alert. The Assessment service consumes that alert directly from the XMPP-Grid and triggers an immediate assessment of the endpoint.

This is an example of XMPP-Grid centralized-data flow. While XMPP-Grid is information model agnostic, in this scenario IF-MAP could be used as the centralized data repository with XMPP-Grid providing the transport in/out of the IF-MAP database..

#### [2.1.4.](#) SACM Endpoint Information Analysis and Reporting

There are endpoints that are uploading large quantities of data to a Suspicious Server on Internet. The admin queries XMPP-Grid for the posture of the endpoints. The XMPP-Grid responds with all the publishers of that information along with the authorization to query for the data. The admin application is now able to query the data sources directly, which indicates that the applicable endpoints all have certain applications installed. The admin is now able to pivot the query and receive information on all other endpoints that have the same application installed.

This usage scenario is an example of XMPP-Grid Broker-Flow.

#### [2.1.5.](#) SACM Asynchronous Compliance/Vulnerability Assessment at Ice Station Zebra

A University Team at Ice Station Zebra registers their Equipment with an Asset Management System. The university puts together a collection request for all deployed assets, and sends the query to the XMPP-Grid. The collection request is queued at the XMPP-Grid for the next window of connectivity when the request is sent to the deployed assets. The remote endpoints fulfill the request and queue the results for the next return opportunity. The results are sent back to the university, where they are compared against what is in the Asset Management System already.

This is an example of XMPP-Grid centralized-data flow. While XMPP-Grid is information model agnostic, in this scenario IF-MAP could be used as the centralized data repository with XMPP-Grid providing the transport in/out of the IF-MAP database.

#### [2.1.6.](#) SACM Identification and Retrieval of Guidance

There are multiple configuration services in the environment, each populating a "guide" Topic in XMPP-Grid. The operator queries XMPP-Grid in order to discover and consolidate a single list to be compared. The XMPP-Grid replies with list of data stores, and authorization to perform the queries directly to those data stores.

As the Admin/Operator defines search criteria, the operator is able to query the data stores directly for that content, only returning to the centralized XMPP-Grid when authorization is required.



This usage scenario is an example of XMPP-Grid in the Broker-Flow

2.1.7. SACM Guidance Change Detection

An Operator identifies content that they desire to assess, and subscribes to that content Topic with XMPP-Grid. When a change to that content occurs, the Operator is notified. Additionally, the operator may be sent a query response. Any Data Collection and evaluation Activities will also trigger an update to the operator (subscriber).

This usage scenario is an example of XMPP-Grid centralized-data flow. While XMPP-Grid is information model agnostic, in this scenario IF-MAP could be used as the centralized data repository with XMPP-Grid providing the transport in/out of the IF-MAP database.

3. XMPP-Grid Architecture

XMPP-Grid is a communication fabric that facilitates secure sharing of information between network elements and networked applications connected to the fabric both in real time and on demand.

XMPP-Grid uses XMPP servers that operate as a cluster with message routing between them, for data plane communication. XMPP-Grid uses a control plane element, the XMPP-Grid Controller, that is an external component of XMPP for centralized policy-based control plane.

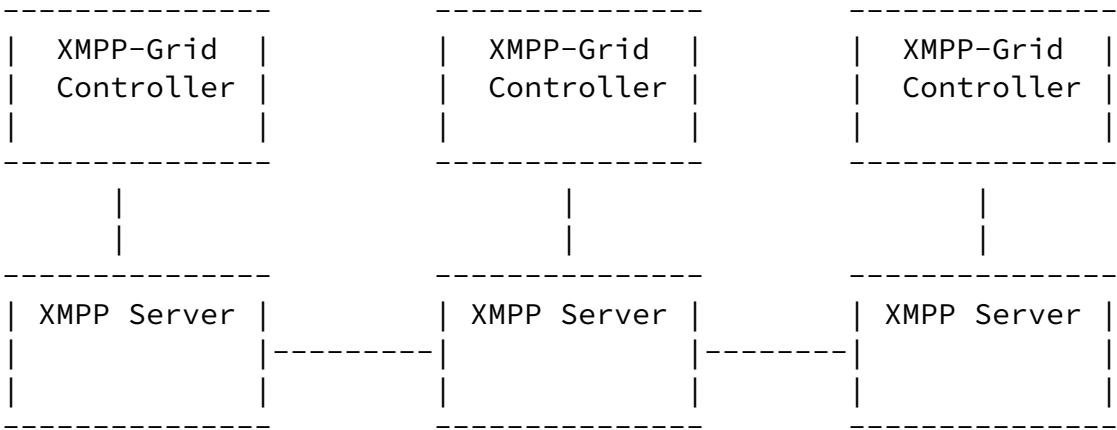


Figure 2: XMPP Server and XMPP-Grid Cluster Architecture

The connected Nodes, with appropriate authorization privileges, can:

- o Receive real-time events of the published messages from the publisher through Topic subscriptions
- o Make directed queries to other Nodes in the XMPP-Grid with appropriate authorization from the Controller
- o Negotiate out-of-band secure file transfer channel with the peer

This model enables flexible API usage depending on the Nodes' contextual and time-sensitivity needs of security information.

### [3.1.](#) XMPP Overview

XMPP is used as the foundation message routing protocol for exchanging security data between systems across XMPP-Grid. XMPP is a communications protocol for message-oriented middleware based on XML. Designed to be extensible, the protocol uses de-centralized client-server architecture where the clients connect to the servers securely and the messages between the clients are routed through the XMPP servers deployed within the cluster. XMPP has been used extensively for publish-subscribe systems, file transfer, video, VoIP, Internet of Things, Smart Grid Software Defined Networks (SDN) and other collaboration and social networking applications. The following are the 4 IETF specifications produced by XMPP working group:

- o [[RFC6120](#)] Extensible Messaging and Presence Protocol (XMPP): Core
- o [[RFC6121](#)] Extensible Messaging and Presence Protocol (XMPP): Instant Messaging and Presence
- o [[RFC3922](#)] Mapping the Extensible Messaging and Presence Protocol (XMPP) to Common Presence and Instant Messaging (CPIM)
- o [[RFC3923](#)] End-to-End Signing and Object Encryption for the Extensible Messaging and Presence Protocol (XMPP)

XMPP offers several of the following salient features for building a security data interexchange protocol:

- o Open - standards-based, decentralized and federated architecture, with no single point of failure
- o Security - Supports domain segregations and federation. Offers strong security via Simple Authentication and Security Layer (SASL) [[RFC4422](#)] and Transport Layer Security (TLS) [[RFC5246](#)].

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- o Real-time event management/exchange - using publish, subscribe notifications
- o Flexibility and Extensibility - XMPP is XML based and is easily extensible to adapt to new use-cases. Custom functionality can be built on top of it.
- o Multiple information exchanges - XMPP offers multiple information exchange mechanisms between the participating clients -
  - o
    - \* Real-time event notifications through publish and subscribe.
    - \* On-demand or directed queries between the clients communicated through the XMPP server
    - \* Facilitates out-of-band, direct communication between participating clients
- o Bi-directional - avoids firewall tunneling and avoids opening up a new connection in each direction between client and server.
- o Scalable - supports cluster mode deployment with fan-out and message routing
- o Peer-to-peer communications also enables scale - directed queries and out-of-band file transfer support
- o XMPP offers Node availability, Node service capability discovery, and Node presence within the XMPP network. Nodes ability to detect the availability, presence and capabilities of other participating nodes eases turnkey deployment.

The XMPP extensions used in XMPP-Grid are now part (e.g. publish/subscribe) of the main XMPP specification [[RFC6120](#)] and the presence in [[RFC6121](#)]. A full list of XMPP Extension Protocols (XEPs) [[RFC6120](#)] can be found in <http://xmpp.org/extensions/xep-0001.html> .

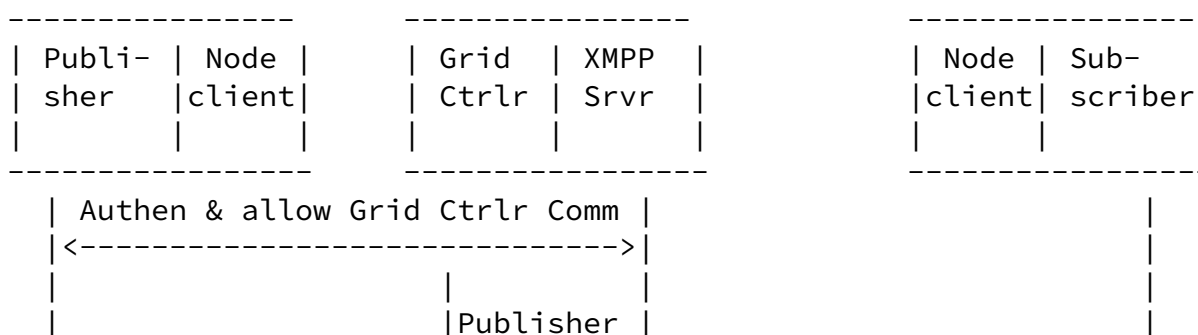
### [3.2](#). XMPP-Grid Protocol Extensions to XMPP

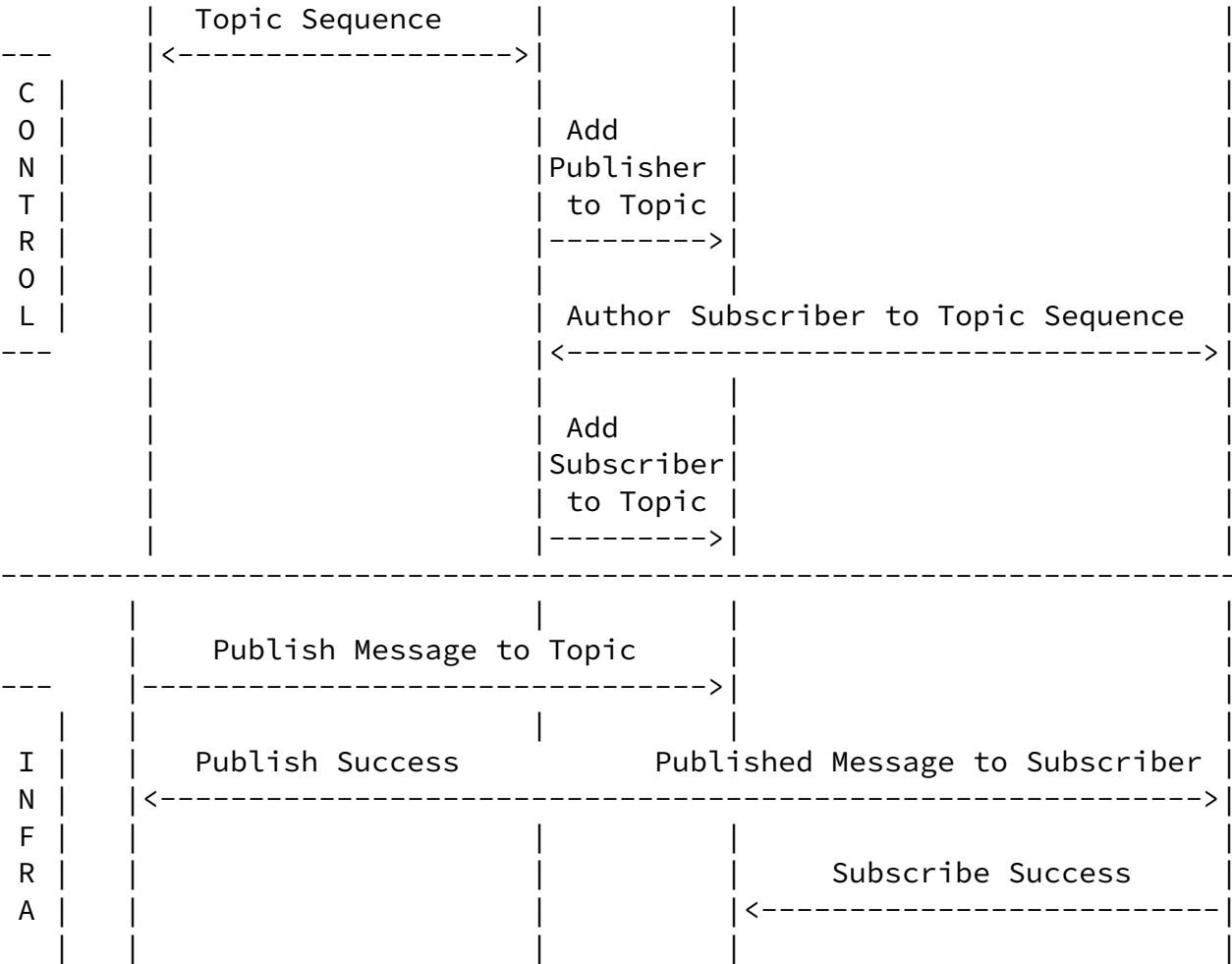
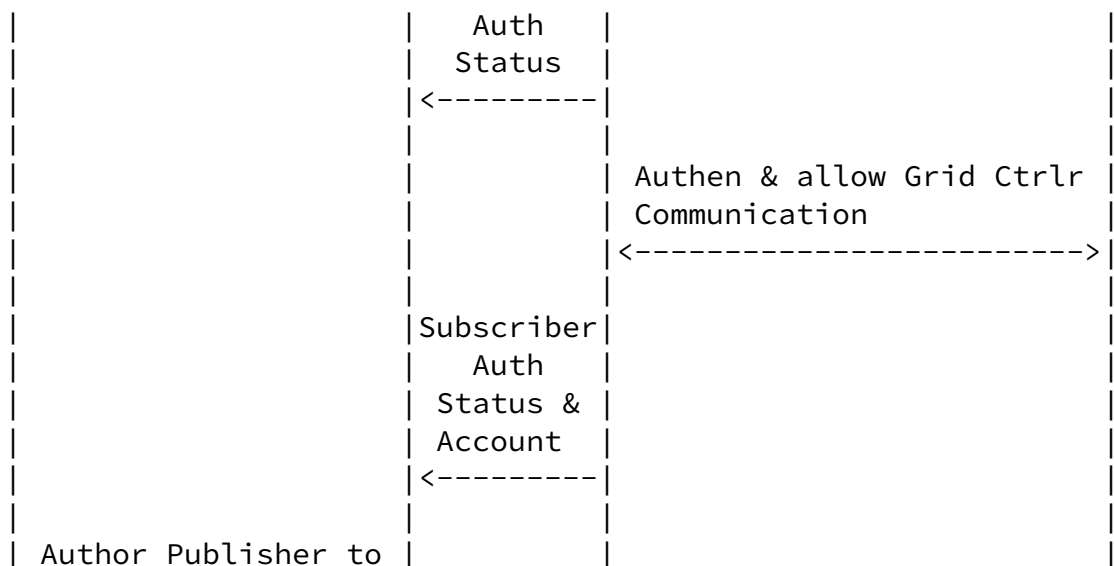
XMPP-Grid defines an infrastructure protocol that hides the nuances of the XMPP data plane protocol and makes the information sharing models extensible with simple intuitive APIs. XMPP-Grid Nodes connect to the Grid using the XMPP-Grid Protocol. The XMPP-Grid Protocol makes use of the XMPP transport protocol and introduces an application layer protocol leveraging XML and XMPP extensions to define the protocol. The capability providers on the Grid extend the

XMPP-Grid Protocol infrastructure model and define capability specific models and schemas, allowing a cleaner separation of infrastructure and capabilities that can run on the infrastructure.

### [3.3.](#) XMPP-Grid Controller Protocol Flow

At the heart of the XMPP-Grid network, the XMPP-Grid Controller serves as the centralized policy-based control plane element managing all Node authentications, authorizations, capabilities/Topics and their subscription list. XMPP-Grid Controller manages all control aspects of the Node communication (including management) with the XMPP-Grid and other participating Nodes with mutual trust and authorizations' enforcement. XMPP-Grid Controller is a component of XMPP server and programs the data plane XMPP server with Node accounts, account status, XMPP Topics that are dynamically created and Topic subscriptions. This is analogous to File Transfer Protocol (FTP) that has control and data plane communication phases. Once the Node requests are authenticated and authorized in the control plane phase by the Controller, the Controller removes itself from the data flow. All data plane communication then occurs between the Nodes, publishers and subscribers of XMPP Topics happen at the XMPP data plane layer.





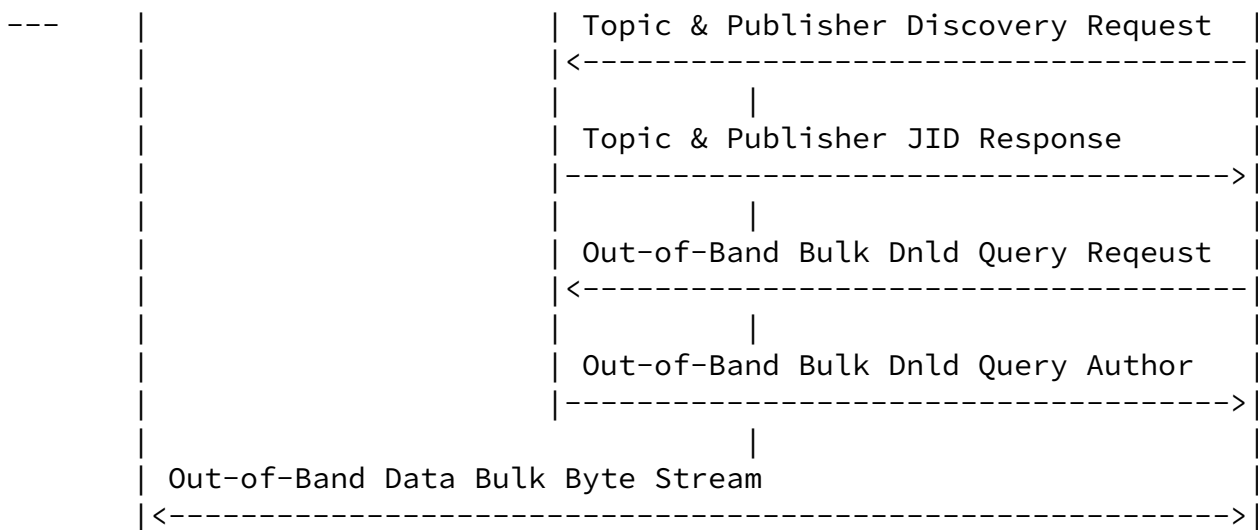


Figure 3: XMPP Controller Message Flow

Through a centralized authorization model, XMPP-Grid Controller provides -

- o Visibility into "who is connecting", "who is accessing what"
- o Node account management with provisions to add, delete or disable accounts, and with provisions to auto or manual approve Node account approval requests during the Node registration phase
- o Centralized, policy-based authorization, providing "who can do what" for publish-subscribe, directed peer-to-peer queries or for bulk out-of-band transfers between participating Nodes
- o Topics and subscription list management with provision to enable or disable Topics
- o Dynamic creation of sub-Topics within the main Topic depending on attributes of interest from the requesting Node
- o Ability to perform message filters on the published messages

#### [3.4.](#) XMPP-Grid Node Connection Protocol Flow

Nodes connecting to XMPP-Grid go through the phases of authentication, registration and authorization before they can participate in information exchange on XMPP-Grid.

#### 3.4.1. Authentication

The communication between the Node and the XMPP-Grid Controller is cryptographically encrypted using TLS. XMPP-Grid uses X.509 certificate-based mutual authentication between the Nodes and Controller. Internally, XMPP uses Simple Authentication and Security Layer (SASL)[[RFC4422](#)] External mechanism to authenticate and establish secure tunnel with the Nodes, allowing the XMPP-Grid Controller to rely on this capability offered by XMPP. If the Node certificate does not pass the validation process, the connection establishment is terminated with the error messages defined by the XMPP standard. On successful authentication, XMPP SASL component extracts the Node certificate and Node username to the Controller for registration.

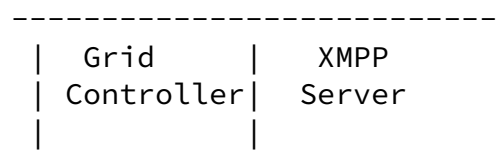
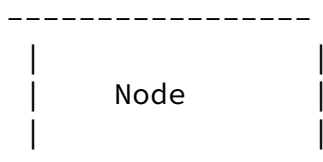
#### 3.4.2. Registration

Once a Node has been authenticated and a secure tunnel has been successfully established, the Nodes will register their accounts with the Controller and Nodes provide their username to the Controller as part of the registration request. XMPP-Grid supports manual registration (requires explicit approval of the Node account) and mutual authentication trust-based auto-approval registration in order to provide additional trust and usability options to the

administrator. The administrator may map the Nodes to the Node groups to add additional level of validation and trust, and enforce Node group based authorization. This allows the certificate-username-group trust to get uniquely establishment for each Node and duplicate registration requests using the same username will be rejected.

During the registration process, the Controller restricts all Node communication with the XMPP-Grid and only Node to Controller communication is allowed. Once the Node is successfully registered, the Controller lifts the restriction and allows the Nodes to communicate on XMPP-Grid after it passes the authorization phase. It

should be noted that the registered and authorized Nodes could publish, subscribe or query to multiple XMPP Topics between login and logout to XMPP-Grid. Multiple Node applications running on a Node could use one XMPP-Grid Node to connect to XMPP-Grid. The XMPP-Grid Node should support Node applications' subscription to Topics and should multiplex messages on its connection to XMPP-Grid. If a Node application wants to be identified explicitly on XMPP-Grid, a new XMPP-Grid Node connection to XMPP-Grid is required.





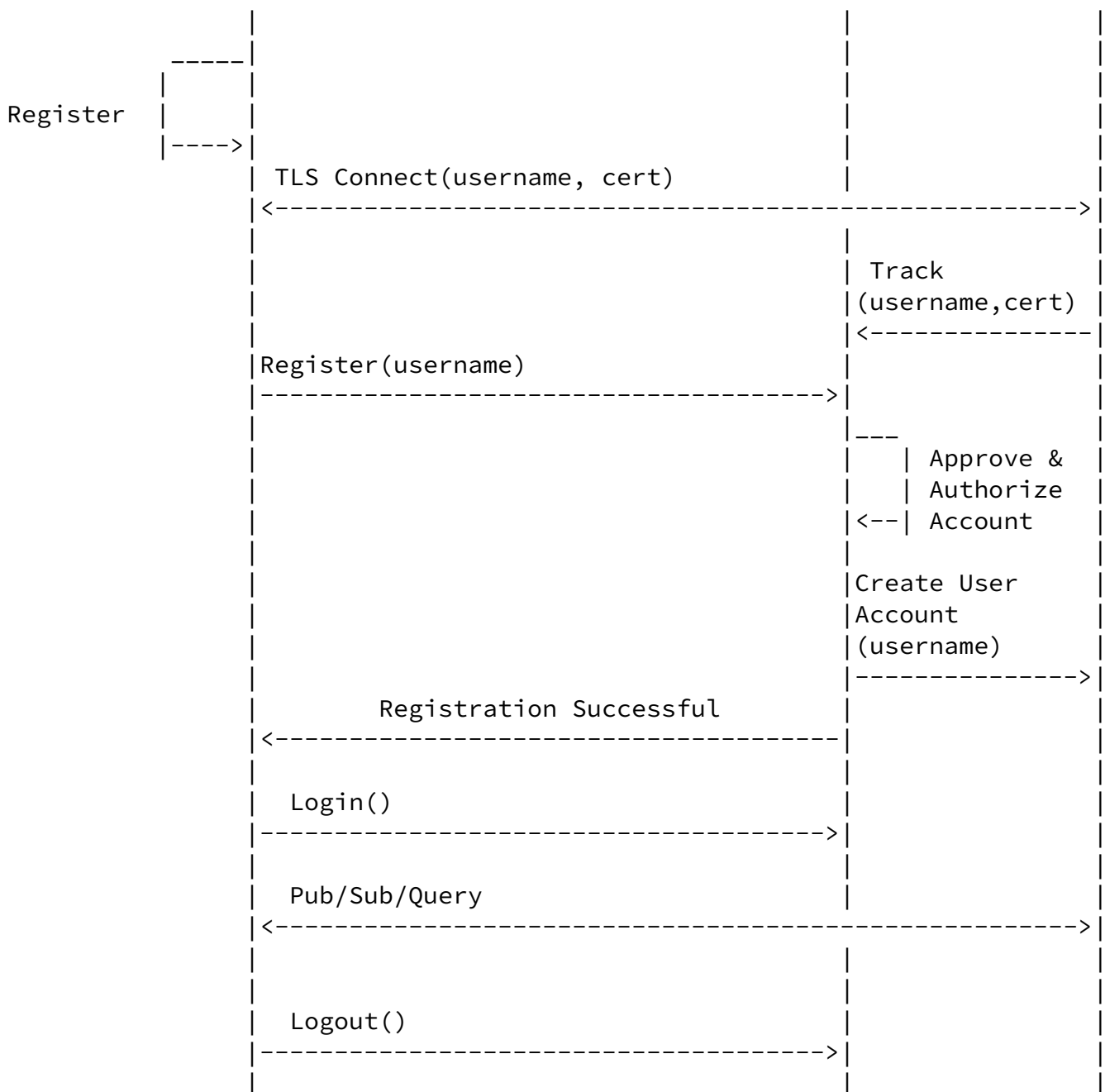


Figure 4: XMPP-Grid Node Registration

### 3.4.3. Authorization

The registered Nodes send subscription requests to the Controller. The Controller, depending on the defined authorization privileges, grants permissions to subscribe and/or publish to a Topic at the registration time. The Controller updates the XMPP data plane server with the new subscriber information and its capability. Node identity extracted from the request, group to which the Node is assigned during account approval and Topic/capability to which the permission is sought could be some of the ways to authorize Nodes and their requests in XMPP-Grid. Similarly, the Controller authorizes directed peer-to-peer or out-of-band requests from a requesting peer. The destination peer has options to query back the Controller to retrieve and enforce granular authorizations such as read-only, write-only, read/write.

In a Query Authorization flow, the capability provider responding to the query is responsible for enforcing the authorization decision. It retrieves "is authorized" from the XMPP-Grid Controller. Based on the result, the service either allows or disallows the flow from continuing.

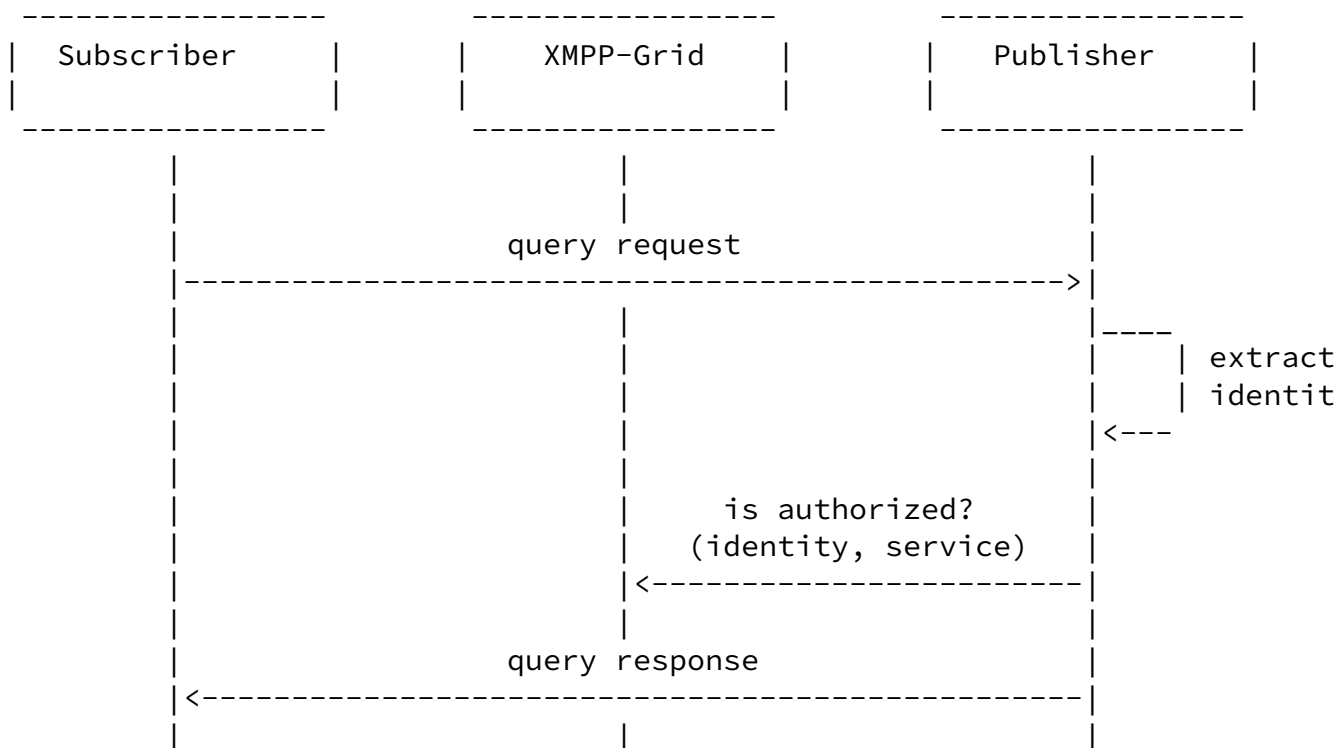


Figure 5: Node Query Authorization Flow

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For Publish Authorization, prior to allowing a publish request by a user, the XMPP-Grid Controller calls the rule evaluation engine directly for "is authorized". Based this result, the Controller either allows or disallowed the flow from continuing.

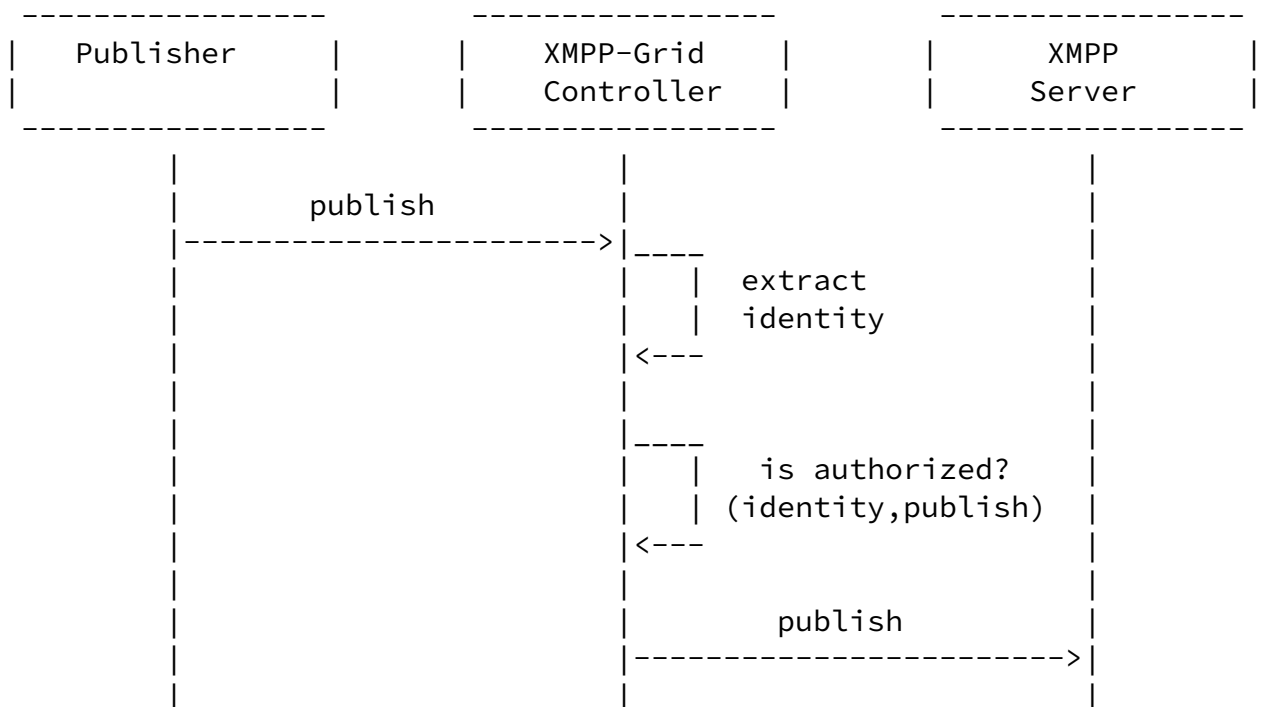


Figure 6: Node Publish Authorization Flow

For Subscribe Authorization, prior to allowing a subscribe request by a user, the XMPP-Grid Controller calls the rule evaluation engine directly for "is authorized". Based this result, the Controller either allows or disallowed the flow from continuing.

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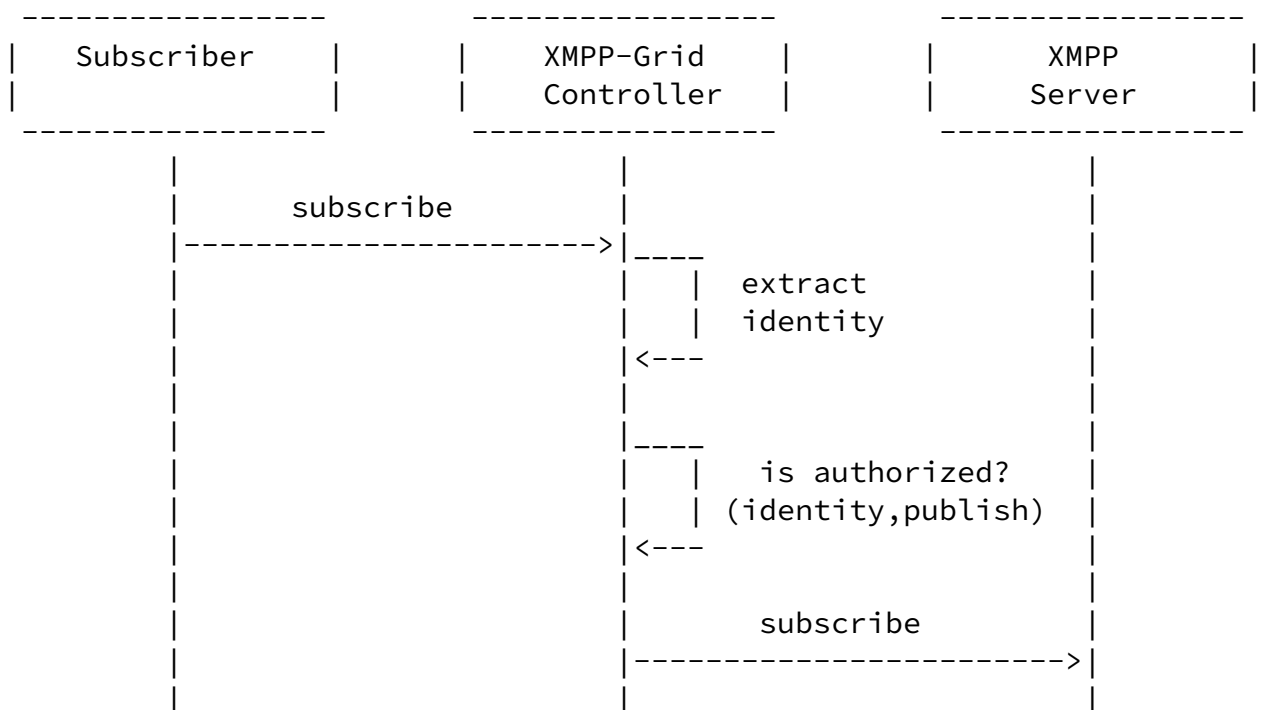


Figure 7: Node Subscribe Authorization Flow

Bulk Data Query differs from other data transfer modes. Unlike with other modes of communication that operate in-band with the XMPP-Grid, bulk downloads occur out-of-band (over a different protocol, outside of the connection that was established with the XMPP-Grid Controller). Previously discussed authorization mechanisms are therefore not appropriate in this context.

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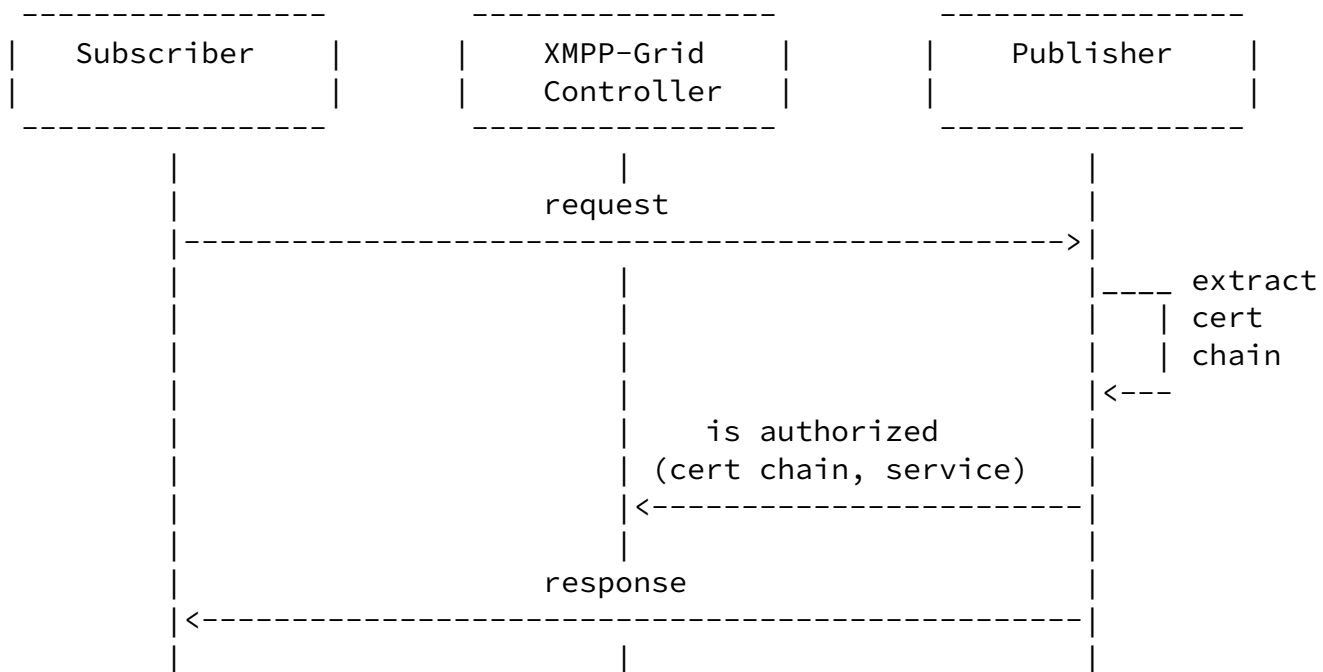


Figure 8: Node Bulk Data Query Flow

Instead the bulk download service sends the certificate chain used by a Node in the TLS connection to the XMPP-Grid Controller for purposes of authenticating and authorizing the Node. Upon receiving a request with a certificate chain, the Controller checks the issuing certificate against the trust store, looks up the identity associated with the certificate, evaluates the rules, and returns "is

authorized" to the service. Then the service can either allow or disallow the flow from continuing.

### [3.5.](#) XMPP-Grid Topics Protocol Flow

For each capability, XMPP-Grid supports extensibility through XML schemas where the providers (publishers) of the capabilities define the schemas for the data exchanged. The capability provider shall also define the version, the available queries and notifications that it can support. The capability provider publishes the messages to one or more XMPP Topics, that it requests XMPP-Grid to create dynamically, depending on:

- a. If the capability provider has mutually exclusive schemas, different Topics will be created where the capability provider will be a publisher to each Topic with a separate schema.
- b. For a given Topic, if the subscribers wants to receive filtered attributes or attribute values in capability provider's published data, XMPP-Grid Controller creates sub Topics to the main Topic

based on the message filters expressed. XMPP-Grid Controller enrolls the capability provider as the publisher and the requesting subscribers based on the message filter criteria they express. The capability provider will be the publisher to both the main Topic and the sub-Topics.

- c. In the case mentioned in (b) above, it is possible for the capability provider to just publish on the main Topic and have the XMPP-Grid Controller filter the published messages on the Controller-side and deliver attributes and attribute values of interest to the subscribers. Controller-side message filter application and the specify mechanisms such as XPATH that can be used for parsing the messages is beyond the scope of this specification.

#### [3.5.1.](#) Topic Versioning

XMPP-Grid supports versioning to support forward and backward compatible information models. The providers of capability include the version number in the messages they publish and the receiving Nodes can interpret the Topic version and process the attributes

accordingly. The expectation is any new version of a capability must be of additive updates only. In other words, existing elements and attributes cannot be changed, only new elements or attributes can be added. This will enable nodes with older capability be able to process newer version. The extra new elements or attributes will be ignored. Instead of using the same Topic for all versions, it is possible in XMPP-Grid to programmatically create separate Topics for each version and allow them to be discovered and subscribed by the Nodes.

In XMPP-Grid, versioning support applies equally to both publish/subscribe, directed and out-of-band queries.

### [3.5.2.](#) Topic Discovery

The Nodes connected to XMPP-Grid can query the Controller and get the list of all capabilities/Topics running on XMPP-Grid. The XML samples provided in XMPP-Grid Protocol section above provide illustrations of Capability Query and Capability Provider Query.

### [3.5.3.](#) Subtopics and Message Filters

XMPP-Grid supports semantic message filtering for Topics. The content being published by a provider can be semantically grouped into categories based on domain, location of endpoints for example. The provider of a capability specifies whether it supports semantic

filtering or not to the Controller at the subscribe time to the Topic under consideration.

XMPP-Grid subscribers query the Controller and obtain the filtering options available for each capability, and express their message filtering criteria at subscription time. The Controller, for each unique filter criteria specified by the subscribers, creates a new sub Topic under the main capability Topic. All the subscribers with the same filtering criteria will be subscribed to the Subtopic. The set of filter criteria for a capability will be predefined by the capability provider and could be based on the well-defined attributes of the message.

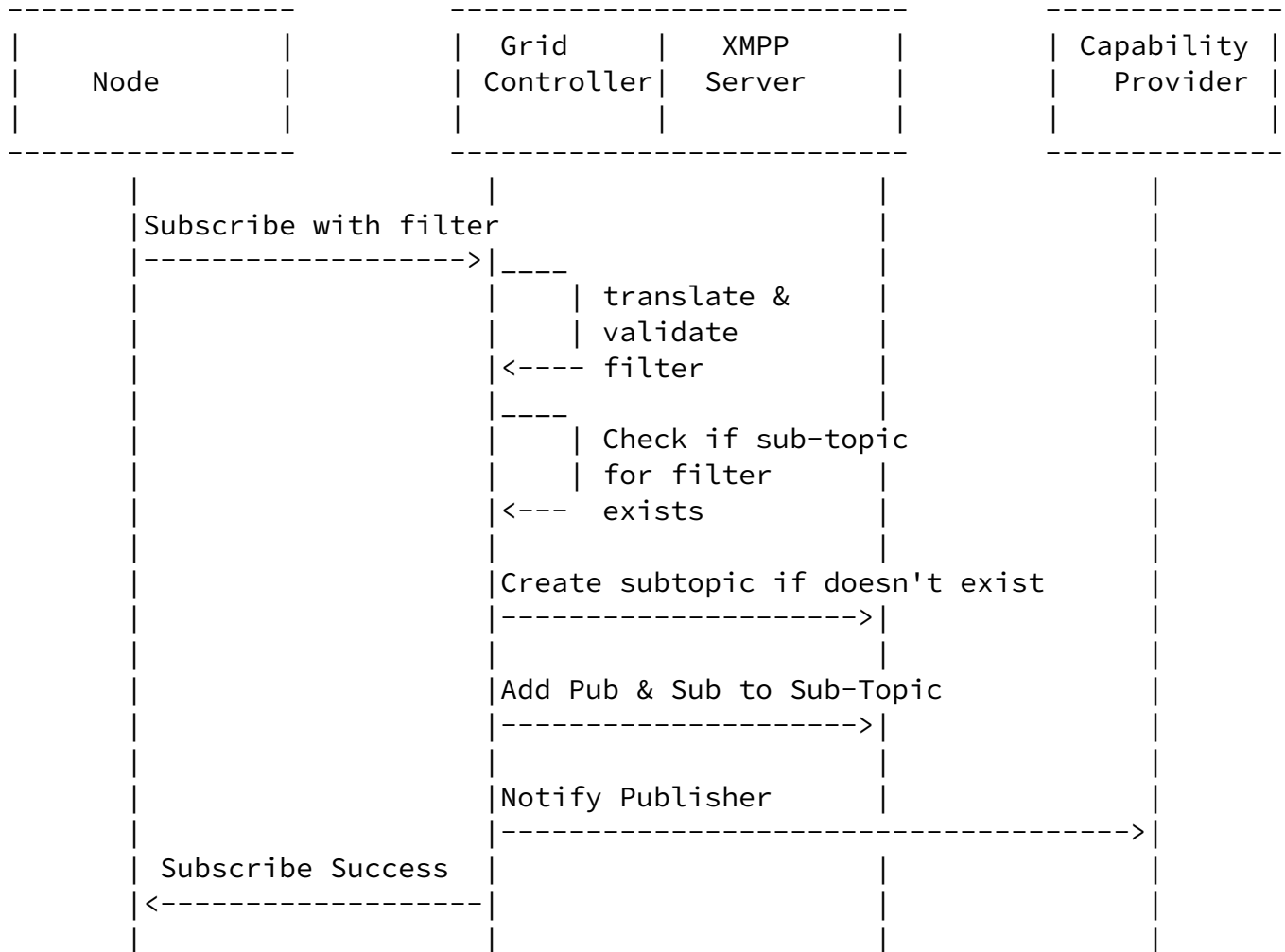


Figure 9: Subtopics and Information Filter Subscribe Operations Flow

The publisher will be responsible for applying the filter on the message and publishing the message on the Topic and the Subtopic based on the filter criteria. Filtering logic will be on the

publisher, as the publisher understands the message content. XMPP-Grid fabric is oblivious to the message content.

To avoid proliferation of new Subtopics, the capability provider could express the configurable limit on the number of Subtopics that can be created for its capability at registration time. The XMPP-Grid Controller will perform periodic cleanup of Subtopics whenever



their subscription list reduces to 0.

In XMPP-Grid, message filters are provided to all APIs i.e. publish/subscribe and directed query.

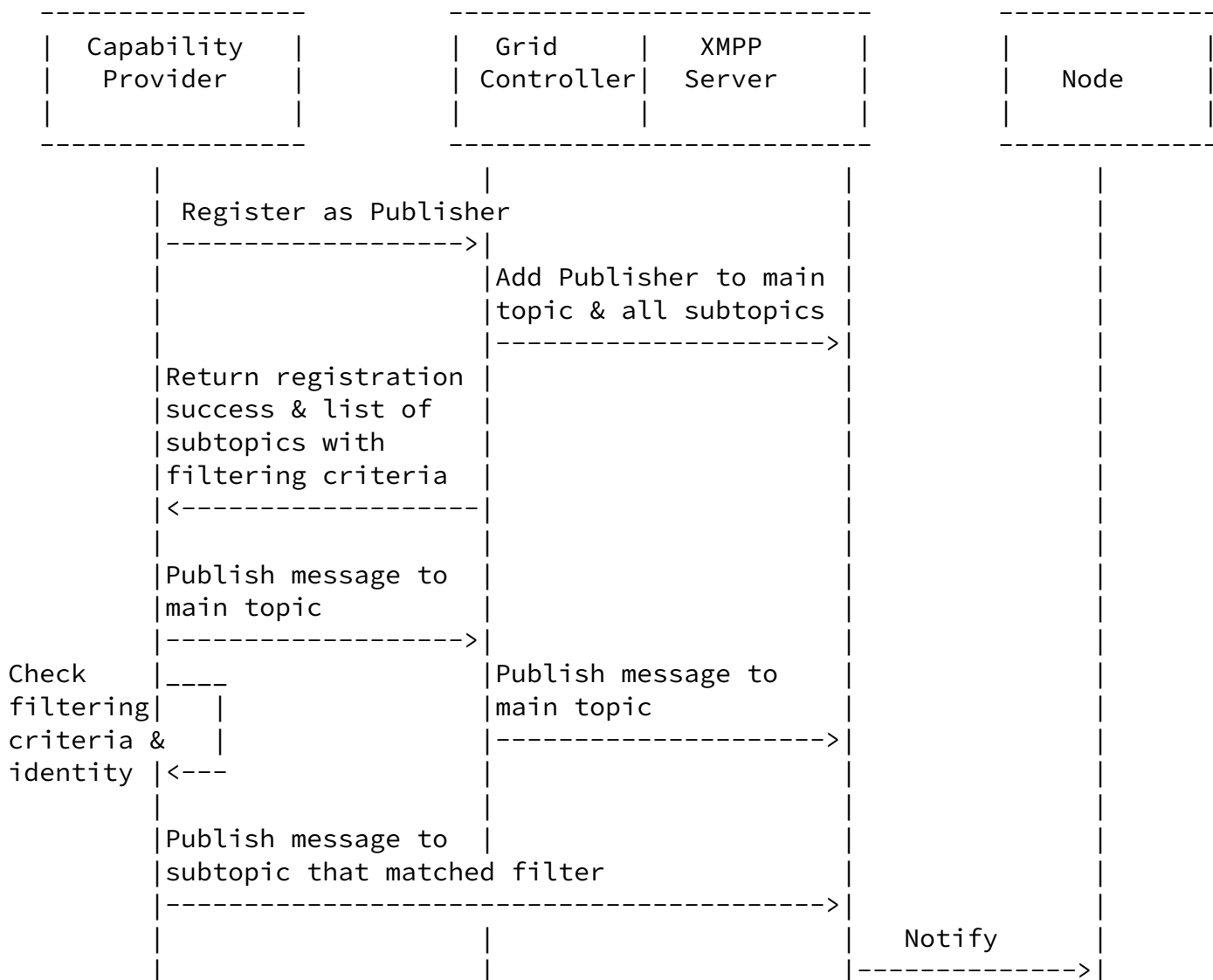


Figure 10: Subtopic Publish Operations Flow

### [3.6.](#) XMPP-Grid Protocol Details

The XMPP-Grid Protocol provides an abstraction layer over and above XMPP messages with the intent to provide intuitive interfaces to the Nodes connecting to XMPP-Grid. Nodes connecting to XMPP-Grid use the following interfaces (provided as XML samples) offered by XMPP-Grid protocol to connect and participate in information exchange on XMPP-Grid:

o Register the Node to XMPP-Grid: Node identified as "Node2@domain.com/mac" sends the following Registration request to XMPP-Grid controller.

```
<iq id="ay0tK-4" to="grid_Controller.jabber"
  from="Node2@domain.com/syam-mac" type="get">
  <grid xmlns='gi' type='request'>
    <AccountQuery xmlns='com.domain.gi.gcl.Controller'>
      <register></register></AccountQuery>
    </grid>
  </iq>
```

o Node login to XMPP-Grid: The following XML sample shows the Login request from Node "Node2@domain.com/mac" to XMPP-Grid controller and Login response returned by the XMPP-Grid controller to the Node.

```
// Request
<iq id="ay0tK-5" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns='gi' type='request'>
    <AccountQuery xmlns='com.domain.gi.gcl.Controller'>
      <login></login>
    </AccountQuery>
  </grid>
</iq>

// Response
<iq xmlns="jabber:client" to=" Node2@domain.com/mac"
  from="grid_Controller.jabber" type="result" id="ay0tK-5">
  <grid xmlns="gi" type="response">
    <AccountQuery xmlns="com.domain.gi.gcl.Controller">
      <login xmlns="">
        <value xmlns:ns2="gi" xmlns:xsi=" xsi:nil="true" />
      </login>
    </AccountQuery>
  </grid>
</iq>
```

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o Node logout from XMPP-Grid: The following XML sample shows the Logout request sent by Node "Node2@domain.com/mac" to XMPP-Grid controller.

```
<iq id="o47m2-8" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns='gi' type='request'>
    <AccountQuery xmlns='com.domain.gi.gcl.Controller'>
      <logout></logout>
    </AccountQuery>
  </grid>
</iq>
```

o Capability Discovery Query: The following XML sample shows the Capability Discovery query request from Node "Node2@domain.com/mac" to XMPP-Grid controller. The XMPP-Grid controller returns the list of capabilities supported by XMPP-Grid and their versions as a response to the Node's request.

// Request

```
<iq id="tVKqm-6" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns="xgrid" type="request">
    <ns2:getCapabilityListRequest xmlns:ns2=" xmlns:ns4="
      xmlns:ns3=" xmlns:ns5=" xmlns:ns6=" xmlns:ns7=" />
  </grid>
</iq>
```

// Response

```
<iq from="grid_Controller.jabber" id="tVKqm-6"
  to="Node2@domain.com/mac" type="result" xmlns="jabber:client">
  <grid type="response" xmlns="xgrid">
    <ns2:getCapabilityListResponse xmlns:ns2=" xmlns:ns3="
      xmlns:ns4=" xmlns:ns5=" xmlns:ns6=" xmlns:ns7=">
      <ns2:capability xmlns:xsi="
        " xsi:type="ns5:TrustSecMetaDataCapability">
        <ns2:id>0</ns2:id>
        <ns2:name>TrustSecMetaDataCapability-1.0</ns2:name>
        <ns2:version>1.0</ns2:version>
      </ns2:capability>
      <ns2:capability
        xmlns:xsi=" xsi:type="ns5:EndpointProfileMetaDataCapability">
```

```
<ns2:id>0</ns2:id>
<ns2:name>
    EndpointProfileMetaDataCapability-1.0</ns2:name>
<ns2:version>1.0</ns2:version>
</ns2:capability>
```

```
<ns2:capability xmlns:xsi=
    " xsi:type="ns5:IdentityGroupCapability">
    <ns2:id>0</ns2:id>
    <ns2:name>IdentityGroupCapability-1.0</ns2:name>
    <ns2:version>1.0</ns2:version>
</ns2:capability>
<ns2:capability xmlns:ns9=" xmlns:xsi="
    xsi:type="ns9:TDAnalysisServiceCapability">
    <ns2:id>0</ns2:id>
    <ns2:name>TDAnalysisServiceCapability-1.0</ns2:name>
    <ns2:version>1.0</ns2:version>
</ns2:capability>
<ns2:capability xmlns:xsi=" xsi:type="
    ns7:NetworkCaptureCapability">
    <ns2:id>0</ns2:id>
    <ns2:name>NetworkCaptureCapability-1.0</ns2:name>
    <ns2:version>1.0</ns2:version>
</ns2:capability>
<ns2:capability xmlns:xsi=
    " xsi:type="ns6:EndpointProtectionServiceCapability">
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    <ns2:name>
        EndpointProtectionServiceCapability-1.0</ns2:name>
    <ns2:version>1.0</ns2:version>
</ns2:capability>
<ns2:capability xmlns:xsi=
    " xsi:type="ns4:GridControllerAdminServiceCapability">
    <ns2:id>0</ns2:id>
    <ns2:name>
        GridControllerAdminServiceCapability-1.0</ns2:name>
    <ns2:version>1.0</ns2:version>
</ns2:capability>
<ns2:capability xmlns:xsi=
    " xsi:type="ns5:SessionDirectoryCapability">
    <ns2:id>0</ns2:id>
    <ns2:name>SessionDirectoryCapability-1.0</ns2:name>
```

```

        <ns2:version>1.0</ns2:version>
      </ns2:capability>
    </ns2:getCapabilityListResponse>
  </grid>
</iq>

```

o Specific Capability Provider Query: The following XML sample shows the Capability Provider hostname query request from Node "Node2@domain.com/mac" to XMPP-Grid controller. XMPP-Grid controller returns the hostname of the specific Capability Provider as a response to the Node's request.

```

// Request
<iq id="996IL-8" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns='gi' type='request'>
    <DiscoveryQuery xmlns='com.domain.gi.gcl.Controller'>
      <find><param xsi:type="xs:string" xmlns:ns2="gi" xmlns:xs
        =" xmlns:xsi=">com.domain.ise.session.SessionQuery
      </param></find>
    </DiscoveryQuery>
  </grid>
</iq>

// Response
<iq from='grid_Controller.jabber' id='996IL-8'
  to='Node2@domain.com/mac' type='result'
  xmlns='jabber:client'>
  <grid type='response' xmlns='gi'>
    <DiscoveryQuery xmlns='com.domain.gi.gcl.Controller'>
      <find xmlns=''><value xmlns:ns3='http://jaxb.dev.java.net/array'
        xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
        xsi:type='ns3:stringArray'>
        <item>ise@syam-06.domain.com/syam-mac</item></value></find>

```

```
</DiscoveryQuery>
</grid>
</iq>
```

o Register as a publisher to the Topic: The following XML sample shows the Register as a Publisher request from a Node "Node2@domain.com/mac" to XMPP-Grid controller.

```
<iq id="fD65a-6" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns="xgrid" type="request">
    <ns2:initPublishRequest xmlns:ns2=" " xmlns:ns4="
      " xmlns:ns3=" xmlns:ns5=" xmlns:ns6=" xmlns:ns7=">
      <ns2:capability xsi:type="ns5:SessionCapability"
        xmlns:xsi="">
        <ns2:id>0</ns2:id>
        <ns2:version>1.0</ns2:version>
      </ns2:capability>
    </ns2:initPublishRequest>
  </grid>
</iq>
```

o Register as a subscriber to the Topic: The following XML sample shows a subscription request made by Node "Node2@domain.com/mac" for "SessionCapability" Topic to XMPP-Grid controller. On success, determined by the Node's authorization privilege, XMPP-Grid controller returns the Topic name, version and the Publishers' hostname as a response to the Node's request.

```
// Subscribe Request
<iq id="lQJIT-6" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns="xgrid" type="request">
    <ns2:subscribeRequest xmlns:ns2=" " xmlns:ns4=" " xmlns:ns3
      =" " xmlns:ns5=" " xmlns:ns6=" " xmlns:ns7=" ">
      <ns2:capability xsi:type="ns5:SessionCapability"
```

```

        xmlns:xsi="
        <ns2:id>0</ns2:id>
        <ns2:version>1.0</ns2:version>
    </ns2:capability>
</ns2:subscribeRequest>
</grid>
</iq>

// Subscribe Response
<iq from="grid_Controller.jabber" id=" lQJIT-6"
to="Node2@domain.com/mac" type="result" xmlns="jabber:client">
  <grid type="response" xmlns="xgrid">
    <ns2:subscribeResponse xmlns:ns2="
      xmlns:ns3=" xmlns:ns4=" xmlns:ns5="
      xmlns:ns6=" xmlns:ns7=">
      <ns2:topicName>SessionCapability-1.0</ns2:topicName>
      <ns2:xmppDetails>
        <ns2:jid>ise-mnt-XMPP-Grid-004@xgrid.domain.com/gcl
        </ns2:jid>
        <ns2:jid>ise-mnt-XMPP-Grid-005@xgrid.domain.com/gcl
        </ns2:jid>
      </ns2:xmppDetails>
    </ns2:subscribeResponse>
  </grid>
</iq>

```

o Peer-to-Peer Directed Query: The following XML sample shows a peer-to-peer directed query request made by Node "Node2@domain.com/mac" to other XMPP-Grid participating Node "grid\_Controller.jabber", seeking identity group information for a specific user "user1". "grid\_Controller.jabber" returns the list of identity groups "user1" belongs as a response to the request.



```

// Query Request
<iq id="kR0YY-8" to="grid_Controller.jabber"
  from="Node2@domain.com/mac" type="get">
  <grid xmlns="xgrid" type="request">
    <ns5:getIdentityGroupRequest xmlns:ns2=" xmlns:ns4="
      xmlns:ns3=" xmlns:ns5=" xmlns:ns6=" xmlns:ns7=">
      <ns5:user>
        <ns2:name>user1</ns2:name>
      </ns5:user>
    </ns5:getIdentityGroupRequest>
  </grid>
</iq>

// Query Response
<iq from="grid_Controller.jabber"
  id=" kR0YY-8" to="Node2@domain.com/mac" type="result">
  <grid type="response" xmlns="xgrid">
    <ns5:getIdentityGroupResponse xmlns:ns2=" xmlns:ns3="
      " xmlns:ns4=" xmlns:ns5=" xmlns:ns6=" xmlns:ns7=">
    <ns5:user>
      <ns2:name>user1</ns2:name>
      <ns3:groupList>
        <ns3:object>
          <ns2:name>User Identity Groups:Employee
          </ns2:name>
          <ns3:type>Identity</ns3:type>
        </ns3:object>
      </ns3:groupList>
    </ns5:user>
  </ns5:getIdentityGroupResponse>
</grid>
</iq>

```

#### 4. XMPP-Grid Compatibility with IF-MAP Information Model

As mentioned throughout this document, XMPP-Grid is information model and data format agnostic, as it focuses on transport of security context data. There are, however, deployment scenarios where accessing data in a common format in a consistent information model will be required for serving SACM use-cases. The most prevalent

standards-based model for such deployments is IF-MAP, thus an XMPP-

Grid/IF-MAP compatibility discussion is salient for this document.

The Trusted Network Connect Working Group (TNC-WG) has defined an open solution architecture [[IF-MAP](#)] that enables network operators to enforce policies regarding the security state of endpoints in order to determine whether to grant access to a requested network infrastructure. Part of the TNC architecture is IF-MAP, a standard interface between the Metadata Access Point and other elements of the TNC architecture. Readers who wish to understand in detail and implement IF-MAP are encouraged to review the following documents:

- o [[IF-MAP](#)]Trusted Computing Group, TNC Architecture for Interoperability, Revision 1.5, May 2012
- o [[IF-MAP-SOAP](#)]Trusted Computing Group, TNC IF-MAP Binding for SOAP, Revision 2.2, March 2014
- o [[IF-MAP-NETSEC](#)]Trusted Computing Group, TNC IF-MAP Metadata for Network Security, Revision 1.0, August 2010
- o [[IF-MAP-ICS](#)]Trusted Computing Group, TNC IF-MAP Metadata for ICS, Security, Revision 1.0, October 2012

From a compatibility perspective, XMPP-Grid can substitute the SOAP-based IF-MAP standard interface between the MAP server and other elements in the network, thereby providing the information transport between IF-MAP clients. This substitution delivers greater scalability and timely data, as well as backwards compatibility with IF-MAP deployments. The IF-MAP data (Topics and Subtopics can be created based on IF-MAP data models) and operation models (interfaces, message filters could be defined for the Topics and Subtopics based on the IF-MAP operations supported for the use-cases developed for use-cases such as network security can be overlaid on XMPP-Grid transport thereby achieving model consistency for both IF-MAP enabled and XMPP-Grid enabled network deployment scenarios. The MAP Server will be the participant in both the IF-MAP enabled network and the XMPP-Grid enabled network serving as aggregator and publisher of information.

## IF-MAP Enabled Devices

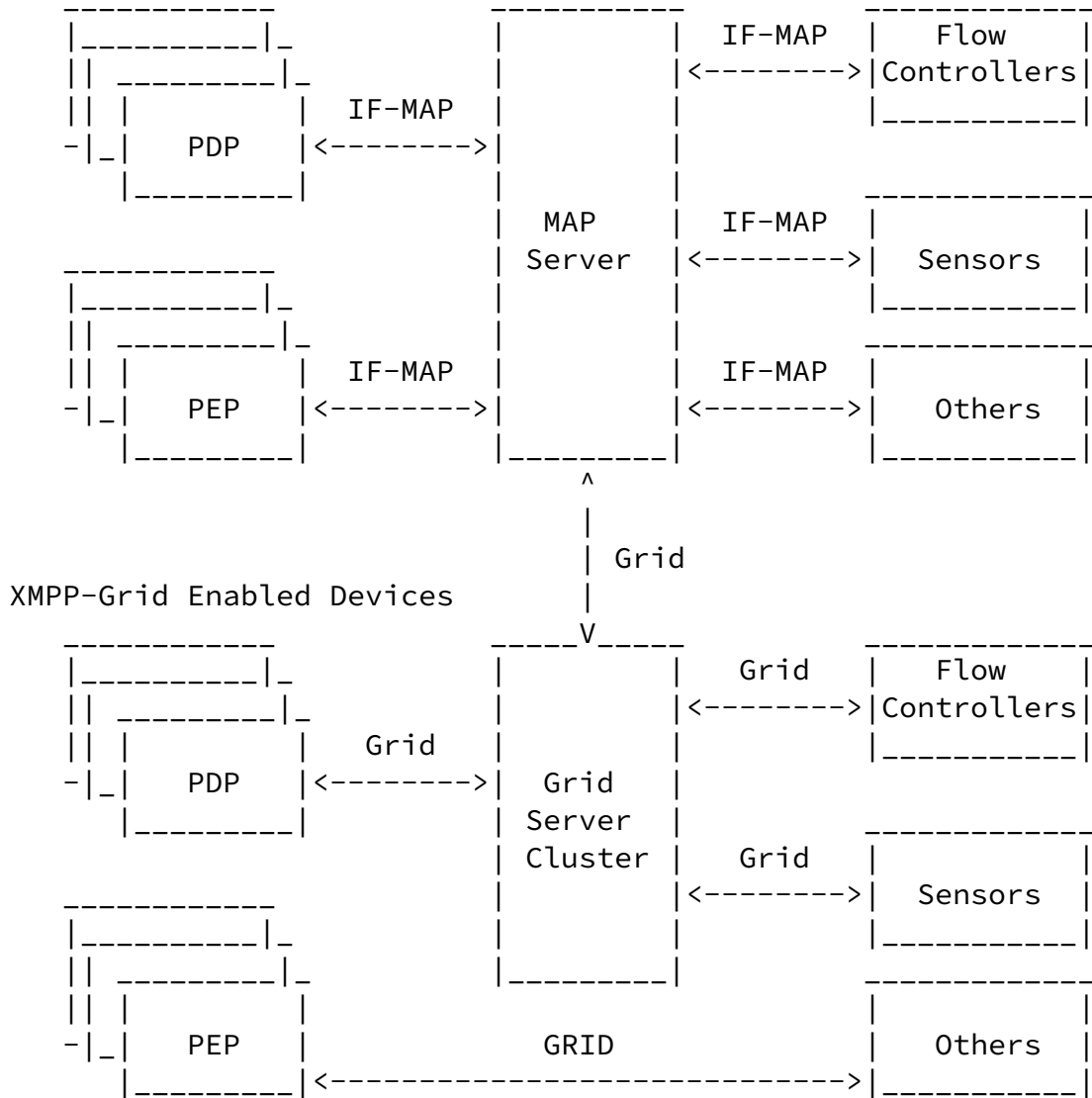


Figure 11: XMPP-Grid and IF-MAP Interoperability

The MAP server will be a XMPP-Grid Node connected to the XMPP-Grid Controller. The MAP server will play the role of subscribers and/or publishers depending on the MAP graphs and the contextual metadata to be aggregated and/or published.

#### [4.1.](#) MAP Server as XMPP-Grid Subscriber for Metadata Aggregation

The MAP Server will be a subscriber when aggregating metadata from various XMPP-Grid-enabled PEPs and PDPs in the network. Topics will be created in XMPP-Grid depending on the metadata to be aggregated, how relational or disjoint the metadata types, metadata-identifier

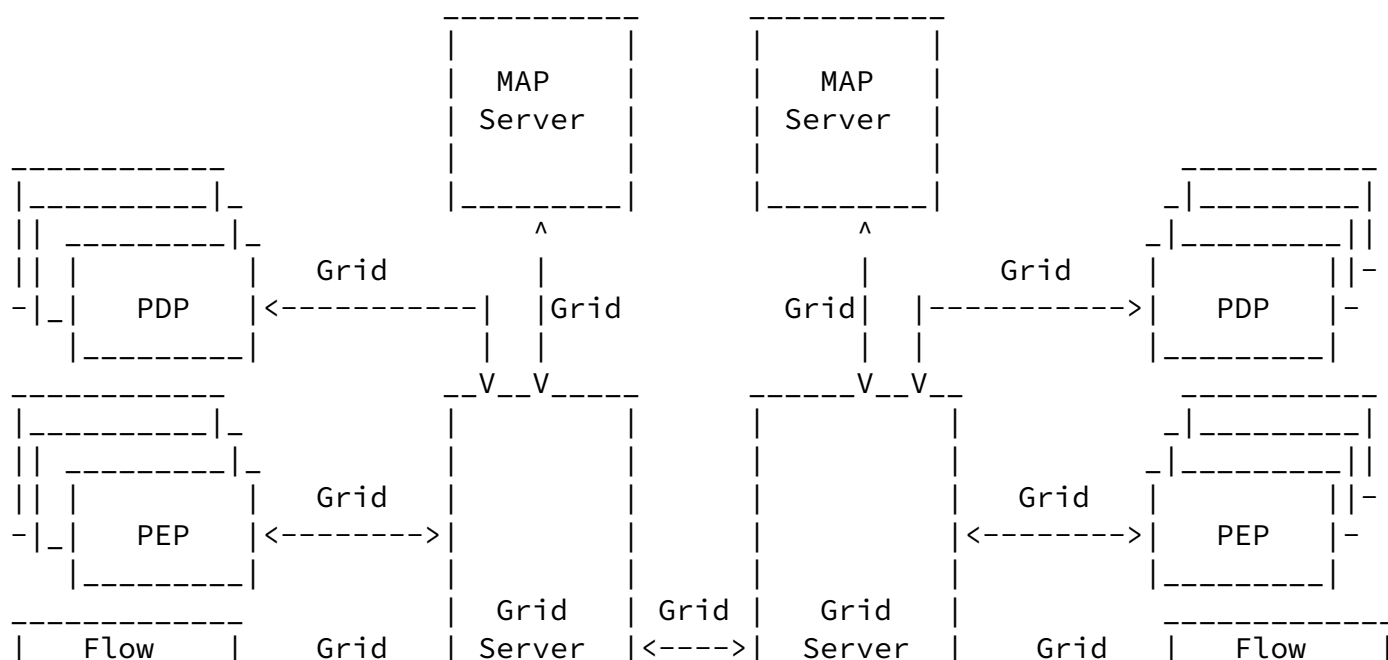
linkages in IF-MAP graph are and the publishers of the data such as the Access Requestors, PEPs and PDPs. As discussed in the Topics

section earlier, XMPP-Grid provides the ability to the Capability provider to create main Topics and Subtopics. The MAP server will be a subscriber to all of the Topics created for such purposes of aggregation. It is the responsibility of the MAP server to use the subscribed metadata to build and manage the MAP graphs.

XMPP-Grid architecture allows multiple MAP servers to be subscribers to the Topics and also other network elements such as Flow Controllers and Sensors to directly consume information from the sources. This enables a complete decentralized architecture for IF-MAP for metadata aggregation where the MAP Server need not always be the sole publisher of metadata for the MAP graph. With such approach it will be possible for time-sensitive subscribers to directly consume information from the sources and use the MAP server for query and search purposes only, enabling the MAP servers to scale significantly. This also allows aggregation of metadata based on domains where MAP server can aggregate and publish metadata based on domain, and subscribers could use message filters such as domain, location to receive only metadata of interest to them.

Region 1

Region 2



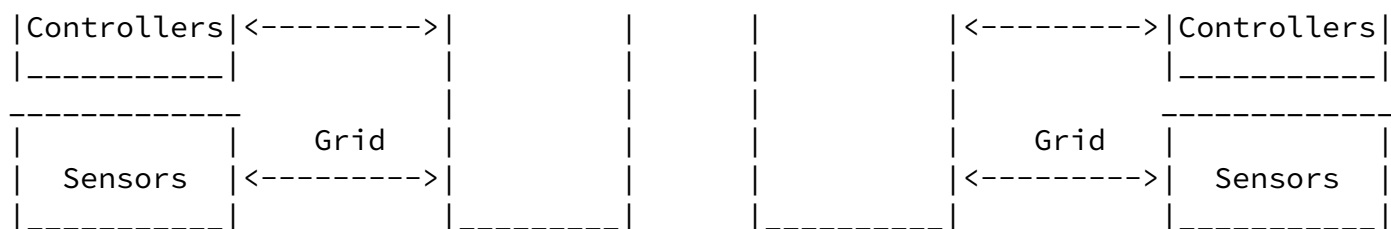


Figure 12: XMPP-Grid Bridging Multiple IF-MAP Instances

#### [4.2.](#) MAP Server as XMPP-Grid Publisher for Metadata Dissemination

MAP Server could publish the MAP graph attribute changes to interested subscribers such as Flow Controllers, Sensors in the following ways

- a. MAP Server to publish all attribute changes of a MAP graph on a main Topic to which the interested network elements participate as subscribers. The subscribers will be able to get real-time notifications through Publish-Subscribe and make on-demand peer-to-peer directed or bulk queries depending on their authorization privileges.
- b. In addition, MAP server, at registration time with XMPP-Grid, could register the MAP graph's filtering criteria as a Publisher with XMPP-Grid. The filtering criteria of a MAP graph could be based on a combination of -
  - A. metadata types
  - B. metadata-identifier linkage attributes
  - C. metadata class
  - D. existing IF-MAP search criteria

As discussed in the Topics section, XMPP-Grid Controller will create Subtopics and manage the Subtopics through the lifecycle based on the subscription list. The MAP Server and XMPP-Grid applies the message filters to publish-subscribe, directed or bulk queries made by the subscribers.

## [5.](#) IANA Considerations

IANA Considerations to be determined

## [6.](#) Security Considerations

A XMPP-Grid Controller serves as an controlling broker for XMPP-Grid Nodes such as Enforcement Points, Policy Servers, CMDBs, and Sensors, using a publish-subscribe-search model of information exchange and lookup. By increasing the ability of XMPP-Grid Nodes to learn about and respond to security-relevant events and data, XMPP-Grid can improve the timeliness and utility of the security system. However, this integrated security system can also be exploited by attackers if they can compromise it. Therefore, strong security protections for XMPP-Grid are essential.

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This section provides a security analysis of the XMPP-Grid transport protocol and the architectural elements that employ it, specifically with respect to their use of this protocol. Three subsections define the trust model (which elements are trusted to do what), the threat model (attacks that may be mounted on the system), and the countermeasures (ways to address or mitigate the threats previously identified).

### [6.1.](#) Trust Model

The first step in analyzing the security of the XMPP-Grid transport protocol is to describe the trust model, listing what each architectural element is trusted to do. The items listed here are assumptions, but provisions are made in the Threat Model and Countermeasures sections for elements that fail to perform as they were trusted to do.

#### [6.1.1.](#) Network

The network used to carry XMPP-Grid messages is trusted to:

- o Perform best effort delivery of network traffic

The network used to carry XMPP-Grid messages is not expected (trusted) to:

- o Provide confidentiality or integrity protection for messages sent over it
- o Provide timely or reliable service

#### [6.1.2.](#) XMPP-Grid Nodes

Authorized XMPP-Grid Nodes are trusted to:

- o Preserve the confidentiality of sensitive data retrieved via the XMPP-Grid Controller

#### [6.1.3.](#) XMPP-Grid Controller

The XMPP-Grid Controller is trusted to:

- o Broker requests for data and enforce authorization of access to this data throughout its lifecycle
- o Perform service requests in a timely and accurate manner
- o Create and maintain accurate operational attributes

- o Only reveal data to and accept service requests from authorized parties

The XMPP-Grid Controller is not expected (trusted) to:

- o Verify the truth (correctness) of data

#### [6.1.4.](#) Certification Authority

The Certification Authority (CA) that issues certificates for the XMPP-Grid Controller and/or XMPP-Grid Nodes (or each CA, if there are several) is trusted to:

- o Protect the confidentiality of the CA's private key
- o Ensure that only proper certificates are issued and that all certificates are issued in accordance with the CA's policies

- o Revoke certificates previously issued when necessary
- o Regularly and securely distribute certificate revocation information
- o Promptly detect and report any violations of this trust so that they can be handled

The CA is not expected (trusted) to:

- o Issue certificates that go beyond name constraints or other constraints imposed by a relying party or a cross-certificate

## [6.2.](#) Threat Model

To secure the XMPP-Grid transport protocol and the architectural elements that implement it, this section identifies the attacks that can be mounted against the protocol and elements.

### [6.2.1.](#) Network Attacks

A variety of attacks can be mounted using the network. For the purposes of this subsection the phrase "network traffic" should be taken to mean messages and/or parts of messages. Any of these attacks may be mounted by network elements, by parties who control network elements, and (in many cases) by parties who control network-attached devices.

- o Network traffic may be passively monitored to glean information from any unencrypted traffic

- o Even if all traffic is encrypted, valuable information can be gained by traffic analysis (volume, timing, source and destination addresses, etc.)
- o Network traffic may be modified in transit
- o Previously transmitted network traffic may be replayed
- o New network traffic may be added
- o Network traffic may be blocked, perhaps selectively



- o A "Man In The Middle" (MITM) attack may be mounted where an attacker interposes itself between two communicating parties and poses as the other end to either party or impersonates the other end to either or both parties
- o Resist attacks (including denial of service and other attacks from XMPP-Grid Nodes)
- o Undesired network traffic may be sent in an effort to overload an architectural component, thus mounting a denial of service attack

#### 6.2.2. XMPP-Grid Nodes

An unauthorized XMPP-Grid Nodes (one which is not recognized by the XMPP-Grid Controller or is recognized but not authorized to perform any actions) cannot mount any attacks other than those listed in the Network Attacks section above.

An authorized XMPP-Grid Node, on the other hand, can mount many attacks. These attacks might occur because the XMPP-Grid Node is controlled by a malicious, careless, or incompetent party (whether because its owner is malicious, careless, or incompetent or because the XMPP-Grid Node has been compromised and is now controlled by a party other than its owner). They might also occur because the XMPP-Grid Node is running malicious software; because the XMPP-Grid Node is running buggy software (which may fail in a state that floods the network with traffic); or because the XMPP-Grid Node has been configured improperly. From a security standpoint, it generally makes no difference why an attack is initiated. The same countermeasures can be employed in any case.

Here is a list of attacks that may be mounted by an authorized XMPP-Grid Node:

- o Cause many false alarms or otherwise overload the XMPP-Grid Controller or other elements in the network security system

(including human administrators) leading to a denial of service or disabling parts of the network security system

- o Omit important actions (such as posting incriminating data),

resulting in incorrect access

- o Use confidential information obtained from the XMPP-Grid Controller to enable further attacks (such as using endpoint health check results to exploit vulnerable endpoints)
- o Advertise data crafted to exploit vulnerabilities in the XMPP-Grid Controller or in other XMPP-Grid Nodes, with a goal of compromising those systems
- o Issue a search request or set up a subscription that matches an enormous result, leading to resource exhaustion on the XMPP-Grid Controller, the publishing XMPP-Grid Node, and/or the network
- o Establish a communication channel using another XMPP-Grid Node's session-id

Dependencies of or vulnerabilities of authorized XMPP-Grid Nodes may be exploited to effect these attacks. Another way to effect these attacks is to gain the ability to impersonate a XMPP-Grid Node (through theft of the XMPP-Grid Node's identity credentials or through other means). Even a clock skew between the XMPP-Grid Node and XMPP-Grid Controller can cause problems if the XMPP-Grid Node assumes that old XMPP-Grid Node data should be ignored.

#### [6.2.3.](#) XMPP-Grid Controllers

An unauthorized XMPP-Grid Controller (one which is not trusted by XMPP-Grid Nodes) cannot mount any attacks other than those listed in the Network Attacks section above.

An authorized XMPP-Grid Controller can mount many attacks. Similar to the XMPP-Grid Node case described above, these attacks might occur because the XMPP-Grid Controller is controlled by a malicious, careless, or incompetent party (either a XMPP-Grid Controller administrator or an attacker who has seized control of the XMPP-Grid Controller). They might also occur because the XMPP-Grid Controller is running malicious software, because the XMPP-Grid Controller is running buggy software (which may fail in a state that corrupts data or floods the network with traffic), or because the XMPP-Grid Controller has been configured improperly.

All of the attacks listed for XMPP-Grid Node above can be mounted by the XMPP-Grid Controller. Detection of these attacks will be more

difficult since the XMPP-Grid Controller can create false operational attributes and/or logs that imply some other party created any bad data.

Additional XMPP-Grid Controller attacks may include:

- o Expose different data to different XMPP-Grid Nodes to mislead investigators or cause inconsistent behavior
- o Mount an even more effective denial of service attack than a single XMPP-Grid Node could
- o Obtain and cache XMPP-Grid Node credentials so they can be used to impersonate XMPP-Grid Nodes even after a breach of the XMPP-Grid Controller is repaired
- o Obtain and cache XMPP-Grid Controller administrator credentials so they can be used to regain control of the XMPP-Grid Controller after the breach of the XMPP-Grid Controller is repaired

Dependencies of or vulnerabilities of the XMPP-Grid Controller may be exploited to obtain control of the XMPP-Grid Controller and effect these attacks.

#### [6.2.4.](#) Certification Authority

A Certification Authority trusted to issue certificates for the XMPP-Grid Controller and/or XMPP-Grid Nodes can mount several attacks:

- o Issue certificates for unauthorized parties, enabling them to impersonate authorized parties such as the XMPP-Grid Controller or a XMPP-Grid Node. This can lead to all the threats that can be mounted by the certificate's subject.
- o Issue certificates without following all of the CA's policies. Because this can result in issuing certificates that may be used to impersonate authorized parties, this can lead to all the threats that can be mounted by the certificate's subject.
- o Fail to revoke previously issued certificates that need to be revoked. This can lead to undetected impersonation of the certificate's subject or failure to revoke authorization of the subject, and therefore can lead to all of the threats that can be mounted by that subject.
- o Fail to regularly and securely distribute certificate revocation information. This may cause a relying party to accept a revoked

certificate, leading to undetected impersonation of the

certificate's subject or failure to revoke authorization of the subject, and therefore can lead to all of the threats that can be mounted by that subject. It can also cause a relying party to refuse to proceed with a transaction because timely revocation information is not available, even though the transaction should be permitted to proceed.

- o Allow the CA's private key to be revealed to an unauthorized party. This can lead to all the threats above. Even worse, the actions taken with the private key will not be known to the CA.
- o Fail to promptly detect and report errors and violations of trust so that relying parties can be promptly notified. This can cause the threats listed earlier in this section to persist longer than necessary, leading to many knock-on effects.

### [6.3.](#) Countermeasures

Below are countermeasures for specific attack scenarios to the XMPP-Grid infrastructure.

#### [6.3.1.](#) Securing the XMPP-Grid Transport Protocol

To address network attacks, the XMPP-Grid transport protocol described in this document requires that the XMPP-Grid messages **MUST** be carried over TLS (minimally TLS 1.2 [[RFC5246](#)]) as described in [[RFC2818](#)]. The XMPP-Grid Node **MUST** verify the XMPP-Grid Controller's certificate and determine whether the XMPP-Grid Controller is trusted by this XMPP-Grid Node before completing the TLS handshake. The XMPP-Grid Controller **MUST** authenticate the XMPP-Grid Node either using mutual certificate-based authentication in the TLS handshake or using Basic Authentication as described in IETF [RFC 2617](#). XMPP-Grid Controller **MUST** use Simple Authentication and Security Layer (SASL), described in [[RFC4422](#)], to support the aforesaid authentication mechanisms. SASL offers authentication mechanism negotiations between the XMPP-Grid Controller and XMPP-Grid node during the connection establishment phase. XMPP-Grid Nodes and XMPP-Grid Controllers using mutual certificate-based authentication **SHOULD** each verify the revocation status of the other party. All XMPP-Grid Controllers and XMPP-Grid Nodes **MUST** implement both mutual

certificate-based authentication and Basic Authentication. The selection of which XMPP-Grid Node authentication technique to use in any particular deployment is left to the administrator.

An XMPP-Grid Controller MAY also support a local, configurable set of Basic Authentication userid-password pairs. If so, it is implementation dependent whether a XMPP-Grid Controller ends a session when an administrator changes the configured password. Since

Basic Authentication has many security disadvantages (especially the transmission of reusable XMPP-Grid Node passwords to the XMPP-Grid Controller), it SHOULD only be used when absolutely necessary. Per the HTTP specification, when basic authentication is in use, a XMPP-Grid Controller MAY respond to any request that lacks credentials with an error code similar to HTTP code 401. A XMPP-Grid Node SHOULD avoid this code by submitting basic auth credentials with every request when basic authentication is in use. If it does not do so, a XMPP-Grid Node MUST respond to this code by resubmitting the same request with credentials (unless the XMPP-Grid Node is shutting down).

As XMPP uses TLS as the transport and security mechanisms, it is understood that best practices such as those in [\[I-D.ietf-uta-tls-bcp\]](#) are followed.

These protocol security measures provide protection against all the network attacks listed in the above document section except denial of service attacks. If protection against these denial of service attacks is desired, ingress filtering, rate limiting per source IP address, and other denial of service mitigation measures may be employed. In addition, a XMPP-Grid Controller MAY automatically disable a misbehaving XMPP-Grid Node.

#### [6.3.2](#). Securing XMPP-Grid Nodes

XMPP-Grid Nodes may be deployed in locations that are susceptible to physical attacks. Physical security measures may be taken to avoid compromise of XMPP-Grid Nodes, but these may not always be practical or completely effective. An alternative measure is to configure the XMPP-Grid Controller to provide read-only access for such systems. The XMPP-Grid Controller SHOULD also include a full authorization model so that individual XMPP-Grid Nodes may be configured to have

only the privileges that they need. The XMPP-Grid Controller MAY provide functional templates so that the administrator can configure a specific XMPP-Grid Node as a DHCP server and authorize only the operations and metadata types needed by a DHCP server to be permitted for that XMPP-Grid Node. These techniques can reduce the negative impacts of a compromised XMPP-Grid Node without diminishing the utility of the overall system.

To handle attacks within the bounds of this authorization model, the XMPP-Grid Controller MAY also include rate limits and alerts for unusual XMPP-Grid Node behavior. XMPP-Grid Controllers SHOULD make it easy to revoke a XMPP-Grid Node's authorization when necessary. Another way to detect attacks from XMPP-Grid Nodes is to create fake entries in the available data (honeytokens) which normal XMPP-Grid

Nodes will not attempt to access. The XMPP-Grid Controller SHOULD include auditable logs of XMPP-Grid Node activities.

To avoid compromise of XMPP-Grid Node, XMPP-Grid Node SHOULD be hardened against attack and minimized to reduce their attack surface. They SHOULD go through a TNC handshake to verify the integrity of the XMPP-Grid Node, and SHOULD, if feasible, utilize a Trusted Platform Module (TPM) for identity and/or integrity measurements of the XMPP-Grid Node within a TNC handshake. They should be well managed to minimize vulnerabilities in the underlying platform and in systems upon which the XMPP-Grid Node depends. Personnel with administrative access should be carefully screened and monitored to detect problems as soon as possible.

### [6.3.3.](#) Securing XMPP-Grid Controllers

Because of the serious consequences of XMPP-Grid Controller compromise, XMPP-Grid Controllers SHOULD be especially well hardened against attack and minimized to reduce their attack surface. They SHOULD go through a regular TNC handshake to verify the integrity of the XMPP-Grid Controller, and SHOULD utilize a Trusted Platform Module (TPM) for identity and/or integrity measurements of the XMPP-Grid Node within a TNC handshake. They should be well managed to minimize vulnerabilities in the underlying platform and in systems upon which the XMPP-Grid Controller depends. Network security measures such as firewalls or intrusion detection systems may be used

to monitor and limit traffic to and from the XMPP-Grid Controller. Personnel with administrative access should be carefully screened and monitored to detect problems as soon as possible. Administrators should not use password-based authentication but should instead use non-reusable credentials and multi-factor authentication (where available). Physical security measures SHOULD be employed to prevent physical attacks on XMPP-Grid Controllers.

To ease detection of XMPP-Grid Controller compromise should it occur, XMPP-Grid Controller behavior should be monitored to detect unusual behavior (such as a reboot, a large increase in traffic, or different views of an information repository for similar XMPP-Grid Nodes). XMPP-Grid Nodes should log and/or notify administrators when peculiar XMPP-Grid Controller behavior is detected. To aid forensic investigation, permanent read-only audit logs of security-relevant information (especially administrative actions) should be maintained. If XMPP-Grid Controller compromise is detected, a careful analysis should be performed of the impact of this compromise. Any reusable credentials that may have been compromised should be reissued.

#### [6.3.4.](#) Limit on search result size

While XMPP-Grid is designed for high scalability to 100,000s of Nodes, an XMPP-Grid Controller MAY establish a limit to the amount of data it is willing to return in search or subscription results. This mitigates the threat of a XMPP-Grid Node causing resource exhaustion by issuing a search or subscription that leads to an enormous result.

#### [6.3.5.](#) Cryptographically random session-id and authentication checks for ARC

A XMPP-Grid Controller SHOULD ensure that the XMPP-Grid Node establishing an ARC is the same XMPP-Grid Node as the XMPP-Grid Node that established the corresponding SSRC. The XMPP-Grid Controller SHOULD employ both of the following strategies:

- o session-ids SHOULD be cryptographically random
- o The HTTPS transport for the SSRC and the ARC SHOULD be

authenticated using the same credentials. SSL session resumption MAY be used to establish the ARC based on the SSRC SSL session.

#### [6.3.6.](#) Securing the Certification Authority

As noted above, compromise of a Certification Authority (CA) trusted to issue certificates for the XMPP-Grid Controller and/or XMPP-Grid Nodes is a major security breach. Many guidelines for proper CA security have been developed: the CA/Browser Forum's Baseline Requirements, the AICPA/CICA Trust Service Principles, etc. The CA operator and relying parties should agree on an appropriately rigorous security practices to be used.

Even with the most rigorous security practices, a CA may be compromised. If this compromise is detected quickly, relying parties can remove the CA from their list of trusted CAs, and other CAs can revoke any certificates issued to the CA. However, CA compromise may go undetected for some time, and there's always the possibility that a CA is being operated improperly or in a manner that is not in the interests of the relying parties. For this reason, relying parties may wish to "pin" a small number of particularly critical certificates (such as the certificate for the XMPP-Grid Controller). Once a certificate has been pinned, the relying party will not accept another certificate in its place unless the Administrator explicitly commands it to do so. This does not mean that the relying party will not check the revocation status of pinned certificates. However, the Administrator may still be consulted if a pinned certificate is revoked, since the CA and revocation process are not completely trusted.

#### [6.4.](#) Summary

XMPP-Grid's considerable value as a broker for security-sensitive data exchange distribution also makes the protocol and the network security elements that implement it a target for attack. Therefore, strong security has been included as a basic design principle within the XMPP-Grid design process.

The XMPP-Grid transport protocol provides strong protection against a variety of different attacks. In the event that a XMPP-Grid Node or XMPP-Grid Controller is compromised, the effects of this compromise have been reduced and limited with the recommended role-based



authorization model and other provisions, and best practices for managing and protecting XMPP-Grid systems have been described. Taken together, these measures should provide protection commensurate with the threat to XMPP-Grid systems, thus ensuring that they fulfill their promise as a network security clearing-house.

## [7.](#) Privacy Considerations

XMPP-Grid Nodes may publish information about endpoint health, network access, events (which may include information about what services an endpoint is accessing), roles and capabilities, and the identity of the end user operating the endpoint. Any of this published information may be queried by other XMPP-Grid Nodes and could potentially be used to correlate network activity to a particular end user.

Dynamic and static information brokered by a XMPP-Grid Controller, ostensibly for purposes of correlation by XMPP-Grid Nodes for intrusion detection, could be misused by a broader set of XMPP-Grid Nodes which hitherto have been performing specific roles with strict well-defined separation of duties.

Care should be taken by deployers of XMPP-Grid to ensure that the information published by XMPP-Grid Nodes does not violate agreements with end users or local and regional laws and regulations. This can be accomplished either by configuring XMPP-Grid Nodes to not publish certain information or by restricting access to sensitive data to trusted XMPP-Grid Nodes. That is, the easiest means to ensure privacy or protect sensitive data, is to omit or not share it at all.

Another consideration for deployers is to enable end-to-end encryption to ensure the data is protected from the data layer to data layer and thus protect it from the transport layer.

## [8.](#) Evolution of XMPP-Grid

XMPP-Grid is the convergence of IF-MAP from the Trusted Computing Group and the Platform-Exchange Grid (pxGrid) from Cisco Systems. Both frameworks focus on enabling end users to implement multi-vendor

systems that share security context information that enables coordinated defense-in-depth and security automation.

An ecosystem of vendors has been shipping IF-MAP enabled products since 2008 to provide an architecture that supports standardized, dynamic security data interexchange among a wide variety of networking and security components. IF-MAP has been continually enhanced by the Trusted Computing Group, culminating in the most recent version, IF-MAP 2.2, published in March 2014. IF-MAP has focused on providing a standardized information model that can be utilized for data interoperability between vendors.

Cisco pxGrid was introduced in 2013 and has since developed a broad-based security and networking vendor ecosystem. pxGrid was developed by extending standards-based XMPP message routing. The goal of pxGrid is to specifically address a lack of transport protocols available in the industry that deliver highly scalable, many-to-many platform security data interexchange in real-time.

XMPP-Grid brings together the strengths of both IF-MAP and pxGrid. IF-MAP provides a mature and standardized information model. This information model is accessible by Cisco pxGrid to transport relevant data between systems. The combined XMPP-Grid delivers a highly scalable, real-time data exchange transport protocol with an interoperable information model based on the experience from real-world, production deployments.

## [9.](#) Acknowledgements

The authors would like to acknowledge the contributions, authoring and/or editing of the following people: Henk Birkholz, Jessica Fitzgerald-McKay, Steve Hanna, Steve Venema.

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#### Authors' Addresses

Joseph Salowey  
Tableau Software  
837 North 34th Street, Suite 200  
Seattle , WA 98103

Email: [joe@salowey.net](mailto:joe@salowey.net)

Lisa Lorenzin  
Pulse Secure  
2700 Zanker Rd., Suite 200  
San Jose, CA 95134  
USA

Email: [llorenzin@pulsesecure.net](mailto:llorenzin@pulsesecure.net)

Cliff Kahn  
Pulse Secure  
2700 Zanker Rd., Suite 200  
San Jose, CA 95134  
USA

Email: [cliffordk@pulsesecure.net](mailto:cliffordk@pulsesecure.net)

Scott Pope  
Cisco Systems  
5400 Meadows Road  
Suite 300  
Lake Oswego, OR 97035  
USA

Email: [scottp@cisco.com](mailto:scottp@cisco.com)

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Syam Appala  
Cisco Systems  
80 West Tasman Drive  
San Jose, CA 95134  
USA

Email: [syam1@cisco.com](mailto:syam1@cisco.com)

Aaron Woland  
Cisco Systems  
1900 South Boulevard  
Charlotte, NC 28203  
USA

Email: [aawoland@cisco.com](mailto:aawoland@cisco.com)

Nancy Cam-Winget (editor)  
Cisco Systems  
3550 Cisco WAY  
San Jose, CA 95134  
USA

Email: [ncamwing@cisco.com](mailto:ncamwing@cisco.com)

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