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ISO/IEC/IEEE 18880

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Information technology — Ubiquitous green community control network protocol

Technologies de l'information — Protocole de contrôle de la communauté verte omniprésente

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IEEE Std 1888™-2014
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Abstract: The standard identifies gateways for field-bus networks, data storage for archiving and developing data sharing platforms, and application units as important system components for developing digital communities, i.e., building-scale and city-wide ubiquitous facility networking infrastructure. The standard defines a data exchange protocol that generalizes and interconnects these components (gateways, storage, application units) over the IPv4/v6-based networks. This enables integration of multiple facilities, data storage, application services such as central management, energy saving, environmental monitoring, and alarm notification systems.

Keywords: access interface, actuator, APP, application, communication protocol, component, data structure, energy management, energy saving, facility networking, gateway, GW, IEEE 1888™, point, registry, sensor, SOAP, storage

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The University of Tokyo

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Dong Liu, *Chair*

Hiroshi Esaki
Ming Feng
Shuai Gao
Chen Gu
Xiaochuan Gu
Lianshan Jiang
Wenjie Li
Hideya Ochiai
Shoichi Sakane
Yang Song
Guoquan Tan
Xiuying Tan
Hongke Zhang
Huiling Zhao
Xiaopeng Zhao
Ning Zou

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Beijing Jiaotong University
Beijing University of Posts and Telecommunications (BUPT)
BII Group Holdings Ltd.
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Introduction

This introduction is not part of IEEE Std 1888-2014, IEEE Standard for Ubiquitous Green Community Control Network Protocol.

The standard identifies gateways for field-bus networks, data storage for archiving and developing data sharing platforms, and application units to be important system components for developing digital communities, i.e., building-scale and city-wide ubiquitous facility networking infrastructure. The standard defines a data exchange protocol that generalizes and interconnects these components (gateways, storage, application units) over the IPv4/v6-based networks. This enables integration of multiple facilities, data storage, application services such as central management, energy saving, environmental monitoring, and alarm notification systems.

Facility networking in buildings, houses, and factories is now considered to be a promising tool for energy management or energy saving, and networking of facilities with TCP/IP protocols has certainly enabled building-scale or city-wide energy management. However, most of the systems are proprietarily and independently developed, deployed, and operated, which makes the installation and running costs quite high.

Traditionally, in order to extend access reachability to sensors and actuators at the field-bus level via the Internet, gateway design has been introduced. However, recent applications of facility networking for such scales are required beyond just a simple access to devices. In most of the practical implementations, they have (1) large storage to archive the history of sensor readings, (2) user interface for interactive operation, (3) reporting systems, and (4) a data analyzer.

Collaboration of these system components is mandatory, especially in energy-aware facility networking. However, they cannot simply collaborate or interoperate with each other without understanding the intended analysis, integration, and operation of systems, because these system components have been independently developed and proprietarily integrated.

Interoperability of these system components by a common communication protocol certainly increases the efficiency of facility networking deployment. It reduces the cost of system integration and interoperability management, allowing installation of them in small and medium-sized buildings and even houses. For vendors, their developed components can be sold worldwide without any customized implementation, sometimes resulting in mass production with reasonable cost.

Targeting building-scale and city-wide energy management, the IEEE P1888 Working Group initiated the project named Ubiquitous Green Community Control Network (UGCCNet), which specifies integration architecture of remote facilities. The scope and purpose of this project is to establish facility networking infrastructure over the Internet by specifying an interoperable communication protocol among the common (building-scale) facility networking components (i.e., device access gateways, data storage, and application units). This standard specifies UGCCNet in order to allow interoperability and open development of those facility networking components. First, the standard generalizes all the facility networking components by a simple component model. Then, the standard defines communication protocol among them. The standard also introduces a registry mechanism to support autonomous collaboration of these components.

It is a communication infrastructure that aims to construct a new network for the renewal of the facilities, next generation's facility management, and the energy conservation including small and medium-sized facilities. The aspect is expanded from a past facility management to the operation management that targets energy conservation and the integration of the management platform. This infrastructure will be used for some system-level collaborations in addition to the energy conservation.

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1. Overview

1.1 Scope

The standard identifies gateways for field-bus networks, data storage for archiving and developing data sharing platforms, and application units such as those providing user interfaces of analysis and for knowing that environmental information is an important system component for developing digital communities, i.e., building-scale and city-wide ubiquitous facility networking infrastructure. The standard defines a data exchange protocol that generalizes and interconnects these components (gateways, storage, application units) over the IPv4/v6-based networks. This opens the application interface to handle the statuses of multi-vendor facilities on a generalized digital infrastructure. The standard assumes distributed operation of the infrastructure by multiple service providers and integrators, and defines a component management protocol that autonomously interoperates such distributed infrastructure. Security requirements are taken into consideration in this standard to ensure the integrity and confidentiality of data.

1.2 Purpose

The standard aims to develop green communities whose energy usage is well managed and highly efficient, by allowing the interconnection of facilities of multiple buildings including small and medium-sized on different converged networks, data sharing platforms, and application units. The products based on the standard implement the functions of sensing, archiving, sharing and presenting of ubiquitous information such as power usage and generation, environmental status and signals, human behavior, heating, ventilation, and air conditioning (HVAC) working status, lighting systems, weather, warnings, analyzed data, forecasted data, and so on. With the capability of interoperable integration of these system

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components, the standard aims to provide and share rich data platforms, including cooperation with control-oriented systems.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IETF RFC 793, Transmission Control Protocol (TCP), Information Sciences Institute.[1]

IETF RFC 2460, Internet Protocol, Version 6 (IPv6) Specification, S. Deering and R. Hinden, editors.

IETF RFC 3986, Uniform Resource Identifiers (URI): Generic Syntax, T. Berners-Lee, R. Fielding, and L. Masinter, editors.

ISO 8601, Data elements and interchange formats—Information interchange—Representation of dates and times.[2]

W3C®, Extensible Markup Language (XML) 1.0, Tim Bray, Jean Paoli, C. M. Sperberg-McQueen, Eve Maler, and François Yergeau, editors.[3, 4]

W3C, Namespaces in XML 1.1, Tim Bray, Dave Hollander, Andrew Layman, Richard Tobin, editors.

W3C, SOAP Version 1.2 Part 1: Messaging Framework, Martin Gudgin, Marc Hadley, Noah Mendelsohn, Jean-Jacques Moreau, Henrik Frystyk Nielsen, Anish Karmarkar, and Yves Lafon, editors.

W3C, XML Schema Part 1: Structures, David Beech, Murray Maloney, Henry S. Thompson and Noah Mendelsohn, editors.

W3C, XML Schema Part 2: Datatypes, Ashok Malhotra and Paul V. Biron, editors.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [5]

access control: The means to allow authorized entry and usage of resources.

actuator: A transducer that accepts a data sample or samples and converts them into physical action.

[1] IETF documents (i.e., RFCs) are available for download at http://www.rfc-archive.org/.
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eXtensible Markup Language (XML) namespace: A method for distinguishing XML elements and attributes that may have the same name but different meanings. A URL is used as a prefix to a "local name." This combination ensures the uniqueness of the element or attribute name. The URL is used only as a way to create a unique prefix and does not have to resolve to a real page on the Internet.

sensor: A transducer that converts a physical, biological, or chemical parameter into a digital signal.

universally unique identifier (UUID): An identifier that has a unique value within some defined universe.

NOTE—In this standard, the query-expression and lookup-expression of transport data structure has a UUID unless otherwise stated.[6]

3.2 Acronyms and abbreviations

AAA	authentication, authorization, and accounting
API	application programming interface
EPR	end-point reference
FTP	File Transfer Protocol
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IP	Internet Protocol
IPv6	Internet Protocol Version 6
NAT	Network Address Translation
RPC	remote procedure call
SIP	Session Initiation Protocol
SMTP	Simple Mail Transfer Protocol
SOAP	Simple Object Access Protocol
SSH	Secure Shell
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TTL	time to live
UGCCNet	Ubiquitous Green Community Control Network Protocol
URI	Uniform Resource Identifier
UUID	Universally Unique Identifier
VPN	Virtual Private Network
W3C	World Wide Web Consortium
WSDL	Web Services Description Language
XML	eXtensible Markup Language

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4. Architecture

4.1 UGCCNet networking architecture

This protocol specification applies to a TCP/IP-based facility networking architecture shown in Figure 1. One of the main goals of this specification is to enable interoperability among facility networking components. Thus gateway (GW), storage, and application (APP), what we call "Component" in this document, have the same generalized communication interface. Registry has a different communication interface with these components, so it is distinguished with a dashed frame as shown in Figure 1. A Component works as a part of the data plane, and Registry works as a part of control plane. In Figure 1, an emphasis is on authentication, authorization, and accounting (AAA) functionality provided for operational management support. This document does not cover AAA, but related work may be taken on in the future.

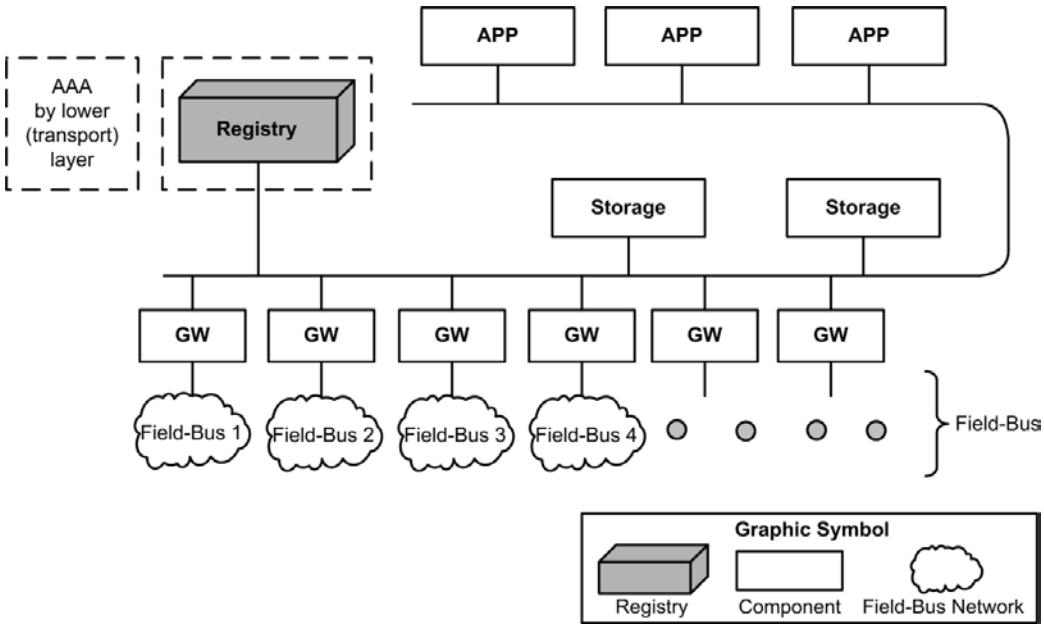

Figure 1—UGCCNet networking architecture

In the UGCCNet networking environment, Registry works as a broker of Components. It manages meta information, e.g., the role of each component and the semantics of Point ID, in order to bind components appropriately and autonomously. We describe them here in more detail and show how they collaborate with each other.

4.1.1 Gateway (GW)

The gateway component has physical sensors and actuators. It generalizes the data model and the access method for those devices, encapsulating each physical (field-bus) data model and access method. It acts on its actuator according to the written value from a component (e.g., APP), and it provides physical sensor readings for other components (e.g., storage and APP).

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4.1.2 Storage

Storage component archives the history of data sequences. The written values from other components should be permanently stored in the backend disks. It provides the archived values to the components that have requested them.

4.1.3 Application (APP)

APP component provides some particular works on sensor readings and actuator commands. It can have user interface to display the latest environmental state. It can also allow a user to input some schedules of actuator settings, and it can as well analyze some sensor data in real time and provide the result as a virtual device.

4.1.4 Registry

The Registry works as a broker of GW, storage, and APPs. The main role of registry is to bind those components appropriately and autonomously. It is separated from the data-plane. It does not work on sensor readings or actuator settings directly. The UGCCNet should allow system operation without Registry.

4.2 Typical sequence

Figure 2 shows typical protocol sequences among components and registry. The bold arrows indicate component-to-component communication, and the dashed arrows indicate component-to-registry communication.

Registry manages the information of Point IDs and the role of components. When components need to access the data or the interface bound to a certain Point ID, it first refers to the Registry. Then, the Registry replies with the access URIs [e.g., SOAP end-point references (EPRs)] of the components that manage the data or the interface of the Point ID. Interaction with the Registry is optional. If the requesting component knows the target access URIs, for example by configuration, it is not necessary to consult to Registry.

Here, we describe the details of communication from case A to case I.

NOTE—Annex A provides more detailed explanations for each case.

Case A: Registration of Components. The registration includes the information of (1) what Point IDs this GW has, (2) what Point IDs this storage manages, (3) what Point IDs this APP reads and provides. See 5.3.2 for details.

Case B: Searching appropriate Points by semantic-query. See 5.3.3 for details.

Case C: Searching a Storage component for a specified Point. It returns the access URI (see IETF RFC 3986) for the resolved component. [7] See 5.3.3 for details.

Case D: Transmission of data; GW is sending observed sensor readings to Storage. See 5.2.3 for details.

Case E: Sequential retrieval of data; APP is retrieving data from Storage. If the retrieving dataset is large, data should be read sequentially. See 5.2.2 for details.

[7] Information on references can be found in Clause 2.

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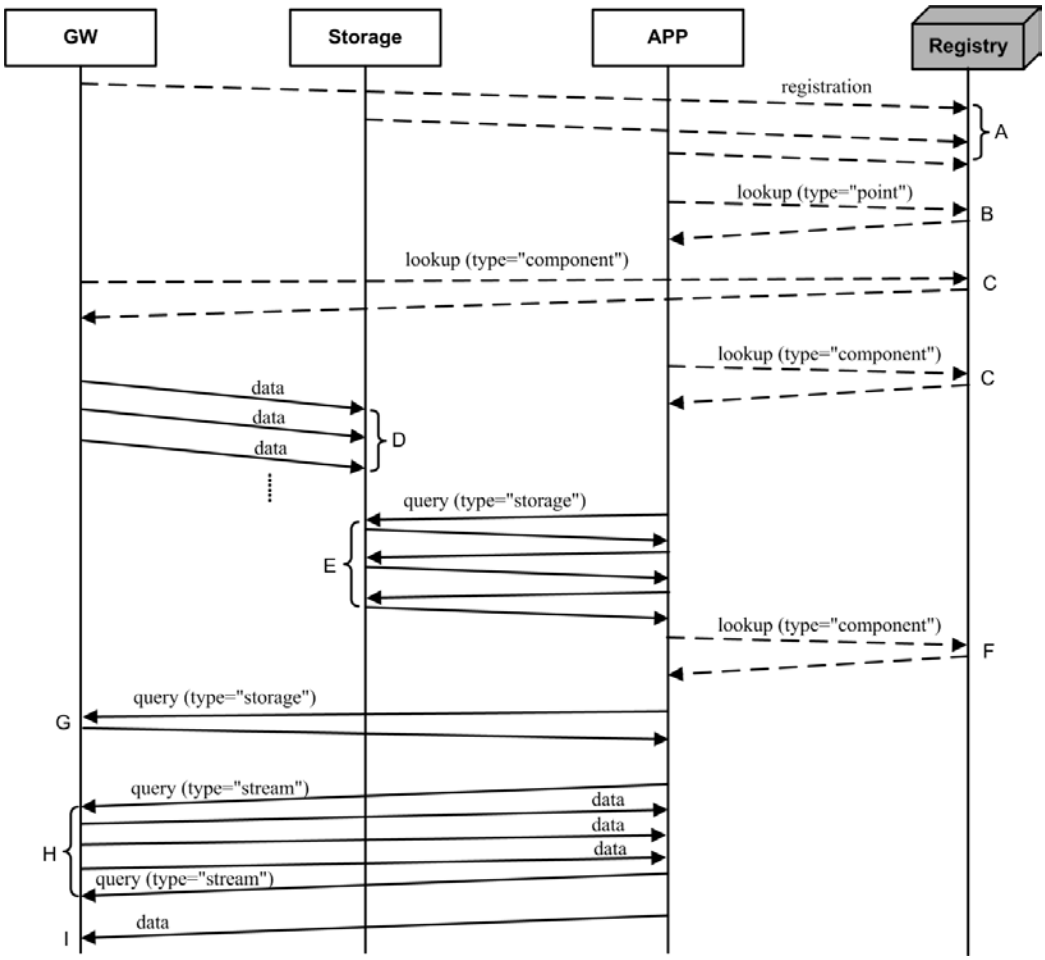

Figure 2—A typical sequence of UGCCNet communication

Case F: Searching a GW component for a specified Point. It returns the access URI for the resolved component. See 5.3.3 for details.

Case G: Retrieval of Data; APP is retrieving data from GW. If the retrieving dataset is small, data can be read in one remote procedure call (RPC). See 5.2.2 for details.

Case H: Notification of Data; APP is putting event query to GW periodically, and the GW submits updates to the APP. See 5.2.4 for details.

Case I: Writing of Data; APP is setting a command to a GW actuator. See 5.2.3 for details.

4.3 Concerns of UGCCNet network design

As we see in the preceding sequences, all components can behave both as the TCP (see IETF RFC 793) initiator and receiver at once. It implies the components should be put on a flat network. A flat network means there are no middle boxes that could disturb bidirectional communications such as NAT routers and firewalls.

To avoid the issue, we strongly recommend building an IPv6 (see IETF RFC 2460) network. There could be other solutions than IPv6 such as http proxy based or NAT traversal solutions. However, they would depend on the requirements of the network configuration. This specification does not reject such solutions,

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but they are required to be made interoperable with other UGCCNet-based systems and not to disturb the specification. Proposing specific solutions other than IPv6 is out of scope of this document.

4.4 System model and deployment

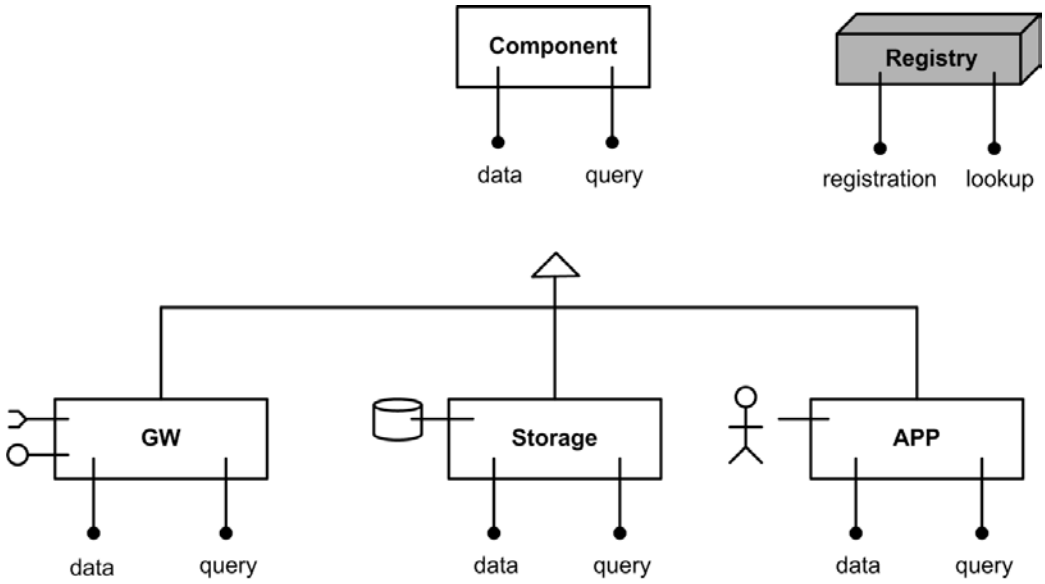

Figure 3—UGCCNet system model

Figure 3 provides the UGCCNet system model. Component is the basic unit for all the GWs, storage, and APPs. The interface of Component provides data and query method. GW, storage, and APP are the inherited classes of Component. Thus, they have the same interface (i.e., data and query method), and they communicate with each other using the same protocol, as follows:

— Query is a method for retrieving data (including event-based data transfer) from Component.

— Data is a method for pushing data into Component.

Registry works as a broker of Components with another type of interface (i.e., registration and lookup method). The interface of Registry provides registration and lookup method, as follows:

— Registration is a method for registering the role of components and semantics of Points.

— Lookup is a method for finding appropriate components and Points.

Typical implementations for GWs, storages, APPs, and Registry would be the following:

— GW implementations encapsulate field-buses and provide INPUT/OUTPUT access for physical devices (by query and data method).

— Storage implementations archive the history of data posted by data method and provide the historical data by query method.

— APP implementations provide other functionalities. For example, they can have user interface. Data processing component must be also categorized to an APP implementation.

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