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USN metadata management agent using IoT-based EMRA

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Abstract

In this paper, we define EMRA-based USN metadata to describe sensor device, sensor node, and sensor network information at the application level. And the proposed method for effectively storing and retrieving USN metadata based on EMRA uses agent technology. As the sensor metadata proposed in this paper is based on SensorML, interoperability can be maintained in the USN environment, and the metadata management system can be directly utilized for metadata management in USN middleware or applications.

Keywords: *USN, MetaData, EMRA, SensorML, IoT, Agent.*

1. INTRODUCTION

The USN (Ubiquitous Sensor Network) is a wireless sensor network called a ubiquitous sensor network. The USN environment for providing various services to users in the IoT environment is composed of numerous heterogeneous resources [1]. For interoperability between UNS resources and IoT center-based applications, metadata standards are required to express and exchange information on IoT-based sensor resources in a standardized form [2]. In addition, the requirements of applications for providing various services to users based on these USN resources are also different. In this paper, an IoT based USN metadata management agent using EMRA (Extended Metadata Registry Access) is proposed. The USN metadata resource is defined based on SensorML considering interworking with SensorML. Also, USN metadata using EMRA presented in this paper was defined as EMRA Query for a standardized data format considering interoperability [3,4]. USN metadata exists at the level of big data due to its characteristics, and it exists together with dynamically generated sensing data. Therefore, considering these characteristics, the USN metadata standard is still being studied at home and abroad. However, it is not easy to find studies to effectively manage USN metadata [5]. In this paper, considering the characteristics of USN metadata, propose a method for effectively storing and managing metadata based on it. The structure of this paper is as follows. Chapter 2 describes USN metadata using EMRA, and Chapter 3 describes the IoT-based USN metadata storage management agent using EMRA proposed in this paper. Chapter 4 describes the effectiveness of performance evaluation. Finally, Chapter 5 describes the future research direction along with the conclusion.

2. Related Work

SensorML [6] is one of the standards proposed by OGC for Sensor Web Enablemen (SWE). It provides a

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standard model that includes the data measured from the sensor and information from the sensor. The purpose of SensorML is to model processes based on sensors, and to describe the USN information required to model the process. The Telecommunications Technology Association (TTA) recommends defining and using the USN metadata model by itself [7]. Since the purpose and purpose of TTA is to describe USN metadata purely, it is more metadata-oriented than SensorML, and is defined to describe information structurally and faithfully. However, since the standards proposed by SensorML and TTA are independent of each other, heterogeneous problems may occur when used together in the USN application or middleware side.

3. USN CONFIGURATION BASED ON EMRA

USN metadata using EMRA(Extended Metadata Registry Access)[3,4] proposed in this paper is composed as shown in Figure 1. In Figure 1, 'SensorNetwork EMRA' defines metadata about the sensor network. And 'System Intelligence EMRA' defines a sensor node that includes a sensor, and 'Element EMRA' defines a sensor device as metadata. Each EMRA is each technically defined and linked by cross-reference as needed. 'SensorNetwork EMRA' metadata can be associated with one or more 'System' metadata. In addition, 'System' metadata may be linked to one or more 'Component' metadata. The structure of this metadata looks similar to the USN metadata model proposed by TTA(TelecommunicationsTechnology Association) . However, in the metadata of TTA [8,9], 'SensorNetwork EMRA' node is placed at the top, 'sensorNode' node is connected as a child, and 'transducer' node is connected as a child node of 'sensorNode'. Therefore, it is defined to describe metadata from top to bottom centering on the sensor network.

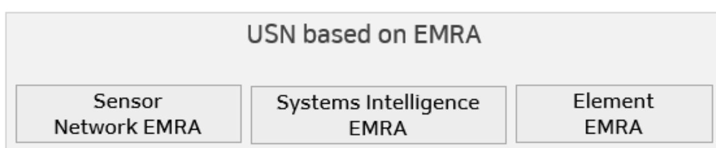

Figure 1. USN Configuration Based on EMRA

In this paper, metadata is not described with a focus on the sensor network, but the USN resource is divided into three parts and each independently describes the metadata. Each metadata is individually divided and described, and metadata can be linked by reference as needed. Therefore, while maintaining independence between each node, it is designed to flexibly cope with various center network environments. In SensorML, Element and System are defined to describe the physical process. This is similar to the concept of a sensor node and a transducer in the USN metadata model proposed by TTA [8,9]. However, SensorML does not define a separate part for describing a sensor network. Therefore, it is difficult to describe sensor network information using SensorML. In this paper, EMRA, which is the basis of USN metadata, is defined with the structure shown in Figure 2.

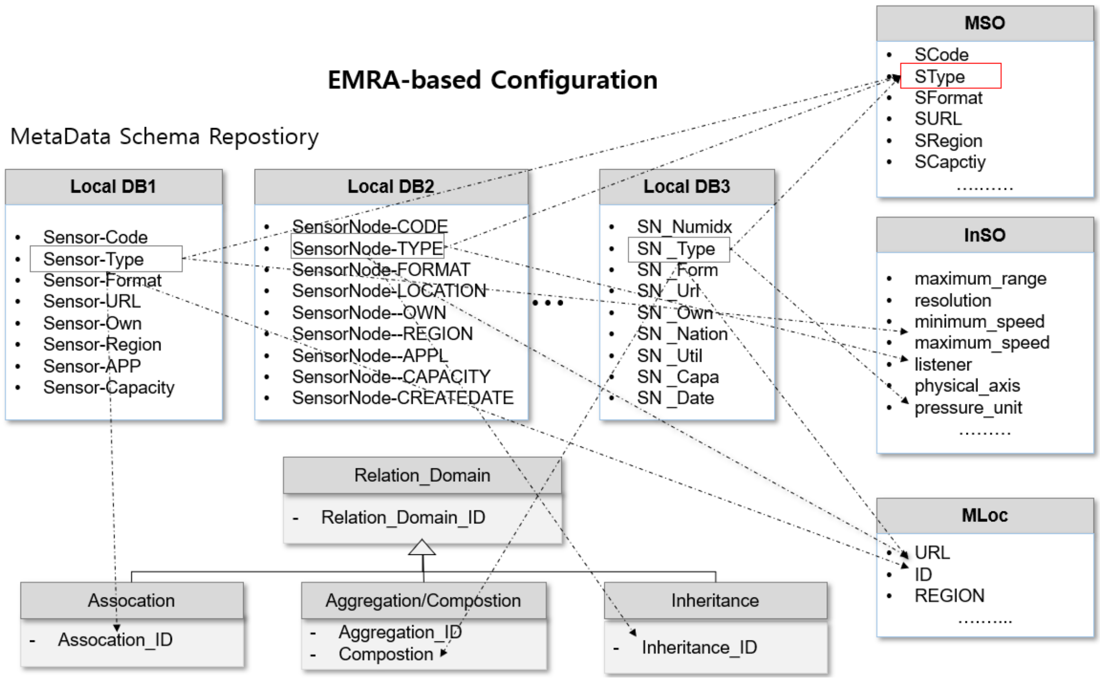

Figure 2. The Composition of The USN EMRA

3. THE PROPOSED AGENT

In addition to the EMRA-based USN metadata proposed in this paper, the USN metadata models of SensorML and TTA are all described in JSON. In the end, managing USN metadata is the same as managing data inside EMRA. Figure 3 is the agent configuration proposed in this paper. This agent is largely composed of DA (Demand Agent), EQA (EMRA Query Agent), and SA (Storage Agent) agents. The main modules are explained as follows.

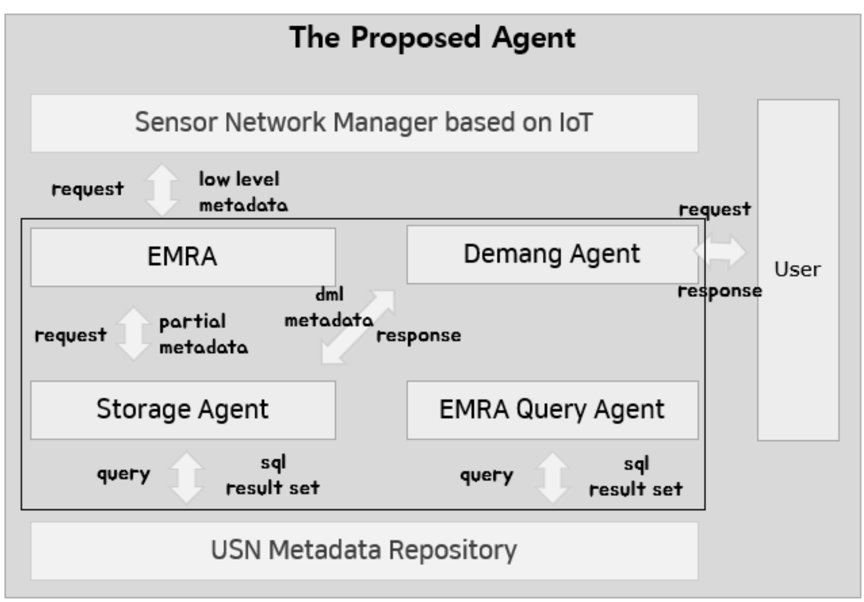

Figure 3. The Proposed Agent

- Demand Agent: It analyzes the requirements of the User or Sensor Network Manager, and is responsible for calling the appropriate module according to the request.
- Storage Agent USN: Inserts, deletes, and updates metadata.
- EMRA Query Agent: Retrieves USN metadata stored in the repository.
- EMRA: When there is a request for USN metadata input, it acts as a coordinator to obtain information of sensor devices, sensor nodes, and sensor networks directly from the sensor network as needed.

As shown in Figure 3, in the agent composed of four modules, the Sensor Network Manager communicates with the sink node of the sensor network. Then, the sensed data and USN metadata are collected and returned to the USN metadata management agent. If the user can input all USN metadata, this process can be omitted. However, in reality, the approach presented in this paper is necessary because there is meta-information that changes dynamically such as power remaining in Node among USN metadata. Figure 4 shows the flow of the EMRA-based USN metadata management system. As shown in Figure 4, the user makes a request from the Demand Agent. Demand Agent delivers MLmeta to Storage Agent after analysis, and USN Metadata Repo executes metaFactQuery. The Demand Agent that has returned the query execution result delivers the EMRAQuery to the EMRA Query Agent. EMRA Query Agent returns the results of Query execution through USN Metadata Repo, and creates the Query as a Json document. After that, the user transmits the sensor data from the Sensor Network Mgmt as a Json-based Query, and the result is returned.

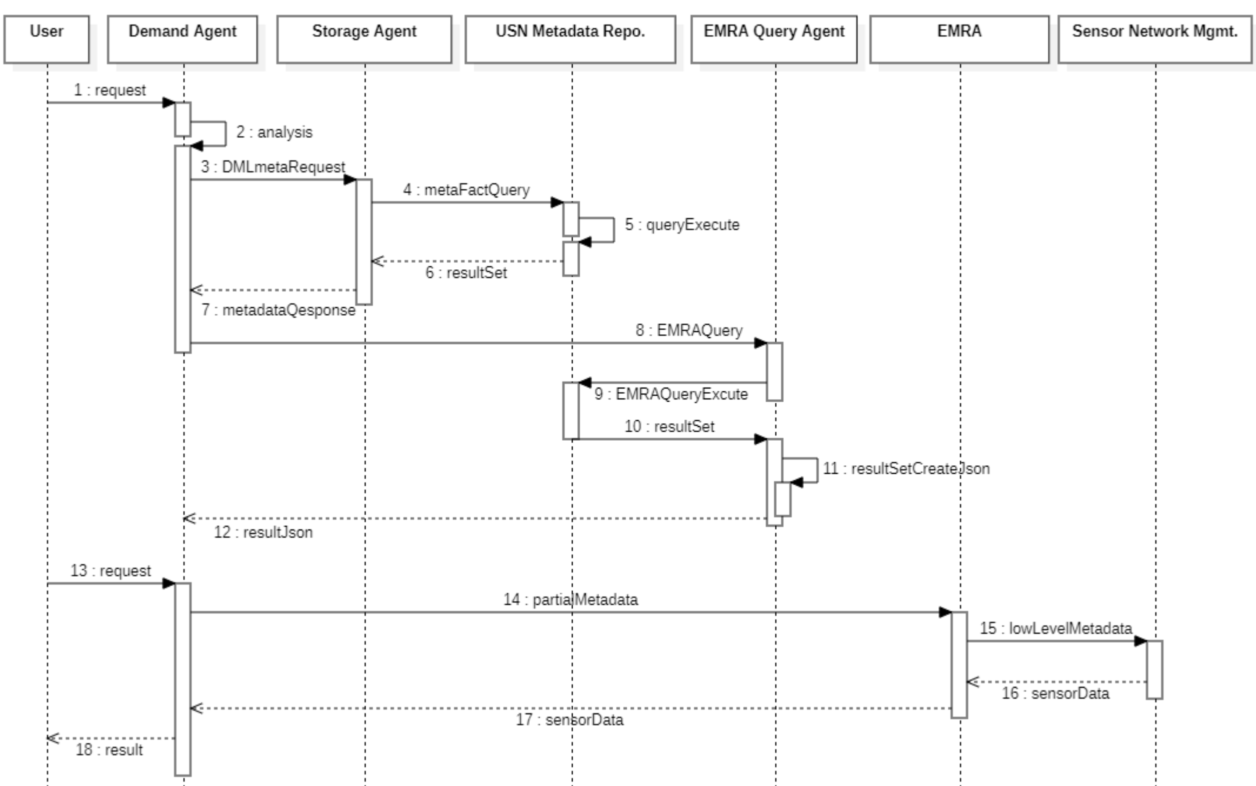

Figure 4. Sequence of USN metadata management System based on EMRA

Figure 5 is an algorithm that creates a master table for storing USN metadata based on EMRA and sets the relationship. This algorithm applies a binary approach that creates one master table for each node. The number of EMRA master tables created in the DB will be as many as the number of node types that exist in the USN metadata of a single global schema. Then, the relationship mapping between tables is set to 1:1, 1:n and n:m by repeating the number of master table rows by attribute value matching.

```
Algorithm-EMRA master create
Input: each node N, table of each node EN, nodes based on single super schema SN
Output: table create super query sql
Begin
    SN gn := EN /* the nodes in a single super schema */
    masterTables[gn] := createTable(nodes in USN metadata )
    sql := ∅
    sql := schemaRelationMapping( masterTables[gn], resultRow )
    Return sql
End
Procedure schemaRelationMapping(masterTables[gn], resultRow )
Begin
    em := attribute in xmra master table
    For i=1 to m do   /* m: rows of master table */
        If  em is the attribute of a node master table Then
            resultRow  <-  1:1 mapping tables
        End If
    End For
    For i=1 to m do   /* m: rows of master table */
        If  em is the attribute of a node master table Then
            resultRow  <-  1: n mapping tables
        End If
    End For
    For i=1 to m do   /* m: rows of master table */
        If  em is the attribute of a node master table Then
            resultRow  <-  n:m mapping tables
        End If
    End For
    Return resultRow
End
```

Figure 5. Algorithm

For USN metadata, it is a very natural approach to use EMRA Query, a standard query word for XML data search, for USN metadata search. However, since USN metadata is stored in the RDB in the form of a table, data cannot be retrieved using EMRA Query directly. In other words, in order to process the EMRA Query query queried by the user, it must be converted into a SQL query suitable for the relational table structure proposed in this paper and processed. Also, the resulting SQL result set must also be converted into XML data, which is the result of the EMRA Query query, and returned. Figure 6 shows the EMRA Query query and the converted SQL query. The content of the EMRA Query query is to return the entire USN metadata document whose 'gml:id' attribute value is 'SN120_0001' among element nodes with 'sml:System' as the tag name. To convert this into an SQL query, all records with the id attribute value of 'SN120_0001' are taken from the table 'sml_System' where the node named 'sml:System' is stored. At this time, each record must be joined with a record whose Path table value is '/sml:SensorML/sml:memebr/sml:System'. Also, to find the correct path, the correct parent node is found by searching which record ID in the 'sml_SensorML' table the ID of the record selected from the 'sml_System' table is derived from.

```
for $SensorML in fn:Doc('SM')/sml:SensorML
let $id := $SensorML/sml:member/sml:System/@gml:id
where contains($id, 'SN120_0001')
return <result> {$SensorML}</result>
```

```
(Select Distinct sml_SensorML.starPoint, sml_SensorML.endpoint, sml_SensorML.ID_sml_SensorML
 From sml_SensorML, Path Path0, sml_System
 Where sml_System.Att_gml_id like    %SN120_00001%
 And Path0.ID_Path = sml_System.ID_Path
 And Path0.PathExp =    sml:SensorML/sml:memer/sml:System
 sml_SensorML.ID_sml_SensorML ||    %   )
```

Figure 6. EMRA Query query and converted SQL query

4. PERFORMANCE EVALUATION

The performance evaluation software and environment of this paper are as follows.

- Execution environment: VMware, MySQL, Linux Ubuntu 5 nodes, Sensor nodes 10, Windows server with metadata deployed.
- Experimental setup: Assume that a total of 5 queries of 5000K and 20000KB are performed for each node for the USN metadata size, and there is no index in the relational database.

Figure 7 shows the results of measuring the time taken to execute the EMRAQ5 query while increasing the size of USN metadata from 5000KB to 20000KB by 5000KB. As can be seen from Figure 7, the method proposed in this paper shows excellent performance independent of the data size. This is probably because it is possible to directly access a specific node using the path table. The relational database used for performance evaluation is the result of storing USN metadata as the most basic storage method without registering USN metadata schema or using any index for search and executing EMRA Query query. Therefore, it is difficult to directly compare the two methods. However, in this paper, since standard SQL queries are used, a method for storing and retrieving metadata is proposed regardless of the type of relational database.

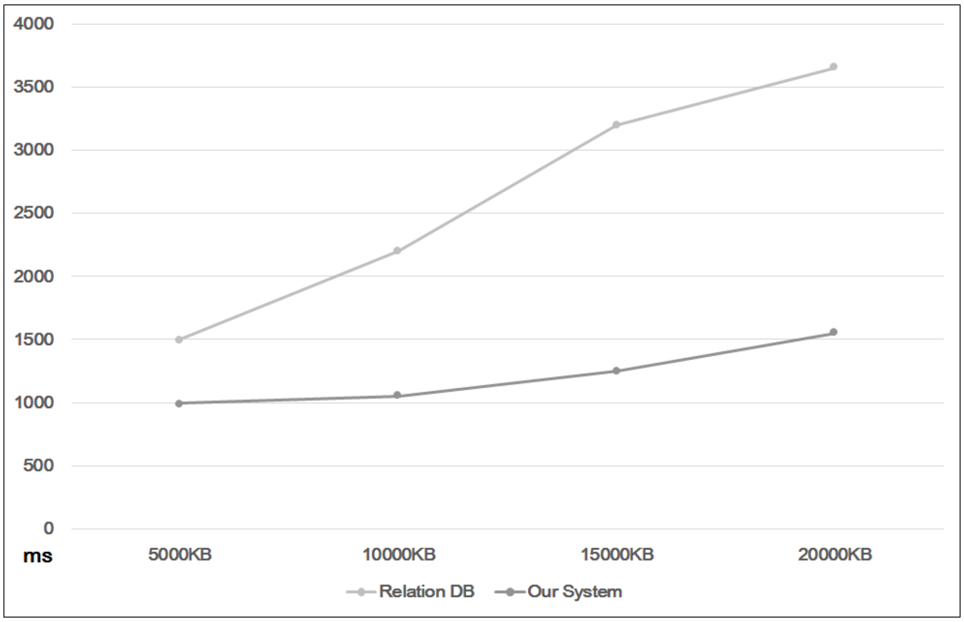

Figure 7. Performance evaluation for scalability property

5. CONCLUSION

In this paper, EMRA Query is presented to effectively store and manage USN metadata. For efficient storage and retrieval of EMRA-based metadata, a new method is used that takes only the advantages of the existing methods for managing XML data and removes the disadvantages. This is possible because the characteristics of USN metadata are considered. In addition, this paper provides a user interface for general users to easily use the USN metadata management system, and evaluates its performance by implementing a metadata management system prototype. The results of this paper can be referenced to define international standard metadata for describing USN resources in a sensor network environment in the future. In addition, since the USN metadata management system is designed independently of the application or environment, it is expected that it can be used directly for metadata management in USN middleware or USN applications in the future.

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REFERENCES

[1] LI, Yuan, et al. A Vision of Intelligent IoT—Trends, Characteristics and Functional Architecture. In: 2022 International Wireless Communications and Mobile Computing (IWCMC). IEEE, pp.184-189, 2022. DOI: https://doi.org/10.3390/fi14020044

[2] DE LA TORRE, Luis, et al. Using IoT-Type Metadata and Smart Web Design to Create User Interfaces Automatically. IEEE Transactions on Industrial Informatics, 2022. DOI: 10.1109/TII.2022.3186638

[3] PARK, Ho-Kyun; MOON, Seok-Jae. Distributed Data Platform Collaboration Agent Design Using

EMRA. International Journal of Internet, Broadcasting and Communication, 14(2), pp.40-46, 2022. DOI: https://doi.org/10.7236/IJIBC.2022.14.2.40

[4] STAUSBERG, Jürgen, et al. Metadata Definition in Registries: What Is a Data Element?. In: Challenges of Trustable AI and Added-Value on Health. IOS Press, pp.174-178, 2022. DOI: 10.3233/SHTI220432

[5] FAHAD, Muhammad; JAVID, Tariq; BEENISH, Hira. Service Oriented Architecture for Agriculture System Integration with Ontology. Technology, 4(3), pp.880-890, 2022.

[6] OGC Sensor Model Language, OpenGIS Standard 2007.

[7] USN Metadata Model, TTAK.KO-06.0168/R1,June 2009.

[8] GU, Xuewu. Open RAN: An Adventurous Antithesis to Globality of 5G. In: Structural Power in the Global Age. Springer, Cham, pp.133-141, 2022. DOI: 10.1007/978-3-031-15467-6_14

[9] MASSARO, Maria; KIM, Seongcheol. Why is South Korea at the forefront of 5G? Insights from technology systems theory. Telecommunications Policy, ,46(5), 102290, 2022. DOI: https://doi.org/10.1016/j.telpol.2021.102290