# METADATA MODELLING OF IPv6 WIRELESS SENSOR NETWORK IN HEIHE RIVER WATERSHED

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## *ABSTRACT*

*Environmental monitoring in ecological and hydrological watershed-scale research is an important and promising area of application for wireless sensor networks. This paper presents a system design of IPv6 wireless sensor network (IPv6WSN) in Heihe river watershed in Gansu province of China to assist ecological and hydrological scientists collecting field scientific data in an extremely harsh environment. To solve the challenging problems, this paper focus on the key technologies adopted in our project, which is Metadata modeling for IPv6WSN. The system design introduced in this paper provides a solid foundation for effective use of self-developed IPv6 wireless sensor network by ecological and hydrological scientists.*

**Keywords:** Metadata, Ecology, Hydrology, HeiHe River

## 1 INTRODUCTION

Environmental monitoring in ecological and hydrological watershed-scale research is an important and promising area of application for wireless sensor networks (WSN). Its potential to provide dynamic, real-time data about monitored variables of a landscape will enable scientists to measure properties that have not previously been observable.

The adoption of the next generation Internet protocol (IPv6) as the Layer-3 protocol to connect wireless sensors is a promising approach to address current issues of WSN, such as scalability, security, mobility and so on. IPv6 extended address space (2^128 instead of 2^32) together with its auto-configuration and mobility capabilities makes IPv6 a suitable protocol for large scale sensor network deployments. Therefore, an IPv6 wireless sensor network is designed and developed by ourselves to assist ecological and hydrological scientists to understand watershed-scale hydrologic cycle and energy balance. The experiment area is the Heihe river watershed, which is a typical continental river basin starting from Qinghai province, through Gansu province and ending Inner Mongolia province in China.

Metadata in IPv6WSN is the descriptive data used to describe the IPv6WSN including the environment, deployment location, data ownership, sensor specifications, sensor status, sensor calibrations and replacements, outlier and error information, etc., which plays a crucial role in processing and properly interpreting raw sensor measurement and management data.

In our project, we define metadata as static, self-describing data for explaining IPv6 wireless sensor networks and node characteristics. We present a metadata model for IPv6 wireless sensor network developed by ourselves for watershed-scale ecological and hydrological research. This model not only involves very rich scientific data but also includes management and control data required by IPv6WSN itself. Obviously, it is necessary to build such a unified metadata model for data transmission and processing. The metadata model introduced in this paper provides a solid foundation for effective use of self-developed IPv6 wireless sensor network by ecological and hydrological scientists.

## 2 METADATA MODELLING

Metadata is structured information that describes, explains, location, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is often called data about data or information about information. The metadata are generally used to describe and structure the principal aspect of data with the aim of sharing, reusing and understanding heterogeneous data sets and allowing the information searching and retrieval [1].

Metadata in IPv6WSN is the descriptive data used to describe the WSN, including the environment, deployment location, data ownership, sensor specifications, sensor status, sensor calibrations and replacements, outlier and error information, etc., which plays a crucial role in processing and properly interpreting raw sensor measurement and management data.

Currently, the metadata need to become an important part of WSN in order to preserve the knowledge of the WSN' status over time. The metadata must describe dynamically the changes of the network status and report them back to other components and systems. For example, if a node changes its location, the system must be able to broadcast a message containing metadata in order to inform other sensor networks and users about these changes. If a node fails, the network must automatically reconfigure new routes to send data. In the same way if a node changes its location, the sensing data (and their metadata) must reflect the new location. [2]

In our project, we define metadata as static, self-describing data for explaining IPv6 wireless sensor networks and node characteristics. The metadata model consists of six categories: *GeneralInfo, SensorInfo, Processes, Position, CollectedData* and *ControlInfo*. Some of them also include sub-elements. The IPv6WSN metadata schema is showed in Figure 1.

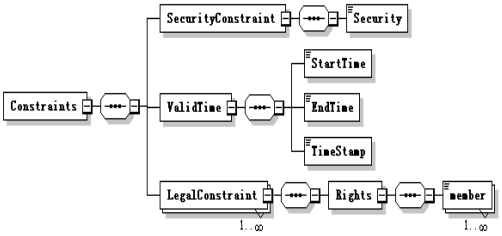


**Figure 1.** IPv6 wireless sensor network metadata schema.

## 2.1 GeneralInfo Metadata

This metadata includes seven elements, which provide the main information to help users find wireless sensor networks, access to monitoring data attributes, WSN owner's contact information, and the constraints for use of the network and so on. These elements include Identification, Description, Constraints, Properties, References, History and SinkType. The detailed description is showed in Figure 2. Description metadata is used to introduce IPv6WSN supplementary information, and Identification metadata includes the name of IPv6WSN.

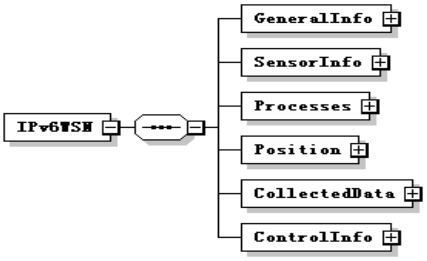


**Figure 2**. GeneralInfo metadata schema

Constraints metadata consists of three elements: SecurityConstraint metadata, ValidTime metadata and LegalConstraint metadata (see Figure 3). SecurityConstraint describes the security requirements for use of IPv6WSN. ValidTime describes the time interval of IPv6WSN operation. LegalConstraint is used to constraint only registered members can access. This element has multiple members. If LegalConstraint does not exist, IPv6WSN can be used by anyone.

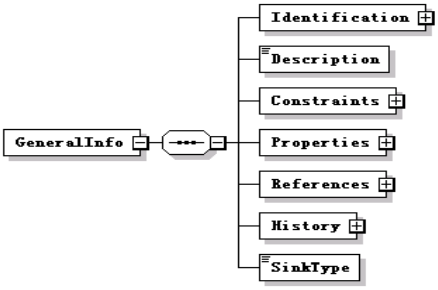


**Figure 3.** Constraints metadata schema

Properties metadata (see Figure 4**)** contains one or more attributes. Any wireless sensor networks have their own attributes or characteristics, for example, a wireless sensor network can only collect radiation in a certain frequency range. The application of the network also needs to have some of the data quality requirements, such as acquisition accuracy. Some limitations on WSN in physics or mathematics can also be described in properties metadata.

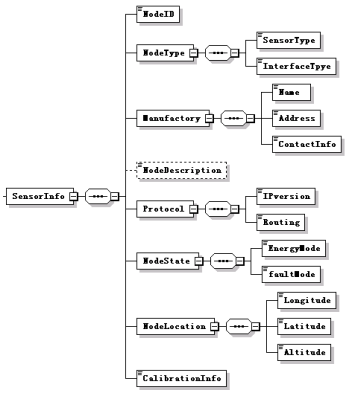


**Figure 4.** Properties metadata schema

References metadata (see Figure 5) includes at least one Documentations element, which describes the information associated with wireless sensor networks, namely Description, Date, Contact, Format and FileLocation. Each documentation corresponds to a wireless sensor network with the individuals or units, such as wireless sensor network owner. Description describes the general information associated with the object. Date describes the time of the document produced. Format is the format used in the document.

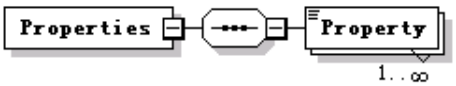


**Figure 5**. Reference metadata schema

History metadata records the general information and associated changes in wireless sensor networks, which contain one or more Event elements (see Figure 6**)**. Each event has a date element (date), GeneralInfo element and References element.

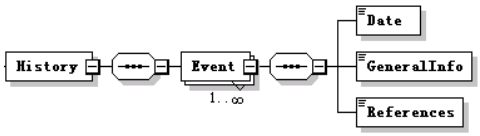


**Figure 6**. History metadata schema

## 2.2 SensorInfo metadata includes eight elements

The concept of this schema is shown in Figure 7. NodeID is the unique ID of the specified sensor node. The NodeType includes the type of sensors carried by the node and interface conditions. Protocol element reflects the network protocol used by the node, for example IP version (IPv4 or IPv6). NodeState describes the node's energy mode (active or sleep) and operation state (good or fault). NodeLocation includes the node's geographical information. CalibrationInfo records the calibration information, which is very important for improving the sensor accuracy.

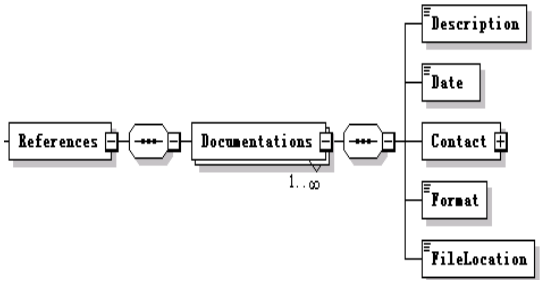


**Figure 7**. SensorInfo metadata schema

## 2.3 Processes metadata

Processes metadata (see Figure 8) includes at least one process element. Each process represents a process which wireless sensor network can perform. As the wireless sensor node itself has the computing power, a small node with a variety of sensing devices can make some analysis and processing on the physical sensing value. The output is the value processed by the node, for example, the average temperature over time. A process metadata includes input, output and parameters. Input represents the physical phenomena in the natural world the wireless sensor network can sense. Output represents the values after wireless sensor networks process the original sensing data. Parameters describe the requirements or conditions of the process. For example, when the frequency of data collection cannot be less than 2 seconds, otherwise nodes would communicate with each other in the conflict. Parameters are associated with the characteristics of specific wireless sensor network node.

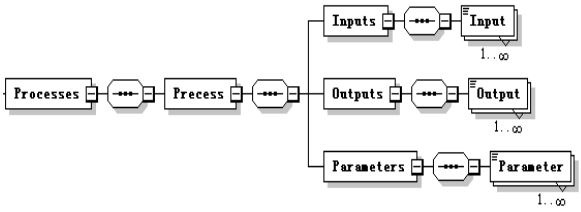


**Figure 8**. Processes metadata schema

## 2.4 Position metadata

Position metadata is used to describe the geographical location of wireless sensor networks, which includes location element, orientation element and an optional description element (see Figure 9). Location element describes the location information according to administrative division including country, provinces, city, town and village. Orientation element includes longitude, latitude and height. In addition, an optional description can be used to introduce general information of the wireless sensor network deployment area.

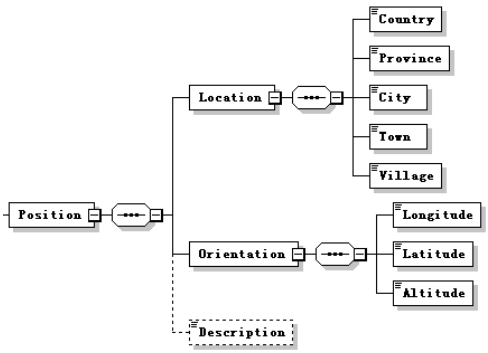


**Figure 9**. Position metadata schema

## 2.5 CollectedData metadata

CollectedData metadata (see Figure 10) describe the available data sets collected by IPv6WSN. In our project, the scientific data need to be collected in the field are mainly multi-disciplinary, multi-scale space-time meteorological, hydrological data, including Lysimeter, Bowen ratio, cosmic rays, soil temperature and moisture profiles, soil heat flux, soil water potential, infrared surface temperature, precipitation, temperature, wind speed, humidity, shortwave radiation, 2cm/5cm/10cm soil moisture and temperature, snow depth and so on. CollectedData metadata includes DataName element, DataType element, DataLength element, Unit element, CollectedTime element, DataDesctiption element (optional).

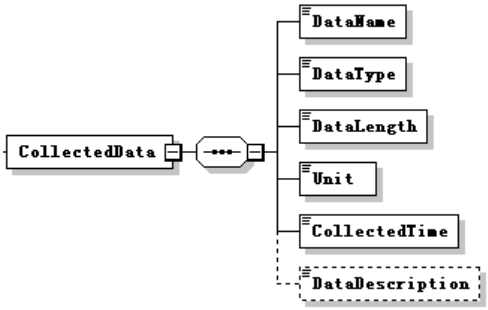


**Figure 10**. CollectedData metadata schema

## 2.6 ControlInfo metadata

In our project the sensor node not only collects field data but also can be controlled as needed. ControlInfo metadata describes the control instructions or commands sent to sensor node, including NodeID element, SendTime element, ControlType element.(see Figure 11)

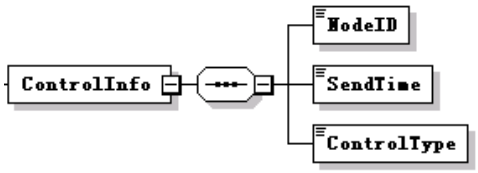


**Figure 11**. ControlInfo metadata schema

## 2.7 Software system based on the metadata model

Based on the above metadata model, a software system responsible for data management and processing in IPv6WSN is developed (see Figure 12). The programming language is C# and development platform is Visual Studio 2008.

**Figure 12.** View of the software system

# 3 CONCLUSION

In this paper, we present a metadata model for IPv6 wireless sensor network developed by ourselves in watershed-scale ecological and hydrological research. This model not only involves very rich scientific data but also includes management and control data required by IPv6WSN itself. Obviously, it is necessary to build such a unified data metadata model for data transmission and processing. The metadata model introduced in this paper provides a solid foundation for effective use of self-developed IPv6 wireless sensor network by ecological and hydrological scientists. The conclusion should indicate the significant contribution of the manuscript with its limitations, advantages and applications.

# 4 REFERENCES

1. National Information Standards Organization, understanding metadata, 2004.

2. Daniela Ballari , Monica Wachowicz , Miguel Angel Manso Callejo "Metadata behind the Interoperability of Wireless Sensor Networks" Sensors 2009, 9, pp.3635-365I