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Open source REST services for environmental sensor networking

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ABSTRACT

The greatest challenge in the implementation of environmental sensing networks is converting a large variety of data streams from diverse sensors, often in proprietary protocols, to international standards such as Extensible Markup Language (XML) with Open Geospatial Consortium (OGC) XML tagging and web service standards. Implementing standards throughout the architecture will not only enable interoperability and reduce cost but will allow scientists to contribute to sensor network innovation. This article introduces open source Representational State Transfer (REST) services created specifically for environmental monitoring. OGC standards are suggested to help guide future community development for sensor description and registration. This article contributes to the design and implementation of affordable, self-documenting, near-real-time geospatial sensor webs for environmental monitoring using international standards.

Introduction

What would computer networking be today without the standardized communications protocols interconnecting networks to form the Internet? A significant part of the Internet's success has been made possible by volunteer adherence to software (e.g. TCP/IP and HTTP) and hardware standards (e.g. CAT6 and RJ45) (Hovav, Patnayakuni, & Schuff, 2004). This resulted in computers with standardized software that were easily connected to a standardized communications network. This approach decreased costs while enabling interoperability for manufacturers and end-users to help create the global information network. Before the mainstream Internet existed, proprietary networks such as CompuServe and AOL connected millions of subscribers delivering limited and controlled services. These services were provided, controlled and monitored by the provider with proprietary protocols. However, these same proprietary controls limited flexibility, functionality and innovation within the system. Without the Internet, these proprietary networks would have had a significantly smaller effect on our society and economic system.

Protecting our environment requires timely and affordable information. In 1998, U.S. Vice President Al Gore articulated the term “Digital Earth” for the visionary concept of a virtual earth to interconnect and to geo-reference the world's digital knowledge. Traditionally sensor networking has occurred from the top down in military applications (Díaz, Granell, Huerta, & Gould, 2012) and more recently in corporate implementations. These proprietary installations have created a controlled development regime with significant advances only within the confines of tethered device releases. Proprietary “in situ” sensor networks are providing similar monitored and controlled services for complete sensor networking solutions. Although these providers are advancing sensor technology, in many cases, they are limiting innovation as well. Proprietary development rarely promotes the development of standards and interoperability within sensor networking. Sensor networking must utilize the business practice of open innovation to enable sensors that are implementable by the general developer. Open innovation suggests that entities not only look beyond their own borders for external ideas but rethink intellectual property as it pertains to research and development. Open source software lowers the entry barrier to sensor networking enabling innovations including new applications of the sensors and standards within the network (Bitzer, 2004; Bitzer & Schröder, 2003). Standardization is essential for low-cost collaboration and rapid innovation of environmental sensor networks.

The Open Geospatial Consortium (OGC) has been the global forum for the development of standardized sensor networks in the form of Sensor Web Enablement (SWE) since 2001 (OGC, 2014). SWE consists of web accessible sensor networks and data that can be discovered, accessed and possible controlled using open

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standard protocols and interfaces (Botts, Percivall, Reed, & Davidson, 2008). The OGC was chosen to host the standards for sensor networks because location is essential to sensor data and often the only common field between heterogenous systems. Similar to the Internet, serious debates must be waged on each part of the most basic protocols with widespread testing to make sensor network standards widely applicable.

Current innovation and applications are being developed between the OGC and the Web of Things, web integration of the "Internet of Things" (IoT). The IoT is the connection of the physical world to the Internet through ubiquitous uniquely identifiable sensors. However the Internet of Things is still being limited by the lack of clear, standardized and interoperable community protocols (Guinard & Trifa, 2009). Guinard and Trifa provide guidelines for integrating real world objects into the Web creating the Web of Things (WOT). They suggest that HTTP becomes an application layer as devices become available through a RESTful API. Our work applies these guidelines to Environmental Sensor Networking (ESN). A RESTful approach is used for client and server software that record, store and transfer the sensor data. The open source software client and server platform is developed independent of the hardware. A modulation approach allows increased innovation and reduced cost throughout the network (Sempere-Payá & Santonja-Climent, 2012). This approach allows for the incorporation of OGC standards were applicable and uses recent advances from the WOT. Hart & Martinez (2006) states, ESNs will produce a revolution in all aspects of earth system and environmental sciences similar to that generated by the use of satellite remote sensing in the 1990s. Whether, a Digital Earth or Hart's revolution neither will occur within environmental science without the help of scientists being involved in every level of the sensor network implementation and development.

This article begins with a discussion of previous research before introducing an open standards-based architecture to enable innovation in the development of environmental sensor networks. The two general categories of web services are discussed to compare OGC web services to current WOT web services. A case study describes the working implementation of the open source software architecture.

Previous research

Web services

Shortly after the challenge was presented to create the Digital Earth, web services were beginning to establish themselves with standardization. With web services, the Web was in its next stage of evolution, in that software components could discover other software components (Roy & Ramanujan, 2001). The World Wide Web Consortium (W3C) categorizes web services into two general categories: 1) arbitrary web services and 2) REST services (W3C, 2014). Arbitrary web services consist of services through a single access point. All of the operations of the web service are executed through this single end point. The operations executed by the service are custom for each individual service (W3C, 2014). Almost all arbitrary web services utilize the Simple Object Access Protocol for standardization (SOAP). SOAP standards were developed in the late 90s and became the de facto standard for arbitrary services in early 2000.

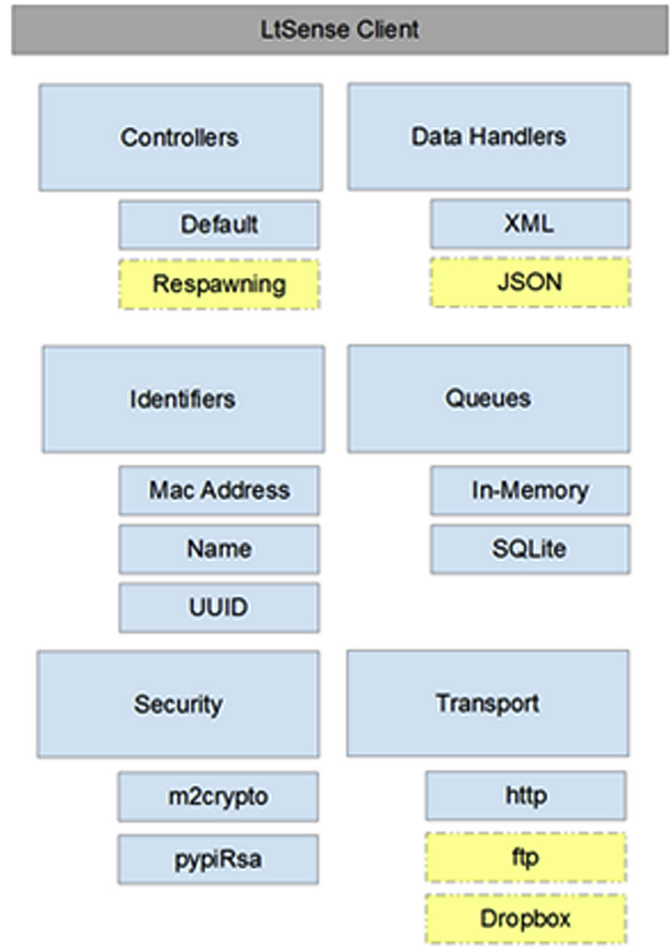

Fig. 2. LtSense Client block diagram.

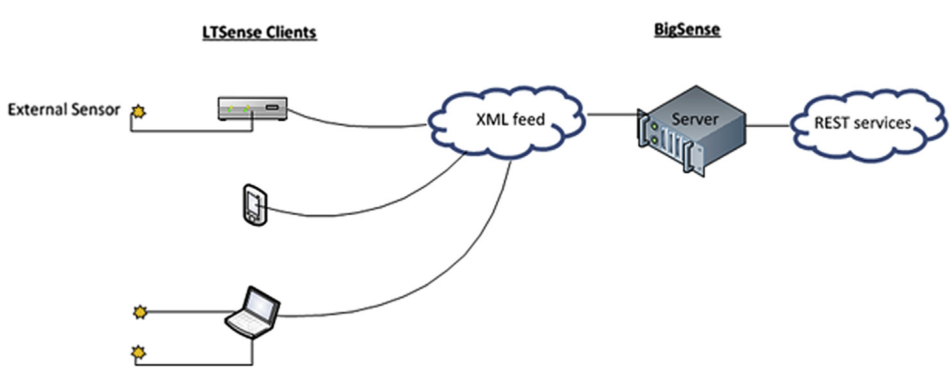

Fig. 1. Basic system architecture for environmental sensor networking.

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