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IoT Technology

NanoService™ Solution:

Optimized Web Service Technology

for an Embedded World

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Abstract

This paper discusses the architecture, features, and benefits of ARM Sensinode NanoService™ solution. Recognizing that Web applications based on the REST architecture have become ubiquitous, IOT deployments in a wide variety of market segments can benefit from using Web technology and the REST architecture. This paper demonstrates how ARM Sensinode NanoService solution can be used to provide a secure and standards-based way for back-end applications to access IOT data using RESTful Web services. Some of the benefits of the NanoService solution include:

- **Fast Time to Market.** The use of well understood Web development environments and Reference Applications, with source code available, allows networks to be rapidly deployed.
- **Efficiency and Scalability.** The new CoAP technology standard enables drastically reduced device power consumption and data transport requirements, and in conjunction with NanoService Platform allows enormous network scalability.
- **Advanced Security.** NanoService uses the most advanced security solutions available in the Web today
- **Future Proof**. The use of standardized technologies ensures that the system will continue to perform as networks expand and functionalities evolve.

Introduction

The NanoService solution leverages the power of the Web architecture for developing and deploying IOT systems efficiently and securely. The NanoService solution consists of software for devices, backend servers and Web applications that together form an end-to-end platform.

Overview of ARM Sensinode NanoService™

ARM Sensinode NanoService™ solution uses standardized Web technology to enable rapid and efficient deployment of a wide variety of IOT services. Powered by the Constrained Application Protocol (CoAP), NanoService consists of 3 key components: NanoService Platform (NSP), NanoService Client (Device Library) and Reference Applications.

As the key element of NanoService, NanoService Platform is a backend application development platform allowing efficient and secure data transport and management. It provides optimized, 2-way end-to-end Web service integration

between back-end services and IOT endpoints. By utilizing RESTful Web interfaces exposed by the NSP, the development time required to develop and deploy Web-based applications is greatly reduced.

NanoService Platform provides REST interfaces to Web Applications and handles communications with IOT devices using efficient, secure and scalable mechanisms. NanoService Platform can be deployed flexibly in a local PC, in a private server, or in a virtualized data center or cloud. NSP includes a graphical Admin Application that enables users to monitor the platform and to browse registered endpoints and resources.

As shown in Figure 1, Web applications interact with the NanoService Platform using a set of RESTful Web interfaces over HTTP. These interfaces provide lookup, HTTP-CoAP proxy, group and subscription services. The NanoService SDK provides an easy to use library for using these services.

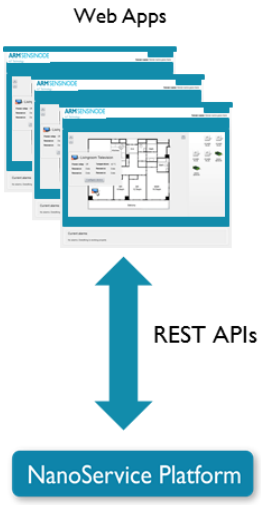


Figure 1. Building Web Apps On Top of NanoService Platform

NanoService Technology

A key technology element of the NanoServices is CoAP, Constrained Application Protocol, a new Web protocol that has been standardized in the IETF, the primary standardization body for all Web protocols. Running over UDP instead of TCP, CoAP allows even the most resource-constrained IOT devices to communicate using a REST model similar to what is used in over HTTP for Web pages, while doing so in a highly reliable fashion. CoAP supports multicast traffic, uses very little overhead (as low as 4 bytes per message), and supports mapping to HTTP, enabling easy integration with the Web. Use of this technology allows

extremely bandwidth-efficient data transport, and optimizes device power consumption by enabling longer sleep times and shorter data transmission.

Security for NanoService is provided using TLS standards, the gold standard for security in the world today. NanoService supports end to end security, from the end node all the way to the back end. Web Interfaces are secured using HTTP authentication and TLS (HTTPS) and IOT Interfaces are secured using optimized DTLS for mutual authentication and efficient security.

NanoService Architecture

The NanoService architecture and components are shown in Figure 2. The REST (Representational State Transfer) paradigm is at the core of the Web. The NanoService solution is an end-to-end Web architecture that is built on the REST paradigm. Web Applications are provided with lookup, subscription and access interfaces to IOT devices and resources using familiar HTTP REST interfaces. Implementation of these interfaces is simplified by using the NanoService Java SDK. These HTTP interfaces are straightforward to implement in any programming or scripting language such as C, C#, PHP, Ruby, Javascript etc.

The IOT interfaces and CoAP protocol are designed for efficiency over all types of constrained access networks and on embedded devices that frequently have very limited resources (processing power, memory, bandwidth, power consumption). The only requirement for using NanoServices is UDP/IP support on the access network.

The elements of the NanoService solution are the NanoService Platform, NanoService Device Library and the Reference Applications.

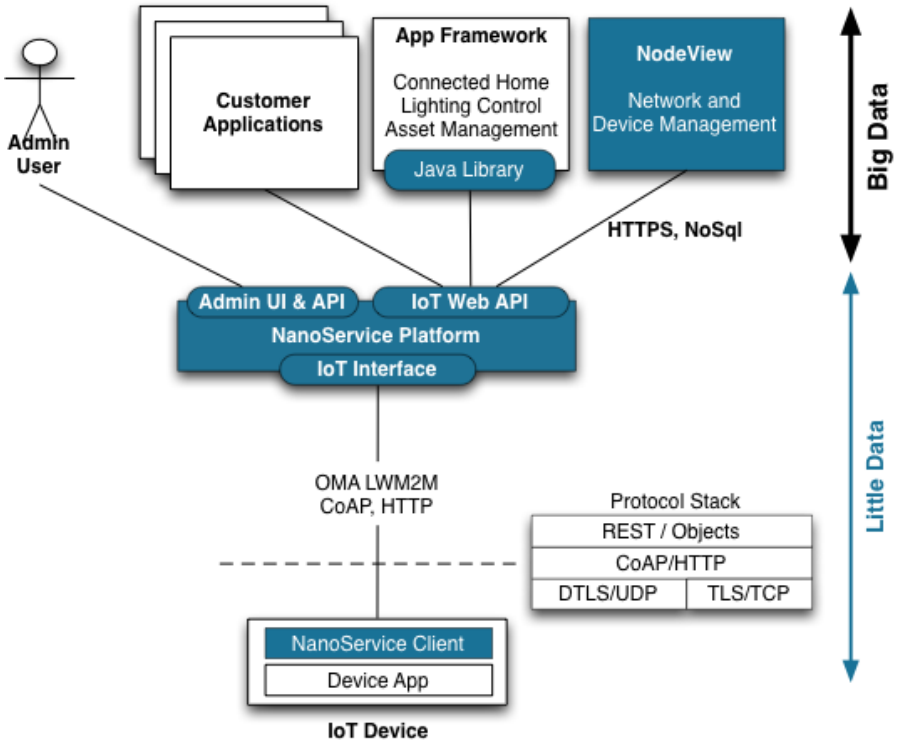


Figure 2. The Overall NanoService Architecture and Components

The NanoService Platform

The NanoService Platform (NSP) is a backend component that ties together efficient IOT communications with IOT endpoints with advanced web interfaces for use by Web Applications. Figure 3 shows the internal architecture of NSP.

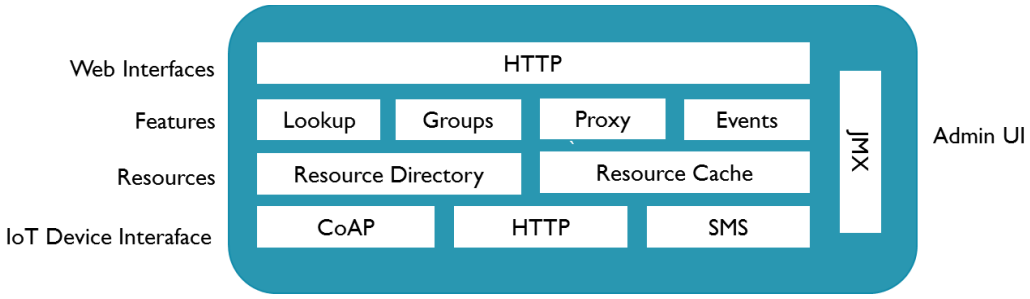


Figure 3. The Internal Architecture of NSP

NanoService Platform is modeled as an a priori populated search engine, called a resource directory, together with a resource cache. When an endpoint

initializes or changes, it registers Web Links with NSP, which are stored in the Resource Directory. When resource requests are made from Web Apps or notifications sent from end-points, the latest data is stored in the Resource Cache.

Key features provided by NSP include Lookup, Group, Proxy and Event functions. The Lookup function is used for finding endpoints and resources, including semantic information. The Group function is used to create and manage Web groups of end-points, enabling RESTful group operations. The Proxy function provides transparent, caching HTTP access to IOT resources. And finally the Event function provides Web Apps with asynchronous notifications about changes in the Resource Directory or new data from subscribed resources.

NanoService Platform communicates through three sets of interfaces: Web Interfaces, IOT Interfaces and a Monitoring Interface. Web Interfaces are realized as RESTful HTTP(S) interfaces with domain based authentication. IOT Interfaces are realized as CoAP, CoAP over SMS or HTTP. Monitoring of NSP itself can be performed using a JMX interface. NSP is provided with the Admin Application, a graphical Web App for monitoring NSP.

An easily configurable Node Emulator is also included which can emulate a device and resource design on a PC before implementation on an embedded device. The Node Emulator can greatly compress design cycle time thus accelerating time-to-market. The Node Emulator is also useful for quick turnaround demonstrations of the end-to-end protocol and data flows in customer applications.

Deployment Models

The NanoService solution allows for flexible deployment models to fit customer needs. These traverse the full spectrum from simple deployments, where all backend components are hosted on a single PC/Server, to large-scale platform service provider deployment by operators. This section explains how the NanoService components can be deployed in different models:

- **Single Server:** In this model a single server is used to host the NanoService Platform, Admin Application (if needed) and the Web Application(s). Localhost communication is used between the Web Application(s) and NSP.
- **Multiple Server:** In this model one server is used to host the NanoService Platform and Admin Application (if needed) and the Web Application(s) are hosted on other servers. All servers would belong to the same entity.

- **Platform as a Service:** In the Platform as a Service (PaaS) model, the NanoService Platform is hosted in a private or public cloud and offered together with other value-added services. Multiple customers could deploy Web Application(s) on their own servers leveraging NSP from the cloud.
- **Native Devices and Gateways:** There are two models for integrating IOT devices with the NanoService solution. Any device that supports UDP/IP can directly communicate with NSP using CoAP. Alternatively, for non-IP technology, the NanoService Device Library can be used to wrap the available data as Web resources, acting as a gateway.

Reference Applications

The NanoService solution can be applied to virtually any IOT system where IP is utilized as part of the access network. As an enable to NanoService deployment, Sensinode has developed a set of Reference Applications. These Reference Applications may be used by NanoService customers as is, and source code may be additionally available to allow rapid customer application development. In this section, the Reference Applications provided with NanoService are introduced along with typical NanoService component deployment options.

Connected Home

Machine-to-machine networks are widely deployed in homes for applications including smart energy, home automation, home monitoring, home security, elderly monitoring and eHealth. These systems usually include a backend user-facing Web Application, a communication infrastructure, and devices that either communicate with the communication infrastructure directly or through an intermediate gateway.

In this scenario, NanoService Platform would be deployed either together with the Web Application or hosted by a third party as a service. Devices that directly support UDP/IP routable to the backend infrastructure, may directly use the NanoService Device Library to support CoAP and the IOT interfaces of NSP. In the case of a gateway architecture, the NanoService Device Library may be integrated into the gateway and used to handle all its resources with NSP.

The NanoService solution allows for Web Applications to be easily developed in the above scenarios by providing a Reference Web Application called Connected

Home. This application provides a GUI for the visualization and monitoring of a home floor plan. Devices and resources are automatically created using NanoService semantics, and data is subscribed to using the NSP subscription interface. The current resource value of a device along with recent history graphing can be displayed. Finally, configurable alarms can be created based on a threshold or a range values associated with a particular resource.

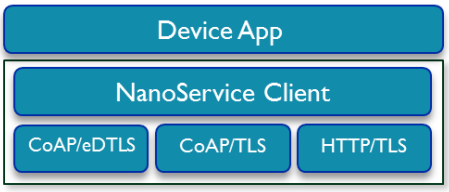
Lighting

Outdoor and public area lighting is becoming a popular application area of IOT technologies. Typical lighting systems that fall under this category include street lighting systems, campus lighting, advertisements and signage. These systems include wireless (e.g. RF mesh or Cellular) or wired (e.g. PLC) local area communication to the lights being controlled, possible intermediate routers and a backend application used by the administrators of the lighting system.

In this scenario, NanoService Platform would typically be deployed together with the administrator Web application. Lights supporting UDP/IP can make use of the NanoService Device Library, making them accessible via NanoService Platform to the Web application. For non-IP based lighting systems, the NanoService Device Library can be used to provide a RESTful interface to the legacy lights, and thus make them available to the Web application.

The NanoService Lighting Reference Application greatly eases the development and deployment of systems for lighting. This application is aimed at administrators of all kinds of outdoor lighting systems. The application includes full Google Maps integration, a resource profile for lighting control, resource monitoring and control interfaces, group management, and light schedule management.

NanoService Client



The NanoService Client included in the NanoService package provides a full implementation of CoAP, optimized DTLS and the IOT interfaces of NSP. The device library automates the integration of any device with

NSP, handling resource requests, registration with NSP and subscriptions for resources. The device library also supports local CoAP discovery and requests between endpoints.

Summary

This paper presents ARM Sensinode NanoService, a solution that brings standardized and efficient IP and Web Accessibility to IOT deployments. Since Web applications built on the NanoService Platform use standard REST Web interfaces, application development is greatly accelerated.

The architecture of the NanoService Platform was discussed, which brings forth efficient IOT technology in order to support all types of constrained access networks. Because the NanoServices is built on top of existing open standards such as TLS, HTTP and CoAP it delivers a secure, scalable and future-proof solution.

Key NSP features such as its Resource Directory and Resource Cache, Lookup, Group, Proxy, and Event functions were discussed. These are the features that make it easy for an application developer to write Web applications on top of the NanoService Platform. In addition, Reference Applications such as Connected Home and Lighting, provided as part of the NanoService Package help accelerate application development by giving application developers a head start.

In summary, ARM Sensinode NanoService solution enables rapid, scalable and highly secure IOT deployments, and is applicable across a wide variety of market segments.

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