Chapter 9
The Design and Implementation of GNSS Data Services Based on SOA

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Abstract The development of network software technology makes data services towards the directions of diversification, real-time, integration and individuation etc. Currently, most GNSS data service centers use file-based data method to distribute, share and transfer data, which is good for storage but not good for data sharing and data using. It is not the direct data waned by GNSS software. The software based on Service Oriented Architecture (SOA) interact with each other by interface, which is independent from hardware platforms, operating systems and programming languages, achieved low coupling sharing of data and functions (services) of the different applications on the network. If the basic GNSS data service center is using SOA architecture to achieve GNSS data and functional services, the current GNSS applications will be greatly expanded. This paper design and briefly achieve the GNSS data services based on SOA architecture, and implement the application of data and functions sharing between different network applications. Practice has proved that the GNSS data services based on SOA conducive to the integration of multi-program, realization of personalized program, and its real-time ability is much better.

Keywords SOA · GNSS · IGS · Service · Data sharing · Function integration

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2. National 863 Project of China "Critical technology for maintaining the global dynamic geocentric reference frame"(2013AA122501).

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9.1 Introductions

As the development of GNSS and networks, the precision and stability of GNSS navigation and positioning are growing better, and the applications based on GNSS are spreading everywhere, popularly and in large scale. Meanwhile, the users of GNSS are requiring a more precise, real-time and individual service [1–4]. The International GNSS Service (IGS) is an authoritative institute in providing precise positioning data service, which include observing data of tacking station or reference station, high level ephemeris data, clock offset, earth rotation parameters, ionosphere and troposphere data, etc., and uses ftp to release its products. In addition, many countries or regions built local area augmentation system, to provide difference of signal and other data service of GNSS. However, these data is mainly for professional users or terminals. It is too difficult for ordinary people and developers in other field to understand. They have to face many complicated algorithm before use it. What's more, all the users wanted are just a service, not the semi-finished GNSS data. Take ephemeris data for example, the navigation satellite provides orbital elements data, and the IGS ftp provides discrete orbit position, but the all the user wanted is just the position of satellite in a specified moment, which is a service, not a static data file. Service-Oriented Architecture (SOA) is a set of principles and methodologies for designing and developing software in the form of interoperable services [5]. It encapsulates user's requirements as services. Both the service provider and user have are only the opening service operation list and its parameter structure. The following discusses how to design and implement GNSS data service based on SOA technology.

9.2 GNSS Data Service

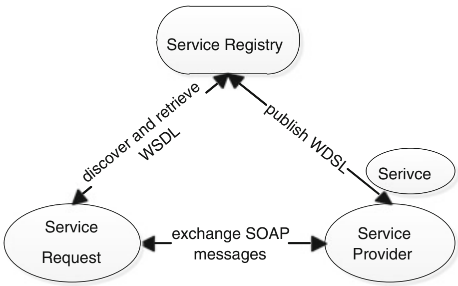
In the navigation and positioning of GNSS, the navigation data of satellite and observation data of receiver include kinds of errors, thus cannot meet the needs of high precise applications. In order to improve the accuracy of navigation and positioning, we must correct the errors of these data using interrelated correct models [6, 7], which include ephemeris of navigation data, clock offset, earth rotation parameters, ionosphere data, troposphere data and tide data, etc. Some organization and institute, like IGS, local CORS, provide these data for precise navigation and positioning. They do a lot to improve the precision of navigation and positioning, such as the implement and improvement of ITRF, solid Earth deformation detection, detection of Earth rotation, orbit determination, and so on. But for a non-professional user, these applications are too professional. The GNSS data offered by IGS is not the data they want, and the IGS cannot satisfy these users' needs by using ftp, because user' demands are always variable, and data in ftp server are always static; data in RTK are pushed, not wanted. These dynastic demands are services, which users really want.

9.3 Service-Oriented Architecture

The service-oriented architecture (SOA) is a component model and architectural style of software, which try to make full use of Internet technology, to meet the growing demand for business operations mode. SOA uses the concept of "service" for the same viewpoint to organize computing resources [8], which is a flexible, secure and seamless way to deal with the inner and outer resources [9] SOA have two significant characteristics: loosely coupled and indirect addressing. It link different functional units of the application (services) with well-defined interfaces and contracts. Interface is defined in a neutral manner; it should be independent of the services of hardware platforms, operating systems and programming languages. This makes the service, built in a variety of different systems, have a unified and common way to interact. Services in SOA is the core of the abstract means, it includes two parts: service interface and service implementation. Service interface is a collection of methods and the desired operation of the service requester, which describes the contract between the requester and the service that both of them must follow; service implementation is the encapsulation of specific functions and data. Separation of the service interface and implementation makes SOA loosely coupled.

The three basic elements of the SOA is service description, service discovery, and service calls, as shown in Fig. 9.1. Also SOA has three roles: service provider, service registry center and service requestor. Service providers are responsible for service implementation, and publish the interface, access address of service description to the service registry. The service requester consuming services is a process of indirect addressing. Firstly they find the description of the related services from the service registry, and then use the information provided by the service description to call services. In addition, the service requester does not have to be through the registration center to lookup service. In a closer environment, for example, can be directly obtained it from the service provider. Due to SOA has broad application prospects, some IT leader such as IBM, Microsoft, Gartner has proposed its own solution [10–12]. The following article is to introduce how to design and implementation the GNSS data service system based on the SOA model.

Fig. 9.1 SOA model



9.4 Design of Architecture and Interfaces of GNSS Data Service

The general idea of design GNSS data service system is to capsulate the GNSS data and its algorithm into different services, such as clock service and ephemeris service. According to user's request, the GNSS data service system response the calculation result. To accomplish this task and get a better result, the server has to connect to other online GNSS data server, usually the IGS ftp, to integration GNSS resources, as shown in Fig. 9.2.

The whole progress is transparent to users, and users cannot see what the server does, they get they want is just like to retrieve data in local database. As the following picture shows, this procedure is very simple; the server receives the user's requirement, which include with service to be called, and the service parameters with values. The server parses the parameters and return calculation result. Unlike ftp technology, this is an interactive process. Users can get they want. And with SOA, low coupling makes the progress much convenient, as shown in Fig. 9.3.

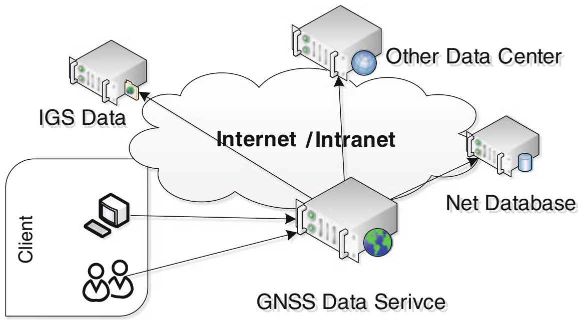


Fig. 9.2 The relationship between systems

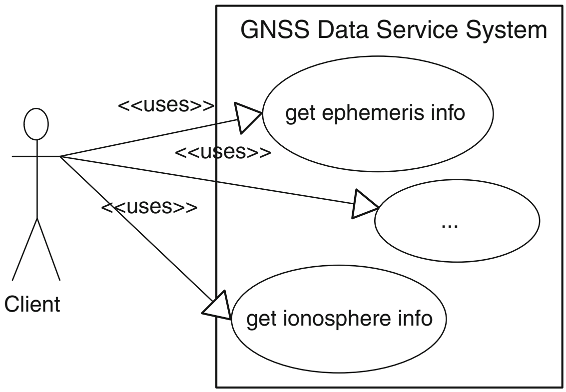


Fig. 9.3 Use case of system

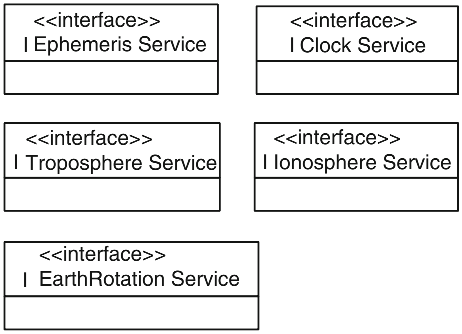


Fig. 9.4 The design of interfaces

In order to facilitate the description, we design the GNSS data service interface with Unified Modeling Language (UML), as shown in Fig. 9.4, which include five service contracts: IEphemerisService, IClockSrevice, ITroposphereService, IIonosphereService and IEarthRotaionService.

9.5 Implementation

We build this system with Visual Studio 2012 as development environment, C# as develop language, IIS 7.0 as web container, SQL Server 2008 as database and Windows Communication Foundation (WCF) to implement SOA. The whole system is divided into two layers: application layer and data layer. According the system design, we implement the interfaces in the application layer with several algorithm and models of GNSS data; the data layer composed with GNSS files and database, which can monitor the change of IGS ftp server, and fetch new IGS products.

Finally, the GNSS service system installs and runs on IIS 7.0 web container. To input its web site address in the browser, we can get the WSDL. The following is a WSDL file of ephemeris service (Fig. 9.5).

WSDL is expressed with XML which is platform-independent, and it describes how to communicate with and use the web services, which is usually parsed by tools automatically.

9.6 Cases

After the service broadcasted, users can call the service according to the WSDL. Because Web service exchanges information with XML, users can get the service in any platform, no matter in mobile phone or notebook computer, whether in

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- <xs:schema xmlns:tns="http://schemas.datacontract.org/2004/07/EphemerisService"
  targetNamespace="http://schemas.datacontract.org/2004/07/EphemerisService"
  xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified">
  - <xs:complexType name="GpsTime">
    - <xs:sequence>
        <xs:element name="TimeString" type="xs:string" nillable="true" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
    <xs:element name="GpsTime" type="tns:GpsTime" nillable="true"/>
  - <xs:complexType name="SatInfo">
    - <xs:sequence>
        <xs:element name="Clock" type="xs:double" minOccurs="0"/>
        <xs:element name="ClockRate" type="xs:double" minOccurs="0"/>
        <xs:element name="GeoCoord" type="tns:GeoCoord" nillable="true" minOccurs="0"/>
        <xs:element name="GpsTime" type="tns:GpsTime" nillable="true" minOccurs="0"/>
        <xs:element name="PRN" type="xs:string" nillable="true" minOccurs="0"/>
        <xs:element name="XYZ" type="tns:XYZ" nillable="true" minOccurs="0"/>
        <xs:element name="XyzDot" type="tns:XYZ" nillable="true" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
    <xs:element name="SatInfo" type="tns:SatInfo" nillable="true"/>
  - <xs:complexType name="GeoCoord">
    - <xs:sequence>
        <xs:element name="Height" type="xs:double" minOccurs="0"/>
        <xs:element name="Lat" type="xs:double" minOccurs="0"/>
        <xs:element name="Lon" type="xs:double" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
    <xs:element name="GeoCoord" type="tns:GeoCoord" nillable="true"/>
  - <xs:complexType name="XYZ">
    - <xs:sequence>
        <xs:element name="X" type="xs:double" minOccurs="0"/>
        <xs:element name="Y" type="xs:double" minOccurs="0"/>
        <xs:element name="Z" type="xs:double" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
    <xs:element name="XYZ" type="tns:XYZ" nillable="true"/>
```


Fig. 9.5 Part of WSDL

Windows operating system or in Unix operating system, as long as the client software follows the standard of Web service.

Figure 9.6 shows in other web program call the GNSS Service. User input the PRN of navigation satellite and the specified GPS time, click request button, after several seconds, the answer is show on the page.

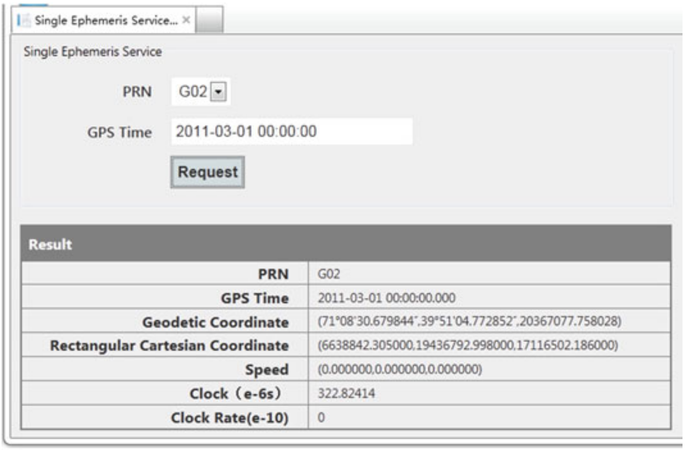

Fig. 9.6 Single ephemeris service

All the process is transparent to users. Users can use the service to build higher GNSS application, while do not worry how to realize the complicated algorithm. The GNSS data service based on SOA focus on service itself, thus can fulfill the user's versatile demands, and increase the degree of automation and timeliness.

9.7 Conclusions

With the development of network infrastructure and network technology, applications based on the network will be more extensive and in-depth. More complicated applications will build on low coupling services. SOA is the fruits of software development, and is being succeed used in many fields, and surely will contribute to GNSS application.

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