

Web Service for Tele-Communication

Wu Chou, Feng Liu, and Li Li

Avaya Labs Research, 233 Mt. Airy Road, Basking Ridge, NJ 07920, USA

{wuchou, fliu1, lli5} @avaya.com

ABSTRACT

In this paper, we introduce WNET/WSIP, a web service enabled converged communication infrastructure that is integrated with VoIP SIP (Session Initiation Protocol). WNET/WSIP consists of a network of WSIP node and it is based on two-way, full duplex web service interaction. WSIP is a new class of IP communication endpoints. Each WSIP node is both a SIP endpoint that communicates in the SIP world through SIP signaling, and a web service SOAP node that provides an application protocol layer alternative to SIP and a generic service integration environment for binding SIP based communication in web services.

From service perspective, WNET/WSIP is an application layer protocol overlay for resilient and versatile communication services over IP. It allows dynamic service discovery and binding that integrate SIP services as a SOA component in business transactions. It separates service integration/extension environment from SIP signaling. The ubiquitous service integration nature of web service provides a disciplined solution to monitor the WNET/WSIP network. It supports dynamic service monitoring, provisioning, endpoint discovery and update, etc. In particular, we introduce the approach of using WS-Security [12] to provide end-to-end message level security over IP in WNET/WSIP. These new capabilities are essential to the success of reliable communication services. The proposed approach was implemented in a prototype research system. Advantages of WNET/WSIP were realized and observed.

Keywords

Web Service, SIP, WSIP, WNET, WS-Session

1. INTRODUCTION

Converged communication services over IP have become increasingly popular. SIP (Session Initiation Protocol) [1] is one of the most important protocols for VoIP (voice over IP) communication. From the internet protocol stack perspective, SIP relies on a set of light weight application protocol operations to set up the call [8].

Despite the success of SIP as a primary VoIP protocol, SIP is under constant expansions to support new communication services which are not in its original scope. Reliability and security of VoIP services have always been a major concern. There is a critical need for

an extensible service integration environment that allows applications to integrate SIP as part of the business transaction process. However, the current extensibility infrastructure in SIP is quite limited. The simple text encoding scheme and SMTP type headers used in SIP can be both a strength and limitation. The advents of XML based protocols for call control, switching and service monitoring, such as CSTA [10] and CCXML [6], have made such needs even more acute.

Web service [2, 3, 4, 5] is a major development in the industry for providing distributed services over IP. It relies on the structured XML (SOAP) message to access, control and integrate various services remotely for complex transactions. However, the current web service methods are mainly designed for service integration and typically based on an one-way, stateless, request/response interaction pattern. Much work needs to be done to advance web services to two-way, full duplex communication to support communication needs over IP.

The focus of this paper is three folds. First, we extend one-way request/response web service interaction to the paradigm of two-way, full duplex web service interaction for communication. This allows web service methods to enable full duplex and complex communication services. It should be noted that web service itself is not an application layer protocol. Instead, web service describes a transport protocol neutral mechanism using SOAP messages to setup and deliver services, which can be carried by multiple transport protocols. In particular, the binding of web service with HTTP provides an application layer infrastructure for distributed services over IP. It makes the services ubiquitous, and can be accessed from anywhere through the Internet.

Secondly, we describe methods for stateful and session based web service interactions, since most services in telecommunication are stateful and often require the stateful service context of a "session". Thirdly, we present a new converged communication paradigm based on WSIP (Web service SIP). WSIP is a new class of communication endpoints over IP. Each WSIP node is both a SIP endpoint that communicates in the SIP world through SIP signaling, and a web service SOAP node that communicates through HTTP or other transport protocol. In our approach, multiple WSIP nodes are linked to form a converged communication infrastructure, WNET (WSIP Net). WNET/WSIP provides an application protocol layer

overlay which is alternative to SIP, and a generic service integration and extension environment for binding SIP based communication in web services.

In the past, SIP and web services have rarely interacted, and each tries to address the needs in its own domain through its own extensions. This has led to some serious issues, and the strength of these approaches have not been fully leveraged.

WNET/WSIP is a fundamental departure from the current practice of mixing service integration environment and ad-hoc service extensions in SIP protocol and signaling. Instead, it leverages the principle of separating signaling and media transmission inherent in SIP to the next level by clearly separating service integration/extension environment from the SIP protocols and media transmission. From the service application perspective, WSIP provides an extensible and modularized three-tier infrastructure among service integration/extension, signaling, and media transmission.

The application-layer overlay infrastructure of WNET/WSIP utilizes the enhanced converged communication capabilities of WSIP that opens many new exciting capabilities. The light weight protocol and efficient media stream transmission in SIP complement nicely with the message based web services, where directly carrying media stream in SOAP messages can be costly. On the other hand, SIP protocol standards and customized SIP applications are under constant revision and extension, leading to various versions of SIP user agents (UAs). The interoperability between SIP UAs has become a serious issue for reliable VoIP services using SIP. The ubiquitous service integration nature of web service provides a disciplined solution to maintain, monitor, and update large number of SIP endpoints from different installation basis. Moreover, the web service mechanism in WSIP provides a powerful method for dynamically discover and update SIP UA endpoints. It provides an alternative to SIP protocol for service delivery, provisioning, monitoring, security, QoS, etc., which are essential to the success of converged communication services over IP.

This paper is organized as follows. In Section 2, we address two-way, full duplex web service interaction for communication over IP. In Section 3, we describe the design principle of WSIP. In Section 4, we establish and characterize the infrastructure of WNET/WSIP, a new converged communication paradigm over IP. The proposed WNET/WSIP framework has been implemented in a research prototype system. Advantages of the proposed WNET/WSIP are summarized in Section 5.

2. TWO-WAY WEB SERVICE DESIGN

From an endpoint perspective, two-way, full duplex web service interaction involves both client initiated service request and proactive server push for event notification. This can be described by three types of generic web service interaction patterns. We use the subscript to indicate the service contact (request) initiator, and use a generic client and server to separate two web service endpoints, although each of them is both a client and a server in the two-way web service paradigm.

- **Type I (R_C):** Requests initiated by the client, with or without response.
- **Type II (E_S):** Event reports from the server, with acknowledgment (solicitation) or without (notification).
- **Type III (R_S):** Request initiated by the server, with or without response.

Type I is the conventional one-way web service request/response interaction pattern, where the client makes a one-way web service request to the server. Type II is the interaction pattern of asynchronous reply and event notification from the server to the client. In practice, an asynchronous reply is often modeled as event notification with some correlation information with which the client can associate the reply to its request. Type III is the reversal of the Type I interaction pattern, where the server issues the service request to the client. The patterns of these interactions are illustrated in the following diagram Fig. 1, where solid arrows indicate initial messages, and dotted arrows indicate optional response messages.

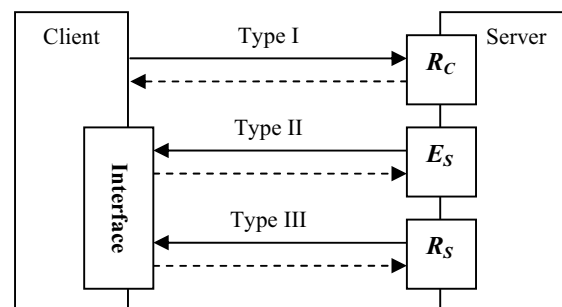


Fig 1. Two-way interaction patterns of client/server

From the endpoint interface perspective, Type I interaction pattern only requires the server to expose a proper service WSDL in order for client to consume services with corresponding SOAP messages. Type II and Type III interaction patterns are two-way web service interactions. It requires that the client has to expose an appropriate matching WSDL interface for the server to communicate

to client in two-way web service interaction. Without a matching web service interface between client and server, the two-way web service interaction will fail and cannot sustain. Therefore, how to design and specify appropriate web service WSDL interfaces for two-way web service interaction is a critical issue and has to be resolved properly in order to enable full duplex web service interactions in communication.

In [7], it provides a theoretical framework on two-way web service interaction and characterizes the WSDL relationships between the client/server, upon which full duplex, two-way web service interactions can be established. For example, by applying the Typed FSA (Finite State Automata) theory to web service design, three types of WSDL interfaces and relations were derived for Type II asynchronous event notification.

1. **Loosely coupled event interface:** It is based on a “wrapped” message delivery model that the client interface is loosely-coupled with the server interface. Therefore, it only needs to expose a small amount of operations to receive a variety of messages.

2. **Tightly coupled event interface:** The client WSDL interface is based on an exact mirrored reversal of the corresponding operations in the server WSDL interface.

3. **Combined (loose+typed) event interface:** It is a combination of both.

This theoretical framework allows systematic interface design, discovery and verification for two-way web service interaction [7]. By advancing one-way web service to two-way, full duplex web service interaction, it opens the opportunity to apply web service as a method of communication, which is in addition to being a method for service integration.

2.1 Stateful and Session based Transactions

Two-way web service interaction is typically stateful. In tele-communication, the stateful transactions are usually based on a stateful context “*Session*”.

ECMA-366, WS-Session, provides a generic solution to stateful and session based web service transactions in communication [11]. Fig. 2 illustrates its WSDL operations. WS-Session defines an explicit and declarative specification of web service operations that are needed to establish, extend and terminate an application session. It separates session management semantics from other operations, for example, event subscription. As a result, it enforces the rule that a client and a server can exchange messages if and only if a valid application context (session) is established. In terms of architecture design, WS-Session offers flexibility for the server to perform context-related tasks for service invocation, outbound operation and event notification.

3. WSIP (Web Service SIP) FRAMEWORK

From the application-layer perspective, VoIP using SIP is achieved through a network of SIP endpoints. Each SIP endpoint has two major components, a SIP user agent (UA) and an application that is built on top of it, such as a SIP phone application, an IM messenger application, etc. The SIP UA handles the low level signaling and media communication, and it exposes a set of APIs to its application. In the framework of SIP, the application interacts with other users or applications by calling the SIP UA APIs and communicates with other SIP UAs through SIP signaling. Applications of SIP are tied to the particular SIP UA APIs, and there is no standard application integration and extension infrastructure in SIP for distributed applications, QoS and network monitoring.

```
<portType name="ApplicationSessionServicesPort">
  <operation name="StartApplicationSession" >
    <input message="apsw:startApplicationSession">
      <output
message="apsw:startApplicationSessionPosResponse">
        <fault
message="apsw:startApplicationSessionNegResponse">
      </operation>
    <operation name="StopApplicationSession" >
      <input message="apsw:stopApplicationSession">
        <output
message="apsw:stopApplicationSessionPosResponse">
          <fault
message="apsw:stopApplicationSessionNegResponse">
        </operation>
      <operation name="ResetApplicationSessionTimer" >
        <input message="apsw:resetApplicationSessionTimer">
          <output
message="apsw:resetApplicationSessionTimerPosResponse">
            <fault
message="apsw:resetApplicationSessionTimerNegResponse">
          </operation>
        <operation name="ApplicationSessionTerminated" >
          <output message="apsw:applicationSessionTerminated">
        </operation>
      </portType>
```

Fig 2. Web service operations of WS-Session

On the other hand, web service is designed for distributed services over Internet. A web service endpoint is typically a SOAP node. A SOAP node is both a client and a server. It listens to the SOAP channel for the incoming SOAP messages and sends the proper SOAP messages as its response. Web service is based on a loosely coupled service model. It separates the service protocol from the application data. It encapsulates the service protocol and application data in a well-formed SOAP message. SOAP is an XML standard from W3C, and it provides a standard based extensible structure for XML based remote procedure calls and data exchange. The binding of SOAP with HTTP is most important in that it provides a ubiquitous application layer infrastructure for services over IP.

Moreover, web service provides a standard based and self-describing service integration environment in the form of WSDL [2, 3]. It allows dynamic application service binding between the SOAP messages and the platform service APIs. This leads to distributed services, where multiple services and platforms can be linked remotely through the exchange of SOAP messages to perform business transactions.

One of the considerations behind WSIP is to avoid further complicating SIP protocol and additional interoperability issues in SIP UAs. The WSIP approach we took in [9] is a multimode, multi-protocol endpoint which is an overlay of SIP and web service on top of the same IP substrate. An endpoint (terminal) in WSIP is both a SIP UA endpoint in SIP environment and a SOAP node in the framework of web services. It leads to a new converged communication paradigm over IP that fully leverages the strength of both SIP and web service approaches.

Two WSIP endpoints can communicate directly using SIP signaling. Moreover, two WSIP terminals can also communicate directly through web service using SOAP. In addition, the WSIP terminals can communicate with remote applications that bundles SIP based VoIP communication directly through web service channel. For example, a SIP phone call to alert the customer of the arrival of his product order can be initiated by the application of a remote agent who travels on the road with only a web connection.

WSIP is a new class of multimode communication endpoints. It can support both a SIP communication mode and a dialogue mode for additional call control, service integration and service extensions through web service and XML protocol. It is also a multi-protocol endpoint that communicates in an integrated fashion, using web services to alleviate limitations of SIP infrastructure.

4. WNET (WSIP NET) INFRASTRUCTURE

WNET is a new communication infrastructure over IP which is formed by a network of WSIP nodes. Each WSIP

node in the WNET can communicate with each other through both methods of SIP and web service. As a consequence, it provides an application layer protocol overlay over IP that uses at least two communication protocols, i.e. SIP and HTTP. A WSIP node can use either protocol to establish the services as it fits. This infrastructure is fundamentally different from SIP, whose service negotiation and extension are limited by lack of extensibility in its SMTP type header structure. This infrastructure is also different from conventional web service, which only uses generic application protocols, e.g. HTTP, not special communication protocols such as SIP or real-time media transmission protocols such as RTP.

The application layer protocol overly provides a new dimension for enhancing service resiliency, service integration, provisioning, monitoring, etc. The ubiquitous of web service over HTTP can be used to overcome obstacles and limitations in VoIP SIP communication. WSIP makes SIP endpoint a service oriented architecture (SOA) component, which allows WNET/WSIP to support dynamically formed service grid. Furthermore, it makes each SIP node into a service oriented node that can be seamlessly integrated into end-to-end business transactions.

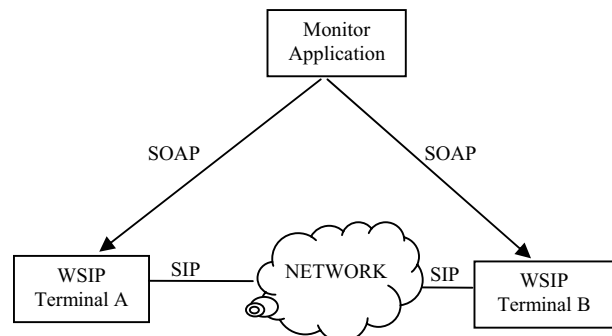


Figure 3: The WSIP architecture for network

One aspect of WNET/WSIP is that it allows distributed service integration and remote monitoring. Fig. 3 depicts our distributed remote service monitoring in the paradigm of WNET/WSIP. In WNET/WSIP, the communication status of WSIP can be exposed as a private web service, allowing the authorized network administrator to perform on demand monitoring the communication quality of the SIP/RTP connection.

In our approach, the RTP/RTCP stack provides both the peer-to-peer media stream delivery and the statistics about the network condition, such as packet loss, inter-arrival jitter, delay. These critical communication parameters are calculated from the transmission and reception statistics in SR (sender report) and RR (receiver report) in the RTCP packets as specified in [13, 14].

In WNET/WSIP, this information can be accessed through the web service method and bind to service applications and transactions. In particular, an application on the receiver WSIP endpoint can launch a web service request to subscribe the network administrator's network monitor service when the packet loss or delay of the RTP/RTCP communication triggers the alarm at the receiver end. The service monitor service can be purely web service based without interference of the current SIP session.

The endpoint monitor service initiated by the end user's application is in addition to allow the network administrator to subscribe the user's endpoint status service for service monitoring. This use case illustrates the power of two-way web services. In WNET/WSIP infrastructure, both network administrator and users at the endpoint can initiate services on network monitoring, and exchange service contents to reach consensus or solutions. The application layer protocol overlay feature of WNET/WSIP makes network monitor services ubiquitously available. Most importantly, the monitoring services can be achieved through a different application layer protocol, e.g. HTTP, without interrupting the ongoing SIP communication or open a new SIP session with the endpoints in question.

One of the major issues for VoIP with SIP is security. It has strong impact to many services, especially for network services, where special network access privilege can be both a blessing and a danger. In addition to the methods which can be implemented through transport layer security (TLS), WNET/WSIP opens a new secure access paradigm of service access through web services. In particular, WS-Security [12] provides a standard based secure access method, which supports end-to-end message security for service access.

It is true when a secure transport is available between two endpoints, building a secure solution can be simplified. With a secure transport, the services need not concern themselves with maintaining integrity and confidentiality for each individual message, and can rely on the underlying secure data transport mechanism for message security. However, existing transport-level security solution is limited to point-to-point messaging. If intermediaries are present when using a secure transport, the initial sender and the ultimate receiver need to trust those intermediaries to help provide end-to-end security, since each hop is secured separately.

For any message based communication scheme, point-to-point security becomes insufficient and end-to-end message security must be provided. This is a long running problem for SIP based communication, when intermediaries are not trusted by the communication endpoints, e.g. proxy, B2B UA, etc. WS-Security is an industry standard that addresses the critical end-to-end message security for secure services access over IP.

Our approach of using web service based security method for secure access of services on WNET/WSIP has several unique advantages. First, it provides end-to-end message security for communication services over IP, which can be applied in addition to the transport layer security. Secondly, end-to-end message security is achieved in WNET/WSIP without introducing non-interoperable changes to SIP protocol, which is a major issue to SIP based communication. Thirdly, WS-Security is designed with the purpose of flexibility and extensibility which forms the basis for securing web service messages within a wide variety of existing security models, such as PKI, Kerberos, and SSL. It provides three major mechanisms: ability to send security tokens as part of a message, message integrity and message confidentiality.

In addition, WNET/WSIP provides a way to administrate dynamic network resource management for communication services over IP. It allows the network resource management policies to be propagated on demand. In the case of network congestion, the network administrator can temporarily disable certain bandwidth resource demanding services on the endpoints in the network, and turn them back on later without interfere other services. For example, one such use case is to tentatively disable the video session between WSIP endpoints when there is a shortage of the bandwidth due to various reasons. It can be done in a way such that it will maintain all the on going communication sessions between WSIP endpoints, but no new video sessions can be established, since the coder option support on WSIP endpoint has the option video stream temporally disabled. The video session capabilities can be turned back on by the network administrator through the web service method, should the congestion issues be resolved.

In the pure SIP environment, dynamic resource management crossing the network is very hard to achieve, because there is no standard service integration environment and service level control as provided by web service. It should be noticed that the network resources management case presented above is a special case of dynamic service provisioning. In WNET/WSIP, it has an inherent service oriented architecture achieved through two-way web service enablement. It allows the service to be dynamically discovered, provisioned and updated based on a consistent policy through web service.

4.1 WNET/WSIP Implementation

We implemented the WNET/WSIP infrastructure for voice and IM services. The web service on WSIP terminal is a stateful web service. It contains the status of the SIP UA, such as the number of active calls, the port number that is using, etc. It also contains the status of each active calls, for example, session type (Voice, IM), the state of the session (ringing, call is preceeding), caller ID, starting

time, etc. So it is important to guarantee that all the states can be kept correctly. The GET and POST methods in HTTP, that carry the web service SOAP messages, are stateless. It is up to the application to maintain and manage a stateful transaction. This situation is further complicated by the multi-thread nature of the WSIP terminal.

This requires WSIP web service infrastructure to maintain a dialogue history registry, and the rule is that if a contact is initiated or answered by one application, all the subsequent contact events have to be forwarded to the same application. For example, when an application initiated a SIP call through the web service of WSIP, then all subsequent events of that application have to interact to the same thread on the SIP UA, until the final call hang up.

To address these issues, we developed a two-way proxy web service middleware to manage the two-way connections between the WSIP web service agent and the application. It consists of the following technical procedures.

- Use XML condition/action rules to specify which application to launch based on the contact events from the SIP UA of WSIP terminal.
- Maintain the web service registry for the contact from the WSIP SOAP server.
- Maintain the sessions between the external applications and the applications running on SIP UA, if necessary.

Each external application from web service link has a unique service key, which is an URI, and when a new contact is routed to WSIP terminal, the event XML includes the service key, event type and contact description, among other information. If necessary, the proxy will launch the specified application, and create a session that maintains the relationship between the external web service that submits the application and the state of the application that is running on the WSIP SIP UA.

5. SUMMARY

In this paper, we introduced a web service based communication infrastructure WNET/WSIP for converged communication services over IP. It is integrated with VoIP SIP infrastructure and based on two-way, full duplex web service interaction. A new class of IP communication endpoints, WSIP (Web Service SIP), is described and studied from the network service infrastructure perspective. We studied two-way, full duplex web service interaction for stateful and session based web service transactions. New capabilities of WNET/WSIP were studied which provide solutions for enhanced service resiliency, service monitoring, and security to support communication over IP. A research prototype

WNET/WSIP system was developed and advantages of the proposed WNET/WSIP approach were observed.

6. REFERENCES

- [1] SIP: Session Initiation Protocol, <http://www.ietf.org/rfc/rfc3261.txt?number=3261>
- [2] SOAP/WSDL, <http://www.w3.org/2002/ws/>
- [3] Web Service Architecture, W3C Working Draft, <http://www.w3.org/TR/2003/WD-ws-arch-20030808/>
- [4] M. Haines, "Web service as Information Systems Innovation: A Theoretical Framework for Web Service Technology Adoption", Proc ICWS'2004, pp. 11-16
- [5] M. Mukarram, et al, "Introduction Dynamic Distributed Coordination in Web Services for Next Generation Service Platform", Proc. ICWS'04, pp. 296-305
- [6] Voice Browser Call Control: CCXML Version 1.0. W3C Working Draft. <http://www.w3.org/TR/ccxml/>
- [7] L. Li and W. Chou, "Two-way Web Service: from Interface Design to Interface Verification", Proceedings of ICWS 2005, Volume 2, page 525-532, July 2005, Orlando Florida
- [8] F. Liu, W. Chou, W. Guo and E. Wong, "An Approach to Integrating SIP in Converged Multimodal/Multimedia Communication Services", Telecommunication Systems, vol. 28, 387-405, Springer Science + Business Media Inc., 2005
- [9] F. Liu, W. Chou, L. Li and J. Li, "WSIP-Web Service SIP Endpoint for Converged Multimedia/Multimodal Communication over IP", Proceedings, ICWS'04, pp. 690-697, July, 2004
- [10] Standard ECMA-323, XML Protocol for Computer Supported Telecommunications Applications (CSTA) Phase III. <http://www.ecma-international.org/publications/standards/Ecma-323.htm>
- [11] Standard ECMA-366, WS-Session, <http://www.ecma-international.org/publications/standards/Ecma-323.htm>
- [12] WS-Security: SOAP Message Security 1.0 (WS-Security 2004) – OASIS Standard 200401, March 2004
- [13] J.-C. Bolot, "End-to-End Packet Delay and Loss Behavior in the Internet", Proc. ACM SIGCOMM'93, Sept. 1993
- [14] A.B. Downey, "Using Pathchar to Estimate Internet Link Characteristics", Proc. ACM SIGCOMM'99, Aug. 1999