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(71) Applicant *(for all designated States except US)*: **INTERNATIONAL BUSINESS MACHINES CORPORATION** [US/US]; New Orchard Road, Armonk, New York 10504 (US).

(71) Applicant *(for MG only)*: **IBM UNITED KINGDOM LIMITED** [GB/GB]; PO Box 41, Portsmouth, Hampshire PO6 3AU (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **NADALIN, Anthony, Joseph** [US/US]; 947 Vanguard, Austin, Texas 78734 (US). **MCINTOSH, Michael** [US/US]; 33 Normandy Road, Clifton, New Jersey 07013 (US). **AUSTEL, Paula** [US/US]; 8 Lake Road, Cortlandt Manor, New York 10567 (US). **HONDO, Maryann** [US/US]; 118 Oakland Avenue, Arlington, Massachusetts 02476 (US). **NAGARATNAM, Nataraj** [IN/US]; 107 Ecklin Lane, Morrisville, North Carolina 27560 (US).

(74) Agent: **SEKAR, Anita**; IBM United Kingdom Limited, Intellectual Property Law, Winchester, Hampshire SO21 2JN (GB).

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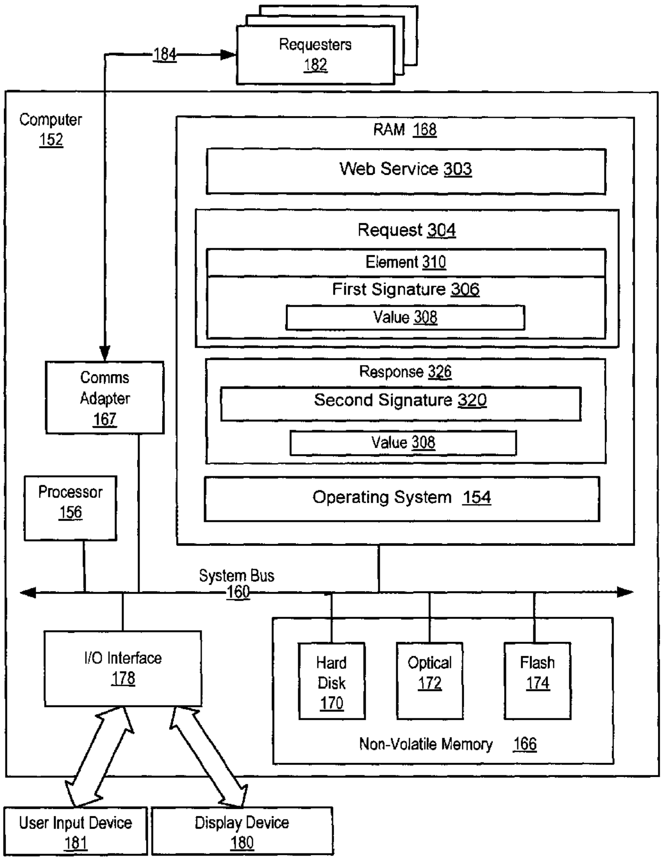
(54) Title: SECURE DATA COMMUNICATIONS IN WEB SERVICES



(57) Abstract: Methods, systems, and products are disclosed in which secure data communications in web services are provided generally by receiving in a web service from a client a request containing an element bearing a first signature, the signature having a value; signing the value of the first signature, thereby creating a second signature; and sending a response from the web service to the client, the response including the second signature. The requester may verify that the response includes the second signature. The request may be encrypted, and the response may be encrypted. The first signature may be encrypted, and the web service may encrypt the value of the first signature and include the encrypted value of the first signature in the response. The web service may receive a request encoded in SOAP and may send a response also encoded in SOAP.

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SECURE DATA COMMUNICATIONS IN WEB SERVICES

TECHNICAL FIELD OF THE INVENTION

The field of the invention is data processing, or, more specifically, methods, systems, and products for secure data communications in web services.

BACKGROUND OF THE INVENTION

The term “web services” refers to a standardized way of integrating web-based applications. Web services typically provide business services upon request through data communications in standardized formats called bindings. A binding is a specification of a data encoding method and a data communications protocol. The most common binding in use for web services is data encoding in XML according to the SOAP protocol and data communications with HTTP. SOAP (Simple Object Access Protocol) is a request/response messaging protocol that supports passing structured and typed data using XML and extensions.

Unlike traditional client/server models, such as an HTTP server that provides HTML documents in response to requests from browser clients, web services are not concerned with display. Web services instead share business logic, data, and processes through a programmatic interface across a network. Web services applications interface with one another, not with users. Because all data communications among web services are carried out according to standardized bindings, Web services are not tied to any one operating system or programming language. A Java client running in a Windows$_{TM}$ platform can call web service operations written in Perl and running under Unix. A Windows application written in C++ can call operations in a web service implemented as a Java servlet.

Web services protocols typically are request/response protocols in which a client or intermediary requester transmits a request message to a web service requesting a particular service, and the web service provides a response in the form of a response message. In certain message exchange patterns, it is desirable for the initiator of an exchange to confirm that a message it receives was indeed a response to a request it initiated. Such a confirmation serves to establish agreement between the requester and a web service as to the content of the request that prompted the associated response. This confirmation helps reduce the risk from certain forms of attack. The current art does not, however, provide a way for a requester to confirm that a message it receives was indeed a response to a request it initiated.

DISCLOSURE OF THE INVENTION

Methods, systems, and products are disclosed in which secure data communications in web services are provided generally by receiving in a web service from a client a request containing an element bearing a first signature, the signature having a value; signing the value of the first signature, thereby creating a second signature; and sending a response from the web service to the client, the response including the second signature. The requester may verify that the response includes the second signature. The request may be encrypted, and the response may be encrypted. The first signature may be encrypted, and the web service may encrypt the value of the first signature and include the encrypted value of the first signature in the response. The web service may receive a request encoded in SOAP and may send a response also encoded in SOAP.

Signing the value of the first signature may be carried out by creating a signature confirmation element, the signature confirmation element having a value; setting the value of the signature confirmation element to the value of the first signature; signing the signature confirmation element, thereby creating a second signature; and including the signature confirmation element and the second signature in the response. When the web service receives a request which contains multiple elements bearing first signatures, each having values, then in some embodiments the web service may sign all of the values of the first signatures, thereby creating multiple second signatures; and the web service may send a response to the requester which includes the multiple second signatures.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of exemplary embodiments of the invention, as illustrated in the accompanying drawings wherein like reference numbers represent like parts of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 sets forth a network diagram illustrating an exemplary system for secure data communications in web services according to embodiments of the present invention.

Figures 2A and 2B set forth line drawings of exemplary architectures for web services in which secure data communications may be implemented according to embodiments of the present invention.

Figure 3 sets forth a block diagram of automated computing machinery comprising an exemplary computer useful in secure data communications in web services according to embodiments of the present invention.

Figure 4 sets forth a flow chart illustrating an exemplary method for secure data communications in web services according to embodiments of the present invention.

Figure 5 sets forth a flow chart illustrating a further exemplary method for secure data communications in web services according to embodiments of the present invention.

Figure 6 sets forth a flow chart illustrating a further exemplary method for secure data communications in web services according to embodiments of the present invention.

Figure 7 sets forth a flow chart illustrating a further exemplary method for secure data communications in web services according to embodiments of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Exemplary methods, systems and products for secure data communications in web services according to embodiments of the present invention are described with reference to the accompanying drawings, beginning with Figure 1. Figure 1 sets forth a network diagram illustrating an exemplary system for secure data communications in web services according to embodiments of the present invention. The term 'network' is used in this specification to mean any networked coupling for data communications among two or more computers. Network data communication typically is implemented with specialized computers called routers. Networks typically implement data communications by encapsulating computer data in messages that are then routed from one computer to another. A well known example of a network is an 'internet,' an interconnected system of computers that communicate with one another according to the 'Internet Protocol' as described in the IETF's RFC 791. Other examples of networks useful with various embodiments of the present invention include intranets, extranets, local area networks ('LANs'), wide area networks ("WANs"), and other network arrangements as will occur to those of skill in the art. The use of any networked coupling from a requester to a web server supporting a web service is well within the scope of the present invention.

The system of Figure 1 includes a data communications network (100). Network (100) provides data communications between requesters (108, 112, 102, 110, 126) and web services (106, 128). Web services server (106) is a computer, coupled for data communications through wireline connection (132) to network (100), upon which a web service (303) is installed and operative. Computer program instructions for carrying out the functions of the web service (303) are stored in a computer memory in web services server (106). Client devices ('requesters') transmit to server (106) requests for services. The web service (303) receives the requests over the network (100), processes the requests, and transmits responses over network (100). The system of Figure 1 includes several requesters capable of transmitting a request for web services to web service (303) and receiving a response. Requesters in the system of Figure 1 include:

- workstation (102), a computer coupled to network (100) through wireline connection (122),
- personal computer (108), coupled to network (100) through wireline connection (120),

- personal digital assistant (112), coupled to network (100) through wireless connection (114),
- laptop computer (126), coupled to network (100) through wireless connection (118); and
- mobile phone (110), coupled to network (100) through wireless connection (116).

The term 'requester' refers to any data communications client device, that is, any device capable of coupling for data communications to a web service, transmitting a request to the web service, and receiving a response back from the web service. Examples of requesters are personal computers, internet-enabled special purpose devices, internet-capable personal data administrators, and others that will occur to those of skill in the art. Various embodiments of requesters are capable of wired and/or wireless couplings to web services. The use as a requester of any client device or instrument capable of accessing a web service through a network is well within the scope of the present invention.

Figure 1 also includes web services intermediary (128), coupled to network (100) through wireline connection (130). Web services intermediary (128) has installed and operative upon it a web service (301). Web service (301) provides intermediary web services. A web services intermediary is a web services component, in this example, a server, that lies between a web services requester and a web service. Intermediaries operate generally by intercepting a request from a client, providing intermediary services, and then forwarding the client request to a web services provider (sometimes referred to as a 'target service'). Similarly, responses from the web services provider (the target service) are intercepted, operated upon, and then returned to the original requester.

Services provided by intermediaries include, for example, authentication of sources of requests for target services, message validation for content and form, and message logging for auditing purposes. Intermediaries may provide management reporting services, number of web service hits, quantity and timing of services used by individual clients, and so on. Intermediaries can be used as caches in support of improved performance by storing frequently changing but frequently requested data such as news stories, for example.

Intermediaries can be used for performance improvement in the sense of load balancing, storing requests for services from several clients and forwarding them to a target service during off-peak service hours. Intermediaries may aggregate services, as, for example, an accounting intermediary that accepts requests for account postings that are then forwarded to separate target services for accounts payable, accounts receivable, and general ledger services.

The system of Figure 1 operates generally to provide secure data communications in web services according to embodiments of the present invention by receiving in a web service, such as web service (303) for example, from a requester a request containing an element bearing a first signature having a value. The web service signs the value of the first signature, thereby creating a second signature, and sends a response from the web service (303) to the requester that includes the second signature. As explained in more detail below, sending a response bearing the second signature (a signature of the first signature) authenticates the identity of the web service to the requester and verifies message integrity, that the response is a response to the exact request received from the requester.

The arrangement of client devices, servers, networks, and other devices making up the exemplary system illustrated in Figure 1 are for explanation, not for limitation. Data processing systems useful for secure data communications in web services according to various embodiments of the present invention may include additional servers, routers, other devices, and peer-to-peer architectures, not shown in Figure 1, as will occur to those of skill in the art. Networks in such data processing systems may support many data communications protocols, including for example TCP/IP, HTTP, WAP, HDTP, and others as will occur to those of skill in the art. Various embodiments of the present invention may be implemented on a variety of hardware platforms and network configurations in addition to those illustrated in Figure 1.

For further explanation, Figure 2A sets forth a line drawing of an exemplary computer architecture for web services in which secure data communications in web services may be implemented according to embodiments of the present invention. In the architecture of Figure 2A, web service intermediary (301) is coupled for data communications through a data communications protocol to requester (102) and target web service (303). Both web service intermediary (301) and target web service (303) are installed upon servers supporting web services. A web services component in the position of requester (102) is referred to generally in this specification as a 'requester.' Similarly, a component in the position of intermediary (301), particular when viewed from the point of view of a requester, may be referred to as a 'web service.'

The client/server distinction, as well as the 'requester' designation, must be used carefully in the context of web services. Whether a particular component is a requester, a client, a server, or a service depends on the component's role in an exchange of request/response messages in a communications protocol. For further explanation, Figure 2A sets forth a line drawing of an exemplary computer architecture for web services in which secure data communications in web services may be implemented according to embodiments of the present invention. In the architecture of Figure 2B, for example, target service (303), in the process of preparing a response to a request from requester (102), may in turn request web services from target web service (204) through web service intermediary (202). In doing so, target web service (303) is acting as a client and as a requester. Intermediary (202) in forwarding requests to target service (204) is acting as a client and as a requester, and intermediary (202) in receiving requests from target service (303) and preparing and sending responses to target service (303) is acting as a web service. Similarly, intermediary (301) in forwarding requests to target service (303) is acting as a client and as a requester, and intermediary (301) in receiving requests from requester (102) and preparing and sending responses to requester (102) is acting as a web service. Thus it is seen that whether a particular web services component is considered a client or a server, a requester or a service, at any particular time depends upon the particular function being performed by the component at the time. A web services component can be a client or requester one moment and a server or a web service the next. To reduce the risk of confusion from terminology, therefore, web services components are usually described in this specification by using the terms 'requester,' 'intermediary,' and 'web service' rather than 'client' or 'server.'

Secure data communications in web services in accordance with the present invention are generally implemented with computers, that is, with automated computing machinery. In the system of Figure 1, for example, all the nodes, servers, and communications devices are implemented to some extent at least as computers. For further explanation, therefore, Figure 3 sets forth a block diagram of automated computing machinery comprising an exemplary computer (152) useful in secure data communications in web services according to embodiments of the present invention. The computer (152) of Figure 3 includes at least one computer processor (156) or 'CPU' as well as random access memory (168) ("RAM") which is connected through a system bus (160) to processor (156) and to other components of the computer.

Stored in RAM (168) is a web service (303), a set of computer program instructions improved for secure data communications in web services according to embodiments of the present invention. Also stored in a RAM (168) is a request (304) for a service. The request contains an element (310) bearing a first signature (306) having a value (308). Also stored in a RAM (168) is a response (326) to the request. The response bears a second signature (320) (a signature of the first signature). The response also bears the value (308) of the first signature. The computer program instructions of the web service (303) include instructions for receiving in the web service (303) from a requester (182) a request (304) containing an element bearing a first signature (306) having a value, signing the value of the first signature, thereby creating a second signature (320), and sending a response from the web service (303) to the requester (182) that includes the second signature (320). Sending a response bearing the second signature (a signature of the first signature) has the useful effect of authenticating the identity of the web service to the requester and verifying message integrity, that is, verifying that the response is a response to the exact request received from the requester.

Also stored in RAM (168) is an operating system (154). Operating systems useful in computers according to embodiments of the present invention include UNIX, Linux, Microsoft NT, AIX, IBM's i5/OS, and others as will occur to those of skill in the art (UNIX is a registered trademark of The Open Group in the United States and other countries; Linux is a registered trademark of Linus Torvalds in the United States, other countries, or both; Microsoft, Windows, Windows NT, and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both; AIX, IBM and i5/OS are registered trademarks of International Business Machines Corporation). Operating system

(154), web service (303), request (304), and response (310) in the example of Figure 3 are shown in RAM (168), but many components of such software typically are stored in non-volatile memory (166) also.

Computer (152) of Figure 3 includes non-volatile computer memory (166) coupled through a system bus (160) to processor (156) and to other components of the computer (152). Non-volatile computer memory (166) may be implemented as a hard disk drive (170), optical disk drive (172), electrically erasable programmable read-only memory space (so-called 'EEPROM' or 'Flash' memory) (174), RAM drives (not shown), or as any other kind of computer memory as will occur to those of skill in the art.

The example computer of Figure 3 includes one or more input/output interface adapters (178). Input/output interface adapters in computers implement user-oriented input/output through, for example, software drivers and computer hardware for controlling output to display devices (180) such as computer display screens, as well as user input from user input devices (181) such as keyboards and mice.

The exemplary computer (152) of Figure 3 includes a communications adapter (167) for implementing data communications connections (184) with clients, requesters (182), web service intermediaries, other web services, and other computers. Such data communications may be carried out through serially through RS-232 connections, through external buses such as USB, through data communications networks such as IP networks, and in other ways as will occur to those of skill in the art. Communications adapters implement the hardware level of data communications through which one computer sends data communications to another computer, directly or through a network. Examples of communications adapters useful for determining availability of a destination according to embodiments of the present invention include modems for wired dial-up communications, Ethernet (IEEE 802.3) adapters for wired network communications, and 802.11b adapters for wireless network communications.

For further explanation, Figure 4 sets forth a flow chart illustrating an exemplary method for secure data communications in web services according to embodiments of the present invention that includes receiving (302) in a web service (303) a request (304) from a requester (102). In the example of Figure 4, request (304) contains an element (310) bearing a first signature (306). The first signature (306) has a value (308). Request (304) may be a message in a web services request/response protocol such as for example, SOAP. Element (310) is an instance of message structure. SOAP messages are expressed in XML, so in the example of SOAP, element (310) may be implemented as an XML element, that is, message structure implemented with XML tags.

First signature (306) may be implemented as a digital signature for element (310), for example, by hashing element (310) and encrypting the hash with requester's private key from a public key infrastructure. This process of creating a digital signature from an element is called 'signing.' First signature (306) may be incorporated into request (304) by including the encrypted hash in the request. In the example of a SOAP message, the signature may be incorporated into the request (304) by creating a SOAP signature element, whose value is that of the encrypted hash, and including the SOAP signature element in the request (304).

The method of Figure 4 also includes signing (309) the value (308) of the first signature (306), thereby creating a second signature (320). The web service generates (324) a response (326) to the request (304). As with the request (304), the response is a message in a web services request/response protocol. The response (326) includes the second signature (320). Like first signature (306), second signature (320) may be implemented by hashing the value (308) of the first signature and encrypting the hash with web service's private key from a public key infrastructure. Second signature (320) may be incorporated into a response (326) by including the encrypted hash in the response (326). In the example of a SOAP message, the signature may be incorporated into response (326) by creating a SOAP signature element, whose value is that of the encrypted hash, and including the SOAP signature element in response (326). The response (326) may also contain the value (308) of the first signature (306). The method of Figure 4 also includes sending (338) the response (326) which includes the second signature from web service (303) to requester (102).

In the method of Figure 4, requester (102) verifies (342) that the response (326) includes a second signature (320) and that the second signature is a signature of the value (308) of the first signature (306). In the case of a SOAP request, for example, a signature may be implemented as a SOAP signature element. Requester (102) may verify that the request contains a signature by examining the message for a SOAP signature element.

Requester (102) may verify that the second signature is a signature of the first signature by, for example, decrypting the second signature, yielding a purported hash of the first signature. Requester may compare the hash so produced with a hash of the first signature computed at the time from a stored copy of the first signature. Alternatively, requester (102) may store the hash of the first signature at the time when requester created the first signature and use the stored copy of the hash of the first signature to compare with the purported hash from the response message. The fact that the second signature is a signature of the value (308) of the first signature (306) is verified (342) if the two hashes are equal. That the two hashes are equal also verifies the decryption of the second signature. Requester's decrypting the second signature with the web service's public key authenticates the identity of the web service because the second signature can only have been encrypted by the web service using the web service's private key. The verification process assures requester (102) of the integrity of the value (308) of the first signature (306) as embedded in second signature (320), that is, that the first signature has been received back from the web service without alteration.

In the example of Figure 4, request (304) contains two elements (310, 312), with each element bearing a first signature (306, 314). The illustration of two elements in request (304) is not a limitation of the present invention. The number two is used merely to illustrate that a request (304) may contain multiple elements (310, 312) bearing first signatures (306, 314), with each first signature having a value (308, 316). The method of Figure 4 further includes signing (309) all the values (308, 316) of the first signatures, thereby creating multiple second signatures (320, 322). The method of Figure 4 further includes sending (338) a response (326) from the web service (303) to the requester (102), the response (326) including the multiple second signatures (320, 322). The values (308, 316) of the first signatures (306, 314) may also be included in the response (326).

For further explanation, Figure 5 sets forth a flow chart illustrating a further exemplary method for secure data communications in web services according to embodiments of the present invention, in which a received request (304) may be encrypted. The process of encrypting data involves applying an algorithm to the data to convert it to an unintelligible form. Typical encryption algorithms may involve use of a secret, known as a key. Some algorithms use one secret key which is shared between a requester and a web service. Other algorithms use two keys, a private key and a public key. Commonly used encryption algorithms include 3DES (Data Encryption Standard), CAST-128, Twofish, and Advanced Encryption Standard (AES).

The exemplary method of Figure 5 is similar to the method of Figure 4. That is, the method of Figure 5 includes receiving (302) an encrypted request (304) bearing a first signature (306) having a value (308), signing the value (308) of the first signature (306), and sending (338) a response (326) from web service (303), all operative in a manner similar to the method of Figure 4. The method of Figure 5, however, also includes determining (321) whether the received request (304) is encrypted. In the case of a SOAP request, for example, a message security header may contain information describing whether a request or elements of a request are encrypted, and determining (321) whether the received request is encrypted may be carried out by examining such a request message security header. In the example of Figure 5, if the request is encrypted (327), the method includes encrypting (325) the response (331) in the web service (303). If the request is not encrypted (329), the web service sends (338) the response (326) without encrypting it.

For further explanation, Figure 6 sets forth a flow chart illustrating an exemplary method for secure data communications in web services according to embodiments of the present invention in which a first signature may be encrypted. The method of Figure 6 is similar to the method of Figure 4. That is, the method of Figure 6 includes receiving (302) an request (304) bearing an encrypted first signature (306) having a value (308), signing the value (308) of the first signature (306), and sending (338) a response (326) from web service (303), all operative in a manner similar to the method of Figure 4. The method of Figure 6, however, also includes determining (354) whether the first signature is encrypted. In the case of a SOAP request, for example, a security header may contain information describing whether a request or elements of a request are encrypted, and determining (354) whether the first signature (306) of the received request is encrypted may be carried out by examining such a request message security header.

When the first signature (306) is encrypted, encrypting the value (308) of the first signature in the response can help protect the key used to produce the first signature. If the first signature is sent encrypted in the request (304), and the value (308) of the first signature (306) is not encrypted in the response (326), then there is some risk of an attacker comparing the encrypted and unencrypted signature values and gaining information about the key used by requester (102) to produce the signature in request (304). In the example of Figure 6, therefore, if the first signature is encrypted (352), the method includes encrypting (350) the value (308) of the first signature in the web service (303) and including the encrypted value (358) in the response (326). If the value of the first signature is not encrypted (356), the web service sends (338) the response (326) without encrypting the value of the first signature.

For further explanation, Figure 7 sets forth a flow chart illustrating a further exemplary method for secure data communications in web services according to embodiments of the present invention that uses the SOAP/HTTP binding for web services. The method of Figure 7 is similar to the method of Figure 4. That is, the method of Figure 7 includes receiving (302) a request (604) encoded in SOAP bearing a first signature (306) having a value (308), signing (309) the value (308) of the first signature (306), and sending a response from web service (303), all operative in a manner similar to the method of Figure 4. The method of Figure 7 further includes receiving (602) a request encoded in SOAP (604) and creating (408) a signature confirmation element (410), the signature confirmation element having a value (406). A signature confirmation element is a SOAP data structure containing a value field. Web service (303) sets (416) the value (406) of the signature confirmation element (410) to the value (308) of the first signature (306). The method of Figure 7 further includes the web service (303) signing (412) the signature confirmation element (410), thereby creating a second signature (320). In this application, "signing" a first element will also include signing a signature confirmation element whose value is the first element. The method of Figure 7 further includes generating a response (326) to the SOAP request (604), which includes the signature confirmation element (410) and the second signature (320).

In the example of Figure 7, SOAP request (604) contained one signature with a value (308), and the response (326) contained one signature confirmation element (410). The illustration of single signature confirmation element is not a limitation of the present invention. The SOAP request (604) may contain multiple signed elements, with multiple signatures. In some methods for secure data communications in web services according to various embodiments of the present invention, the SOAP response (326) may include a signature confirmation element (410) for each signature in the original request. Each signature confirmation element (410) contains the value (406) of the corresponding signature. In some methods for secure data communications in web services according to various embodiments of the present invention, the SOAP response (326) may include a single signature confirmation element (410), whose value (406) is the value of one of the signatures in the original request.

Following is an example of a pseudocode SOAP request:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..." xmlns:xenc="..."
    xmlns:ds="...">
     <S11:Header>
          ...
          <wsse:Security>
               ...
                 <ds:Signature>
                         ...
                         <ds:SignedInfo>
                         <ds:Reference URI="# CreditCardInfo">
                              ...
                         </ds:Reference>
                    </ds:SignedInfo>
                    <ds:SignatureValue>
                            kpRyejY4uxwT9I74FYv8nQ==
                    </ds:SignatureValue>
                    <ds:KeyInfo>
                         ...
                    </ds:KeyInfo>
               </ds:Signature>
```

```
            </wsse:Security>
                ...
        </S11:Header>
        <S11:Body>
            <CreditCardInfo  wsu:Id="CreditCardInfo">
            </CreditCardInfo>
                        ...
        </S11:Body>
</S11:Envelope>
```

This example is described as 'pseudocode' because it is an explanation presented in the general form of XML code rather than an actual working model of a request. This example encapsulates a SOAP <header> element and a SOAP <body> element in a SOAP <envelope>. The header includes security data in a <security> element. The body includes the request data. This exemplary SOAP request contains an element named <wsse:Security> bearing a signature named <ds:Signature>. The signature has a value named <ds:SignatureValue>. Thus the SOAP request illustrated in this example implements a request of the kind described above and illustrated at reference (604) of Figure 7.

The value of the signature is "kpRyejY4uxwT9I74FYv8nQ." The value is obtained by hashing and then encrypting the element that was signed. The <reference> element of the signature element indicates that the name of the element signed by the signature is "CreditCardInfo." The <creditCardInfo> element is contained in the body of the request. The "Id" attribute of CreditCardInfo is CreditCardInfo, indicating that the element may be referenced by "CreditCardInfo". Thus, the signature signs the CreditCardInfo element.

The following is an example of a pseudocode SOAP response message that may implement a response to the web services request represented by the above request message:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..." xmlns:xenc="..."
    xmlns:ds="..." xmlns:wsse11="...">
        <S11:Header>
         ...
                <wsse:Security>
                <wsse11:SignatureConfirmation     wsu:Id="SignatureConfirmation"
                        Value="kpRyejY4uxwT9174FYv8nQ=="/>
                         ...
                 <ds:Signature>
                                ...
                        <ds:SignedInfo>
                                        ...
                                <ds:Reference URI="#SignatureConfirmation">
                                                <ds:DigestMethod
                                        Algorithm="http://www.w3.org/2000/xmldsig#sha1" />
                                 <ds:DigestValue>
                                        LyLsF0Pi4wPU...
                                 </ds:Digest Value>
                                         </ds:Reference>
                   </ds:SignedInfo>
                   <ds:SignatureValue>
                        MC0CFFrVLtRlk
                   </ds:SignatureValue>
                   <ds:KeyInfo> ... </ds:KeyInfo>
                </ds:Signature>
                                ...
                 </wsse:Security>
                               ...
        </S11:Header>
        <S11:Body>
                ...
        </S11:Body>
</S11:Envelope>
```

In this example, a SOAP response contains a signature confirmation element having a value equal to the value of the signature in the request. The SOAP response also contains a signature, which signs the signature confirmation element. Thus the SOAP response described in this example implements a response of the kind described above and illustrated at reference (326) of Figure 7.

Similar to the exemplary SOAP request set forth above, this exemplary SOAP response contains a header and body within a SOAP envelope. The header contains security information set forth in an element named <wsse:Security>. Within the security element is a <signatureConfirmation> element which conveys, in an attribute named "Value," the value of the first signature from the corresponding request. The "Value" attribute in this example is set to "kpRyejY4uxwT9174FYv8nQ," equal to the value of the signature in the request. The <signatureConfirmation> element also has an identification attribute named "Id" whose value is "SignatureConfirmation."

The security element <wsse:Security> also contains a signature element named <ds:Signature>. The value of a second signature, a signature of the first signature from the request, is set forth in an element of the <ds:Signature> element named <ds:SignatureValue>. The value of the second signature in this example is set to "MC0CFFrVLtRlk." The <ds:Reference> element of the signature element, by its "URI" attribute set to "#SignatureConfirmation" identifies the data that is signed to create the second signature. In this example, <ds:Reference> identifies the first signature as the signed data, that is, the value in the <wsse11:SignatureConfirmation> element, "kpRyejY4uxwT9174FYv8nQ." This example SOAP response therefore contains a first signature, a second signature, and a URI identifying the first signature as the data that is signed to create the second signature.

In secure data communications in web services according to various embodiments of the present invention, a requester may verify that a SOAP response corresponds to a particular SOAP request by finding the signature confirmation element in the response and comparing the value of the signature confirmation element with the value of the signature in the corresponding SOAP request. When the SOAP request contains multiple signatures, the requester may find all of the signature confirmation elements contained in the response, and check the values of the value fields of the signature confirmation elements against the values of the signatures in the original SOAP request.

The exact formats of the example SOAP request and example SOAP response set forth above are not a limitation of the present invention. The above examples are merely explanations of a possible format for a SOAP request and SOAP response for secure data communications in web services according to the present invention. When using SOAP message structures or the SOAP data communications protocol for secure data communications in web services according to various embodiments of the present invention, signatures may be implemented in any data structure that will occur to those of skill in the art, and all such structures are well within the scope of the present invention.

Exemplary embodiments of the present invention are described largely in the context of a fully functional computer system for secure data communications in web services. Readers of skill in the art will recognize, however, that the present invention also may be embodied in a computer program product disposed on signal bearing media for use with any suitable data processing system. Such signal bearing media may be transmission media or recordable media for machine-readable information, including magnetic media, optical media, or other suitable media. Examples of recordable media include magnetic disks in hard drives or diskettes, compact disks for optical drives, magnetic tape, and others as will occur to those of skill in the art. Examples of transmission media include telephone networks for voice communications and digital data communications networks such as, for example, Ethernets and networks that communicate with the Internet Protocol and the World Wide Web. Persons skilled in the art will immediately recognize that any computer system having suitable programming means will be capable of executing the steps of the method of the invention as embodied in a program product. Persons skilled in the art will recognize immediately that, although some of the exemplary embodiments described in this specification are oriented to software installed and executing on computer hardware, nevertheless, alternative embodiments implemented as firmware or as hardware are well within the scope of the present invention.

It will be understood from the foregoing description that modifications and changes may be made in various embodiments of the present invention without departing from its scope. The descriptions in this specification are for purposes of illustration only and are not to be construed in a limiting sense. The scope of the present invention is limited only by the language of the following claims.

CLAIMS

1. A method for secure data communications in web services, the method comprising:

receiving in a web service from a requester a request containing an element bearing a first signature, the signature having a value;

signing the value of the first signature, thereby creating a second signature; and

sending a response from the web service to the requester, the response including the second signature.

2. The method of claim 1, further comprising verifying by the requester that the response includes the second signature.

3. The method of claim 1 or claim 2, wherein:

receiving a request further comprises receiving an encrypted request; and

the method further comprises encrypting the response in the web service.

4. The method of any preceding claim, wherein:

receiving a request further comprises receiving a request with the first signature encrypted;

the method further comprises encrypting the value of the first signature; and

the response further comprises the encrypted value of the first signature.

5. The method of any preceding claim, wherein:

receiving a request further comprises receiving a request encoded in SOAP; and

sending a response further comprises sending a response encoded in SOAP.

6. The method of claim 5, wherein signing the value of the first signature further comprises:

creating a signature confirmation element, the signature confirmation element having a value;

setting the value of the signature confirmation element to the value of the first signature; and

signing the signature confirmation element, thereby creating a second signature;

wherein the response includes the signature confirmation element and the second signature.

7. The method of any preceding claim, wherein:

the request further comprises a plurality of elements bearing first signatures, the first signatures having values;

signing the value of the first signature further comprises signing the values of all of the first signatures, thereby creating a plurality of second signatures; and

sending a response further comprises sending a response that includes the plurality of second signatures.

8. A system for secure data communications in web services, the system comprising a computer processor and computer memory, the computer memory operatively coupled to the

computer processor, the computer memory having disposed within it computer program instructions capable of:

receiving in a web service from a requester a request containing an element bearing a first signature, the signature having a value;

signing the value of the first signature, thereby creating a second signature; and

sending a response from the web service to the requester, the response including the second signature.

9. The system of claim 8, further comprising computer program instructions capable of verifying by the requester that the response includes the second signature.

10. The system of claim 8 or claim 9, wherein:

receiving a request further comprises receiving an encrypted request; and

the system further comprises computer program instructions capable of encrypting the response in the web service.

11. The system of any of claims 8 to 10, wherein:

receiving a request further comprises receiving a request with the first signature encrypted;

the system further comprises computer program instructions capable of encrypting the value of the first signature; and

the response further comprises the encrypted value of the first signature.

12. The system of any of claims 8 to 11, wherein:

receiving a request further comprises receiving a request encoded in SOAP; and

sending a response further comprises sending a response encoded in SOAP.

13. The system of claim 12, wherein signing the value of the first signature further comprises:

creating a signature confirmation element, the signature confirmation element having a value;

setting the value of the signature confirmation element to the value of the first signature; and

signing the signature confirmation element, thereby creating a second signature;

wherein the response includes the signature confirmation element and the second signature.

14. The system of any of claims 8 to 13, wherein:

the request further comprises a plurality of elements bearing first signatures, the first signatures having values;

signing the value of the first signature further comprises signing the values of all of the first signatures, thereby creating a plurality of second signatures; and

sending a response further comprises sending a response that includes the plurality of second signatures.

15. A computer program comprising program code means adapted to perform all the steps of any of claims 1 to 7 when said program is run on a computer.

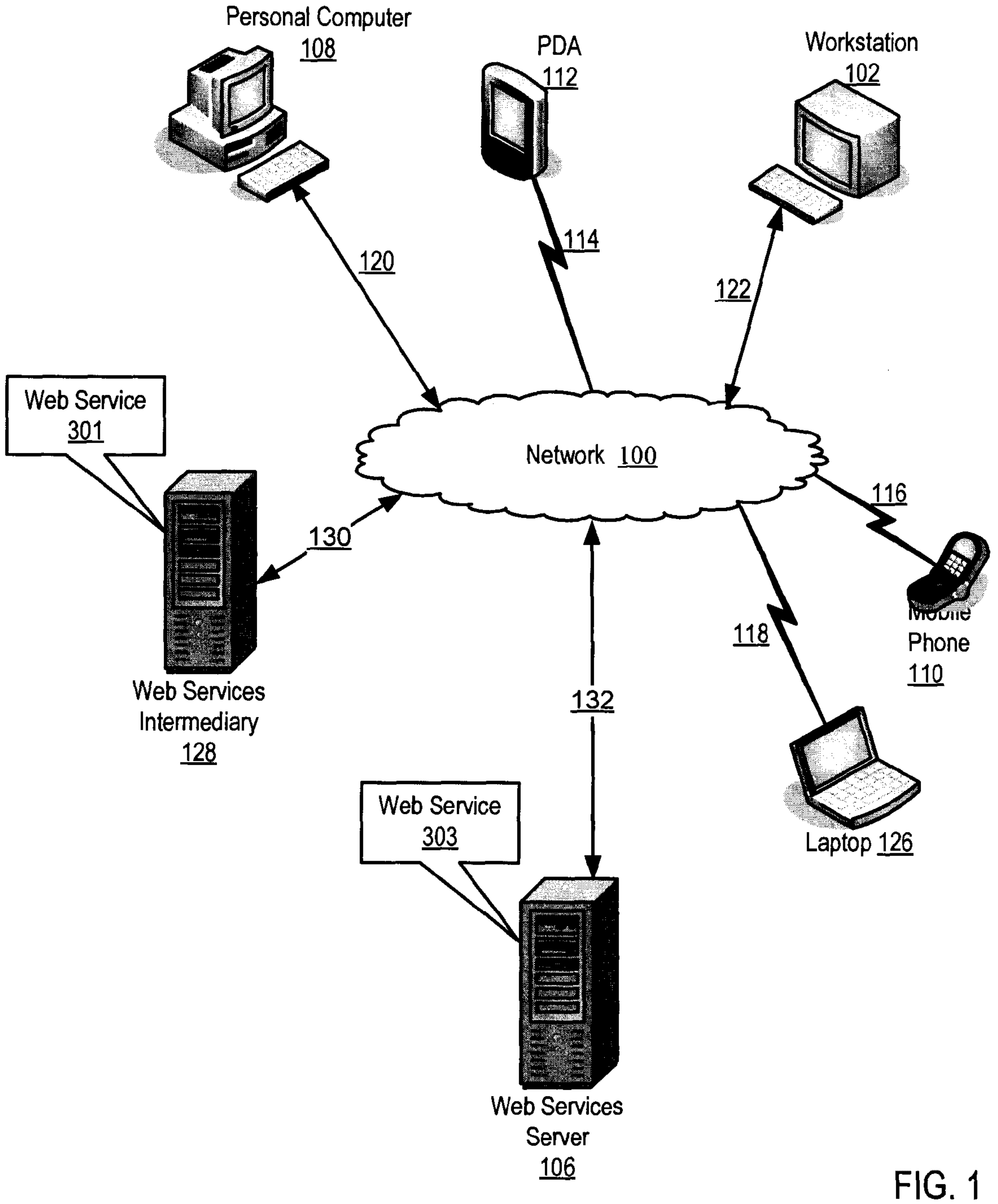
Personal Computer
108
PDA
112
Workstation
102
120
114
122
Web Service
301
Network 100
116
130
Mobile
Phone
110
118
Web Services
Intermediary
128
132
Web Service
303
Laptop 126
Web Services
Server
106

FIG. 1

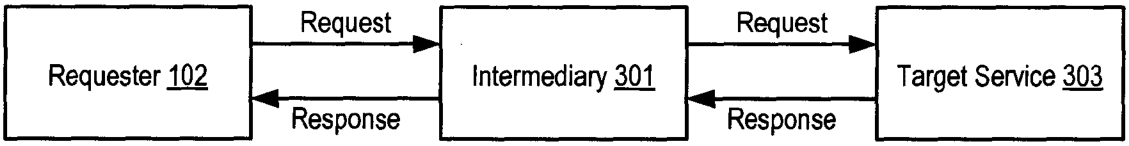
Requester 102
Request
Response
Intermediary 301
Request
Response
Target Service 303

FIG. 2A

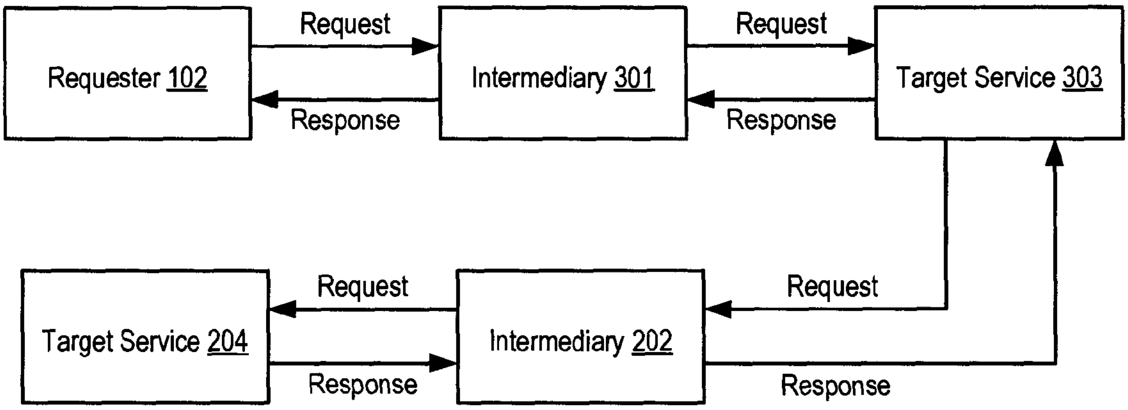
Requester 102
Request
Response
Intermediary 301
Request
Response
Target Service 303
Target Service 204
Request
Response
Intermediary 202
Request
Response

FIG. 2B

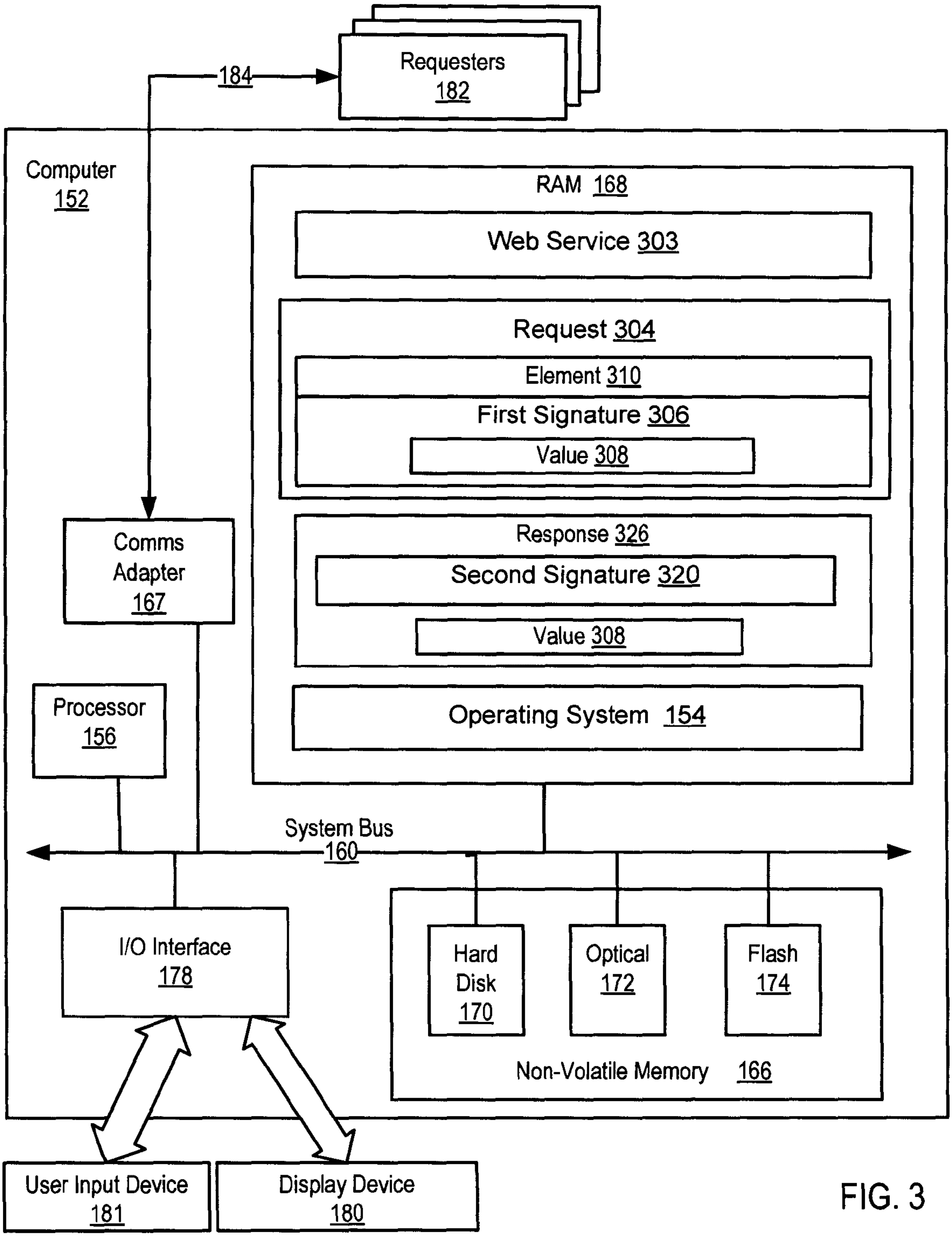
Requesters
182
184
Computer
152
RAM 168
Web Service 303
Request 304
Element 310
First Signature 306
Value 308
Response 326
Second Signature 320
Value 308
Operating System 154
Comms
Adapter
167
Processor
156
System Bus
160
I/O Interface
178
Hard
Disk
170
Optical
172
Flash
174
Non-Volatile Memory 166
User Input Device
181
Display Device
180

FIG. 3

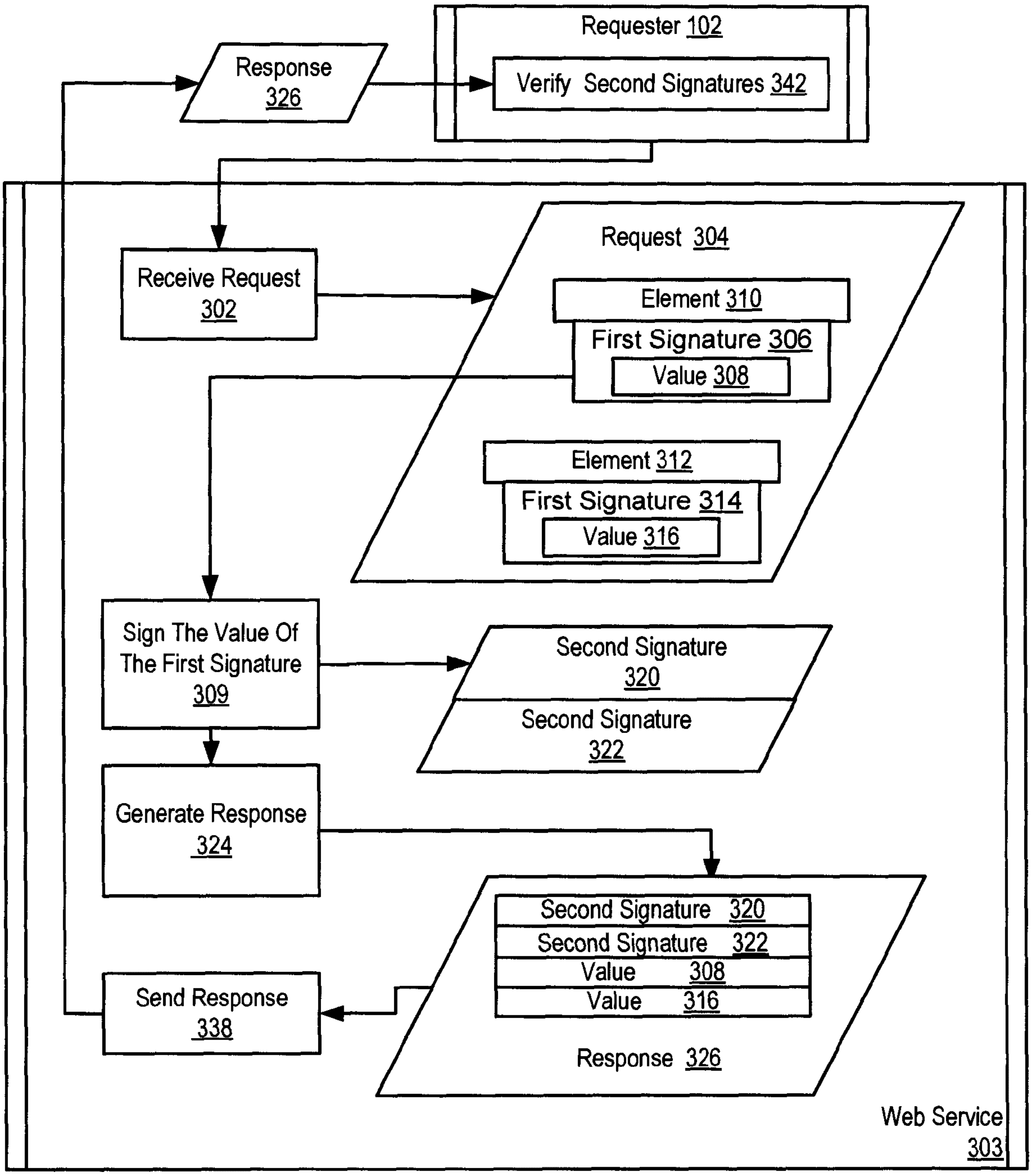
Requester 102
Verify Second Signatures 342
Response 326
Receive Request 302
Request 304
Element 310
First Signature 306
Value 308
Element 312
First Signature 314
Value 316
Sign The Value Of The First Signature 309
Second Signature 320
Second Signature 322
Generate Response 324
Second Signature 320
Second Signature 322
Value 308
Value 316
Response 326
Send Response 338
Web Service 303

FIG. 4

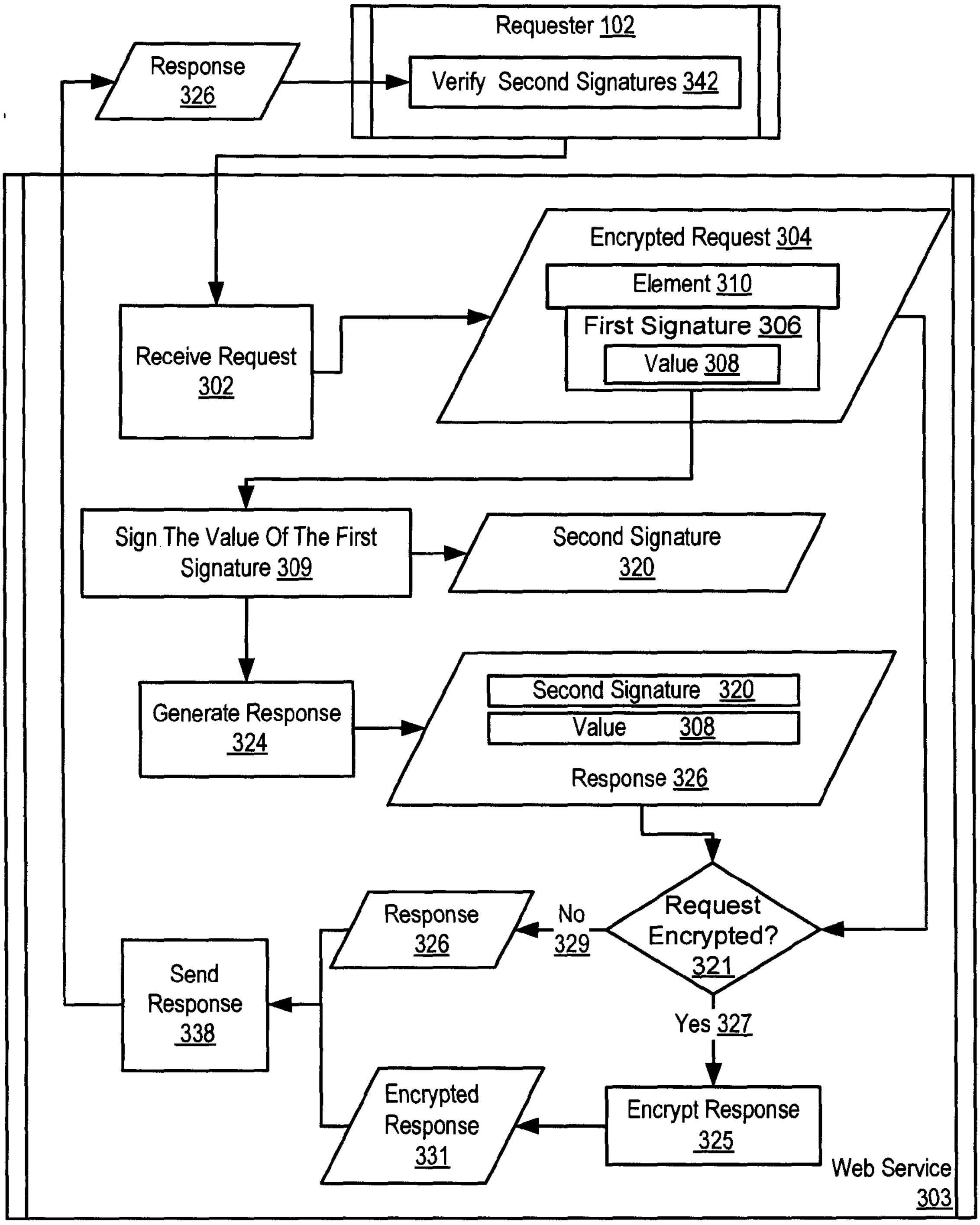
Requester 102
Verify Second Signatures 342
Response 326
Receive Request 302
Encrypted Request 304
Element 310
First Signature 306
Value 308
Sign The Value Of The First Signature 309
Second Signature 320
Generate Response 324
Second Signature 320
Value 308
Response 326
Request Encrypted? 321
No 329
Response 326
Yes 327
Send Response 338
Encrypted Response 331
Encrypt Response 325
Web Service 303

FIG. 5

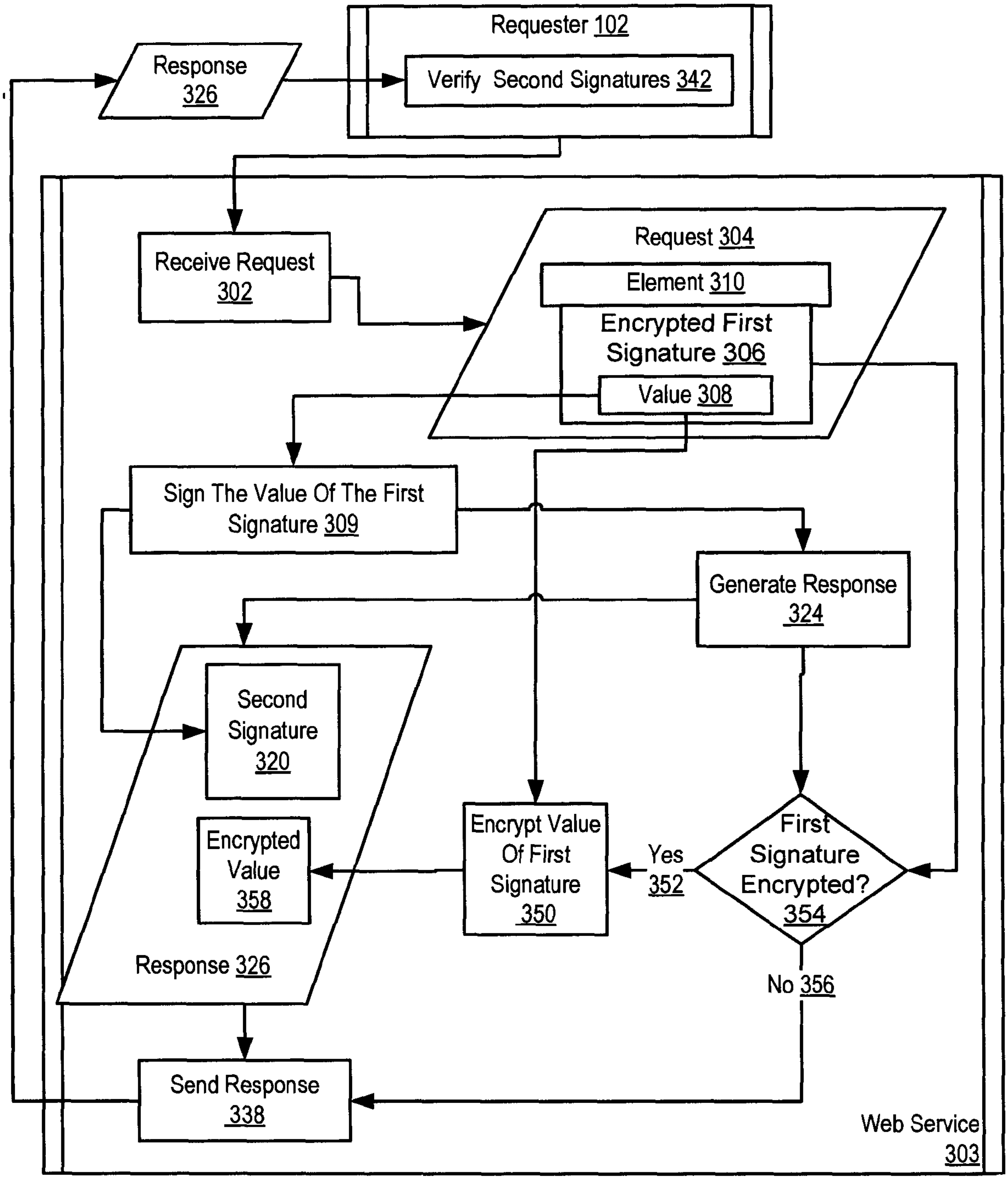
Requester 102
Verify Second Signatures 342
Response 326
Receive Request 302
Request 304
Element 310
Encrypted First Signature 306
Value 308
Sign The Value Of The First Signature 309
Generate Response 324
Second Signature 320
Encrypted Value 358
Response 326
Encrypt Value Of First Signature 350
Yes 352
First Signature Encrypted? 354
No 356
Send Response 338
Web Service 303

FIG. 6

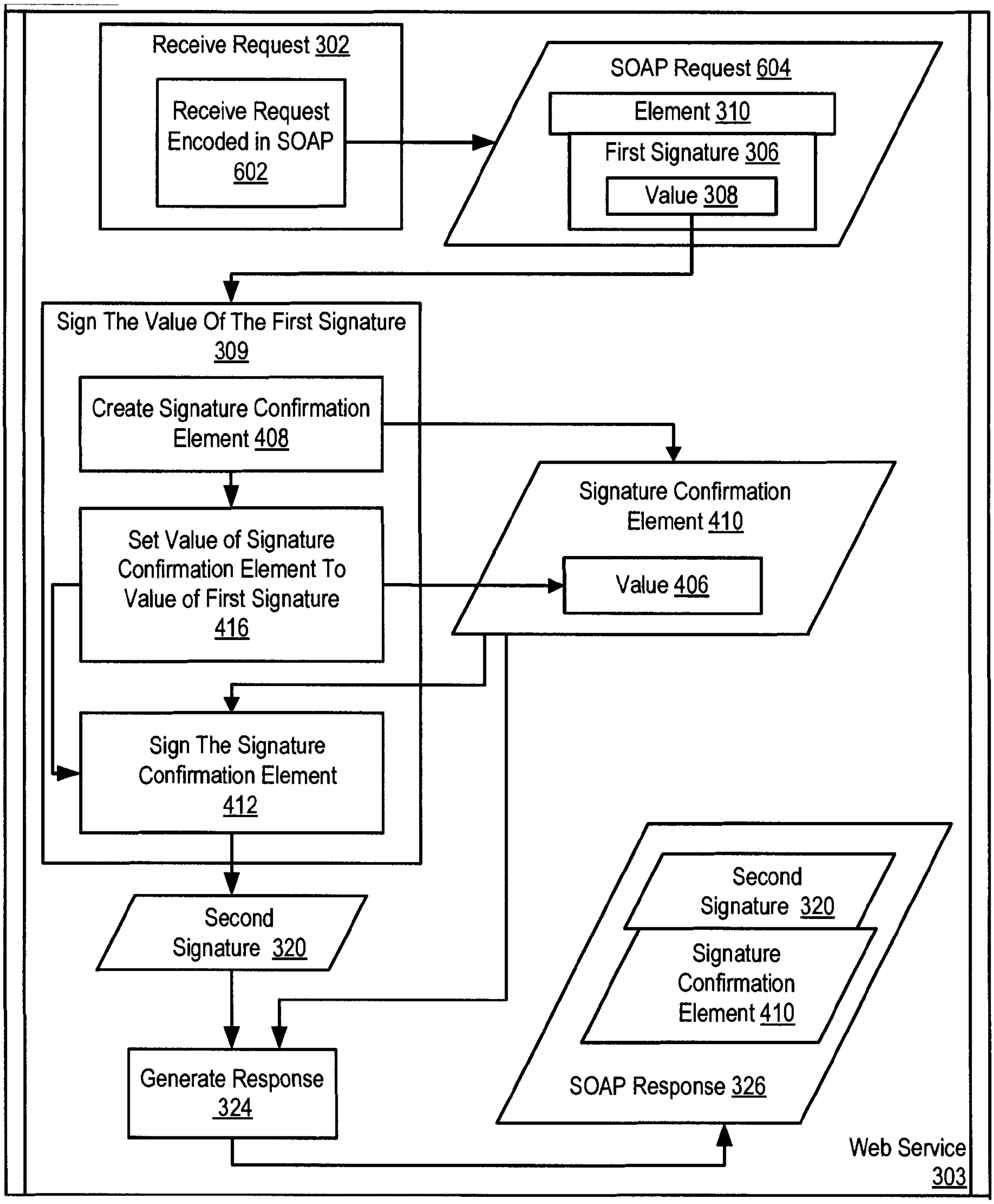
Receive Request 302
Receive Request Encoded in SOAP 602
SOAP Request 604
Element 310
First Signature 306
Value 308
Sign The Value Of The First Signature 309
Create Signature Confirmation Element 408
Signature Confirmation Element 410
Set Value of Signature Confirmation Element To Value of First Signature 416
Value 406
Sign The Signature Confirmation Element 412
Second Signature 320
Second Signature 320
Signature Confirmation Element 410
Generate Response 324
SOAP Response 326
Web Service 303

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/062923

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F21/00 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004/208164 A1 (KEENAN SEAN M [US] ET AL) 21 October 2004 (2004-10-21) paragraph [0032] - paragraph [0055] figures 1A,1B -----	1-15

□ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 13 November 2006	Date of mailing of the international search report 20/11/2006
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Horn, Marc Philipp

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2006/062923

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004208164 A1	21-10-2004	CA 2522445 A1 WO 2004100497 A1	18-11-2004 18-11-2004