SIP Servlet API
Version 1.0

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Summary of Open Issues

OPEN ISSUE 3-1: OK for the default action for OPTIONS to be a 500 response?

OPEN ISSUE 8-1: If a recursive search yields no 2xx response but one or more URIs returned in 3xx’s remain in the “target set” and the container is unable to route based on those URIs (e.g. because they are http or mailto URLs), should the container return a 4xx or is it OK to return a 300 response containing the set of untried URIs? Should be configurable (e.g. in the proxy-config element of the deployment descriptor)?

OPEN ISSUE 8-2: How are target URI and branch URI compared? Is reference comparison OK?

OPEN ISSUE 9-1: It would be nice if SIP servlet containers were able to correctly recognize creation of new dialogs, without having to know about the specific extension in use. However, it is not clear that this is possible, at least not without significant overhead resulting from trying to recognize patterns similar to the subsequent NOTIFY case. The multiple 2xx might be handled but future extensions will likely follow SUBSCRIBE-NOTIFY pattern so looking for To tags in 2xx’s is insufficient.

OPEN ISSUE 10-1: Include subscriber check? Might involve From, To, or Remote-Party-Id headers.

OPEN ISSUE 10-2: Include check for direction: incoming or outgoing? A B2BUA app that “proxies” without changing From, To, or request URI will also match the outgoing request. A mechanism is needed that allows the rule not to match the outgoing request.

OPEN ISSUE 11-1: This section is almost identical to chapter 9 of the Java Servlet Specification. We could simply refer to that chapter (and not define a SAR file format essentially identical to the WAR format), except that doing so would seem to require that we always have a valid web.xml deployment descriptor in application archives, see also Open Issue 14-1.

OPEN ISSUE 12-1: Add support for timers?

OPEN ISSUE 13-1: Is it sufficiently explicit whether declarative security (authentication and integrity/confidentiality) and each of isSecure, getRemoteUser, isUserInRole, getUserPrincipal reflect the characteristics of a hop-by-hop “secure” connection?

OPEN ISSUE 13-2: Need ability to indicate that a security constraint should apply only to the initial request or only to requests in one of the two directions?

OPEN ISSUE 13-3: Need ability to apply user data constraints to outgoing requests, e.g. to declaratively require a request to be transmitted over TLS? How would this interact with a request URI or Route header with a non-null transport parameter?

OPEN ISSUE 14-1: SIP servlet applications currently have a single deployment descriptor, sip.xml. This is, intentionally, very similar to the HTTP DD, say 80% identical. An alternative to copying from the web.xml definition would be to retain web.xml for SIP servlet applications and define sip.xml to contain only the SIP specific deployment information.

OPEN ISSUE 14-2: JSR 154 is chartered to modularize the HTTP deployment descriptor, possibly
Summary of Open Issues

using XML schema. Should we skip DTDs and define the deployment descriptor using the XML Schema standard?
Preface

This document defines version 1.0 of the SIP Servlet API. The specification assumes JDK 1.1 and requires support for SIP as defined in [bis-09].

Who should read this Document

The intended audience for this specification includes the following groups:

- SIP application server vendors who want to provide servlet engines that conform to this standard.
- Servlet authors who want to understand the underlying mechanisms of servlet technology.

Familiarity with SIP is assumed throughout.

Typographic Conventions

SIP method and header names are printed in Arial. Java classes, method names, parameters, literal values, and fragments of code are printed in constant width as are XML elements and documents.

Providing Feedback

Feedback on this specification is welcomed. Please e-mail your comments to sipservlet-interest@mailman.dynamicsoft.com.

Acknowledgements

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Preface

An important goal of the SIP Servlet API is to build on the work of the well-established (HTTP) Servlet API. For this reason, this specification copies text from the Java Servlet Specification in many places [Servlet API].

The glossary includes a large number of entries copied from the SIP specification [bis-09].

The definition of the tel properties of sip, sips, and tel URLs and the subdomain-of expression in the SIP Servlet API rule language were taken from CPL [CPL].
1 Overview

The Session Initiation Protocol (SIP) is used to establish, modify, and tear down multimedia IP sessions including IP telephony, presence, and instant messaging. An important aspect of any communication infrastructure is programmability and the purpose of the SIP Servlet API is to standardize the platform for delivering SIP based services. The term platform is used here to include the Java API itself as well as standards covering the packaging and deployment of whole applications.

1.1 Goals of the SIP Servlet API

The following summarizes some important properties of the SIP Servlet API:

- **SIP Signaling**: It allows applications to perform a fairly complete set of SIP signaling actions, including support for acting as user agent client (UAC), user agent server (UAS), and proxy.
- **Simplicity**: Containers handle “non-essential” complexity such as managing network listen points, CSeq, Call-ID and Via headers, routes, etc. Application developers do not need to be SIP experts.
- **Converged applications**: It is possible for containers to support converged applications, that is, applications that span multiple protocols, for example, Web, telephony, and presence.
- **Third party application development**: The servlet model supports third party application development. An XML deployment descriptor is used to communicate application information from the application developer to deployers.
- **Application composition**: It is possible for several applications to execute on the same incoming or outgoing request or response. Each application has its own set of rules and execute independently of other applications in a well-defined and orderly fashion.
- **Carrier grade**: Servlets store application data in container managed session objects. Implementations may persist and/or replicate this data to achieve high availability.
- **Security**: Implementations may utilize the Java 2 security model to restrict the operations allowed by different applications. This applies equally to SIP signaling actions and other sensitive operation, for example, access to the file system or ability to create threads.
- **Expressiveness**: Applications have full use of the Java programming language plus access to a wide variety of APIs: JDBC, JNDI, EJB, CORBA, JMF, etc.
- **Familiarity**: A huge developer community is already familiar with the process of developing web applications based on Java servlets. The SIP Servlet API leverages the knowledge and inventiveness of this community by building on the foundation of the HTTP Servlet API.

1.2 What is a SIP Servlet?

A SIP servlet is a Java-based application component, managed by a container, which performs SIP signaling. Like other Java-based components, servlets are platform independent Java classes that are compiled to platform neutral bytecode that can be loaded dynamically into and run by a java-
enabled SIP application server. Containers, sometimes called servlet engines, are server extensions that provide servlet functionality. Servlets interact with (SIP) clients by exchanging request and response messages through the servlet container.

### 1.3 What is a SIP Servlet Container?

The servlet container is a part of an application server that provides the network services over which requests and responses are received and sent. It decides which applications to invoke and in what order. A servlet container also contains and manages servlets through their lifecycle.

A servlet container can be built into a host SIP server, or installed as an add-on component to a SIP Server via that server’s native extension API. Servlet containers can also be built into or possibly installed into servlet-enabled application servers.

A SIP server/servlet container manages the network listen points (network addresses and port numbers) on which it listens for incoming SIP traffic. They should support both UDP and TCP, and may support TLS.

A servlet container may place security restrictions on the environment in which a servlet executes. In a Java 2 Platform Standard Edition 1.2 (J2SE) or Java 2 Platform Enterprise Edition 1.3 (J2EE) environment, these restrictions should be placed using the permission architecture defined by the Java 2 Platform. For example, high-end application servers may limit the creation of a Thread object, to insure that other components of the container are not negatively impacted.

### 1.4 Relationship with the HTTP Servlet API

The Java Servlet API is defined in the *Java Servlet Specification* [Servlet API]. It consists of a generic part defined as package `javax.servlet` and an HTTP specific part in package `javax.servlet.http`. This specification refers to the generic part using the unqualified term *Servlet API* and to the HTTP specific API as the *HTTP Servlet API*. The SIP Servlet API builds on the generic servlet API in much the same way as the HTTP Servlet API, and is defined as package `javax.servlet.sip`. As such, a SIP servlet container must support the packages `javax.servlet` and `javax.servlet.sip`.

This specification is structured along the lines of the *Java Servlet Specification*, and like it, includes text not specific to the SIP Servlet API. Much of this text has been copied from that other document, albeit modified to reflect the non-HTTP nature of SIP servlets, for example to use the broader term *servlet application* instead of *web application* when the context applies equally to SIP and HTTP applications.

#### 1.4.1 Differences from the HTTP Servlet API

SIP was to some extent derived from HTTP and so the two protocols have much in common. Both are request-response protocols and messages have very similar structure and formats. However, in terms of providing services, there are important differences between the two protocols:
Overview

- HTTP services (including HTTP servlet applications) are almost exclusively hosted on HTTP origin servers, that is, the entity that generates a final response to requests (as opposed to a proxy server).
- HTTP is not a peer-to-peer protocol in the way that SIP is and web applications never originate requests.

In contrast, given that an important function of SIP is call routing and an important function of SIP applications is intelligent call routing, it must be possible for SIP services to reside on SIP proxy servers in order to control request routing.

Additionally, SIP applications need the ability to initiate requests of their own. An application that accepts an incoming call may have to terminate it by sending a subsequent BYE request, a wakeup-call application may have to send the initial INVITE establishing a session, and a presence server application needs to be able to initiate NOTIFY requests. A back-to-back user agent (B2BUA) is a type of network based application that achieves a level of control over calls not attainable through proxying, and that requires client functionality, also. These examples demonstrate why client-side (UAC) functionality is necessarily part of a SIP service infrastructure and explains the presence of such functionality in the SIP Servlet API.

The previous paragraphs imply that in addition to the ability inherited from the Servlet API of responding to incoming requests, the SIP Servlet API must support the following capabilities:

- generate multiple response (for example, one or more 1xx followed by a final response)
- proxying requests, possibly to multiple destinations
- initiate requests
- receive responses as well as requests

1.4.1.1 Use of Servlet.service()

In order to allow for these features, the SIP Servlet API uses the original Servlet API interfaces in a manner that differs from the HTTP Servlet API. SIP servlet applications are invoked when events occur in which they have registered an interest. These events can be either incoming requests or responses and they are delivered to applications through the javax.servlet.Servlet method:

```java
void service(ServletRequest req, ServletResponse resp)
```

similar to the HTTP Servlet API but different in that only one of the request and response objects is non-null. When invoked to handle incoming requests, the response argument will be null and vice versa, when invoked to handle an incoming response the request argument will be null.

**NOTE:** This caters for the fact that there is not necessarily a one-to-one correspondence between requests and responses in SIP applications.
1.4.1.2 Asynchronicity

Another important difference is the fact that the SIP Servlet API event model is asynchronous rather than synchronous as in the HTTP API. This means that applications are not obliged to respond to incoming requests in the upcall reporting the event. They may initiate some other action, return control to the calling container, and then respond to the request at some later point in time. The container relies on timeout of the application instance as a whole in order to guarantee that resources are always recovered eventually, even if an application fails to respond to the request in a timely manner.

Asynchronicity simplifies the programming of event driven services and allows an application such as a B2BUA not to hog threads while waiting for a potentially long-lived transaction to complete.

1.4.1.3 Application Composition

While the model of the HTTP Servlet API is to select a single application to process each incoming request, it is often desirable to apply multiple services to incoming SIP requests. This specification describes an application composition model that defines the conditions that a SIP servlet container must ensure are satisfied when it chooses to invoke multiple applications. This model is described further in the section 2.

1.4.2 Converged Applications

While the SIP Servlet API can certainly be implemented independently of the HTTP Servlet API, it is expected that many interesting services will combine multiple modes of communication, for example telephony, Web, email, presence and instant messaging. For this reason, it is an important goal that it be possible to implement a servlet container that supports both the SIP and HTTP Servlet APIs at the same time and in a manner that allows applications to include both SIP and HTTP components. This specification defines requirements of such converged containers throughout the text.

A combined SIP/HTTP servlet application will contain deployment descriptors pertaining to both the SIP and HTTP parts and will share state through the notion of application session objects representing instances of the application (see section 9).

1.5 Examples

1.5.3 A Location Service

Routing is an integral part of SIP and is a common function of SIP services. This example is a location service that performs a database lookup on the request URI of incoming requests and proxies the request to the set of destination addresses associated with that URI. The steps performed by the application and container are as follows:

1. Alice makes a call to sip:bob@example.com. The INVITE is received by the servlet container which invokes the location service.
Overview

2. The location service determines, using non-SIP means, that the callee (Bob) is registered with two locations, identified by, say, two SIP URIs.
3. The service proxies to those two destinations in parallel, without record-routing, and in unsupervised mode.
4. One of the destinations return 200 (OK) and the other branch is cancelled by the container.
5. The 200 is forwarded upstream to Alice and the call setup is completed as per usual.

In this example, the application (and the host application server) is involved only in establishing the SIP dialog and will not be involved in subsequent signaling within that dialog.

1.5.4 A Multi-Protocol Servlet Application

The following is an example of a converged application. It consists of both SIP and HTTP components with SIP being used both in its capacity to establish media sessions and as a presence subscription and notification protocol [simple].

The service is called Call Schedule on Busy or No Answer (CSBNA). As in the previous example, it resides on a network server situated on the path between a caller and callee. When a call setup attempt fails because the callee is busy or not available, the service returns a URL pointing to a Web page allowing the caller to ask for a call to be set up the moment the callee becomes available. The service knows about the availability of the callee by subscribing to his presence status. When a notification is received that the callee has become available, the service sets up a session between the original caller and callee using third party call control techniques.

Figure 1 illustrates the call flow. The steps are as follows:

1. Alice makes a call to Bob. The INVITE is routed to the converged servlet container.
2. The CSBNA SIP servlet acts a B2BUA and sends an INVITE to Bob’s SIP phone.
3. It also sends a 100 (Trying) informational response upstream to stop retransmissions.
4. Bob’s phone returns a 486 (Busy Here) as Bob is currently in a phone call.
5. The CSBNA servlet returns a 302 (Temporarily Unavailable) response containing a single Contact with an HTTP URL pointing back to an HTTP servlet that is part of the CSBNA application.
6. The SIP container sends an ACK as per the SIP specification.
7. Alice’s SIP UA sends an ACK.
8. Alice’s SIP UA launches a Web browser to retrieve the HTTP Contact URL from the 302 response.
9. The HTTP CSBNA servlet returns an HTML page containing a form allowing Alice to have a call automatically setup based on Bob's availability. The form is pre-populated by the servlet with all required information, in particular Alice and Bob's SIP addresses.
Overview

10. Alice gasps at the sight of such a cool service and hits the *Submit* button on the HTML page.
11. The HTTP CSBNA servlet receives the posted form and returns a Web page that Alice can subsequently use to modify or cancel the scheduled call.
12. The service sends a SIP *SUBSCRIBE* request to Bob’s SIP UA. This will allow the service to know when Bob becomes available again.
13. Bob’s phone accepts the subscription.
14. At some later point in time, Bob hangs up and his phone sends a notification of his new availability status to the CSBNA subscriber servlet in a SIP *NOTIFY* request.
15. The CSBNA application responds to the *NOTIFY*. (The application will unsubscribe from Bob’s status at this point—this is not shown in the diagram.)
16–24. Set up the call between Alice and Bob using third party call control mechanisms as described in [3pcc]¹. In this case, a call is established and media exchanged over RTP.
25–28. The call is terminated.

In addition to illustrating the functioning of a converged container, this example demonstrates the need for the concept of *application sessions*. Over the lifetime of an instance of the CSBNA application, some 5 point-to-point SIP signaling relationships are created. Each of these correspond to a *SipSession* instance. Additionally, one *HttpSession* is created—this also corresponds to a point-to-point “signaling” relationship between the container and the HTTP client. Obviously, all of these *protocol sessions* are related and need to share state. The application session represents an instance of the application and binds together the protocol sessions representing individual signaling relationships and allows for sharing of state between them. The session model is further discussed in section 9.

---

¹. Here the general purpose recommended 3pcc call flow is used to set up the call. However, in this particular case, the application does have enough information that it may be reasonable to use a simpler call flow that avoids the re-INVITE in step 21. First, from the initial failed INVITE it knows the session description used by Alice’s SIP UA, and second it has reason to believe that Bob is available to answer the call immediately.
Overview
2 Application Composition

SIP application servers typically host many different services simultaneously. Each application has a set of rules associated with it, specifying under what circumstances, i.e. for which requests, the service is interested in executing. The application rules are formulated declaratively and are carried in the deployment descriptor (the rule language is defined in section 10). Since more than one application may be interested in processing the same incoming request, multiple rules may be satisfied for any given request, and it is desirable to allow multiple applications to trigger on the same request. A typical example from traditional telephony is a call-screening and a call-forwarding service as these would both execute on incoming \texttt{INVITE}s destined for subscribers to these services.

It is clear that precautions must be taken by containers to ensure that applications will not interfere adversely with one another and that the application server behaves in accordance with the SIP specification. This section specifies what conditions for application composition must be satisfied by any compliant SIP servlet container.

2.1 The Cascaded Service Model

The model of application composition adopted in the SIP Servlet API is that of the \textit{cascaded services model} \cite{SERL}. This model states that:

\begin{quote}
Triggering of service applications on the same host, shall be performed in the same sequence as if triggering had occurred on different hosts.
\end{quote}

This principle guarantees that each invoked service has a consistent view of the context in which it is executing—application developers can write SIP services \textit{as if} they were the only application processing the incoming request. This means services can execute independently of one another, which greatly simplifies application development.

The simplistic strategy of always ignoring all but a single matching rule is consistent with the cascaded services model and is thus a valid implementation.

2.2 The Role of Proxying

SIP requests are propagated from one host to another through proxying. Therefore, for SIP, the requirement that multiple applications execute as if they were located on separate physical hosts implies that SIP requests are propagated from one application to another by means of proxying.

If two services, A and B, are deployed with rules matching an incoming \texttt{INVITE}, the container may choose to first invoke application A. If A then proxies the \texttt{INVITE}, the container may choose to invoke B (provided B’s rule still matches, see below). B is then free to respond or proxy the request independently of A. Regardless of how B choose to handle the request, A is guaranteed to be presented with a consistent view of the transaction. For example, it will be invoked to handle responses in accordance with the SIP and SIP Servlet API specifications regardless. Implementa-
Application Composition

tions are free to employ any mechanism of their choice for deciding which of several matching applications to invoke next.

It follows that a forking proxy may cause multiple invocations of the same or different applications logically downstream on the same host. For example, depending on the rule configuration, an out-bound call screening application might be invoked once for each INVITE proxied by a forking find-me application.

Another implication of the “composition-by-proxying” model is that responses are processed in reverse order of requests, that is, they are passed upstream from the last application to handle the request logically upstream towards the application first invoked to handle the corresponding request.

2.2.1 Pure Proxying

When dispatching incoming requests, a SIP servlet container distinguishes between initial requests, and subsequent requests. An initial request is a request for which the container has no internal routing knowledge. Such requests are dispatched to applications based on the set of rules the container is configured with, and may set up the state on which subsequent requests in the same dialog are routed internally in the container.

It is important that the matching rule hold true at the point in time when an application is invoked to handle an initial request as a result of the rule match. This implies that an approach where the container computes a list of matching rules once and then invokes the corresponding applications in turn does not work. The reason is that the first application might modify the proxied request in a way that would cause the second rule to no longer match.

The term pure proxying is used to denote the case where an application proxies an initial request without changing any properties that can affect rule matching, that is, without altering any of the request variables accessible through the rule language – in particular without modifying the request URI. In the case of pure proxying, application selection may continue with the next matching rule from the list. In all other cases, it is necessary to compute a new list of matching rules, or else verify that the rules on the existing list still match applications when they’re actually invoked.

2.3 The Application Path: Routing of Subsequent Requests

Unlike initial requests, subsequent requests are not dispatched to applications based on configured rules, but rather follow the path of the corresponding initial request, or the reverse path if the subsequent request originated from the callee. Basically, the initial request establishes an application path along which subsequent requests in that dialog are routed within the container. The application path is a logical concept—it may or may not be explicitly represented within containers. It consists of application instances, each of which can be thought of as a triplet of information:

- application
- application session
- SipSession
A subsequent request received from the original caller is passed to the applications that form the application path. Subsequent requests received from the callee follow the reverse path, that is, they are passed to the last application first, then to the last but one application, up to the first application, before being proxied towards the caller (if appropriate). Proxying applications are invoked for subsequent requests only if they record-routed, see section 8.1.

For illustration, suppose three applications, A, B, and C, are invoked one after another to process an initial INVITE request. All three applications proxy but only A and C record-route, and so the application path consists of A and C. A subsequent BYE request received from the callee will then be routed based on this application path, and will be passed first to C and then to A.

**NOTE:** Routing subsequent requests based on the path established by the initial request is consistent with the cascaded services model and greatly simplifies the task of writing rules.

The distinction between initial and subsequent requests also applies to dispatching of locally initiated requests. If, for example, application A initiates an INVITE, and this is passed to application B that proxies it towards a destination outside the application server (with record-routing enabled), then a subsequent BYE from A for the same dialog will be passed to B and then further downstream. Proxying of subsequent requests is discussed in section 8.2.8.

### 2.3.2 Sessions

SipServletRequests are always associated with a SipSession which, in turn, belongs to a SipApplicationSession (although for performance reasons containers may defer creation of session objects when applications cannot observe the difference).

When multiple applications are invoked to process the same request, the SipServletRequests passed to different applications will be associated with different SipSession and SipApplicationSession objects. In other words, each application has its own copy of the session objects, which is independent of those of other applications. Specifically, application data placed into a session object by application A is not accessible to a subsequent application B.

When invoked to handle subsequent requests, applications are invoked in the context of the same SipApplicationSession and SipSession objects as when they were invoked to handle the original request. In the example of the previous section, A and C will have each their own independent session objects, and they will obtain the same session objects from the BYE request that they did from the INVITE.

### 2.3.3 Application Path Cleanup

When a SipSession terminates, either because the SipApplicationSession it was associated with terminated or because it was explicitly invalidated, it is removed from the application path it was on, if any. When the path becomes empty it is removed from the container.

It is possible for a container to receive a request belonging to a dialog it used to have internal routing information for but which has been invalidated, either explicitly by the application(s) or
because the information timed out. In this case it is up to container policy whether to reject the request, proxy it without application involvement, or whether to treat it as an initial request, that is, to dispatch it to applications based on the rule set.

2.4 Loop Detection

The requirement that a triggering rule always be true when the associated servlet is invoked may cause some implementations to re-execute rules when a request is proxied. For such servers there is a possibility that loops in invoked service logic may occur, that is, A proxies to B which proxies back to A, etc. It is obviously important that such loops be detected and handled somehow. This specification does not mandate a particular mechanism. One strategy that is consistent with the cascaded services model is to mimic the existing SIP “inter-host” mechanisms for loop detection in the “intra-host” case of SIP servlet containers. In particular, a simple and effective mechanism is to decrement the value of the Max-Forwards header whenever a request is proxied internally. Section 8.2.9 discuss the issue of when to generate 483 (Too Many Hops) error responses on basis of the Max-Forwards header.

2.5 Limitations of the Model

The Servlet API defines the logical roles of application developer, assembler, and deployer, and there is an implicit understanding that applications deployed to a servlet container are independent. For this reason, and because it is simple, well-defined, clean, and easily explained, the cascaded services model is a good fit to the SIP Servlet API.

However, in some cases services are indeed written by the same person or organization, and they may not be independent. In such cases of more closely coupled services, it may be desirable to have other models for application composition. Future versions of the SIP Servlet API may define such alternative models.

2.6 An Example

For a simple illustration of application composition, consider the location service (LS) of section 1.5.3 and an originating call screening application (OCS). This latter application screens outgoing calls based on the destination address.

1. An incoming INVITE matches the rule of the LS and it is invoked by the container.
2. The LS proxies to two destinations, \( d_1 \) and \( d_2 \).
3. For each proxied request, the container invokes the OCS application. These two invocations are independent and are associated with different application sessions. The two instances of the OCS application will see different request objects with request URIs \( d_1 \) and \( d_2 \), respectively.
4. The first instance of the OCS application finds that \( d_1 \) is on the screening list and rejects the request with a 403 (Forbidden) response.
5. The 403 response is passed to the LS where it contributes to finding the best response. It is not passed to the application at this point.
6. The second instance of the OCS application finds that \( d2 \) should not be screened and so proxies the request (without changing the request URI).

7. No more rules match the \( \text{INVITE 2} \) request, so it is proxied towards its destination, \( d2 \), that is, outside the application server.

8. A 200 is received for the second OCS application and is forwarded “upstream” to the LS service.

9. The 200 is the best response received by the LS proxying application and so the application is passed the 200 response (if it proxied in supervised mode) and it is forwarded upstream towards the caller.

10. The call setup proceeds as per usual (with \( \text{ACK} \) and \( \text{BYE} \) etc.) since neither application is involved in subsequent signaling.

**FIGURE 2. Example of Application Composition**

This is a classical example of feature interaction. The order in which the applications execute is significant as call screening could be circumvented if applied before the location service. Containers will typically provide administrators with some mechanism for prioritizing applications.
Application Composition
3 The Servlet Interface

The Servlet interface is the central abstraction of the Servlet API and hence of the SIP Servlet API. All servlets implement this interface either directly or, more commonly, by extending a class that implements the interface. The generic Servlet API defines a class GenericServlet that is an implementation of the Servlet interface. The SIP Servlet API defines a class SipServlet that extends the GenericServlet interface and performs dispatching based on the type of message received. For most purposes, developers will extend SipServlet to implement their servlets.

3.1 Servlet Life Cycle

SIP servlets follow the lifecycle of servlets defined in [Servlet API, section 2.3]. All provisions in that section apply directly to SIP servlets. The lifecycle is illustrated in Figure 3.

Very briefly, the servlet container loads the servlet class, instantiates it and invokes init() on it, passing along configuration information in the form of a ServletConfig object. Having been successfully initialized, the servlet is available for service, and the container repeatedly invokes the service by calling the service() method with arguments representing incoming requests and responses. When the container decides to deactivate the servlet instance it invokes the destroy() method – the servlet frees up resources allocated in init() and becomes garbage collected.

There is no explicit provision for dynamically changing rules or other configuration information, or for updating the application code itself. Implementations may support such operations by deploying a separate application with the new configuration and/or code and destroying the old application.

3.2 Processing SIP Messages

The basic Servlet interface defines a service method for handling client requests. This method is called for each message that the servlet container routes to an instance of a servlet.
The handling of concurrent messages in a servlet application generally requires the developer to design servlets that can deal with multiple threads executing within the service method at a particular time.

Generally, the servlet container handles concurrent requests to the same servlet by concurrent execution of the service method on different threads.

SIP servlets are invoked to handle both incoming requests and responses. In either case, the message is delivered through the service method of the Servlet interface:

```java
void service(ServletRequest req, ServletResponse res)
throws ServletException, java.io.IOException;
```

If the event is a request the response argument is null, and vice versa, if the event is a response, the request argument is null. When invoked to process a SIP event, the arguments must implement the SipServletRequest and SipServletResponse interfaces\(^1\). The SipServlet implementation of the service method dispatches incoming messages to methods doRequest and doResponse for requests and responses, respectively:

```java
protected void doRequest(SipServletRequest req)
protected void doResponse(SipServletResponse resp)
```

These methods then dispatches further as described in the following sections.

### 3.3 SIP Specific Request Handling Methods

The SipServlet abstract subclass defines a number of methods beyond what is available in the basic Servlet interface. These methods are automatically called by the doRequest method (and indirectly from service) in the SipServlet class to aid in processing SIP based requests. These methods are:

- `doInvite` for handling SIP INVITE requests
- `doAck` for handling SIP ACK requests
- `doOptions` for handling SIP OPTIONS requests
- `doBye` for handling SIP BYE requests
- `doCancel` for handling SIP CANCEL requests
- `doRegister` for handling SIP REGISTER requests
- `doSubscribe` for handling SIP SUBSCRIBE requests
- `doNotify` for handling SIP NOTIFY requests
- `doMessage` for handling SIP MESSAGE requests
- `doInfo` for handling SIP INFO requests

The first six methods correspond to types of requests defined in the baseline SIP specification [bis-09]. The last four methods correspond to SIP methods defined in various SIP extensions. The SUBSCRIBE and NOTIFY methods are defined by the SIP event notification framework [SIP Events].

---

\(^1\) Analogous to HttpServletRequest and HttpServletResponse in the HTTP Servlet API.
The Servlet Interface

upon which the SIP presence framework is defined [simple]. The MESSAGE method supports instant messaging [IM], and the INFO method is a general purpose mid-call signaling transport mechanism [RFC 2976].

The SipServlet implementation of these methods is as follows. The doAck and doCancel methods do nothing. All other methods check whether the request is an initial request, as described in section 8.2.8. If the request is initial, it is rejected with status code 500; otherwise the method does nothing (if the application proxied the initial request, the container will proxy the subsequent request when the method call returns). A servlet will typically override only those methods that are relevant for the service it is providing.

OPEN ISSUE 3-1: OK for the default action for OPTIONS to be a 500 response?

NOTE: The handling of incoming requests is asynchronous in the sense that servlets are not required to fully process incoming requests in the containers invocation of the service method. The request may be stored in a SipSession or SipApplicationSession object to be retrieved and responded to later—typically triggered by some other event. In other words, the container will not generate a response of its own if a servlet returns control to the container without having responded to an incoming request1.

Applications wishing to handle SIP methods unknown to SipServlet.doRequest can override this method and invoke super as follows:

```java
protected void doRequest(SipServletRequest request)
    throws ServletException
{    
    if ("STORE".equals(request.getMethod())) {
        doStore(request);
    } else {
        super.doRequest(request);
    }
}
```

3.4 SIP Specific Response Handling Methods

The doResponse method dispatches to one of the following methods based on the class of the status code of the response:

- doProvisionalResponse for handling SIP 1xx informational responses
- doSuccessResponse for handling SIP 2xx responses
- doRedirectResponse for handling SIP 3xx responses

1. This is different from the HTTP Servlet API where the container will generate a response upon return of control from the servlet.
The Servlet Interface

- doErrorResponse for handling SIP 4xx, 5xx, and 6xx responses

Sections 7 and 8 describe, in detail, the rules surrounding the invocation of these methods.

3.5 Number of Instances

Refer to [Servlet API, section 2.2].

NOTE: The number of servlet instances created by a container is different from what is called application instances in this specification. This latter term effectively refers to an application session together with its contained protocol sessions as described in section 9. Servlet objects are independent of any particular application instance and will typically process requests belonging to many different application instances.
4 Servlet Context

The ServletContext defines a servlet’s view of the SIP application within which the servlet is running. Chapter 3 of the Java Servlet Specification describes the ServletContext [Servlet API] and applies to the SIP servlet API, also. The following sections address issues specific to the SIP Servlet API.

4.1 The SipFactory

The SipFactory interface is used by servlets to create instances of various interfaces:

- **requests:** the createRequest methods create instances of the SipServletRequest interface and is used by UAC applications when creating requests in a new dialog. When creating subsequent requests in an existing dialog, SipSession.createRequest is used instead. Section 7.1.1 discusses requirements of the createRequest methods.
- **address objects:** ability to create URI, SipURI, SipAddress, and Contact instances.
- **application sessions:** ability to create new application sessions. This is meant primarily to be used during startup when the application is invoked to initialize itself, and should be used sparingly.

All servlet containers must make an instance of the javax.servlet.sip.SipFactory interface available to servlets via the context attribute of the same name, javax.servlet.sip.SipFactory.

4.2 Context Path

The Servlet API defines the notion of a *context path*. This is a URL path prefix with which a web application is associated. All requests with an HTTP URL starting with the context path of a web application will be routed to the corresponding servlet context. As SIP URIs do not have a notion of paths, the following ServletContext methods have no meaning for SIP-only servlet applications/containers and must return null:

```java
ServletContext getContext(String uripath)
String getRealPath(String path)
RequestDispatcher getRequestDispatcher(String path)
```

As far as resource loading is concerned, the context path of a SIP-only servlet is always “/”. For a combined HTTP and SIP application executing in an HTTP Servlet capable container, the context path is defined by the HTTP Servlet API and resource loading proceeds according to the Java Servlet Specification [Servlet API].
5 Addressing

Addresses appear in a number of contexts in SIP. The SIP Servlet API is concerned mainly with the request URI, From, To and Contact headers. Figure 4 shows the relationship between the addressing abstractions that are part of the SIP Servlet API.

**FIGURE 4. Addressing abstractions**

The `SipFactory` interface described in section 4.1 is used to construct instances of these interfaces.

5.1 The `SipAddress` Interface

The value of From and To headers is a URI plus an optional display name (a `String`) and a set of name-value parameters. Since any legal value of a From header is also a legal value for a To header and vice versa, these two headers are both represented by the `SipAddress` interface.

5.2 Contact Headers

A Contact header is like a From or To header with the additional definition of two well-known parameters, `q` and `expires`, and so the Contact interface extends `SipAddress` as illustrated in figure 4.

The value of the Contact header is sometimes a list of contact addresses (for example, in a REGISTER request or response) and so the API represents the value of Contact headers as a `java.util.List` consisting of a list of Contact instances.

The SIP Contact header specifies one or more locations (URIs) where a user is reachable. This header plays two different roles in SIP. One is as a mechanism for a UA to specify, in INVITE and 2xx responses to INVITE, to its peer UA the exact address to which the peer should address subsequent messages within that dialog. In this case, there is always a single URI. Servlets must not set the Contact header in these cases. Containers know which network interfaces they listen on and are responsible for choosing and adding the Contact header in these cases. Containers should throw an
IllegalArgumentException on application attempts to set the Contact header in these cases.

The other use of Contact is in REGISTER requests and responses, as well as 3xx and 485 responses. Contacts in these messages are alternate addresses for a user, and there may be more than one. These are the uses where SIP servlets may legitimately set addresses that will show up in Contact headers.

For this purpose SipServletMessage defines the following getter and setter methods:

```java
List getContacts();
void setContacts(List contacts);
```

In both methods the List contains only Contact instances.

5.3 URI

SIP entities are addressed by URI. When initiating or proxying a request, SIP servlets identify the destination by specifying a URI. SIP defines its own URI scheme that SIP containers are required to support. Particular implementations may know how to handle other URI schemes, e.g. tel URLs [RFC 2806].

Implementations are required to be able to represent URIs of any scheme, so that if, for example, a 3xx response contains a Contact header with a mailto or http URL, the container is able to construct Contact objects containing URIs representing those Contact URIs. Also, SipFactory.createURI should return a URI instance given any valid URI string. The container may not be able to do anything with those URIs except presenting them to the application.

5.3.1 SipURI

This interface represents SIP and SIPS URIs. Implementations are required to be able to represent and route requests based on SIP URIs.

SIP and SIPS URIs are similar to email addresses in that they are of the form user@host where user is either a user name or telephone number, and host is a host or domain name, or a numeric IP address. Additionally, SIP/SIPS URIs may contain parameters and headers. See RFC 2543, section 2 for restrictions on the contexts in which various parameters are allowed. Headers are allowed only in SIP/SIPS URIs appearing in Contact headers or in external URIs, for example when being used as a link on a Web page.

As an example, the following SIP URI:

```text
sip:alice@example.com;transport=tcp?Subject=SIP%20Servlets
```

contains a transport parameter with value “tcp” and a Subject header with value “SIP Servlets”.

The string form of SIP/SIPS URIs may contain escaped characters. The SIP servlet container is responsible for unescaping those characters before presenting URIs to servlets. Likewise, string values passed to setters for various SIP/SIPS URI components may contain reserved or excluded
characters that need escaping before being used. The container is responsible for escaping those values as necessary.

Syntactically, SIP and SIPS URIs are identical except for the name of URI scheme. The semantics differs in that the SIPS scheme implies that the identified resource is to be contacted using TLS. Quoting from the SIP specification:

A SIPS URI specifies that the resource be contacted securely. This means, in particular, that TLS is to be used between the UAC and the domain that owns the URI. From there, secure communications are used to reach the user, where the specific security mechanism depends on the policy of the domain. Any resource described by a SIP URI can be “upgraded” to a SIPS URI by just changing the scheme, if it is desired to communicate with that resource securely.

Because SIP and SIPS URIs are syntactically identical and because they're used the same way, they're both represented by the SipURI interface.

### 5.3.2 TelURL

Represents tel URLs as defined in [RFC 2806]. The tel URL scheme is used to represent addresses of terminals in the phone network, i.e. telephone numbers. SIP Servlet containers are not required to be able to route SIP requests based on tel URLs, but must be able to parse and represent them. SipFactory.createURI must return an instance of the TelURL interface.
Addressing
6 Requests and Responses

This section describes the structure of SIP servlet message objects. Sections 7 and 8 describe operational aspects of the API.

6.1 The SipServletMessage

The generic Servlet API is defined with an implicit assumption that servlets receive requests from clients, inspects various aspects of the corresponding ServletRequest object, and generate a response by setting various attributes of a ServletResponse object. As HTTP servlets reside only on origin servers, always responding to incoming requests, this model is a good fit for HTTP.

The requirement that SIP services must be able to initiate and proxy requests implies that SIP request and response classes need to be more symmetric, that is, requests must be writable as well as readable, and likewise, responses must be readable as well as writable.

The SipServletMessage interface defines a number of methods which are common to SipServletRequest and SipServletResponse, for example setters and getters for message headers and content.

Figure 5 illustrates how the SIP request and response interfaces extend the generic javax.servlet interfaces the same way the HTTP request and response interfaces does, but additionally implement the SipServletMessage interface.

6.2 Implicit Transaction State

SipServletRequest and SipServletResponse objects always implicitly belong to a SIP transaction, and the transaction state machine (as defined by the SIP specification) constrains what messages can legally be sent at various points of processing. If a servlet attempts to send a message which would violate the the transaction state machine, the container throws an IllegalState-Exception.
Requests and Responses

NOTE: ACKs for non-2xx responses are generated by the container and it is an error for applications to attempt to generate them.

A SipServletMessage for which one of the following conditions is true is called committed:

- the message is an incoming request for which a final response has been generated
- the message is an outgoing request which has been sent
- the message is an incoming response received by a servlet acting as a UAC
- the message is a response which has been forwarded upstream

Containers may throw IllegalStateExceptions when servlets attempt to modify or send an already committed SipServletMessage.

6.3 Access to Message Content

The HTTP Servlet API provides access to message content through a stream metaphor. Applications have access to posted data through an InputStream or a Reader and can generate content through either an OutputStream or a Writer.

SIP is more like email than HTTP with regard to message content. Messages are generally smaller and buffering is not practical due to the need to include a Content-Length header in all messages. Also, SIP applications will often need access to parsed representations of message content.

The SipServletMessage interface defines the following setters and getters for message content:

```java
int getContentLength();
void setContentLength(int len);

String getContentType();
void setContentType(String type);

Object getContent();
byte[] getRawContent();
void setRawContent(Object obj, String type);

ServletInputStream getInputStream() throws IOException;
ServletOutputStream getOutputStream() throws IOException;
```

The interface parallels how the JavaMail API defines access to message content in the javax.mail.Part interface [JavaMail]. There is a small difference in that getInputStream() returns a ServletInputStream and not an InputStream. Also, getRawContent is not present in JavaMail but is useful when writing back-to-back user agents (B2BUA) as these may wish to copy content from one message to another without incurring the overhead of parsing it (as they may not actually care what is in the body).
Requests and Responses

At most one input or output stream per message may be open at any point in time. Attempts to obtain a stream when an open stream currently exists results in an IOException being thrown. However, multiple streams may be used sequentially.

Implementations may use the Java Activation Framework (JAF) as the underlying data handling framework but are not required to do so [JAF].

---

NOTE: Containers may disallow modification of content of committed messages by throwing IllegalStateExceptions.

6.4 Headers

A servlet can access the headers of a SIP message through the following methods of the SipServletMessage interface (see also [Servlet API, sections 4.3 and 5.2]):

- `getHeader`
- `getHeaders`
- `getHeaderNames`
- `setHeader`
- `addHeader`

The `getHeader` method allows access to the value of a header given the name of the header. Multiple headers, such as the Warning header, can be present in a SIP message. If there are multiple headers with the same name in a message, the `getHeader` method returns the first header contained in the message. The `getHeaders` method allows access to all the header values associated with a particular header name returning an Enumeration of String objects.

The `setHeader` method sets a header with a given name and value. If a previous header exists, it is replaced by the new header. In the case where a set of header values exist for the given name, all values are cleared and replaced with the new value.

The `addHeader` method adds a header with the specified name and value to the message. If one or more headers with the given name already exists, the new value is appended to the existing list.

6.4.1 System Headers

The term system header is used to refer to those headers that are managed by the servlet container and which servlets must not attempt to modify directly via calls to `setHeader` or `addHeader`. This includes the headers Call-ID, From, To, CSeq, Via, Record-Route, Route, as well as Contact when used to confer a session signaling address (that is, in messages that are not REGISTER request or response or a 3xx or 485 response). There is no need for services to set these headers directly and disallowing it makes it easier for containers to ensure correct protocol behavior.
6.4.2 TLS Attributes

If an incoming request or response has been transmitted over a secure protocol, such as TLS, this information must be exposed via the `isSecure` method of the `SipServletMessage` interface.

NOTE: The `isSecure` method indicates whether a message was received over a secure transport. However, since secure protocols are frequently used in a hop-by-hop manner in SIP, it does not follow that the message was sent over a secure protocol end-to-end. It may well have passed over an insecure link at some point.

In servlet containers that are running in a Java 2 Standard Edition, v 1.2 or Java 2 Enterprise Edition, v 1.2 environment, if there is a TLS certificate associated with the message, it must be exposed to the servlet programmer as an array of objects of type `java.security.cert.X509Certificate` and accessible via a `SipServletRequest` or `SipServletResponse` attribute of `javax.servlet.request.X509Certificate` for requests and `javax.servlet.response.X509Certificate` for responses.

For a servlet container that is not running in a Java 2 Standard Edition 1.2 environment, vendors may provide vendor specific request attributes to access TLS certificate information.

6.5 Requests

The `SipServletRequest` object encapsulates information of a SIP request, including headers and the message body.

6.5.3 Parameters

Request parameters are strings sent by the client to a servlet container as part of a request. When the request is a `SipServletRequest`, the attributes are populated from the URI query string. The parameters are stored by the servlet container as a set of name-value pairs. Multiple parameter values can exist for any given parameter name. The following `ServletRequest` methods are available to access parameters:

- `getParameter`
- `getParameterNames`
- `getParameterValues`

The `getParameterValues` method returns an array of `String` objects containing all the parameter values associated with a parameter name. The value returned from the `getParameter` method must always equal the first value in the array of `String` objects returned by `getParameterValues`.

NOTE: Support for multi-valued parameters is defined mainly for HTTP because HTML forms may contain multi-valued parameters in form submissions.
Requests and Responses

When the request is a SipServletRequest and the request URI is a SIP or a SIPS URI, SipServletRequest.getParameter is required to be equivalent to invoking SipURI.getParameter on the SipURI obtained through the getUri method of SipServletRequest.

6.5.4 Attributes

Attributes are objects associated with a request. Attributes may be set by the container to express information that otherwise could not be expressed via the API, or may be set by a servlet to communicate information to another servlet (via RequestDispatcher). Attributes are accessed with the following methods of the ServletRequest interface:

- getAttribute
- getAttributeNames
- setAttribute

Only one attribute value may be associated with an attribute name.

Attribute names beginning with the prefix “javax.servlet.sip” are reserved for definition by this specification. It is suggested that all attributes placed into the attribute set be named in accordance with the reverse package name convention suggested by the Java Programming Language Specification for package naming [JLS].

6.6 Responses

Response objects encapsulate headers and content sent from UA servers upstream to the client. Unlike the case for HTTP, a single request may result in multiple responses.

The SipServletResponse.getRequest() method returns the request object associated with a response. For UAC and UAS applications this is the original SipServletRequest. For proxying applications it is an object representing the request that was sent on the branch on which the response was received — getProxy().getOriginalRequest() can be used to obtain the original request object (see also sections 8.2.3.1 and 9.2.4).

6.6.5 Buffering

The Servlet API defines a number of ServletResponse methods related to buffering of content returned by a server in responses [Servlet API, section 5.1]:

- getBufferSize
- setBufferSize
- reset
- flushBuffer

These methods can improve performance of HTTP servlets significantly. However, unlike HTTP, SIP is not intended as a content transfer protocol and buffering is not an issue of concern. Therefore, it is not expected that these methods will yield any useful result and implementations may simply do nothing. It is recommended that getBufferSize return 0.
The `isCommitted` method returns true if the message is committed in the sense of section 6.2.

## 6.7 Internationalization

Language identification tags are used in several places in SIP, notably `Accept-Language` and `Content-Language` headers and the `charset` parameter of various `Content-Type` header values.

In the SIP Servlet API languages are identified by instances of `java.util.Locale`.

<table>
<thead>
<tr>
<th>NOTE:</th>
<th>While the <code>javax.servlet</code> interfaces <code>ServletRequest</code> and <code>ServletResponse</code> contains methods related to internationalization, these assume that servlets only respond to incoming requests and are insufficient for the SIP Servlet API.</th>
</tr>
</thead>
</table>

### 6.7.6 Indicating Preferred Language

User agents may optionally indicate to proxies and peer UAs in which natural language(s) it prefers to receive content, reason phrases, warnings, etc. This information can be communicated from the UA using the `Accept-Language` header.

The following methods are provided in the `SipServletMessage` interface to allow the sender of a message to indicate preferred locale(s):

- `void setAcceptLanguage(Locale locale);`
- `void addAcceptLanguage(Locale locale);`

The `setAcceptLanguage` method sets the preferred language of the `Accept-Language` header and removes any existing `Accept-Language` header, while `addAcceptLanguage` adds another (least preferred) locale to the list of acceptable locales.

The following `SipServletMessage` methods are used to determine the preferred locale of the sender of the message:

- `Locale getAcceptLanguage();`
- `Iterator getAcceptLanguages();`

The `getAcceptLanguage` method will return the preferred locale that the client will accept content in. See section 14.4 of RFC 2616 (HTTP/1.1) for more information about how the `Accept-Language` header must interpreted to determine the preferred language of the client.

The `getLocales` method will return an `Iterator` over the set of `Locale` objects indicating, in decreasing order starting with the preferred locale, the locales that are acceptable to the UA originating the message.

If no preferred locale is specified by the client, `getLocale` must return the default locale for the servlet container and `getLocales` must return an `Iterator` over a single `Locale` element of the default locale.
6.7.7 Indicating Language of Message Content

When sending a message containing a body, SIP servlets may indicate the language of the body by calling the `setLocale` method of the `SipServletMessage` interface:

```java
void setLocale(Locale locale);
```

This method must correctly set the `Content-Language` header (along with other mechanisms described in the SIP specification), to accurately communicate the `Locale` to the client.

Note that a call to the `setContentType` method with a charset component for a particular content type, will override the value set via a prior call to `setLocale`.

The default encoding of message content is “ISO-8859-1” if none has been specified by the servlet-programmer.

Upon receiving messages, servlets can obtain information regarding the locale of the message content using the following `SipServletMessage` method:

```java
Locale getContentLanguage();
```
Requests and Responses
7 Acting as a User Agent

This section describes how SIP servlets perform various UA operations such as initiating and responding to requests. The SIP specification lists client and server transaction state machines that define at which points in processing various actions are allowed. As mentioned in section 6.2, when an application attempts to perform an action that would violate the SIP state machine, an IllegalArgumentException is thrown by the container.

The notions of SIP client and server are meaningful only in relation to a particular transaction. An application acting as a UA will often have to be able to act as both a client and a server in a dialog.

7.1 Client Functions

The following specify how applications can send requests and receive responses.

7.1.1 Sending an Initial Requests

When initiating a request a UAC first creates a SipServletRequest object and then sends it, possibly after having modified it. Creation of the request object is done by invoking the overloaded createRequest method on a SipFactory if the request is an initial request, that is, if it doesn’t belong to an existing SIP dialog.

More precisely, a SIP servlet carries out the following steps in order to send a new request which does not belong to an existing dialog:

- look up a SipFactory as an attribute on the ServletContext, see section 4.1
- invoke one of the overloaded SipFactory.createRequest methods
- modify the resulting SipServletRequest as appropriate, for example, set the content
- invoke send on the request object

The SipFactory interface defines the following methods for creating new requests:

```java
SipServletRequest createRequest(
    SipApplicationSession appSession,
    String method,
    SipAddress from,
    SipAddress to)
```

```java
SipServletRequest createRequest(
    SipApplicationSession appSession,
    String method,
    URI from,
    URI to)
```
SipServletRequest createRequest(
    SipApplicationSession appSession,
    String method,
    String from,
    String to) throws ServletException

The returned SipServletRequest exists in a new SipSession which belongs to the specified ApplicationSession. The handler for the newly created SipSession is the application's default servlet, see section 9.2.8. This can be changed by the application by invoking SipSession.setHandler. The container is required to assign the returned request a fresh, globally unique Call-ID as defined by the SIP specification. The From and To headers are as specified by the from and to parameters, respectively. The container is responsible for adding a CSeq header. The request method is given by the method parameter. The default value of the request URI is the URI of the To header. The application can change this by invoking setRequestURI on the newly created SipServletRequest.

**NOTE:** ACK and CANCEL requests have special status in SIP. Sections 7.1.5 and 7.1.6 discuss how and when applications generate those requests. The SipFactory methods listed above throw an IllegalArgumentException when invoked to create ACK or CANCEL requests.

Once constructed, the application may modify the request object, for example, by setting the request URI, adding headers, or setting the content. The request is then sent by invoking the send() method on SipServletRequest. The request is routed by the container based on the request URI and any Route headers present in the request as per the SIP specification.

### 7.1.2 Pushing Route Header Field Values

A UAC may push Route header field values, basically SIP or SIPS URIs, onto the Route header field of the request. The effect is that the request will visit the set of proxies identified in those Route values before being delivered to the destination. This is what is known as a pre-loaded Route in the SIP specification.

The SipServletRequest interface defines the following overloaded methods for adding entries to the Route header field:

```java
void pushRoute(SipAddress proxyAddr);
void pushRoute(SipURI proxyAddr);
```

The Route header behaves like a stack – pushRoute adds items to the head of the list and the SIP routing algorithm pops items from the top. Therefore, if pushRoute is called more than once, the request will visit the most recently added proxy first.

**NOTE:** If only one Route header field value is added, the container may choose to not actually push a Route header field value but rather to use the alternative of bypassing
Acting as a User Agent

the usual forwarding logic, and instead just sending the request to the address, port, and transport for the proxy specified in the single pushRoute call.

The same mechanism is available for proxying applications and is discussed in section 8.2.1.

7.1.2.1 Immutability of the From and To Headers

The SipFactory.createRequest makes a copy of the from and to SipAddress arguments and associates them with the new SipSession. Subsequent requests belonging to the same SipSession will have the same From and To headers. Any component of the from and to URIs not allowed in the context of SIP From and To headers are removed from the copies. This includes, headers and various parameters. Also, the container removes tag parameters in either of the copied from or to, as this is illegal in an initial To header and as the container will choose it's own tag for the From header when it is appropriate to include one. Applications can retrieve the copied from and to addresses from the SipSession but they are not allowed to modify them.

7.1.3 Sending a Subsequent Request

For subsequent requests, that is, requests made in an already established dialog, applications use the following method on the SipSession representing the dialog:

SipServletRequest createRequest(String method);

This method constructs a request with container provided values for the Call-ID, From, To, CSeq, and Route headers. Again, the application may modify the request before sending it.

7.1.4 Receiving Responses

The UAC application is invoked for all incoming responses, including all non-100 informational and all final responses received. The servlet invoked is the current handler for the SipSession to which the request belongs (see section 9.2.8). The container invokes Servlet.service with SipServletResponse and a null value for the request argument. If the servlet extends the SipServlet abstract class, the response will be further dispatched based on the value of the status code.

7.1.4.2 Handling Multiple Dialogs

Due to forking at downstream proxies it is possible that multiple 2xx responses will be received for a single INVITE request. In this (and similar) cases the container clones the original SipSession for the second and subsequent dialogs, as detailed in section 9.2.4. The cloned session object will contain the same application data but its createRequest method will create requests belonging to that second or subsequent dialog, that is, with a To tag specific to that dialog.

7.1.5 Sending ACK

In SIP, final responses to INVITE requests trigger sending of an ACK for that response from the UAC to the UAS. ACKs to non-2xx final responses are needed for reliability purposes only and are
Acting as a User Agent

sent hop-by-hop, that is, they are generated by proxies as well as the UAC. ACKs to 2xx responses, on the other hand, signal completed session setup and may carry semantically useful information in the body, for example IP addresses and codecs for the media streams of the session. These ACKs are sent end-to-end from the UAC all the way to the UAS.

Since only ACKs for 2xx responses are of interest to services, SIP servlet containers are responsible for generating ACKs for non-2xx responses, while applications are responsible for generating ACKs for 2xx responses. A request object representing the ACK is created by calling the SipServletResponse method:

```
SipServletRequest createAck()
```

The application may modify the returned ACK object before invoking send on it.

It is recommended that containers generate ACKs for non-2xx final responses prior to invoking the application, so as to stop response retransmission as soon as possible.

7.1.6 Sending CANCEL

A UAC can cancel an INVITE requests in progress by sending a CANCEL request for the INVITE. A SIP servlet acting as a UAC can invoke the following SipServletRequest method on the original INVITE request object:

```
SipServletRequest createCancel()
```

The application sends the returned CANCEL request by invoking send on it.

7.2 Server Functions

By definition, a SIP servlet that responds to an incoming request with a final response becomes a UAS for the corresponding transaction.

7.2.7 Receiving Requests

A servlet may be invoked to process an incoming request because the request
- matched a rule associated with the servlet (initial request)
- is a subsequent request in a dialog for which the application is a UA or in which it is a proxy and it record-routed on the initial request
- is an ACK for an INVITE the application responded to, either as a proxy or a UAS
- is a CANCEL for an INVITE the application has received but not yet generated a final response for

In all cases the servlet is invoked by the container through Servlet.service with a SipServletRequest object and null for the response argument.
7.2.8 Sending Responses

A servlet may generate a number of provisional responses as well as a single final response for an incoming request. It does so by invoking createResponse on the request object. The resulting SipServletResponse is then subsequently sent, possibly after having been modified, by invocation of the send method.

When proxying a request, applications does not generate a final response of their own. However, they may still generate provisional responses until the transaction has terminated. This works using the mechanism described above.

7.2.9 Receiving ACK

Applications are notified of incoming ACKs for 2xx responses to INVITEs which the application sent upstream.

Applications are not notified of incoming ACKs for non-2xx final responses to INVITE. These ACKs are needed for reliability of final responses but are not usually of interest to applications.

It is possible that a UAC fails to send an ACK for an accepted INVITE request before the transaction times out. This is communicated to the servlet through the SipErrorListener mechanism discussed in section 12.1.

7.2.10 Receiving CANCEL

When a CANCEL is received for a request which has been passed to an application, and the application has not responded yet or proxied the original request, the container responds to the original request with a 487 (Request Terminated) and to the CANCEL with a 200 OK final response, and it notifies the application by passing it a SipServletRequest object representing the CANCEL request. The application should not attempt to respond to a request after receiving a CANCEL for it. Neither should it respond to the CANCEL notification.

Clearly, there is a race condition between the container generating the 487 response and the SIP servlet generating its own response. This should be handled using standard Java mechanisms for resolving race conditions. If the application wins, it will not be notified that a CANCEL request was received. If the container wins and the servlet tries to send a response before (or for that matter after) being notified of the CANCEL, the container throws an IllegalStateException.
Acting as a User Agent
8 Proxying

One important function of SIP is the ability to route requests, that is, for incoming requests to decide which destination or destinations should receive the request. The ability to proxy requests is essential to many SIP services. In some cases the service may have a choice between proxying and redirecting but many services require proxying because they need to see responses and/or stay on the signaling path.

One of the most important differences between the HTTP and SIP servlet APIs is that whereas HTTP servlets execute on origin servers only and are concerned only with responding to incoming requests, SIP servlets are typically located on proxy servers and must be able to proxy incoming requests as well as responding to them directly.

Proxying is initiated and controlled via a Proxy object obtained from an incoming SipServletRequest. When proxying statefully, there is at most one Proxy object per SIP transaction, meaning that SipServletMessage.getProxy() will return the same Proxy instance whenever invoked on the original request object or on any response relating to that transaction.

8.1 Parameters

A number of Proxy parameters control various aspects of the proxying operation:

- **recurse**: flag specifying whether the servlet engine will automatically recurse or not. If recursion is enabled the servlet engine will automatically attempt to proxy to contact addresses received in redirect (3xx) responses. The default value is true.

- **recordRoute**: flag controlling whether the application stays on the signaling path for this dialog or not. This should be set to true if the application wishes to see subsequent requests belonging to the dialog. The default value is false.

- **parallel**: flag specifying whether to proxy to multiple destinations in parallel (true) or sequentially (false). In the case of parallel search, the server may proxy the request to multiple destinations without waiting for final responses to previous requests. The default value is true.

- **stateful**: whether the proxying operation should be transaction stateless or stateful. The default value is true. The ability to proxy without maintaining transaction state has important performance benefits for some services. However, as this has no semantic implications for applications, containers are free to consider this parameter a hint.

- **supervised**: whether the servlet is invoked to handle responses. Note that since proxying is per-transaction setting supervised to false affects only the transaction to which the Proxy object relates. The default value is true.

- **sequentialSearchTimeout**: the time the container waits for a final response before it cancels the branch and proxies to the next destination in the target set. The default value is the value of the sequential-search-timeout element of the deployment descriptor or a container specific value, if this is not specified.
Not all combinations of these parameters are allowed. In particular, if any of \textit{recurse}, \textit{parallel}, and \textit{supervised} are true, proxying cannot be stateless.

The \textit{recordRoute} and \textit{stateful} flags may only be set before the first call to \texttt{Proxy.proxy}. Any attempt to set them afterwards results in an \texttt{IllegalStateException} being thrown. The \textit{recurse}, \textit{parallel}, and \textit{supervised} flags as well as the \textit{sequentialSearchTimeout} parameter may be modified by applications while a proxying operation is in progress.

\textbf{OPEN ISSUE 8-1:} If a recursive search yields no 2xx response but one or more URIs returned in 3xx’s remain in the “target set” and the container is unable to route based on those URIs (e.g. because they are http or mailto URLs), should the container return a 4xx or is it OK to return a 300 response containing the set of untired URIs? Should be configurable (e.g. in the \texttt{proxy-config} element of the deployment descriptor)?

\section*{8.2 Operation}

An application performs a proxying operation by obtaining a \texttt{Proxy} object from a \texttt{SipServletRequest}. When creating the \texttt{Proxy} object for an incoming \texttt{INVITE} request, the server also sends a 100 provisional response upstream if the application did not already sent a 1xx response itself. This is done to stop retransmissions from the client.

Before proxying the request the application may modify the \texttt{Proxy} parameters as appropriate and may also modify the request object itself. This includes adding or removing headers and modifying or replacing the body. The application then invokes \texttt{proxy()} to initiate the proxying operation. This method is overloaded to take either a single \texttt{URI} or a \texttt{List} of \texttt{URI}s specifying downstream destination(s). Compliant servlet engines are required to be able to handle SIP URIs and may know how to handle other URI schemes, for example, SIPS and Tel URIs.

For each \texttt{URI} passed to it in one of the \texttt{proxy} methods, the container creates a new branch on which the request is proxied. The proxied request will have the request URI replaced with that of the specified destination URI and is routed either based on that modified request URI, or based on the value of the \texttt{Route} header, if one is specified.

The \texttt{proxy} method may be invoked any number of times to add additional addresses to the set of destinations the engine should proxy to.

Applications that wish to stay on the signaling path but which doesn’t perform any routing decisions or otherwise influence the call setup may proxy with record-routing enabled without changing the request URI, specifically it will do the following:

\begin{verbatim}
  public void doInvite(SipServletRequest req) {
      ...
      Proxy p = req.getProxy();
      p.setRecordRoute(true);
      p.proxy(req.getRequestURI());
      ...
  }
\end{verbatim}
Proxying

The request will be proxied either to other applications with matching rules or towards the external destination specified by the request URI.

8.2.1 Pushing Route headers

As mentioned in the SIP specification, a proxy may have a local policy that mandates that a request visit a specific set of proxies before being delivered to the destination [RFC 3261, section 16.6]. This is done by pushing a set of SIP/SIPS URIs on to the Route header field of the request.

This is the purpose of the `pushRoute` method of the `SipServletRequest` interface. The argument identifies a proxy that should be visited before the request reaches its final destination. If only one `Route` header field value is added, the container may choose to not actually push a Route header field value but rather to use the alternative of bypassing the usual forwarding logic, and instead just sending the request to the address, port, and transport for the proxy specified in the single `pushRoute` call. This is subject to the constraints specified in [RFC 3261].

8.2.2 Sending Responses

Applications may generate informational responses of their own before or during a proxying operation. This is done the same way it’s done when acting as a UAS.

Once a request has been proxied, the application will not usually generate a final response of its own. However, it’s occasionally useful to generate a different error response from the one chosen by the container as the best response. For this reason, applications may generate their own final response for a request that it previously proxied but only if the status code of the best response is not a 2xx and it can do so only in the `doResponse` notification.

If an application does generate its own final response when passed the best response received, it cannot also proxy to more destinations.

8.2.3 Receiving Responses

For requests proxied statelessly, responses are always forwarded upstream without any application involvement whatsoever.

When in stateful mode, the servlet container is responsible for automatically forwarding the following responses received for a proxying operation upstream:

- all informational responses other than 100
- the _best_ response received when final responses have been received from all destinations.
- all 2xx responses

Additionally, if the _supervised_ flag is true, the servlet engine invokes the application for these responses _before_ forwarding them upstream. The application may modify responses in the notification callback. In this case the modified responses are forwarded upstream. This is useful, for example, for application level gateways that need to modify addresses in the body of responses.

When a 2xx or 6xx response is received, the server CANCELS all outstanding branches.
Proxying

When an application is invoked to handle the best final response received and this is not a 2xx, the application may add addresses for further destinations through the `Proxy.proxy` method. The effect is that a new branch is created for each additional destination, as if the method had been invoked before a (tentative) best answer had been passed to the application. If, in the upcall informing a servlet of the best response received, the servlet proxies to one or more additional destinations, the container does not immediately forward the best response received so far as the new branch may result in a “better” response. The ability to call `proxy` in the callback for best response received is useful, for example, for writing call-forward-no-answer type services.

A consequence of the described behavior is that an application may be notified of more than one final response for a transaction. This can happen either because

1. multiple destinations returned 2xx
2. the application proxied to more destinations in the notification for a final response.

In this latter case, the application may end up being notified of the same final response more than once.

8.2.3.1 Correlating responses to proxy branches

For incoming responses to proxied requests, `SipServletResponse.getRequest()` returns a `SipServletRequest` object representing the request that was sent on the branch on which the response was received. The request URI can then be obtained from the request object and be compared against destination URIs as a means for applications to correlate an incoming response to a particular branch when the request was proxied in parallel to multiple destinations.

**OPEN ISSUE 8-2:** How are target URI and branch URI compared? Is reference comparison OK?

8.2.4 Sending CANCEL

An INVITE proxy operation can be aborted by invoking `Proxy.cancel()`. This will cause the container to terminate all outstanding branches by sending CANCEL requests to the corresponding proxied INVITEs. The proxy operation then proceeds as in the normal case, as per the SIP specification. As far as response handling is concerned the act of cancelling a branch can be thought of as a way of speeding up the generation of a final response. The application will still be invoked to handle responses if the `supervised` flag is enabled.

There is no provision for cancelling individual branches.

8.2.5 Receiving CANCEL

When receiving a CANCEL for a transaction for which a `Proxy` object exists the server responds to the CANCEL with a 200 and

- if the original request has not been proxied yet the container responds to it with a 487 final response
- otherwise, all branches are cancelled, and response processing continues as usual
In either case, the application is subsequently invoked with the CANCEL request. This is a notification only, as the server has already responded to the CANCEL and cancelled outstanding branches as appropriate. The race condition between the server sending the 487 response and the application proxying the request is handled as in the UAS case as discussed in section 7.2.10.

8.2.6 Sending ACK

The SIP specification requires stateful proxies to generate ACKs for non-2xx final responses to INVITE requests. The purpose of these ACKs is to stop response retransmissions at the downstream server and have no semantic significance. Therefore, in the SIP Servlet API, the servlet container is responsible for generating ACKs for non-2xx final responses and so SIP servlets should never generate ACKs for proxied requests.

8.2.7 Receiving ACK

The servlet engine is responsible for proxying ACKs received for a proxied request. However, if the application proxied the corresponding INVITE with record-routing enabled, the application is invoked before the ACK is proxied so as to give it an opportunity to modify the ACK (for example to modify addresses in a session description carried in the body of the ACK). In this case, as when proxying the original request, the ACK is proxied downstream in its modified form.

NOTE: As for subsequent requests, the container is responsible for proxying ACKs for 2xx’s and applications should not attempt to explicitly proxy it.

8.2.8 Handling Subsequent Requests

As discussed in section 2, a “subsequent” request is one that is dispatched to applications based on a previously established application path as opposed to initial requests that are dispatched to applications based on rule matching.

When proxying with the recordRoute flag being true, the server may receive subsequent requests in the same dialog. In these cases processing takes place as described above except that the server is responsible for proxying the request to the destination specified in the top Route header as specified in the SIP specification [bis-09, section 16.6].

The application is still passed the request object, though, and may modify it in the upcall before the server proxies it downstream. Applications should not attempt to explicitly proxy subsequent requests. The isInitial method on the SipServletRequest interface returns true if the request is initial as defined above, and can be used as an indication of whether the application should explicitly proxy an incoming request or not.

Applications are allowed to reject subsequent requests. This is needed, for example, for applications wishing to perform proxy authentication.
8.2.9 Max-Forwards Check

The Max-Forwards header serves to limit the number of elements a SIP request can traverse on the way to its destination. It consists of an integer that is decremented by one at each hop. RFC 3261 specifies that for a request to be proxied it must have a Max-Forwards value greater than 0 [RFC 3261, section 16.3].

Since a SIP Servlet container cannot know a priori whether an application will proxy a request or not, it cannot perform the Max-Forwards check before invoking the application. Instead, the container performs the check when the application invokes getProxy() on a SipServletRequest, and if Max-Forwards is 0 a TooManyHopsException is thrown. If unhandled by the application, this will be caught by the container and a 483 (Too many hops) error response will be generated.

8.3 Proxying and Sessions

When an application proxies a request it may subsequently be invoked to handle requests and responses related to that transaction or to subsequent transactions if the application record-routed. Whenever an application is invoked because an event occurred on an existing transaction or for a subsequent routed request and the application has previously obtained a SipApplicationSession and/or SipSession, the container must ensure that those same session objects are associated with subsequent requests and responses that the application is invoked to handle.

Also, as a result of forking proxies an initial request may result in multiple dialogs being established. Section 9.2.4 discusses under which circumstances a container must associate an incoming response or even a subsequent request with a SipSession cloned from that of an existing dialog.
9 Sessions

All but the simplest SIP services involve processing multiple messages. As servlets themselves are stateless (or rather contain no per-dialog data), the API provides a mechanism that allows messages to be correlated and associates application data with subsequent messages processed in an “application instance”.

The HTTP Servlet API provides such a mechanism in the form of HTTP sessions. The HttpSession interface allows servlets to correlate a series of HTTP requests from a particular client and also acts as a store for application data.

The SipSession interface is the SIP Servlet API equivalent of HttpSession. It represents a point-to-point relationship between two user agents, that is, a dialog [bis-09].

Services targeted by the SIP Servlet API are more complicated than Web applications:

- many services involve multiple dialogs, for example conferencing applications and applications acting as back-to-back user agents and third-party controllers
- converged applications communicate with other network elements using multiple protocols, for example SIP, HTTP, email, etc.

This implies that a single application instance may consist of multiple point-to-point relationships, and that these relationships may employ different protocols. This is reflected in the SIP Servlet API through the notions of protocol sessions and application sessions. A protocol session is a protocol specific session object typically representing a point-to-point relationship. The SipSession and HttpSession interfaces are both examples of protocol sessions. An application session in a sense represents an application instance. It contains a number of protocol sessions and is also used as a container for application data. All protocol sessions belonging to the same application instance belongs to the same SipApplicationSession. For example, a SIP servlet acting as a back-to-back user agent will consist of two SipSessions and one SipApplicationSession for each application instance.

Containers may, as an optimization, create application session and SIP session objects lazily, for example postpone creation until requested by the application. The result should be indistinguishable from an implementation that always creates the session objects.

9.1 SipApplicationSession

The application session serves two purposes: it provides storage for application data and correlates a number of protocol sessions.

NOTE: For practical reasons, this version of the SIP Servlet API defines the application session as javax.servlet.sip.SipApplicationSession, whereas the more logical choice would be javax.servlet.ApplicationSession. It is our hope that a future version of the Servlet API will adopt the notion of application sessions, in
which case the SipApplicationSession will be deprecated and/or refactored to extend ApplicationSession.

9.1.1 Protocol Session Iterators

Two SipApplicationSession methods allow servlets to obtain Iterator objects over contained protocol sessions:

- `getSessions()` iterates over all valid child protocol session objects
- `getSessions(String protocol)` iterates over all valid child session objects that are of the specified protocol, for example “SIP” to get all SipSessions, and “HTTP” to get all HttpSession.

9.1.2 SipApplicationSession Lifetime

Containers manage session data and so need a mechanism for allowing session objects to become garbage. When an application session is destroyed, all contained protocol sessions are destroyed with it. An application session is destroyed either because it times out or because a servlet explicitly invalidates it by invoking the `invalidate` method. For reasons of performance, it is recommended that applications explicitly invalidate session objects as soon as possible.

The timer ensures that application sessions will eventually become garbage regardless of whether an application explicitly invalidates it or not. Servlets can register for application session timeout notifications (the SipApplicationSessionListener interface). In the `sessionExpired` callback method, the application may request an extension of the application session lifetime by invoking `setExpires` on the timed out SipApplicationSession giving as an argument the number of minutes until the session expires again. The container may grant the extension of session lifetime, grant it with a modified timeout value, or reject. The ability to accept with a different timeout value allows containers to apply their own policies on application session lifetime and timeouts. A container might for example choose to enforce a maximum total lifetime for all application sessions.

The ability to extend session lifetime is useful because it allows applications not to use an unrealistically high timeout value in cases where application lifetime depends on some “external” event, that is, some condition unknown to the servlet container.

9.2 SipSession

All message objects are associated with a SipSession. The SipSession can be obtained from a SipServletMessage by calling the `getSession` method.

9.2.3 Relationship to SIP Dialogs

The SipSession interface roughly corresponds to a SIP dialog and `getSession` must return the same SipSession instance when applied to SipServletMessage objects representing messages belonging to the same dialog.
Sessions

When a SipSession terminates, either because the parent application session timed out or because the SipSession was explicitly invalidated, the container may purge all knowledge of that SipSession from its memory. In this case, if a subsequent request belonging to the corresponding dialog is received, the container is free to handle it in any one of the following ways:

1. reject the request
2. route the request without application involvement
3. if the application path is empty, treat the request as an initial request, i.e. match against existing rules and dispatch to applications accordingly, in the process establishing a new application path

It is quite possible that different application instances on the same application path have different lifetimes. Containers may apply either option 1 or 2 to subsequent requests received on a dialog corresponding to a partially invalidated application path, that is, a path for which at least one, but not all, application instances have been invalidated. When receiving a request that belongs to a partially invalidated application path, the container first invokes all applications up to the first invalidated instance. Then, in case of option 1, the request is rejected, and in case of option 2, the next valid application instance is invoked or, if the application path is exhausted, the request is proxied according to the rules of section 8.2.8.

9.2.4 Creation of SipSessions

As previously mentioned, from applications’ point of view, SipSessions roughly correspond to SIP dialogs. The main difference is that whereas SIP requests may exist outside of a dialog (for example, OPTIONS and REGISTER), in the SIP Servlet API all messages belong to a SipSession. The first dialog established as a result of a request becomes associated with the already existing SipSession. In the event that multiple dialogs are established as the result of a request, the second and subsequent dialogs get associated with new SipSessions.

SIP dialogs get created as a result of non-failure responses being received to requests with certain methods capable of setting up dialogs. The baseline SIP specification defines one such method, namely INVITE. When an initial request results in one dialog being set up, the SipSession of the initial SipServletRequest will correspond to that dialog. When more than one dialog is established, the first one will correspond to the existing SipSession and for each subsequent dialog a new SipSession is created in the manner defined below.

NOTE: Multiple dialogs – and therefore SipSessions – can be created as a result of a downstream forking proxy, both in the case of UAC and proxy applications.

In summary, the rules for when SipSessions are created are:

- New initial requests (created via SipFactory.createRequest) always belong to a new SipSession.
- Incoming initial requests always belong to a new SipSession.

1. This is usually relatively rare.
Sessions

- Responses to an initial request that do not establish a dialog, belong to the “original” SipSession of the request.
- The first response that establishes a SIP dialog (for example, a 2xx to an initial INVITE request) is associated with the original SipSession as are all other messages belonging to that dialog.
- Subsequent responses that establish dialogs are associated with new SipSessions.

When a proxying application receives a response that is associated with a new SipSession (say, because it is a second 200 response to an INVITE request), the getSession method of that response returns the new SipSession. The original SipSession continues to be available through the original request object — itself available through the getOriginalRequest method on the Proxy interface.

9.2.4.1 Derived SipSessions

A derived SipSession created as a result of steps 4 or 5 will essentially be a copy of the SipSession associated with the original request. It is constructed at the time the response creating the new dialog is passed to the application. The new SipSession differs only in the values for the tag parameter of the address of the callee (this is the value used for the To header in subsequent outgoing requests) and possibly the route set. These values are derived from the corresponding response or subsequent request as defined by the SIP specification. The set of attributes in the cloned SipSession is the same as that of the original—in particular the values are not cloned.

New SipSessions corresponding to the second and subsequent 2xx responses (or 1xx responses in case of early media) are available through the getSession method on the SipServletResponse. The “original” SipSession of the request continues to be available through the original request object.

9.2.4.2 Extensions Creating Dialogs

Extensions to the baseline SIP specification may define additional methods capable of establishing dialogs. The SIP event framework is one such extension. In the event framework, a 2xx response to an initial SUBSCRIBE may establish a dialog with subsequent NOTIFY requests establishing additional dialogs. In fact, one or more NOTIFY requests may well arrive at the caller and intervening proxies before the 2xx for the SUBSCRIBE.

A SIP servlet container that “understands” an extension capable of setting up dialogs may create new SipSessions when a second and subsequent dialog is created as a result of a single request.

OPEN ISSUE 9-1: It would be nice if SIP servlet containers were able to correctly recognize creation of new dialogs, without having to know about the specific extension in use. However, it is not clear that this is possible, at least not without significant overhead resulting from trying to recognize patterns similar to the subsequent NOTIFY case. The multiple 2xx might be handled but future extensions will likely follow SUBSCRIBE-NOTIFY pattern so looking for To tags in 2xx’s is insufficient.

SIP Servlet API 1.0 • draft version 0.51 • March 25, 2002
9.2.5 SipSession Lifetime

SipSessions may be explicitly invalidated just like application sessions. They do not, however, have a timeout value of their own separate from that of the parent SipApplicationSession. Rather, as mentioned above, when the parent session times out, all child protocol sessions time out with it. There is no separate listener interface for receiving notifications of SipSession timeout.

Any attempt to retrieve or store data on an invalidated SipSession causes an IllegalStateException to be thrown by the container as does any calls to createRequest.

9.2.6 Non-Application State Associated with SipSession

Containers are required to maintain several pieces of data related to SipSessions.

9.2.6.3 User Agents

When acting as a UA, the container must maintain enough information to allow it to correctly implement SipSession.createRequest. This requires maintaining the following:

- **from**: the value of the From header in outgoing requests
- **to**: the value of the To header in outgoing requests
- **Call-ID**: the value of the Call-ID header for all requests belonging to this SipSession
- **CSeq**: value of the CSeq sequence number to be used in the next outgoing request (the CSeq value expected in the next incoming request must be maintained separately so as to check sequencing of incoming requests as per the SIP specification)
- **route set**: the container is responsible for computing and storing the route set associated with a dialog. This is inserted into subsequent outgoing requests.

9.2.6.4 Proxies

Proxies cannot generate new requests of their own and so SipSession.createRequest results in an IllegalStateException. However, the methods getCallId, getLocalParty and getRemoteParty must be implemented. getLocalParty returns the address of the caller (value of the From header of the initial request in the dialog) and getRemoteParty returns the address of the callee. This implies that Call-ID, From, and To must be associated with “proxy” SipSessions along with any application state.

9.2.7 The RequestDispatcher Interface

There is a need for a structuring mechanism, that allows applications to consist of multiple servlets that are designated to handle various parts of the application. In the case of HTTP, servlets may use a RequestDispatcher to forward a request to another servlet or to include the output of another servlet in its own response.

SIP servlets can use the RequestDispatcher interface the same way—as a mechanism for passing a request or response to another servlet in the same application using the forward method and can be thought of as an “indirect method call”. (In the case of SIP, the name “RequestDis-
patcher” is a bit of a misnomer as it applies equally well to responses and requests). The include method has no meaning for SIP servlets.

9.2.8 The SipSession Handler

The RequestDispatcher interface provides one structuring mechanism for SIP servlets. Additionally, the SipSession interface has a notion of a handler—a reference to a servlet that is effectively the callback interface through which the container dispatches all incoming events to the application.

When a servlet application creates an initial request defining a dialog, a SipSession springs into existence. At this point, the container assigns the applications default servlet to be the handler for the newly created SipSession. This servlet will be invoked to handle responses for all requests as well as new incoming requests. The application default servlet is defined to be the first one listed in the deployment descriptor.

When a SipSession is created as part of processing an initial incoming request, the servlet object invoked becomes the initial handler for that SipSession.

In either case, the application may subsequently specify that a different servlet within the same application should become the handler for a particular SipSession. This is done by calling the SipSession method:

```java
void setHandler(String name);
```

The argument is the same as in the call to ServletContext.getNamedDispatcher, that is, it is a servlet name. Servlet names are typically associated with servlets through the deployment descriptor.

9.2.9 Binding Attributes into a SipSession

A servlet can bind an object attribute into an SipSession implementation by name. Any object bound into a session is available to any other servlet that belongs to the same ServletContext and that handles a request identified as being a part of the same session.

Some objects may require notification when they are placed into, or removed from, a session. This information can be obtained by having the object implement the SipSessionBindingListener interface. This interface defines the following methods that will signal an object being bound into, or being unbound from, a session.

- valueBound
- valueUnbound

The valueBound method must be called before the object is made available via the getAttribute method of the SipSession interface. The valueUnbound method must be called after the object is no longer available via the getAttribute method of the SipSession interface.
9.3 Last Accessed Times

The `getLastAccessedTime` method of the `SipApplicationSession` and `SipSession` interfaces allows a servlet to determine the last time a session was accessed before the current request. A session is considered to be accessed when a message that is part of the session is handled by the servlet container. The last accessed time of a `SipApplicationSession` will thus always be the most recent last accessed time of any of its contained protocol sessions.

9.4 Important Session Semantics

9.4.10 Threading Issues

Multiple servlets executing request threads may have active access to a single session object at the same time. The developer has the responsibility for synchronizing access to session resources as appropriate.

9.4.11 Distributed Environments

Within an application marked as distributable, all requests that are part of a session can only be handled on a single VM at any one time. In addition the container must be able to handle all objects placed into instances of the `SipSession` class using the `setAttribute` or `putValue` methods appropriately.

- The container must accept objects that implement the `Serializable` interface.
- The container may choose to support storage of other objects in the `SipSession`, such as references to Enterprise JavaBeans and transactions.
- Migration of sessions will be handled by container-specific facilities.

The servlet container may throw an `IllegalArgumentException` if an object is placed into the session that is not `Serializable` or for which specific support has not been made available. The `IllegalArgumentException` must be thrown for objects where the container cannot support the mechanism necessary for migration of a session storing them.

These restrictions mean that the Developer is ensured that there are no additional concurrency issues beyond those encountered in a non-distributed container.

The container provider can ensure scalability and quality of service features like load-balancing and failover by having the ability to move a session object and its contents from any active node of the distributed system to a different node of the system.

If distributed containers persist or migrate sessions to provide quality of service features, they are not restricted to using the native JVM serialization mechanism for serializing `SipSessions` and their attributes. Developers are not guaranteed that containers will call `readObject()` and `writeObject()` methods on session attributes if they implement them, but are guaranteed that the `Serializable` closure of their attributes will be preserved.
Containers must notify any session attributes implementing the SipSessionActivationListener during migration of a session. They must notify listeners of passivation prior to serialization of a session, and of activation after deserialization of a session.

Developers writing distributed applications should be aware that since the container may run in more than one Java VM, the developer cannot depend on static or instance variables for storing application states. They should store such states using an EJB or a database.
Mapping Requests to Servlets

Servlet engines maintain a set of mappings which specify the conditions under which particular servlets should be invoked. Section 2 described how when an initial request is received it is matched against configured rules and matching servlet(s) are invoked. This section defines the rule language itself.

A rule consists of a set of conditions, each of which test some property of the incoming request. The rule language specified here is defined in terms of an object model for SIP requests.

10.1 SIP Request Object Model

For purposes of the rule language, an object model is defined for SIP requests. This model defines a number of object types along with their properties. An object property is either undefined, another object, or a primitive value like a string or an integer.

The model of the SIP Servlet API rule language consists of the following object types and associated properties:

- **request object**: represents the request itself. This is the entry point for rule matching. It has the following properties:
  - **method**: the request method, a string
  - **uri**: the request URI; for example a SIP or SIPS URI or a tel URL
  - **from**: represents the value of the From header
  - **to**: represents the value of the To header

- **SIP/SIPS URI**:
  - **scheme**: a literal string – either “sip” or “sips”
  - **user**: the “user” part of the SIP/SIPS URI
  - **host**: the “host” part of the SIP/SIPS URI. This may be a domain name or a dotted decimal IP address
  - **port**: the URI port number in decimal format; if absent the default value is used (5060 for UDP and TCP, 5061 for TLS)
  - **tel**: if the “user” parameter is not “phone”, this variable is undefined. Otherwise, its value is the telephone number contained in the “user” part of the SIP/SIPS URI with visual separators stripped. This variable is always matched case insensitively (the telephone numbers may contain the symbols ‘A’, ‘B’, ‘C’ and ‘D’).
  - **param.name**: value of the named parameter within a SIP/SIPS URI; name must be a valid SIP/SIPS URI parameter name.

- **Tel URL**:
  - **scheme**: always the literal string “tel”
  - **tel**: the tel URL subscriber name with visual separators stripped off
  - **param.name**: value of the named parameter within a tel URL; name must be a valid tel URL parameter name
Mapping Requests to Servlets

From, To:
- uri the URI object; see SIP/SIPS URI, Tel URL above
- display: the display-name portion of the From or To header

Unless otherwise noted, variable values are case sensitive, meaning that the operators listed below by default take case into account when matching on those variables.

**OPEN ISSUE 10-1:** Include subscriber check? Might involve From, To, or Remote-Party-Id headers.

**OPEN ISSUE 10-2:** Include check for direction: incoming or outgoing? A B2BUA app that “proxies” without changing From, To, or request URI will also match the outgoing request. A mechanism is needed that allows the rule not to match the outgoing request.

### 10.2 Conditions

The following operators are defined:

- **equal**: compares the value of a variable with a literal value and evaluates to true if the variable is defined and its value equals that of the literal. Otherwise, the result is false.
- **exists**: takes a variable name and evaluates to true if the variable is defined, and false otherwise.
- **contains**: returns true if the first argument, a variable, contains the literal string specified as the second argument.
- **subdomain-of**: given a variable denoting a domain name (SIP/SIPS URI host) or telephone subscriber (tel property of SIP or Tel URLs), and a literal value, this operator returns true if the variable denotes a subdomain of the domain given by the literal value. Domain names are matched according to the DNS definition of what constitutes a subdomain; for example, the domain names "example.com" and "research.example.com" are both subdomains of "example.com". IP addresses may be given as arguments to this operator; however, they only match exactly. In the case of the tel variables, the subdomain-of operator evaluates to true if the telephone number denoted by the first argument has a prefix that matches the literal value given in the second argument; for example, the telephone number "1 212 555 1212" would be considered a subdomain of "1212555".

Additionally, the following logical connectors are supported:

- **and**: contains a number of conditions and evaluates to true if and only if all contained conditions evaluate to true
- **or**: contains a number of conditions and evaluates to true if and only if at least one contained condition evaluates to true
- **not**: negates the value of the contained condition.

The equal and contains operators optionally ignores character case when making comparisons. The default is case sensitive matching.
10.3 XML Encoding

A variable is denoted as a path through the request object structure. Individual objects on the path are separated by a “.”, as in “request.uri.user”.

The following XML definitions specify how the rule language defined above is encoded in the servlet-mapping element of the deployment descriptor (the deployment descriptor DTD is listed in its entirety in section 14).

```xml
<!ENTITY % condition "and | or | not |
              equal | contains | exists | subdomain-of">
<!ELEMENT servlet-mapping (servlet-name, pattern)>
<!ELEMENT servlet-name (#PCDATA)>
<!ELEMENT pattern (%condition;)
<!ELEMENT and (%condition;)+>
<!ELEMENT or (%condition;)+>
<!ELEMENT not (%condition;)
<!ELEMENT equal (var, value)>
<!ELEMENT contains (var, value)>
<!ELEMENT exists (var)>
<!ELEMENT subdomain-of (var, value)>
<!ELEMENT var (#PCDATA)>
<!ELEMENT value (#PCDATA)>
<!ATTLIST equal ignore-case (true|false) "false">
<!ATTLIST contains ignore-case (true|false) "false"高于
<!ATTLIST contains ignore-case (true|false) "false">
```

10.4 An Example

Given the SIP request:

```
INVITE sip:watson@boston.bell-tel.com SIP/2.0
From: A. Bell <sip:a.g.bell@bell-tel.com>;tag=3pcc
To: T. Watson <sip:watson@bell-tel.com>
... 
```

Table 1 shows the value of various variables:

<table>
<thead>
<tr>
<th>variable</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>request.method</td>
<td>“INVITE”</td>
</tr>
<tr>
<td>request.uri</td>
<td>“sip:<a href="mailto:watson@boston.bell-tel.com">watson@boston.bell-tel.com</a>”</td>
</tr>
<tr>
<td>request.uri.scheme</td>
<td>“sip”</td>
</tr>
<tr>
<td>request.uri.user</td>
<td>“watson”</td>
</tr>
<tr>
<td>request.uri.port</td>
<td>5060</td>
</tr>
<tr>
<td>request.uri.tel</td>
<td>undefined</td>
</tr>
</tbody>
</table>
Mapping Requests to Servlets

and the following sample rule evaluates to false:

```xml
<pattern>
  <and>
    <equal>
      <var>request.method</var>
      <value>INVITE</value>
    </equal>
    <not>
      <contains ignore-case="true">
        <var>request.from.display</var>
        <value>bell</value>
      </contains>
    </not>
    <subdomain-of>
      <var>request.from.uri.host</var>
      <value>bell-tel.com</value>
    </subdomain-of>
  </and>
</pattern>
```

In this example, the first and third clauses of the and are satisfied but the rule fails because the second clause is false (as the From display name does contain the string “bell” when disregarding case).

<table>
<thead>
<tr>
<th>variable</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>request.from.uri.host</td>
<td>“bell-tel.com”</td>
</tr>
<tr>
<td>request.from.display</td>
<td>“A. Bell”</td>
</tr>
</tbody>
</table>

TABLE 1. Variables and Corresponding Values
11 SIP Servlet Applications

OPEN ISSUE 11-1: This section is almost identical to chapter 9 of the Java Servlet Specification. We could simply refer to that chapter (and not define a SAR file format essentially identical to the WAR format), except that doing so would seem to require that we always have a valid web.xml deployment descriptor in application archives, see also Open Issue 14-1.

A SIP servlet application is a collection of servlets, class files, and other resources that comprise a complete application on a SIP server. The SIP application can be bundled and run on multiple containers from multiple vendors.

By default, an instance of a SIP application must run on one VM at any one time. This behavior can be overridden if the application is marked as “distributable” via its the deployment descriptor. An application marked as distributable must obey a more restrictive set of rules than is required of a normal servlet application. These rules are set out throughout this specification.

11.1 Relationship with HTTP Servlet Applications

The directory structure used for SIP servlet applications is very similar to the one defined for HTTP servlets, in particular, the deployment descriptor, class files, libraries etc. of SIP servlet applications exists underneath /WEB-INF/. This allows converged HTTP and SIP servlet applications to be packaged in a single archive file and deployed as a unit without having any part of the SIP application be interpreted as content to be published by the Web server.

11.2 Relationship to ServletContext

The servlet container must enforce a one-to-one correspondence between a servlet application and a ServletContext. A ServletContext object provides a servlet with its view of the application.

11.3 Elements of a SIP Application

A SIP application may consist of the following items:

- Servlets
- Utility classes
- Static resources and content (text and speech announcements, configuration files, etc.)
- Descriptive meta information which ties all of the above elements together.
11.4 Deployment Hierarchies

This specification defines a hierarchical structure used for deployment and packaging purposes that can exist in an open file system, in an archive file, or in some other form. It is recommended, but not required, that servlet containers support this structure as a runtime representation.

11.5 Directory Structure

A SIP application exists as a structured hierarchy of directories. As mentioned above, for compatibility with the HTTP servlet archive file format, the root of this hierarchy serves as the document root for files intended to be published from a Web server. This feature is only actually used for combined HTTP and SIP servlet applications.

A special directory exists within the application hierarchy named “WEB-INF”. This directory contains all things related to the application that are not in the document root of the application, that is, everything for SIP-only servlet applications. The WEB-INF node is not part of the public document tree of the application. No file contained in the WEB-INF directory may be served directly to a client by the container. However, the contents of the WEB-INF directory are visible to servlet code using the getResource() and getResourceAsStream() method calls on the ServletContext. Any application specific configuration information that the developer needs access to from servlet code yet does not wish to be exposed to a web client may be placed under this directory. Since requests are matched to resource mappings case-sensitively, client requests for `/WEB-INF/foo`, `/WEB-inf/foo`, for example, should not result in contents of the web application located under /WEB-INF being returned, or any form of directory listing thereof.

The contents of the WEB-INF directory are:

- The `/WEB-INF/sip.xml` deployment descriptor.
- The `/WEB-INF/classes/*` directory for servlet and utility classes. The classes in this directory are available to the application class loader.
- The `/WEB-INF/lib/*.*.jar` area for Java ARchive files. These files contain servlets, beans, and other utility classes useful to the web application. The web application class loader can load class from any of these archive files.

The application classloader must load classes from the WEB-INF/ classes directory first, and then from library JARs in the WEB-INF/ lib directory.

11.5.1 Example Application Directory Structure

The following is a listing of all the files in a sample SIP servlet application:

```
/WEB-INF/sip.xml
/WEB-INF/wakeup.wav
/WEB-INF/lib/foo.jar
/WEB-INF/classes/WakeupServlet.class
```

The following is the same example but with an HTTP servlet component included:
SIP Servlet Applications

/wakeup.html
/register.html
/WEB-INF/sip.xml
/WEB-INF/web.xml
/WEB-INF/wakeup.wav
/WEB-INF/lib/foo.jar
/WEB-INF/classes/RegisterWakeupCall.class
/WEB-INF/classes/WakeupServlet.class

In this latter case there are separate SIP and HTTP deployment descriptors: sip.xml and web.xml, respectively. Resources not under /WEB-INF/ will be part of the content served from the HTTP part of the converged application.

11.6 Servlet Application Archive File

Servlet applications can be packaged and signed into a Servlet ARchive format (sar) file using the standard Java Archive tools. For example, a click-to-dial application might be distributed in an archive file called click2dial.sar.

When packaged into such a form, a META-INF directory will be present, which contains information useful to Java Archive tools. This directory cannot be directly served as content by the container in response to a web client’s request, though its contents are visible to servlet code via the getResource() and getResourceAsStream() calls on the ServletContext.

11.7 SIP Application Configuration Descriptor

The following are types of configuration and deployment information in the SIP application deployment descriptor (the DTD is presented in section 14):

- ServletContext init parameters
- Session configuration
- Servlet definitions
- Security

11.8 Dependencies On Extensions

When a number of applications make use of code or resources, they will typically be installed as library files in the container in current implementations of servlet containers. These files are often common or standard API that can be used without portability being sacrificed. Files used only by one or a few applications will be made part of the servlet application to be available for access.

Application developers need to know what extensions are installed on a servlet container, and containers need to know what dependencies on such libraries servlets in a SAR may have, in order to preserve portability.
Servlet containers are recommended to have a mechanism by which servlet applications can learn what JAR files containing resources and code are available, and for making them available to the application. Containers should provide a convenient procedure for editing and configuring library files or extensions.

It is recommended that application developers provide a META-INF/MANIFEST.MF entry in the SAR file listing extensions, if any, needed by the SAR. The format of the manifest entry should follow standard JAR manifest format. In expressing dependencies on extensions installed on the servlet container, the manifest entry should follow the specification for standard extensions defined at http://java.sun.com/j2se/1.3/docs/guide/extensions/versioning.html.

Servlet containers should be able to recognize declared dependencies expressed in the optional manifest entry in a SAR file, or in the manifest entry of any of the library JARs under the WEB-INF/lib entry in a SAR. If a servlet container is not able to satisfy the dependencies declared in this manner, it should reject the application with an informative error message.

11.9 Servlet Application Classloader

The classloader that a container uses to load a servlet in a SAR must not allow the SAR to override J2SE or Java servlet API classes. It is further recommended that the loader not allow servlets in the SAR access to the servlet containers implementation classes.

It is recommended, however, that the application classloader be implemented so that classes and resources packaged within the SAR are loaded in preference to classes and resources residing in container-wide library JARs.

11.10 Replacing a Servlet Application

A server should be able to replace an application with a new version without restarting the container. When an application is replaced, the container should provide a robust method for preserving session data within that application.

11.11 Servlet Application Environment

Java 2 Platform Enterprise Edition defines a naming environment that allows applications to easily access resources and external information without the explicit knowledge of how the external information is named or organized.

As servlets are an integral component type of J2EE\(^1\), provision has been made in the SIP servlet application deployment descriptor for specifying information allowing a servlet to obtain references to resources and enterprise beans. The deployment elements that contain this information are:

---

1. At the time of writing this is true for HTTP servlets only, but the same mechanisms apply to SIP servlets nonetheless.
**SIP Servlet Applications**

- env-entry
- ejb-ref
- resource-ref

The **env-entry** element contains information to set up basic environment entry names relative to the `java:comp/env` context, the expected Java type of the environment entry value (the type of object returned from the JNDI lookup method), and an optional environment entry value. The **ejb-ref** element contains the information needed to allow a servlet to locate the home interfaces of an enterprise bean. The **resource-ref** element contains the information needed to set up a resource factory.

The requirements of the J2EE environment with regards to setting up the environment are described in section 5 of the Java 2 Platform Enterprise Edition v1.3 specification 2. Servlet containers that are not part of a J2EE compliant implementation are encouraged, but not required, to implement the application environment functionality described in the J2EE specification. If they do not implement the facilities required to support this environment, upon deploying an application that relies on them, the container should provide a warning.
12 Application Listeners and Events

Version 2.3 of the Java Servlet Specification introduced the notion of application listeners [Servlet API, chapter 10]. The SIP Servlet API requires full support for application listeners and events as defined in that document, except for the HTTP specific events defined in package javax.servlet.http. The servlet context events defined in javax.servlet must be supported. Additionally, this specification defines some SIP specific events for which support is also required.

For full details on application listeners and events, see [Servlet API, chapter 10].

12.1 SIP Servlet Event Types and Listener Interfaces

The SIP specific events types and the listener interfaces used to monitor them are as follows.

- listener on SipApplicationSession:
  - javax.servlet.sip.SipApplicationSessionListener
    A SipApplicationSession has been created, destroyed, or has timed out.
- listeners on SipSession:
  - javax.servlet.sip.SipSessionListener
    A SipSession has been created or destroyed.
  - javax.servlet.sip.SipSessionAttributeListener
    Attributes on the servlet context have been added, removed or replaced.
- error listener:
  - javax.servlet.sip.SipErrorListener
    notification that an expected ACK was not received.

Additionally, objects stored as attributes on session objects may implement the SipSession-BindingListener and SipSessionActivationListener interfaces to get notified of attribute binding and session activation events, respectively, but implementations of those listener interfaces are not listed in the deployment descriptor.

OPEN ISSUE 12-1: Add support for timers?
13 Security

Servlet applications are created by application developers who give, sell, or otherwise transfer the application to a deployer for installation into a runtime environment. Application developers need to communicate to deployers how the security is to be set up for the deployed application. This is accomplished declaratively by use of the deployment descriptor mechanism.

This section describes deployment representations for security requirements. Similarly to servlet application directory layouts and deployment descriptors, this section does not describe requirements for runtime representations. It is recommended, however, that containers implement the elements set out here as part of their runtime representations.

13.1 Introduction

A servlet application represents resources that can be accessed by many users. These resources are accessed over unprotected, open networks such as the Internet. In such an environment, a substantial number of servlet applications will have security requirements.

Although the quality assurances and implementation details may vary, servlet containers have mechanisms and infrastructure for meeting these requirements that share some of the following characteristics:

- **Authentication**: The means by which communicating entities prove to one another that they are acting on behalf of specific identities that are authorized for access.
- **Access control for resources**: The means by which interactions with resources are limited to collections of users or programs for the purpose of enforcing integrity, confidentiality, or availability constraints.
- **Data integrity**: The means used to prove that information has not been modified by a third party while in transit.
- **Confidentiality or data privacy**: The means used to ensure that information is made available only to users who are authorized to access it.

13.2 Declarative Security

Declarative security refers to the means of expressing an application’s security structure, including roles, access control, and authentication requirements in a form external to the application. The deployment descriptor is the primary vehicle for declarative security in servlet applications.

The deployer maps the application’s logical security requirements to a representation of the security policy that is specific to the runtime environment. At runtime, the servlet container uses the security policy representation to enforce authentication and authorization.
The security model applies to servlets invoked to handle requests on behalf of either caller or callee. The security model does not apply when a servlet uses the RequestDispatcher to invoke a static resource or servlet using a forward.

13.3 Programmatic Security

Programmatic security is used by security aware applications when declarative security alone is not sufficient to express the security model of the application. Programmatic security consists of the following methods of the SipServletMessage interface:

- getRemoteUser
- isUserInRole
- getUserPrincipal

The getRemoteUser method returns the user name the client used for authentication. The isUserInRole method determines if a remote user is in a specified security role. The getUserPrincipal method determines the principal name of the current user and returns a java.security.Principal object. These APIs allow servlets to make business logic decisions based on the information obtained.

If no user has been authenticated, the getRemoteUser method returns null, the isUserInRole method always returns false, and the getUserPrincipal method returns null.

NOTE: A response may contain credentials of the UAS. For this reason, the programmatic security methods apply to responses as well as to requests. However, since there is no mechanism for a proxy to challenge a UAS upon unsuccessful response authentication, the SIP deployment descriptor cannot express a requirement that responses be authenticated.

The isUserInRole method expects a String user role-name parameter. A security-role-ref element should be declared in the deployment descriptor with a role-name sub-element containing the rolename to be passed to the method. A security-role element should contain a role-link sub-element whose value is the name of the security role that the user may be mapped into. The container uses the mapping of security-role-ref to security-role when determining the return value of the call.

For example, to map the security role reference "FOO" to the security role with role-name "manager" the syntax would be:

```
<security-role-ref>
  <role-name>FOO</role-name>
  <role-link>manager</manager>
</security-role-ref>
```

In this case, if the servlet called by a user belonging to the "manager" security role made the API call isUserInRole("FOO"), the result would be true.
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If no security-role-ref element matching a security-role element has been declared, the container must default to checking the role-name element argument against the list of security-role elements for the servlet application. The isUserInRole method references the list to determine whether the caller is mapped to a security role. The developer must be aware that the use of this default mechanism may limit the flexibility in changing rolenames in the application without having to recompile the servlet making the call.

13.4 Roles

A security role is a logical grouping of users defined by the application developer or assembler. When the application is deployed, roles are mapped by a deployer to principals or groups in the runtime environment.

A servlet container enforces declarative or programmatic security for the principal associated with an incoming request based on the security attributes of the principal. This may happen in either of the following ways:

1. A deployer has mapped a security role to a user group in the operational environment. The user group to which the calling principal belongs is retrieved from its security attributes. The principal is in the security role only if the principal’s user group matches the user group to which the security role has been mapped by the deployer.

2. A deployer has mapped a security role to a principal name in a security policy domain. In this case, the principal name of the calling principal is retrieved from its security attributes. The principal is in the security role only if the principal name is the same as a principal name to which the security role was mapped.

13.5 Authentication

A SIP user agent can authenticate a user to a SIP server using, for example, one of the following mechanisms:

- SIP basic authentication
- SIP digest authentication
- the Remote-Party-ID header, thus trusting an upstream/downstream proxy to have authenticated the caller/callee, as specified in [privacy]

The HTTP Servlet specification also allows user authentication based on SSL. With SSL, TLS, and IPSec, it is actually the previous hop that is being authenticated and from which the user-data constraints are enforced. As proxies are more common in SIP, and may not be strongly associated with the UAC, the entity authenticating itself on an incoming TLS connection is not, generally speaking, the UAC itself.

For this reason SIP servlet containers will not typically perform authentication based on credentials received as part of a TLS handshake. However, it is possible that in some environments it is known that the TLS connection really does identify the UAC and in such cases it is reasonable for the container to reflect this knowledge in its implementation of the declarative and programmatic security
Security features discussed here. These security features relate to end-users, not proxies, but it is up to individual containers to determine what constitutes an authenticated message.

**OPEN ISSUE 13-I:** Is it sufficiently explicit whether declarative security (authentication and integrity/confidentiality) and each of `isSecure`, `getRemoteUser`, `isUserInRole`, `getUserPrincipal` reflect the characteristics of a hop-by-hop “secure” connection?

### 13.6 Server Tracking of Authentication Information

As the underlying security identities (such as users and groups) to which roles are mapped in a runtime environment are environment specific rather than application specific, it is desirable to:

1. Make login mechanisms and policies a property of the environment the servlet application is deployed in.
2. Be able to use the same authentication information to represent a principal to all applications deployed in the same container, and
3. Require re-authentication of users only when a security policy domain boundary has been crossed.

Therefore, a servlet container is required to track authentication information at the container level (rather than at the servlet application level). This allows users authenticated for one servlet application to access other resources managed by the container permitted to the same security identity.

### 13.7 Propagation of Security Identity in EJB™ Calls

A security identity, or principal, must always be provided for use in a call to an enterprise bean. The default mode in calls to enterprise beans from servlet applications is for the security identity of a user to be propagated to the EJB™ container.

In other scenarios, containers are required to allow users that are not known to the servlet container or to the EJB™ container to make calls:

- SIP servlet containers are required to support access to applications by clients that have not authenticated themselves to the container.
- Application code may be the sole processor of signon and customization of data based on caller identity.

In these scenarios, a servlet application deployment descriptor may specify a `run-as` element. When it is specified, the container must propagate the security identity of the caller to the EJB layer in terms of the security role name defined in the `run-as` element. The security role name must one of the security role names defined for the servlet application.

For servlet containers running as part of a J2EE platform, the use of `run-as` elements must be supported both for calls to EJB components within the same J2EE application, and for calls to EJB components deployed in other J2EE applications.
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13.8 Specifying Security Constraints

Security constraints are a declarative way of annotating the intended protection of applications. A SIP servlet security constraint consists of the following elements:

- resource collection (a set of servlets)
- type of authentication
- authorization constraint
- user data constraint

OPEN ISSUE 13-2: Need ability to indicate that a security constraint should apply only to the initial request or only to requests in one of the two directions?

OPEN ISSUE 13-3: Need ability to apply user data constraints to outgoing requests, e.g. to declaratively require a request to be transmitted over TLS? How would this interact with a request URI or Route header with a non-null transport parameter?

A resource collection is a set of servlets and SIP methods. A servlet may have one or more security constraints associated with it. Before invoking a servlet to handle an incoming request, the container must ensure that all security constraints associated with that servlet are satisfied. If this is not the case, the request must be rejected with a 401 or 407 status code.

NOTE: SIP servlet resource collections are identified by names of servlets being invoked instead of URL patterns as in the HTTP Servlet API.

The authentication type is an indication of whether the container should return a 401 (Unauthorized) or 407 (Proxy Authentication Required) response status code when authenticating an incoming request.

An authorization constraint is a set of security roles at least one of which users must belong for access to resources described by the resource collection. If the user is not part of an allowed role, the user must be denied access to the resource requiring it. If the authorization constraint defines no roles, no user is allowed access to the portion of the servlet application defined by the security constraint.

A user data constraint describes requirements for the transport layer of the client server. The requirement may be for content integrity (preventing data tampering in the communication process) or for confidentiality (preventing reading while in transit). The container must at least use TLS to respond to requests to resources marked integral or confidential. If the original request was over TCP, the container must redirect the client to the TLS port.

13.9 Default Policies

By default, authentication is not needed to access resources (servlets). Authentication is needed for requests for a resource collection only when specified by the deployment descriptor.
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14 Deployment Descriptor

This section specifies the SIP Servlet Specification, v1.0 requirements for SIP servlet container support of deployment descriptors. The deployment descriptor conveys the elements and configuration information of a servlet application between application developers, application assemblers, and deployers.

OPEN ISSUE 14-1: SIP servlet applications currently have a single deployment descriptor, sip.xml. This is, intentionally, very similar to the HTTP DD, say 80% identical. An alternative to copying from the web.xml definition would be to retain web.xml for SIP servlet applications and define sip.xml to contain only the SIP specific deployment information.

OPEN ISSUE 14-2: JSR 154 is chartered to modularize the HTTP deployment descriptor, possibly using XML schema. Should we skip DTDs and define the deployment descriptor using the XML Schema standard?

14.1 Differences from the HTTP Servlet Deployment Descriptor

The SIP servlet deployment descriptor is very similar to the HTTP servlet deployment descriptor. The main differences are:

- The root element is sip-app rather than web-app.
- Incoming requests are mapped to servlets based on the rule language defined in section 10 rather than the HTTP specific URL mapping.
- The following elements (together with child elements) have no meaning for SIP and are not present in the deployment descriptor: form-login-config, mime-mapping, welcome-file-list, error-page, taglib, jsp-file.
- Resource collections are defined to be a named set of servlets rather than a set of URL patterns as in the case of HTTP.
- The notion of filters introduced in version 2.3 of the Servlet API is not supported. The application composition model of the SIP Servlet API allows multiple applications to execute on a single request and, while this is not exactly the same as filters, it does meet many of the same requirements.

A SIP servlet application must have a deployment descriptor that conforms to the XML DTD presented below. As mentioned in section 11, this deployment descriptor exists as a file sip.xml in the /WEB-INF directory of the servlet application.

14.2 Converged SIP and HTTP Applications

Applications may have both SIP and HTTP components (and potentially components related to protocols for other, as of yet unspecified, servlet APIs). When this is the case, there will be both a
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A web.xml deployment descriptor conforming to the DTD defined by the HTTP Servlet API, and a sip.xml deployment descriptor.

A number of deployment descriptor elements apply to the application as a whole. The following rules specify how those elements are handled when they appear in both the SIP and HTTP descriptors (the rules apply equally to the case where there are deployment descriptors for other servlet APIs alongside SIP and/or HTTP):

- **distributable**: if this “tagging” element is present in one deployment descriptor it must be present in the other.
- **context-param**: SIP and HTTP servlets belonging to the same application are presented with a single ServletContext. The set of initialization parameters available from the ServletContext is the union of parameters specified in context-param elements present in the SIP and HTTP deployment descriptors. A parameter may be configured in both descriptors but in that case must have the same value in both declarations.
- **listener**: the set of listeners of an application is the union of listeners defined in the SIP and HTTP deployment descriptors.

Also, the application display-name and icons should be identical and, if present, in one should be present in the other.

14.3 Deployment Descriptor Elements

The following types of configuration and deployment information exist in the SIP servlet application deployment descriptor and are required to be supported, with the exception of the security syntax, for all servlet containers:

- ServletContext init parameters
- Session configuration
- Servlet definitions
- Servlet mappings
- Application life cycle listener classes
- Error handler
- Filter definitions and filter mappings
- Security

Also, elements exist in the SIP servlet application deployment descriptor to support the additional requirements of servlet containers that are part of a J2EE application server. These elements allow for looking up JNDI objects (env-entry, ejb-ref, ejb-local-ref, resource-ref, resource-env-ref), and are not required to be supported by containers wishing to support only the servlet specification. See the DTD comments for further description of these elements.

14.4 Rules for Processing the Deployment Descriptor

This section lists some general rules that servlet containers and developers must note concerning the processing of the deployment descriptor for a servlet application.
Servlet containers should ignore all leading whitespace characters before the first non-whitespace character, and all trailing whitespace characters after the last non-whitespace character for PCDATA within text nodes of a deployment descriptor.

Servlet containers and tools that manipulate servlet applications have a wide range of options for checking the validity of a SAR. This includes checking the validity of the deployment descriptor document held within. It is recommended, but not required, that servlet containers and tools validate deployment descriptors against the DTD document for structural correctness.

Additionally, it is recommended that they provide a level of semantic checking. For example, it should be checked that a role referenced in a security constraint has the same name as one of the security roles defined in the deployment descriptor.

In cases of non-conformant servlet applications, tools, and containers should inform the developer with descriptive error messages. High-end application server vendors are encouraged to supply this kind of validity checking in the form of a tool separate from the container.

### 14.4.1 Deployment Descriptor DOCTYPE

All valid web application deployment descriptors must contain the following DOCTYPE declaration:

```
<!DOCTYPE sip-app PUBLIC "-//dynamicsoft, Inc.//DTD SIP Servlet Application 1.0//EN"
 "http://www.dynamicsoft.com/dtd/sip-servlet-1_0.dtd">
```

### 14.5 DTD

The following DTD defines the XML grammar for a SIP servlet application deployment descriptor.

```xml
```

```xml
<!-- The icon element contains small-icon and large-icon elements that specify the file names for small and a large GIF or JPEG icon images used to represent the parent element in a GUI tool. -->

```
<!ELEMENT icon (small-icon?, large-icon?)>
```

```xml
<!-- The small-icon element contains the name of a file containing a small (16 x 16) icon image. The file name is a path relative to the root of the SAR. The image may be either in the JPEG or GIF
```
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format. The icon can be used by tools.

Example:
  <small-icon>/employee-service-icon16x16.jpg</small-icon>
-->

<!ELEMENT small-icon (#PCDATA)>

<!-- The large-icon element contains the name of a file containing a large (32 x 32) icon image. The file name is a path relative to the root of the SAR. The image may be either in the JPEG or GIF format. The icon can be used by tools. Example:

  <large-icon>/employee-service-icon32x32.jpg</large-icon>
-->

<!ELEMENT large-icon (#PCDATA)>

<!-- The display-name element contains a short name that is intended to be displayed by tools. The display name need not be unique.
Example:

  <display-name>Employee Self Service</display-name>
-->

<!ELEMENT display-name (#PCDATA)>

<!-- The description element is used to provide text describing the parent element. The description element should include any information that SAR producer wants to provide to the consumer of SAR (i.e., to the Deployer). Typically, the tools used by SAR consumer will display the description when processing the parent element that contains the description. -->

<!ELEMENT description (#PCDATA)>

<!-- The distributable element, by its presence in a servlet application deployment descriptor, indicates that this servlet application is programmed appropriately to be deployed into a distributed servlet container -->

<!ELEMENT distributable EMPTY>

<!-- The context-param element contains the declaration of a servlet application's servlet context initialization parameters. -->

<!ELEMENT context-param (param-name, param-value, description?)>
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<!-- The param-name element contains the name of a parameter. Each parameter name must be unique in the servlet application. -->
<!ELEMENT param-name (#PCDATA)>

<!-- The param-value element contains the value of a parameter. -->
<!ELEMENT param-value (#PCDATA)>

<!-- The listener element indicates the deployment properties for a servlet application listener bean. -->
<!ELEMENT listener (listener-class)>

<!-- The listener-class element declares a class in the application must be registered as a servlet application listener bean. The value is the fully qualified classname of the listener class. -->
<!ELEMENT listener-class (#PCDATA)>

<!-- The servlet element contains the declarative data of a servlet. -->
<!ELEMENT servlet (icon?, servlet-name, display-name?, description?, servlet-class, init-param*, load-on-startup?, run-as?, security-role-ref*)>

<!-- The servlet-name element contains the canonical name of the servlet. Each servlet name is unique within the servlet application. -->
<!ELEMENT servlet-name (#PCDATA)>

<!-- The servlet-class element contains the fully qualified class name of the servlet. -->
<!ELEMENT servlet-class (#PCDATA)>

<!-- The init-param element contains a name/value pair as an initialization param of the servlet -->
<!ELEMENT init-param (param-name, param-value, description?)>

<!-- The load-on-startup element indicates that this servlet should be loaded (instantiated and have its init() called) on the startup of the servlet application. The optional contents of these element must be an integer indicating the order in which the servlet should be loaded. If the value is a negative integer, or the element is not present, the container is free to load the servlet whenever it chooses. If the value is a positive integer or 0, the container must load and initialize the servlet as the application start-up sequence requires. -->
<!ELEMENT load-on-startup (#PCDATA)>

<!-- The run-as element indicates the execution environment for the servlet. The possible values are: -->
<!ELEMENT run-as (java-only?, plain-context?, init-param)*>

<!-- The security-role-ref element indicates the role the servlet is configured to run under. The role configuration is used for enforcing security policies. -->
<!ELEMENT security-role-ref (role-name)*>
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...is deployed. The container must guarantee that servlets marked with lower integers are loaded before servlets marked with higher integers. The container may choose the order of loading of servlets with the same load-on-start-up value. -->

<!ELEMENT load-on-startup (#PCDATA)>

<!-- The servlet-mapping element defines a mapping between a servlet and a pattern -->

<!ELEMENT servlet-mapping (servlet-name, pattern)>

<!-- The different types of conditions supported. -->

<!ENTITY % condition "and | or | not | equal | contains | exists | subdomain-of">

<!-- A pattern is a condition: a predicate over the set of SIP requests. -->

<!ELEMENT pattern (%condition;)

<!-- An "and" condition is true if and only if all its constituent conditions are true. -->

<!ELEMENT and (%condition;)+>

<!-- An "or" condition is true if at least one of its constituent conditions is true. -->

<!ELEMENT or (%condition;)+>

<!-- Negates the value of the contained condition. -->

<!ELEMENT not (%condition;)

<!-- True if the value of the variable equals the specified literal value. -->

<!ELEMENT equal (var, value)>

<!-- True if the value of the variable contains the specified literal value. -->

<!ELEMENT contains (var, value)>

<!-- True if the specified variable exists. -->

<!ELEMENT exists (var)>

<!-- -->

<!ELEMENT subdomain-of (var, value)>
<!--
Specifies a variable.
Example: <var>request.uri.user</var>
-->  
<!ELEMENT var (#PCDATA)>  
<!-- Specifies a literal string value that is used to specify rules. -->  
<!ELEMENT value (#PCDATA)>  
<!-- Specifies whether the "equal" test is case sensitive or not. -->  
<!ATTLIST equal ignore-case (true|false) "false">  
<!-- Specifies whether the "contains" test is case sensitive or not. -->  
<!ATTLIST contains ignore-case (true|false) "false">  
<!-- The proxy-config element configures proxy-related parameters. -->  
<!ELEMENT proxy-config (sequential-search-timeout?)>  
<!-- The sequential-search-timeout element defines the default timeout for sequential searches for all proxy operations performed by this application. The specified timeout must be expressed in a whole number of seconds. The container may override this value as a result of its own local policy. -->  
<!ELEMENT sequential-search-timeout (#PCDATA)>  
<!-- The session-config element defines the session parameters for this servlet application. -->  
<!ELEMENT session-config (session-timeout?)>  
<!-- The session-timeout element defines the default session time-out interval for all application sessions created in this servlet application. SipSessions have no timeout independent of that of the containing application session. The lifetime of a SipSession is tied to that of the parent application session. The specified timeout must be expressed in a whole number of minutes. If the timeout is 0 or less, the container ensures the default behavior of sessions is never to time out. -->  
<!ELEMENT session-timeout (#PCDATA)>
<!-- The resource-env-ref element contains a declaration of a servlet's reference to an administered object associated with a resource in servlet's environment. It consists of an optional description, the resource environment reference name, and an indication of the resource environment reference type expected by servlet code.

Example:

    <resource-env-ref>
        <resource-env-ref-name>jms/StockQueue</resource-env-ref-name>
        <resource-env-ref-type>javax.jms.Queue</resource-env-ref-type>
    </resource-env-ref>
-->

<!-- ELEMENT resource-env-ref (description?, resource-env-ref-name, resource-env-ref-type) -->

<!-- The resource-env-ref-name element specifies the name of a resource environment reference; its value is the environment entry name used in servlet code. The name is a JNDI name relative to the java:comp/env context and must be unique within a servlet applica-

<!-- ELEMENT resource-env-ref-name (#PCDATA) -->

<!-- The resource-env-ref-type element specifies the type of a resource environment reference. It is the fully qualified name of a Java language class or interface. -->

<!-- ELEMENT resource-env-ref-type (#PCDATA) -->

<!-- The resource-ref element contains a declaration of a servlet's reference to an external resource. It consists of an optional description, the resource manager connection factory reference name, the indication of the resource manager connection factory type expected by servlet code, the type of authentication (Application or Container), and an optional specification of the share-

Example:

    <resource-ref>
        <res-ref-name>jdbc/EmployeeAppDB</res-ref-name>
        <res-type>javax.sql.DataSource</res-type>
        <res-auth>Container</res-auth>
        <res-sharing-scope>Shareable</res-sharing-scope>
    </resource-ref>
-->

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<!ELEMENT resource-ref (description?, res-ref-name, res-type, res-auth, res-sharing-scope?)>

<!-- The res-ref-name element specifies the name of the resource factory reference name. -->

<!ELEMENT res-ref-name (#PCDATA)>

<!-- The res-ref-name element specifies the name of a resource manager connection factory reference. The name is a JNDI name relative to the java:comp/env context. The name must be unique within servlet application. -->

<!ELEMENT res-type (#PCDATA)>

<!-- The res-auth element specifies whether the servlet code signs on programmatically to the resource manager, or whether the Container will sign on to the resource manager on behalf of the servlet. In the latter case, the Container uses information that is supplied by the Deployer.

The value of this element must be one of the two following:

<res-auth>Application</res-auth>
<res-auth>Container</res-auth>

<!-- The res-sharing-scope element specifies whether connections obtained through the given resource manager connection factory reference can be shared. The value of this element, if specified, must be one of the two following:

<res-sharing-scope>Shareable</res-sharing-scope>
<res-sharing-scope>Unshareable</res-sharing-scope>

The default value is Shareable. -->

<!ELEMENT res-sharing-scope (#PCDATA)>

<!-- The security-constraint element is used to associate security constraints with one or more servlet resource collections -->

<!ELEMENT security-constraint (display-name?, resource-collection+, auth-constraint?, user-data-constraint?)>

<!-- The resource-collection element is used to identify a subset of the resources and SIP methods on those resources within a servlet application to which a security constraint applies. If no SIP -->
methods are specified, then the security constraint applies to all SIP methods. -->

<!ELEMENT resource-collection (resource-name, description?, servlet-name*, sip-method*)>

<!-- The resource-name contains the name of this resource collection -->

<!ELEMENT resource-name (#PCDATA)>

<!-- The sip-method contains an SIP method (INVITE | BYE | ...) -->

<!ELEMENT sip-method (#PCDATA)>

<!-- The presence of the proxy-authentication element indicates to the container that it must challenge the user agent with a 407 (Proxy Authentication Required) response status code when authenticating an incoming request. If not present a 401 (Unauthorized) status code is used. -->

<!ELEMENT proxy-authentication EMPTY>

<!-- The user-data-constraint element is used to indicate how data communicated between the client and container should be protected -->

<!ELEMENT user-data-constraint (description?, transport-guarantee)>

<!-- The transport-guarantee element specifies that the communication between client and server should be NONE, INTEGRAL, or CONFIDENTIAL. NONE means that the application does not require any transport guarantees. A value of INTEGRAL means that the application requires that the data sent between the client and server be sent in such a way that it can't be changed in transit. CONFIDENTIAL means that the application requires that the data be transmitted in a fashion that prevents other entities from observing the contents of the transmission. In most cases, the presence of the INTEGRAL or CONFIDENTIAL flag will indicate that the use of TLS is required. -->

<!ELEMENT transport-guarantee (#PCDATA)>

<!-- The auth-constraint element indicates the user roles that should be permitted access to this resource collection. The role-name used here must either correspond to the role-name of one of the security-role elements defined for this servlet application, or be the specially reserved role-name "*" that is a compact syntax for indicating all roles in the servlet application. If both "*" and rolenames appear, the container interprets this as all roles. If no roles are defined, no user is allowed access to the -->
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portion of the servlet application described by the containing security-constraint. The container matches role names case sensi-
tively when determining access. -->

<!ELEMENT auth-constraint (description?, role-name*)>

<!-- The role-name element contains the name of a security role. -->

<!ELEMENT role-name (#PCDATA)>

<!-- The login-config element is used to configure the authentica-
tion method that should be used, the realm name that should be used for this application, and the attributes that are needed by the form login mechanism. -->

<!ELEMENT login-config (auth-method?, realm-name?)>

<!-- The realm name element specifies the realm name to use in HTTP Basic authorization -->

<!ELEMENT realm-name (#PCDATA)>

<!-- The auth-method element is used to configure the authentica-
tion mechanism for the SIP servlet application. As a prerequisite to gaining service from any SIP servlet which is protected by an authorization constraint, a user must have authenticated using the configured mechanism. Legal values for this element are "BASIC", "DIGEST", or "CLIENT-CERT". -->

<!ELEMENT auth-method (#PCDATA)>

<!-- The security-role element contains the declaration of a secu-
rity role which is used in the security-constraints placed on the servlet application. -->

<!ELEMENT security-role (description?, role-name)>

<!-- The security-role-ref element defines a mapping between the name of role called from a Servlet using isUserInRole(String name) and the name of a security role defined for the servlet application. For example, to map the security role reference "FOO" to the security role with role-name "manager" the syntax would be:

<security-role-ref>
  <role-name>FOO</role-name>
  <role-link>manager</manager>
</security-role-ref>

In this case if the servlet called by a user belonging to the "man-
ger" security role made the API call isUserInRole("FOO") the result would be true. Since the role-name "*" has a special meaning
for authorization constraints, its value is not permitted here.

<!ELEMENT security-role-ref (description?, role-name, role-link)>

<!-- The role-link element is used to link a security role reference to a defined security role. The role-link element must contain the name of one of the security roles defined in the security-role elements. -->

<!ELEMENT role-link (#PCDATA)>

<!-- The env-entry element contains the declaration of a servlet application's environment entry. The declaration consists of an optional description, the name of the environment entry, and an optional value. If a value is not specified, one must be supplied during deployment. -->

<!ELEMENT env-entry (description?, env-entry-name, env-entry-value?, env-entry-type)>

<!-- The env-entry-name element contains the name of a servlet application's environment entry. The name is a JNDI name relative to the java:comp/env context. The name must be unique within a servlet application. Example: -->

<env-entry-name>minAmount</env-entry-name>

<!ELEMENT env-entry-name (#PCDATA)>

<!-- The env-entry-value element contains the value of a component's environment entry. The value must be a String that is valid for the constructor of the specified type that takes a single String parameter, or for java.lang.Character, a single character. Example: -->

<env-entry-value>100.00</env-entry-value>

<!ELEMENT env-entry-value (#PCDATA)>

<!-- The env-entry-type element contains the fully-qualified Java type of the environment entry value that is expected by the components code. The following are the legal values of env-entry-type: -->

java.lang.Boolean
java.lang.Byte
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```
java.lang.Character
java.lang.String
java.lang.Short
java.lang.Integer
java.lang.Long
java.lang.Float
java.lang.Double

<!--
<!ELEMENT env-entry-type (#PCDATA)>

<!-- The ejb-ref element is used for the declaration of a reference to an enterprise bean's home. The declaration consists of: -- an optional description - the EJB reference name used in the code of the servlet that's referencing the enterprise bean - the expected type of the referenced enterprise bean - the expected home and remote interfaces of the referenced enterprise bean - optional ejb-link information, used to specify the referenced enterprise bean -->

<!ELEMENT ejb-ref (description?, ejb-ref-name, ejb-ref-type, home, remote, ejb-link?)>

<!-- The ejb-ref-name element contains the name of an EJB reference. The EJB reference is an entry in the servlet's environment and is relative to the java:comp/env context. The name must be unique within the servlet application. It is recommended that name is prefixed with "ejb/". Example:
   <ejb-ref-name>ejb/Payroll</ejb-ref-name>
-->

<!ELEMENT ejb-ref-name (#PCDATA)>

<!-- The ejb-ref-type element contains the expected type of the referenced enterprise bean. The ejb-ref-type element must be one of the following:
   <ejb-ref-type>Entity</ejb-ref-type>
   <ejb-ref-type>Session</ejb-ref-type>
-->

<!ELEMENT ejb-ref-type (#PCDATA)>

<!-- The home element contains the fully-qualified name of the enterprise bean's home interface.

Example:
   <home>com.aardvark.payroll.PayrollHome</home>
-->
```
<!ELEMENT home (#PCDATA)>

<!-- The remote element contains the fully-qualified name of the enterprise bean's remote interface.

Example:
<remote>com.wombat.empl.EmployeeService</remote>
-->

<!ELEMENT remote (#PCDATA)>

<!-- The ejb-link element is used in the ejb-ref or ejb-local-ref elements to specify that an EJB reference is linked to another enterprise bean. The value of the ejb-link element must be the ejb-name of an enterprise bean in the same J2EE application unit. The name in the ejb-link element may be composed of a path name specifying the ejb-jar containing the referenced enterprise bean with the ejb-name of the target bean appended and separated from the path name by "#". The path name is relative to the SAR containing the servlet application that is referencing the enterprise bean. This allows multiple enterprise beans with the same ejb-name to be uniquely identified.

Examples:
<ejb-link>EmployeeRecord</ejb-link>
<ejb-link>./products/product.jar#ProductEJB</ejb-link>
-->

<!ELEMENT ejb-link (#PCDATA)>

<!-- The ejb-local-ref element is used for the declaration of a reference to an enterprise bean's local home. The declaration consists of: - an optional description - the EJB reference name used in the code of THE_COMPONENT that's referencing the enterprise bean - the expected type of the referenced enterprise bean - the expected local home and local interfaces of the referenced enterprise bean - optional ejb-link information, used to specify the referenced enterprise bean -->

<!ELEMENT ejb-local-ref (description?, ejb-ref-name, ejb-ref-type, local-home, local, ejb-link?)>

<!-- The local element contains the fully-qualified name of the enterprise bean's local interface. Used by ejb-local-ref -->

<!ELEMENT local (#PCDATA)>

<!-- The local-home element contains the fully-qualified name of the enterprise bean's local home interface. Used by ejb-local-ref -->
<!ELEMENT local-home (#PCDATA)>

<!-- The run-as element, if defined for a servlet, overrides the security identity used to call an EJB by that servlet in this servlet application. The role-name is one of the security roles already defined for this servlet application. Used by: <servlet> -->

<!ELEMENT run-as (description?, role-name)>

<!-- The ID mechanism is to allow tools to easily make tool-specific references to the elements of the deployment descriptor. This allows tools that produce additional deployment information (i.e information beyond the standard deployment descriptor information) to store the non-standard information in a separate file, and easily refer from these tools-specific files to the information in the standard sip-app deployment descriptor. -->

<!ATTLIST sip-app id ID #IMPLIED>
<!ATTLIST icon id ID #IMPLIED>
<!ATTLIST small-icon id ID #IMPLIED>
<!ATTLIST large-icon id ID #IMPLIED>
<!ATTLIST display-name id ID #IMPLIED>
<!ATTLIST description id ID #IMPLIED>
<!ATTLIST distributable id ID #IMPLIED>
<!ATTLIST context-param id ID #IMPLIED>
<!ATTLIST param-name id ID #IMPLIED>
<!ATTLIST param-value id ID #IMPLIED>
<!ATTLIST listener id ID #IMPLIED>
<!ATTLIST listener-class id ID #IMPLIED>
<!ATTLIST servlet id ID #IMPLIED>
<!ATTLIST servlet-name id ID #IMPLIED>
<!ATTLIST servlet-class id ID #IMPLIED>
<!ATTLIST init-param id ID #IMPLIED>
<!ATTLIST load-on-startup id ID #IMPLIED>
<!ATTLIST servlet-mapping id ID #IMPLIED>
<!ATTLIST proxy-config id ID #IMPLIED>
<!ATTLIST sequential-search-timeout id ID #IMPLIED>
<!ATTLIST session-config id ID #IMPLIED>
<!ATTLIST session-timeout id ID #IMPLIED>
<!ATTLIST resource-env-ref id ID #IMPLIED>
<!ATTLIST resource-env-ref-name id ID #IMPLIED>
<!ATTLIST resource-env-ref-type id ID #IMPLIED>
<!ATTLIST resource-ref id ID #IMPLIED>
<!ATTLIST res-ref-name id ID #IMPLIED>
<!ATTLIST res-type id ID #IMPLIED>
<!ATTLIST res-auth id ID #IMPLIED>
<!ATTLIST res-sharing-scope id ID #IMPLIED>
<!ATTLIST security-constraint id ID #IMPLIED>
<!ATTLIST resource-collection id ID #IMPLIED>
14.6 Examples

14.6.2 A Basic Example

<sip-app>
  <display-name>A Simple SIP Application</display-name>
  <context-param>
    <param-name>vxml-server</param-name>
    <param-value>sip:server17@vxml.example.com</param-value>
  </context-param>
</sip-app>
Deployment Descriptor

```xml
<context-param>
  <servlet>
    <servlet-name>WeatherService</servlet-name>
    <servlet-class>com.example.Weather</servlet-class>
    <init-param>
      <param-name>weather-server</param-name>
      <param-value>http://example.com/weather</param-value>
    </init-param>
  </servlet>
</context-param>

<servlet-mapping>
  <servlet-name>WeatherService</servlet-name>
  <pattern>
    <and>
      <equal>
        <var>request.method</var>
        <value>INVITE</value>
      </equal>
      <equal>
        <var>request.from.uri.user</var>
        <value>weather</value>
      </equal>
    </and>
  </pattern>
</servlet-mapping>

<session-config>
  <session-timeout>30</session-timeout>
</session-config>
</sip-app>
```
Deployment Descriptor
A References


B Glossary

Address-of-Record  An address-of-record (AOR) is a SIP or SIPS URI that points to a domain with a location service that can map the URI to another URI where the user might be available. Typically, the location service is populated through registrations. An AOR is frequently thought of as the “public address” of the user.

Application developer  The producer of a SIP application. The output of an application developer is a set of servlet classes and supporting libraries and files (such as images, compressed archive files, etc.) for the servlet application. The application developer is typically an application domain expert. The developer is required to be aware of the servlet environment and its consequences when programming, including concurrency considerations, and create the SIP application accordingly.

Application assembler  Takes the output of the application developer and ensures that it is a deployable unit. Thus, the input of the application assembler is the servlet classes, JSP pages, HTML pages, and other supporting libraries and files for the servlet application. The output of the application assembler is a servlet application archive or a servlet application in an open directory structure.

Application path  A list of application instances to be invoked for incoming messages belonging to a particular dialog. This list is constructed as a side effect of the handling of the initial request and consists of the application acting as a UAC if the initial request was created within the container, the application acting as UAS if an application responded to the initial request, as well as all applications that proxied with record-routing enabled. The application path is a logical concept and may or may not be explicitly represented by implementations.

Application session  Represents application instances. Application sessions acts as a store for application data and provides access to contained protocol sessions.

Back-To-Back User Agent  A back-to-back user agent (B2BUA) is a logical entity that receives a request and processes it as an user agent server (UAS). In order to determine how the request should be answered, it acts as an user agent client (UAC) and generates requests. Unlike a proxy server, it maintains dialog state and must participate in all requests sent on the dialogs it has established. Since it is a concatenation of a UAC and UAS, no explicit definitions are needed for its behavior.

Call  A call is an informal term that refers to some communication between peers generally set up for the purposes of a multimedia conversation.

Call leg  Another name for a dialog [RFC 2543]; not used in the revised SIP specification [bis-09].
<table>
<thead>
<tr>
<th>Glossary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Call Stateful</strong></td>
<td>A proxy is call stateful if it retains state for a dialog from the initiating INVITE to the terminating BYE request. A call stateful proxy is always transaction stateful, but the converse is not necessarily true.</td>
</tr>
<tr>
<td><strong>Client</strong></td>
<td>A client is any network element that sends SIP requests and receives SIP responses. Clients may or may not interact directly with a human user. User agent clients and proxies are clients.</td>
</tr>
<tr>
<td><strong>Committed message</strong></td>
<td>A SIP message object that has been fully processed according to this specification and that should not be further modified, see section 6.2.</td>
</tr>
<tr>
<td><strong>Conference</strong></td>
<td>A multimedia session that contains multiple participants.</td>
</tr>
<tr>
<td><strong>Default servlet</strong></td>
<td>The first servlet listed in the deployment descriptor.</td>
</tr>
<tr>
<td><strong>Deployer</strong></td>
<td>The deployer takes one or more servlet application archive files or other directory structures provided by an application developer and deploys the application into a specific operational environment. The operational environment includes a specific servlet container and SIP server. The deployer must resolve all the external dependencies declared by the developer. To perform his role, the deployer uses tools provided by the servlet container provider.</td>
</tr>
<tr>
<td></td>
<td>The deployer is an expert in a specific operational environment. For example, the deployer is responsible for mapping the security roles defined by the application developer to the user groups and accounts that exist in the operational environment where the servlet application is deployed.</td>
</tr>
<tr>
<td><strong>Dialog</strong></td>
<td>A dialog is a peer-to-peer SIP relationship between two UAs that persists for some time. A dialog is established by SIP messages, such as a 2xx response to an INVITE request. A dialog is identified by a call identifier, local tag, and a remote tag. A dialog was formerly known as a call leg in RFC 2543.</td>
</tr>
<tr>
<td></td>
<td>The baseline SIP specification defines only INVITE–BYE as a mechanism of establishing and terminating dialogs but allows extensions to define other methods capable of initiating dialogs. The SUBSCRIBE/NOTIFY methods defined by the event framework is an example of this [SIP Events].</td>
</tr>
<tr>
<td><strong>Downstream</strong></td>
<td>A direction of message forwarding within a transaction that refers to the direction that requests flow from the user agent client to user agent server.</td>
</tr>
<tr>
<td><strong>Final response</strong></td>
<td>A response that terminates a SIP transaction, as opposed to a provisional response that does not. All 2xx, 3xx, 4xx, 5xx and 6xx responses are final.</td>
</tr>
<tr>
<td><strong>Header</strong></td>
<td>A header is a component of a SIP message that conveys information about the message. It is structured as a sequence of header fields.</td>
</tr>
<tr>
<td><strong>Header field</strong></td>
<td>A header field is a component of the SIP message header. It consists of one or more header field values separated by comma or having the same header field name.</td>
</tr>
<tr>
<td><strong>Header field value:</strong></td>
<td>A header field value is a singular value, which can be one of many in a header field.</td>
</tr>
</tbody>
</table>
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home Domain</strong></td>
<td>The domain providing service to a SIP user. Typically, this is the domain present in the URI in the address-of-record of a registration.</td>
</tr>
<tr>
<td><strong>Informational Response</strong></td>
<td>Same as a provisional response.</td>
</tr>
<tr>
<td><strong>Initial request</strong></td>
<td>A request that is dispatched to applications based on rule matching rather than on an existing application path. Compare with subsequent request.</td>
</tr>
<tr>
<td><strong>Initiator, calling party, caller</strong></td>
<td>The party initiating a session (and dialog) with an INVITE request. A caller retains this role from the time it sends the initial INVITE that established a dialog until the termination of that dialog.</td>
</tr>
<tr>
<td><strong>Invitation</strong></td>
<td>An INVITE request.</td>
</tr>
<tr>
<td><strong>Invitee, invited user, called party, callee</strong></td>
<td>The party that receives an INVITE request for the purposes of establishing a new session. A callee retains this role from the time it receives the INVITE until the termination of the dialog established by that INVITE.</td>
</tr>
<tr>
<td><strong>Location server</strong></td>
<td>See location service.</td>
</tr>
<tr>
<td><strong>Location service</strong></td>
<td>A location service is used by a SIP redirect or proxy server to obtain information about a callee's possible location(s). It contains a list of bindings of address-of-record keys to zero or more contact addresses. The bindings can be created and removed in many ways; this specification defines a REGISTER method that updates the bindings.</td>
</tr>
<tr>
<td><strong>Loose Routing</strong></td>
<td>A proxy is said to be loose routing if it follows the procedures defined in this specification for processing of the Route header field. These procedures separate the destination of the request (present in the Request-URI) from the set of proxies that need to be visited along the way (present in the Route header field). A proxy compliant to these mechanisms is also known as a loose router.</td>
</tr>
<tr>
<td><strong>Message</strong></td>
<td>Data sent between SIP elements as part of the protocol. SIP messages are either requests or responses.</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td>The method is the primary function that a request is meant to invoke on a server. The method is carried in the request message itself. Example methods are INVITE and BYE.</td>
</tr>
<tr>
<td><strong>Outbound proxy</strong></td>
<td>A proxy that receives requests from a client, even though it may not be the server resolved by the Request-URI. Typically, a UA is manually configured with an outbound proxy, or can learn about one through auto-configuration protocols.</td>
</tr>
<tr>
<td><strong>Parallel search</strong></td>
<td>In a parallel search, a proxy issues several requests to possible user locations upon receiving an incoming request. Rather than issuing one request and then waiting for the final response before issuing the next request as in a sequential search, a parallel search issues requests without waiting for the result of previous requests.</td>
</tr>
</tbody>
</table>
| **Principal** | A principal is an entity that can be authenticated by an authentication protocol. A principal is identified by a principal name and authenticated by using authentication-
Glossary

Protocol session  Common name for protocol specific session objects. A protocol session represents a point-to-point signaling relationship and serves as a repository for application data relating to that relationship. Examples include the SipSession and HttpSession interfaces defined by the SIP and HTTP servlet specifications, respectively. A number of protocol sessions may belong to a single application session.

Provisional response  A response used by the server to indicate progress, but that does not terminate a SIP transaction. 1xx responses are provisional, other responses are considered final. Provisional responses are not sent reliably.

Proxy, proxy server  An intermediary entity that acts as both a server and a client for the purpose of making requests on behalf of other clients. A proxy server primarily plays the role of routing, which means its job is to ensure that a request is sent to another entity "closer" to the targeted user. Proxies are also useful for enforcing policy (for example, making sure a user is allowed to make a call). A proxy interprets, and, if necessary, rewrites specific parts of a request message before forwarding it.

Recursion  A client recurses on a 3xx response when it generates a new request to one or more of the URIs in the Contact header field in the response.

Redirect server  A redirect server is a user agent server that generates 3xx responses to requests it receives, directing the client to contact an alternate set of URIs.

Registrar  A registrar is a server that accepts REGISTER requests and places the information it receives in those requests into the location service for the domain it handles.

Regular transaction  A regular transaction is any transaction with a method other than INVITE, ACK, or CANCEL.

Request  A SIP message sent from a client to a server, for the purpose of invoking a particular operation.

Response  A SIP message sent from a server to a client, for indicating the status of a request sent from the client to the server.

Ringback  Ringback is the signaling tone produced by the calling party's application indicating that a called party is being alerted (ringing).

Role (development)  The actions and responsibilities taken by various parties during the development, deployment, and running of a servlet application. In some scenarios, a single party may perform several roles; in others, each role may be performed by a different party.

Role (security)  An abstract notion used by an application developer in an application that can be mapped by the Deployer to a user, or group of users, in a security policy domain.
### Glossary

**Route set**  
A route set is a collection of ordered SIP or SIPS URI which represent a list of proxies that must be traversed when sending a particular request. A route set can be learned, through headers like `Record-Route`, or it can be configured.

**Security policy domain**  
The scope over which security policies are defined and enforced by a security administrator of the security service. A security policy domain is also sometimes referred to as a *realm*.

**Security technology domain**  
The scope over which the same security mechanism, such as Kerberos, is used to enforce a security policy. Multiple security policy domains can exist within a single technology domain.

**Server**  
A server is a network element that receives requests in order to service them and sends back responses to those requests. Examples of servers are proxies, user agent servers, redirect servers, and registrars.

**Sequential Search**  
In a sequential search, a proxy server attempts each contact address in sequence, proceeding to the next one only after the previous has generated a final response. A 2xx or 6xx class final response always terminates a sequential search.

**Servlet application archive**  
A single file that contains all of the components of a servlet application. This archive file is created by using standard JAR tools which allow any or all of the application components to be signed. Servlet application archive files are identified by the `.sar` extension. The SAR file layout is derived from the Web application archive (.war) file format but may contain servlets and deployment descriptors pertaining to different protocols, for example SIP and HTTP.

**Servlet Container Provider**  
A vendor that provides the runtime environment, namely the servlet container and possibly the SIP server, in which a servlet application runs as well as the tools necessary to deploy servlet applications.

The expertise of the container provider is in HTTP-level programming. Since this specification does not specify the interface between the SIP server and the servlet container, it is left to the container provider to split the implementation of the required functionality between the container and the server.

**Servlet definition**  
A unique name associated with a fully qualified class name of a class implementing the `Servlet` interface. A set of initialization parameters can be associated with a servlet definition.

**Servlet mapping**  
A servlet definition that is associated by a servlet container with a URL path pattern. All requests to that path pattern are handled by the servlet associated with the servlet definition.

**Session**  
From the SDP specification: "A multimedia session is a set of multimedia senders and receivers and the data streams flowing from senders to receivers. A multimedia conference is an example of a multimedia session." [RFC 2327] (A session as defined for SDP can comprise one or more RTP sessions.) As defined, a callee can be invited several times, by different calls, to the same session. If
Glossary

SDP is used, a session is defined by the concatenation of the user name, session id, network type, address type and address elements in the origin field.

**SIP application**
A collection of SIP servlets and static resources which might include voice prompts, grammars, VoiceXML scripts, and other data. A SIP application may be packaged into an archive or exist in an open directory structure.

All compatible servlet containers must accept a SIP application and perform a deployment of its contents into their runtime. This may mean that a container can run the application directly from a servlet application archive file or it may mean that it will move the contents of a servlet application into the appropriate locations for that particular container.

SIP applications are to the SIP Servlet API what web applications are to the HTTP Servlet API.

**SIP transaction**
A SIP transaction occurs between a client and a server and comprises all messages from the first request sent from the client to the server up to a final (non-1xx) response sent from the server to the client. If the request is INVITE and the final response is a non-2xx, the transaction also includes an ACK to the response. The ACK for a 2xx response to an INVITE request is a separate transaction.

**SIP/web application, distributable**
A SIP or web application that is written so that it can be deployed in a servlet container distributed across multiple Java virtual machines running on the same host or different hosts. The deployment descriptor for such an application uses the `distributable` element.

**Stateful Proxy**
A logical entity that maintains the client and server transaction state machines defined by this specification during the processing of a request. Also known as a transaction stateful proxy. The behavior of a stateful proxy is further defined in Section 16. A (transaction) stateful proxy is not the same as a call stateful proxy.

**Stateless Proxy**
A logical entity that does not maintain the client or server transaction state machines defined in this specification when it processes requests. A stateless proxy forwards every request it receives downstream and every response it receives upstream.

**Strict routing**
A proxy is said to be strict routing if it follows the Route processing rules of RFC 2543 and many prior Internet Draft versions of RFC 3261. That rule caused proxies to destroy the contents of the Request-URI when a Route header field was present. Strict routing behavior is not used in RFC 3261, in favor of a loose routing behavior. Proxies that perform strict routing are also known as strict routers.

**Subsequent request**
A request which is dispatched to applications based on an existing application path established while processing an earlier initial request belonging to the same dialog.

**System Administrator**
The person responsible for the configuration and administration of the servlet container. The administrator is also responsible for overseeing the well-being of the deployed applications at run time.
This specification does not define the contracts for system management and administration. The administrator typically uses runtime monitoring and management tools provided by the container provider and server vendors to accomplish these tasks.

| **System headers** | Headers that are managed by the SIP servlet container and which servlets must not attempt to modify directly via calls to setHeader or addHeader. This includes Call-ID, From, To, CSeq, Via, Record-Route, Route, as well as Contact when used to specify a session signaling address, for example, in INVITEs and 200 response to INVITEs. System headers are discussed in section 6.4.1. |
| **TLS** | Transport Layer Security. A layer four means of protecting TCP connections providing integrity, confidentiality, replay protection, and authentication. |
| **Uniform resource locator (URL)** | A compact string representation of information for location and access of resources via the Internet [RFC 1738]. SIP and SIPS URIs are syntactically similar to mailto URLs, that is, they are typically of the form sip:user@host. The user part is a user name or a telephone number. The host part is either a fully qualified domain name or a numeric IP address. SIP URIs are used within SIP messages to indicate the originator (From), current destination (Request-URI) and final recipient (To) of a SIP request, and to specify redirection addresses (Contact). When used as a hyperlink (for example in a Web page) a SIP URI indicates that the specified user or service can be contacted using SIP. |
| **Upstream** | A direction of message forwarding within a transaction that refers to the direction that responses flow from the user agent server back to the user agent client. |
| **URL-encoded** | A character string encoded according to RFC 1738 [RFC 1738, section 2.2]. |
| **User agent client (UAC)** | A user agent client is a logical entity that creates a new request, and then uses the client transaction state machinery to send it. The role of UAC lasts only for the duration of that transaction. In other words, if a piece of software initiates a request, it acts as a UAC for the duration of that transaction. If it receives a request later, it assumes the role of a user agent server for the processing of that transaction. |
| **User agent server (UAS)** | A user agent server is a logical entity that generates a response to a SIP request. The response accepts, rejects, or redirects the request. This role lasts only for the duration of that transaction. In other words, if a piece of software responds to a request, it acts as a UAS for the duration of that transaction. If it generates a request later, it assumes the role of a user agent client for the processing of that transaction. |
| **User agent (UA)** | A logical entity that can act as both a user agent client and user agent server. |
| **Web application** | A collection of servlets, JSP pages, HTML documents, and other web resources which might include image files, compressed archives, and other data. A web |
application may be packaged into an archive or exist in an open directory structure.

All compatible servlet containers must accept a web application and perform a deployment of its contents into their runtime. This may mean that a container can run the application directly from a web application archive file or it may mean that it will move the contents of a web application into the appropriate locations for that particular container.

Web application archive
A single file that contains all of the components of a web application. This archive file is created by using standard JAR tools which allow any or all of the web components to be signed. Web application archive files are identified by the .war extension. A new extension is used instead of .jar because that extension is reserved for files which contain a set of class files and that can be placed in the classpath or double clicked using a GUI to launch an application. As the contents of a web application archive are not suitable for such use, a new extension was in order.