```
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- these URL's may have to be expanded to their full and proper locations -->

    <!-- include the schema files for the building block types -->
    <include schemaLocation="smil20-utility.xsd"/>
    <include schemaLocation="smil20-layout.xsd"/>
    <include schemaLocation="smil20-struct.xsd"/>
    <include schemaLocation="smil20-animate.xsd"/>
    <include schemaLocation="smil20-media.xsd"/>
    <include schemaLocation="smil20-content.xsd"/>
    <include schemaLocation="smil20-linking.xsd"/>
    <include schemaLocation="smil20-meta.xsd"/>
    <include schemaLocation="smil20-timemanip.xsd"/>
    <include schemaLocation="smil20-transitions.xsd"/>
    <include schemaLocation="smil20-timing.xsd"/>

    <!-- import the smil20 language namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/Language" schemaLocation="smil20-language.xsd"/>

    <!-- import the definitions in the modules namespaces -->
    <import namespace="http://www.w3.org/2001/SMIL20/AccessKeyTiming" schemaLocation="smil20-AccessKeyTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/AudioLayout" schemaLocation="smil20-AudioLayout.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicAnimation" schemaLocation="smil20-BasicAnimation.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicContentControl" schemaLocation="smil20-BasicContentControl.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming" schemaLocation="smil20-BasicInlineTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicLayout" schemaLocation="smil20-BasicLayout.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicLinking" schemaLocation="smil20-BasicLinking.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicMedia" schemaLocation="smil20-BasicMedia.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicTimeContainers" schemaLocation="smil20-BasicTimeContainers.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BasicTransitions" schemaLocation="smil20-BasicTransitions.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/BrushMedia" schemaLocation="smil20-BrushMedia.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/CustomTestAttributes" schemaLocation="smil20-CustomTestAttributes.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/EventTiming" schemaLocation="smil20-EventTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/ExclTimeContainers" schemaLocation="smil20-ExclTimeContainers.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/FillDefault" schemaLocation="smil20-FillDefault.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/HierarchicalLayout" schemaLocation="smil20-HierarchicalLayout.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/InlineTransitions" schemaLocation="smil20-InlineTransitions.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/LinkingAttributes" schemaLocation="smil20-LinkingAttributes.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaAccessibility" schemaLocation="smil20-MediaAccessibility.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaClipMarkers" schemaLocation="smil20-MediaClipMarkers.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaClipping" schemaLocation="smil20-MediaClipping.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaDescription" schemaLocation="smil20-MediaDescription.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaMarkerTiming" schemaLocation="smil20-MediaMarkerTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MediaParam" schemaLocation="smil20-MediaParam.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/Metainformation" schemaLocation="smil20-Metainformation.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MinMaxTiming" schemaLocation="smil20-MinMaxTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MultiArcTiming" schemaLocation="smil20-MultiArcTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/MultiWindowLayout" schemaLocation="smil20-MultiWindowLayout.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/PrefetchControl" schemaLocation="smil20-PrefetchControl.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/RepeatTiming" schemaLocation="smil20-RepeatTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/RepeatValueTiming" schemaLocation="smil20-RepeatValueTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/RestartDefault" schemaLocation="smil20-RestartDefault.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/RestartTiming" schemaLocation="smil20-RestartTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/SkipContentControl" schemaLocation="smil20-SkipContentControl.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/Structure" schemaLocation="smil20-Structure.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/SyncbaseTiming" schemaLocation="smil20-SyncbaseTiming.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/SyncBehavior" schemaLocation="smil20-SyncBehavior.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/SyncBehaviorDefault" schemaLocation="smil20-SyncBehaviorDefault.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/SyncMaster" schemaLocation="smil20-SyncMaster.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/TimeContainerAttributes" schemaLocation="smil20-TimeContainerAttributes.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/TimeManipulations" schemaLocation="smil20-TimeManipulations.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/TransitionModifiers" schemaLocation="smil20-TransitionModifiers.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/WallclockTiming" schemaLocation="smil20-WallclockTiming.xsd"/>

    <!-- import the definitions in the module collection namespaces -->
    <import namespace="http://www.w3.org/2001/SMIL20/HostLanguage" schemaLocation="smil20-HostLanguage.xsd"/>
    <import namespace="http://www.w3.org/2001/SMIL20/IntegrationSet" schemaLocation="smil20-IntegrationSet.xsd"/>

</schema>
```

B.1.2 The SMIL Animation Module

```
<!--
XML Schema for the SMIL 2.0 Animation functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-animate.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!--
        in general, an integration language should include only
        one of "animTargetAttrs" and "animTargetXLinkAttrs"
    -->
    <attributeGroup name="animTargetAttrs">
        <attribute name="targetElement" type="IDREF" use="optional" />
    </attributeGroup>

    <attributeGroup name="animTargetXLinkAttrs">
        <attribute name="actuate" use="optional"  default="onLoad">
            <simpleType>
                <restriction base="string">
                    <enumeration value="onRequest"/>
                </restriction>
            </simpleType>
        </attribute>

        <attribute name="href" type="anyURI" use="optional"/>

        <attribute name="show" use="optional"  default="embed">
            <simpleType>
                <restriction base="string">
                    <enumeration value="new"/>
                    <enumeration value="embed"/>
                    <enumeration value="replace"/>
                </restriction>
            </simpleType>
        </attribute>
```

```
    <attribute name="type" use="optional"  default="simple">
        <simpleType>
            <restriction base="string">
                <enumeration value="simple"/>
                <enumeration value="extended"/>
                <enumeration value="locator"/>
                <enumeration value="arc"/>
            </restriction>
        </simpleType>
    </attribute>
</attributeGroup>

<attributeGroup name="animNamedTargetAttrs">
    <attribute name="attributeName" type="string" use="required"/>
    <attribute name="attributeType" use="optional"  default="auto">
        <simpleType>
            <restriction base="string">
                <enumeration value="XML"/>
                <enumeration value="CSS"/>
                <enumeration value="auto"/>
            </restriction>
        </simpleType>
    </attribute>
</attributeGroup>

<!--
    'spline' is only included with SplineAnimation module,
     but it is not clear how to exclude it otherwise, so we
     have two otherwise identical attribute groups, 'animModeAttrs'
     and 'animSplineModeAttrs', that only differ by included the 'spline'
     attribute value. Use one or the other of these.
-->
<attributeGroup name="animModeAttrs">
    <attribute name="calcMode" use="optional"  default="linear">
        <simpleType>
            <restriction base="string">
                <enumeration value="discrete"/>
                <enumeration value="linear"/>
                <enumeration value="paced"/>
            </restriction>
        </simpleType>
    </attribute>
</attributeGroup>

<attributeGroup name="animSplineModeAttrs">
    <attribute name="calcMode" use="optional"  default="linear">
        <simpleType>
            <restriction base="string">
                <enumeration value="discrete"/>
                <enumeration value="linear"/>
                <enumeration value="paced"/>
                <enumeration value="spline"/>
            </restriction>
        </simpleType>
    </attribute>
</attributeGroup>

<!--
    include the next two attribute groups only if the
    SplineAnimation module is included
-->
<attributeGroup name="splineAnimValueAttrs">
    <attribute name="keyTimes" type="string" use="optional"/>
    <attribute name="keySplines" type="string" use="optional"/>
</attributeGroup>

<attributeGroup name="splineAnimPathAttrs">
    <attribute name="path" type="string" use="optional"/>
</attributeGroup>

<attributeGroup name="animAddAccumAttrs">
    <attribute name="additive" use="optional"  default="replace">
        <simpleType>
            <restriction base="string">
                <enumeration value="replace"/>
                <enumeration value="sum"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="accumulate" use="optional"  default="none">
            <restriction base="string">
                <enumeration value="none"/>
                <enumeration value="sum"/>
            </restriction>
        </simpleType>
    </attribute>
</attributeGroup>

<attributeGroup name="animSetValuesAttrs">
    <attribute name="to" use="optional" type="string"/>
</attributeGroup>

<attributeGroup name="animValuesAttrs">
    <attributeGroup ref="smil20:animSetValuesAttrs"/>
    <attribute name="from" use="optional" type="string"/>
    <attribute name="by" use="optional" type="string"/>
    <attribute name="values" use="optional" type="string"/>
</attributeGroup>

<complexType name="animatePrototype">
    <attributeGroup ref="smil20:animNamedTargetAttrs"/>
    <attributeGroup ref="smil20:animAddAccumAttrs"/>
    <attributeGroup ref="smil20:animValuesAttrs"/>
</complexType>

<complexType name="setPrototype">
    <attributeGroup ref="smil20:animNamedTargetAttrs"/>
    <attributeGroup ref="smil20:animSetValuesAttrs"/>
</complexType>

<complexType name="animateMotionPrototype">
    <attributeGroup ref="smil20:animAddAccumAttrs"/>
    <attributeGroup ref="smil20:animValuesAttrs"/>
    <attribute name="origin" type="string" use="optional"/>
</complexType>

<complexType name="animateColorPrototype">
    <attributeGroup ref="smil20:animNamedTargetAttrs"/>
    <attributeGroup ref="smil20:animAddAccumAttrs"/>
    <attributeGroup ref="smil20:animValuesAttrs"/>
</complexType>

<!-- global animate element -->
```

```
    <element name="animate" type="smil20lang:animateType" substitutionGroup="smil20lang:animate"/>
    <complexType name="animateType">
        <complexContent>
            <extension base="smil20:animatePrototype">
                <choice minOccurs="0" maxOccurs="unbounded">
                    <any namespace="##other" processContents="lax"/>
                </choice>
                <attributeGroup ref="smil20:animTargetAttrs"/>
                <attributeGroup ref="smil20:skipContentAttrs"/>
                <attributeGroup ref="smil20:animSplineModeAttrs"/>
                <attributeGroup ref="smil20:splineAnimValueAttrs"/>
                <attributeGroup ref="smil20:splineAnimPathAttrs"/>
                <anyAttribute namespace="##any" processContents="strict"/>
            </extension>
        </complexContent>
    </complexType>

    <!-- global animateMotion element -->
    <element name="animateMotion" type="smil20lang:animateMotionType" substitutionGroup="smil20lang:animateMotion"/>
    <complexType name="animateMotionType">
        <complexContent>
            <extension base="smil20:animateMotionPrototype">
                <choice minOccurs="0" maxOccurs="unbounded">
                    <any namespace="##other" processContents="lax"/>
                </choice>
                <attributeGroup ref="smil20:animTargetAttrs"/>
                <attributeGroup ref="smil20:skipContentAttrs"/>
                <attributeGroup ref="smil20:animSplineModeAttrs"/>
                <attributeGroup ref="smil20:splineAnimValueAttrs"/>
                <attributeGroup ref="smil20:splineAnimPathAttrs"/>
                <anyAttribute namespace="##any" processContents="strict"/>
            </extension>
        </complexContent>
    </complexType>

    <!-- global animateColor element -->
    <element name="animateColor" type="smil20lang:animateColorType" substitutionGroup="smil20lang:animateColor"/>
    <complexType name="animateColorType">
        <complexContent>
            <extension base="smil20:animateColorPrototype">
                <choice minOccurs="0" maxOccurs="unbounded">
                    <any namespace="##other" processContents="lax"/>
                </choice>
                <attributeGroup ref="smil20:animTargetAttrs"/>
                <attributeGroup ref="smil20:skipContentAttrs"/>
                <attributeGroup ref="smil20:animSplineModeAttrs"/>
                <attributeGroup ref="smil20:splineAnimValueAttrs"/>
                <attributeGroup ref="smil20:splineAnimPathAttrs"/>
                <anyAttribute namespace="##any" processContents="strict"/>
            </extension>
        </complexContent>
    </complexType>

    <!-- global set element -->
    <element name="set" type="smil20lang:setType" substitutionGroup="smil20lang:set"/>
</schema>
```

B.1.3 The SMIL Content Control Module

```
<!--
XML Schema for the SMIL 2.0 Content Control functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-content.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 content control attributes.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- utility type for test attribute values -->
    <simpleType name="onOrOffType">
        <restriction base="string">
            <enumeration value="on"/>
            <enumeration value="off"/>
        </restriction>
    </simpleType>

    <simpleType name="overdubOrSubtitleType">
        <restriction base="string">
            <enumeration value="overdub"/>
            <enumeration value="subtitle"/>
        </restriction>
    </simpleType>

    <simpleType name="overdubOrCaptionsType">
        <restriction base="string">
            <enumeration value="overdub"/>
            <enumeration value="caption"/>
        </restriction>
    </simpleType>

    <!-- is there a type for a namespace prefix? -->
    <!-- currently using NMTOKEN -->

    <!-- global system test attributes-->
    <attribute name="systemAudioDesc" type="smil20:onOrOffType"/>
    <attribute name="systemBitrate" type="string"/>
    <attribute name="systemCaptions" type="smil20:onOrOffType"/>
    <attribute name="systemComponent" type="string"/>
    <attribute name="systemCPU" type="NMTOKEN"/>
    <attribute name="systemLanguage" type="string"/>
    <attribute name="systemOperatingSystem" type="NMTOKEN"/>
    <attribute name="systemOverdubOrSubtitle" type="smil20:overdubOrSubtitleType"/>
    <attribute name="systemRequired" type="string"/>
    <attribute name="systemScreenDepth" type="positiveInteger"/>
    <attribute name="systemScreenSize" type="string"/>

    <!-- system test attribute group -->
    <attributeGroup name="systemTestAttrs">
        <attribute name="systemAudioDesc" type="smil20:onOrOffType" use="optional"/>
        <attribute name="systemBitrate" type="string" use="optional"/>
        <attribute name="systemCaptions" type="smil20:onOrOffType" use="optional"/>
        <attribute name="systemComponent" type="string" use="optional"/>
```

```
        <attribute name="systemCPU" type="NMTOKEN" use="optional"/>
        <attribute name="systemLanguage" type="string" use="optional"/>
        <attribute name="systemOperatingSystem" type="NMTOKEN" use="optional"/>
        <attribute name="systemOverdubOrSubtitle" type="smil20:overdubOrSubtitleType" use="optional"/>
        <attribute name="systemRequired" type="string" use="optional"/>
        <attribute name="systemScreenDepth" type="positiveInteger" use="optional"/>
        <attribute name="systemScreenSize" type="string" use="optional"/>
    </attributeGroup>

    <!-- deprecated global system test attributes-->
    <attribute name="system-bitrate" type="string"/>
    <attribute name="system-captions" type="smil20:onOrOffType"/>
    <attribute name="system-language" type="string"/>
    <attribute name="system-overdub-or-caption" type="smil20:overdubOrCaptionsType"/>
    <attribute name="system-required" type="string"/>
    <attribute name="system-screen-depth" type="positiveInteger"/>
    <attribute name="system-screen-size" type="string"/>

    <!-- deprecated system test attribute group -->
    <attributeGroup name="deprecatedSystemTestAttrs">
        <attribute name="system-bitrate" type="string" use="optional"/>
        <attribute name="system-captions" type="smil20:onOrOffType" use="optional"/>
        <attribute name="system-language" type="string" use="optional"/>
        <attribute name="system-overdub-or-caption" type="smil20:overdubOrCaptionsType" use="optional"/>
        <attribute name="system-required" type="string" use="optional"/>
        <attribute name="system-screen-depth" type="positiveInteger" use="optional"/>
        <attribute name="system-screen-size" type="string" use="optional"/>
    </attributeGroup>
```

```
    <!-- define the switch element prototype -->
    <complexType name="switchPrototype">
        <attributeGroup ref="smil20:systemTestAttrs"/>
    </complexType>

    <!-- define the global customTest attribute -->
    <attribute name="customTest" type="string"/>

    <!-- define the customTest attribute group -->
    <attributeGroup name="customTestAttrs">
        <attribute name="customTest" type="string" use="optional"/>
    </attributeGroup>

    <!-- define the global skip-content attribute -->
    <attribute name="skip-content" type="boolean"/>

    <!-- define the skip-content attribute group -->
    <attributeGroup name="skipContentAttrs">
        <attribute name="skip-content" type="boolean" use="optional"  default="true"/>
    </attributeGroup>

    <!-- define the customTest element prototype -->
    <complexType name="customTestPrototype">
        <attribute name="defaultState" type="boolean" use="optional"  default="false"/>

        <attribute name="override" use="optional"  default="hidden">
            <simpleType>
                <restriction base="string">
                    <enumeration value="visible"/>
                    <enumeration value="hidden"/>
                </restriction>
            </simpleType>
        </attribute>

        <attribute name="uid" type="anyURI" use="optional"/>
    </complexType>

    <!-- define the customAttributes element prototype -->
    <complexType name="customAttributesPrototype">
    </complexType>

    <!-- define the prefetch element prototype -->
    <complexType name="prefetchPrototype">
        <attribute name="src" type="anyURI" use="optional"/>
        <attribute name="mediaSize" type="string" use="optional"/>
        <attribute name="mediaTime" type="string" use="optional"/>
        <attribute name="bandwidth" type="string" use="optional"/>
    </complexType>
```

```
    <element name="switch" type="smil20lang:switchType" substitutionGroup="smil20lang:switch"/>
    <element name="prefetch" type="smil20lang:prefetchType" substitutionGroup="smil20lang:prefetch"/>
    <element name="customAttributes" type="smil20lang:customAttributesType" substitutionGroup="smil20lang:customAttributes"/>
    <element name="customTest" type="smil20lang:customTestType" substitutionGroup="smil20lang:customTest"/>

</schema>
```

B.1.4 The SMIL Layout Module

```
<!--
XML Schema for the SMIL 2.0 Layout functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-layout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 layout attributes.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- utility type for CSS style dimension attribute values -->
    <simpleType name="autoOrInheritType">
        <restriction base="string">
            <enumeration value="auto"/>
            <enumeration value="inherit"/>
        </restriction>
```

```
</simpleType>

<!-- utility type for fit attribute values -->
<simpleType name="fitAttributeType">
    <restriction base="string">
        <enumeration value="fill"/>
        <enumeration value="hidden"/>
        <enumeration value="meet"/>
        <enumeration value="scroll"/>
        <enumeration value="slice"/>
    </restriction>
</simpleType>

<!-- utility type for regPoint values -->
<simpleType name="regPointAlignValueType">
    <restriction base="string">
        <enumeration value="topLeft"/>
        <enumeration value="topMid"/>
        <enumeration value="topRight"/>
        <enumeration value="midLeft"/>
        <enumeration value="center"/>
        <enumeration value="midRight"/>
        <enumeration value="bottomLeft"/>
        <enumeration value="bottomMid"/>
        <enumeration value="bottomRight"/>
    </restriction>
</simpleType>

<!-- utility type for z-index values -->
<simpleType name="zIndexValueType">
    <union memberTypes="smil20:autoOrInheritType integer"/>
</simpleType>

<!-- define the layout element prototype -->
<complexType name="layoutPrototype">
    <attribute name="type" type="string" use="optional"  default="text/smil-basic-layout"/>
</complexType>

<!-- define the region element prototype -->
<complexType name="regionPrototype">
    <attribute name="backgroundColor" type="string" use="optional" />

    <attribute name="background-color" type="string" use="optional" />

    <attribute name="bottom" type="string" use="optional"  default="auto"/>

    <attribute name="fit" use="optional"  default="hidden" type="smil20:fitAttributeType"/>

    <attribute name="height" type="string" use="optional"  default="auto"/>

    <attribute name="left" type="string" use="optional"  default="auto"/>

    <attribute name="regionName" type="string" use="optional"/>

    <attribute name="right" type="string" use="optional"  default="auto"/>

    <attribute name="showBackground" use="optional"  default="always">
        <simpleType>
            <restriction base="string">
                <enumeration value="always"/>
                <enumeration value="whenActive"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="top" type="string" use="optional"  default="auto"/>

    <attribute name="width" type="string" use="optional"  default="auto"/>

    <attribute name="z-index" type="smil20:zIndexValueType" use="optional"  default="auto"/>

</complexType>

<!-- define the root-layout element prototype -->
<complexType name="root-layoutPrototype">
    <attribute name="backgroundColor" type="string" use="optional" />
    <attribute name="background-color" type="string" use="optional" />
    <attribute name="height" type="string" use="optional"  default="auto"/>
    <attribute name="width" type="string" use="optional"  default="auto"/>
</complexType> <!-- end root-layoutType -->

<!-- define the global region attribute -->
<attribute name="region" type="string"/>

<!-- define the region attributeGroup -->
<attributeGroup name="regionAttrs">
    <attribute name="region" type="string" use="optional"/>
</attributeGroup>

<!-- define the global soundLevel attribute -->
<attribute name="soundLevel" type="smil20:positivePercentageType"/>

<!-- define the soundLevel attributeGroup -->
<attributeGroup name="soundLevelAttrs">
    <attribute name="soundLevel" type="smil20:positivePercentageType" use="optional"/>
</attributeGroup>

<!-- define the topLayout element prototype -->
<complexType name="topLayoutPrototype">
    <attribute name="backgroundColor" type="string" use="optional" />

    <attribute name="close" use="optional"  default="onRequest">
        <simpleType>
            <restriction base="string">
                <enumeration value="onRequest"/>
                <enumeration value="whenNotActive"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="height" type="string" use="optional"  default="auto"/>

    <attribute name="open" use="optional"  default="onStart">
        <simpleType>
            <restriction base="string">
                <enumeration value="onStart"/>
                <enumeration value="whenActive"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="width" type="string" use="optional"  default="auto"/>
</complexType>

<!-- define the media object override global attributes -->
<attribute name="fit" type="smil20:fitAttributeType"/>
```

```
    <attribute name="backgroundColor" type="string"/>
    <attribute name="z-index" type="smil20:zIndexValueType"/>

    <!-- define the media object override attributeGroup -->
    <attributeGroup name="mediaObjectOverrideAttrs">
        <attribute name="fit" type="smil20:fitAttributeType"  use="optional" />
        <attribute name="backgroundColor" type="string" use="optional" />
        <attribute name="z-index" type="smil20:zIndexValueType" use="optional"/>
    </attributeGroup>

    <!-- define the regPoint element prototype -->
    <complexType name="regPointPrototype">
        <attribute name="bottom" type="string" use="optional"  default="auto"/>
        <attribute name="left" type="string" use="optional"  default="auto"/>
        <attribute name="right" type="string" use="optional"  default="auto"/>
        <attribute name="top" type="string" use="optional"  default="auto"/>
        <attribute name="regAlign" use="optional"  default="topLeft" type="smil20:regPointAlignValueType"/>
    </complexType>

    <!-- define the global subregion positioning attributes -->
    <attribute name="bottom" type="string"/>
    <attribute name="left" type="string"/>
    <attribute name="right" type="string"/>
    <attribute name="top" type="string"/>
    <attribute name="height" type="string"/>

    <!-- define the subregion positioning attributeGroup -->
    <attributeGroup name="subregionPositioningAttrs">
        <attribute name="bottom" type="string" use="optional"  default="auto"/>
        <attribute name="left" type="string" use="optional"  default="auto"/>
        <attribute name="right" type="string" use="optional"  default="auto"/>
        <attribute name="top" type="string" use="optional"  default="auto"/>
        <attribute name="width" type="string" use="optional"  default="auto"/>
        <attribute name="height" type="string" use="optional"  default="auto"/>
    </attributeGroup>

    <!-- define the regPoint attribute type-->
    <simpleType name="regPointValueType">
        <union memberTypes="smil20:regPointAlignValueType string"/>
    </simpleType>

    <!-- define the global regPoint attributes -->
    <attribute name="regPoint" type="smil20:regPointValueType"/>
    <attribute name="regAlign" type="smil20:regPointAlignValueType"/>

    <!-- define the regPoint attributeGroup -->
    <attributeGroup name="regPointAttrs">
        <attribute name="regPoint" type="smil20:regPointValueType" use="optional"/>
        <attribute name="regAlign" type="smil20:regPointAlignValueType" use="optional"  default="topLeft"/>
    </attributeGroup>

    <!-- define the global layout elements -->
    <element name="layout" type="smil20lang:layoutType" substitutionGroup="smil20lang:layout"/>
    <element name="root-layout" type="smil20lang:root-layoutType" substitutionGroup="smil20lang:root-layout"/>
    <element name="region" type="smil20lang:regionType" substitutionGroup="smil20lang:region"/>
    <element name="regPoint" type="smil20lang:regPointType" substitutionGroup="smil20lang:regPoint"/>
    <element name="topLayout" type="smil20lang:topLayoutType" substitutionGroup="smil20lang:topLayout"/>

</schema>
```

B.1.5 The SMIL Linking Module

```
<!--
XML Schema for the SMIL 2.0 Linking functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-linking.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 linking attributes.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- linking attribute types -->
    <simpleType name="sourcePlaystateType">
        <restriction base="string">
            <enumeration value="play"/>
            <enumeration value="pause"/>
            <enumeration value="stop"/>
        </restriction>
    </simpleType>

    <simpleType name="destinationPlaystateType">
        <restriction base="string">
            <enumeration value="play"/>
            <enumeration value="pause"/>
        </restriction>
    </simpleType>

    <simpleType name="showType">
        <restriction base="string">
            <enumeration value="new"/>
            <enumeration value="pause"/>
            <enumeration value="replace"/>
        </restriction>
    </simpleType>

    <simpleType name="actuateType">
        <restriction base="string">
            <enumeration value="onRequest"/>
            <enumeration value="onLoad"/>
        </restriction>
    </simpleType>

    <!-- global linking attributes -->
```

```
    <attribute name="destinationLevel" type="smil20:positivePercentageType"/>
    <attribute name="sourcePlaystate" type="smil20:sourcePlaystateType"/>
    <attribute name="destinationPlaystate" type="smil20:destinationPlaystateType"/>
    <attribute name="show" type="smil20:showType"/>
    <attribute name="external" type="boolean"/>
    <attribute name="actuate" type="smil20:actuateType"/>
    <attribute name="accesskey" type="string"/>
    <attribute name="target" type="string"/>

    <!-- linking attributes from the LinkingAttributes module -->
    <attributeGroup name="linkingAttrs">
        <attribute name="sourceLevel" type="smil20:positivePercentageType" use="optional"/>
        <attribute name="destinationLevel" type="smil20:positivePercentageType" use="optional"/>
        <attribute name="sourcePlaystate" type="smil20:sourcePlaystateType" use="optional"/>
        <attribute name="destinationPlaystate" type="smil20:destinationPlaystateType" use="optional"/>
        <attribute name="show" type="smil20:showType" use="optional"  default="replace"/>
        <attribute name="external" type="boolean" use="optional"  default="false"/>
        <attribute name="actuate" type="smil20:actuateType" use="optional"  default="onRequest"/>
        <attribute name="accesskey" type="string" use="optional"/>
        <attribute name="target" type="string" use="optional"/>
        <attributeGroup ref="smil20:tabindexAttrs"/>
    </attributeGroup>

    <!-- global tabindex attribute -->
    <attribute name="tabindex" type="integer"/>

    <!-- tabindex attribute group -->
    <attributeGroup name="tabindexAttrs">
        <attribute name="tabindex" type="integer" use="optional"/>
    </attributeGroup>

    <!-- fragment attribute group -->
    <attributeGroup name="fragmentAttrs">
        <attribute name="fragment" type="string" use="optional"/>
    </attributeGroup>

    <!-- define the a element prototype -->
    <complexType name="aPrototype">
        <attributeGroup ref="smil20:linkingAttrs"/>
        <attribute name="href" type="anyURI" use="required"/>
    </complexType>

    <!-- define the area element prototype -->
    <complexType name="areaPrototype">
        <attributeGroup ref="smil20:linkingAttrs"/>
        <attribute name="href" type="anyURI" use="optional"/>
        <attribute name="nohref" type="boolean" use="optional"  default="false"/>
        <attribute name="shape" type="string" use="optional"/>
        <attribute name="coords" type="string" use="optional"/>
    </complexType>

    <!-- global linking elements -->
    <element name="a" type="smil20lang:aType" substitutionGroup="smil20lang:a"/>
    <element name="area" type="smil20lang:areaType" substitutionGroup="smil20lang:area"/>
    <element name="anchor" type="smil20lang:anchorType" substitutionGroup="smil20lang:anchor"/>

</schema>
```

B.1.6 The SMIL Media Object Module

```
<!--
XML Schema for the SMIL 2.0 Media functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-media.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 media attributes.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- define the alternative content attributes -->
    <attribute name="alt" type="string"/>
    <attribute name="longdesc" type="anyURI"/>

    <!-- define the alternative content attribute group-->
    <attributeGroup name="altAttrs">
        <attribute name="alt" type="string" use="optional"/>
        <attribute name="longdesc" type="anyURI" use="optional"/>
    </attributeGroup>

    <!-- define the media annotation attributes -->
    <attribute name="abstract" type="string"/>
    <attribute name="author" type="string"/>
    <attribute name="copyright" type="string"/>
    <attribute name="title" type="string"/>

    <!-- define the media annotation attribute group -->
    <attributeGroup name="mediaAnnotateAttrs">
        <attribute name="abstract" type="string" use="optional"/>
        <attribute name="author" type="string" use="optional"/>
        <attribute name="copyright" type="string" use="optional"/>
        <attribute name="title" type="string" use="optional"/>
    </attributeGroup>

    <!-- define the media access attributes -->
    <attribute name="readIndex" type="integer"/>

    <!-- define the media access attribute group -->
    <attributeGroup name="mediaAccessAttrs">
        <attribute name="readIndex" type="integer" use="optional"/>
    </attributeGroup>

    <!-- define the media src attributes-->
    <attribute name="type" type="string"/>
```

```
<attribute name= src  type= anyURI />

<!-- define the media src attribute group -->
<attributeGroup name="mediaSrcAttrs">
    <attribute name="type" type="string" use="optional"/>
    <attribute name="src" type="anyURI" use="optional"/>
</attributeGroup>

<!-- define the erase media attribute value type -->
<simpleType name="eraseMediaType">
    <restriction base="string">
        <enumeration value="whenDone"/>
        <enumeration value="never"/>
    </restriction>
</simpleType>

<!-- define the erase media attribute -->
<attribute name="erase" type="smil20:eraseMediaType"/>

<!-- define the eraseMediaAttrs attribute group -->
<attributeGroup name="eraseMediaAttrs">
                                                                                                    >
</attributeGroup>

<!-- define the media repeat attribute value type -->
<simpleType name="mediaRepeatType">
    <restriction base="string">
        <enumeration value="preserve"/>
        <enumeration value="strip"/>
    </restriction>
</simpleType>

<!-- define the media repeat attribute -->
<attribute name="mediaRepeat" type="smil20:mediaRepeatType"/>

<!-- define the media repeat attribute group -->
<attributeGroup name="mediaRepeatAttrs">
    <attribute name="mediaRepeat" type="smil20:mediaRepeatType" use="optional"  default="preserve"/>
</attributeGroup>


<!-- define the media sensitivity attribute value type -->
<simpleType name="opaqueOrTransparentType">
    <restriction base="string">
        <enumeration value="opaque"/>
        <enumeration value="transparent"/>
    </restriction>
</simpleType>
<simpleType name="sensitivityType">
    <union memberTypes="smil20:opaqueOrTransparentType smil20:positivePercentageType"/>
</simpleType>

<!-- define the media sensitivity attribute -->
<attribute name="sensitivity" type="smil20:sensitivityType"/>

<!-- define the media sensitivity attribute group -->
<attributeGroup name="sensitivityMediaAttrs">
    <attribute name="sensitivity" type="smil20:sensitivityType" use="optional"  default="opaque"/>
</attributeGroup>

<!-- define the media clipping attributes-->
<attribute name="clipBegin" type="string"/>
<attribute name="clipEnd" type="string"/>

<!-- define the media clipping attribute group -->
<attributeGroup name="mediaClippingAttrs">
    <attribute name="clipBegin" type="string" use="optional"/>
    <attribute name="clipEnd" type="string" use="optional"/>
</attributeGroup>

                                                                                                    >
<attribute name="clip-begin" type="string"/>
<attribute name="clip-end" type="string"/>

<!-- define the deprecated media clipping attribute group -->
<attributeGroup name="deprecatedMediaClippingAttrs">
    <attribute name="clip-begin" type="string" use="optional"/>
    <attribute name="clip-end" type="string" use="optional"/>
</attributeGroup>

<!--
    define the media object element prototype
    ref, animation, audio, img, text, textstream, video
    are all identical and use this prototype
-->
<complexType name="mediaPrototype">
    <attributeGroup ref="smil20:mediaSrcAttrs" />
</complexType>

<!-- define the param element prototype -->
<complexType name="paramPrototype">
    <attribute name="name" type="string" use="optional"/>
    <attribute name="value" type="string" use="optional"/>
    <attribute name="valueType" use="optional"  default="data">
        <simpleType>
            <restriction base="string">
                <enumeration value="data"/>
                <enumeration value="ref"/>
                <enumeration value="object"/>
            </restriction>
        </simpleType>
    </attribute>
    <attribute name="type" type="string" use="optional"/>
</complexType>

<!-- define the brush element prototype -->
<complexType name="brushPrototype">
    <attribute name="color" type="string" use="optional"/>
</complexType>

<!-- define the global media elements -->
<element name="text" type="smil20lang:mediaType" substitutionGroup="smil20lang:text"/>
<element name="img" type="smil20lang:mediaType" substitutionGroup="smil20lang:img"/>
<element name="audio" type="smil20lang:mediaType" substitutionGroup="smil20lang:audio"/>
<element name="animation" type="smil20lang:mediaType" substitutionGroup="smil20lang:animation"/>
<element name="video" type="smil20lang:mediaType" substitutionGroup="smil20lang:video"/>
<element name="textstream" type="smil20lang:mediaType" substitutionGroup="smil20lang:textstream"/>
<element name="ref" type="smil20lang:mediaType" substitutionGroup="smil20lang:ref"/>
<element name="brush" type="smil20lang:brushType" substitutionGroup="smil20lang:brush"/>
<element name="param" type="smil20lang:paramType" substitutionGroup="smil20lang:param"/>
                                                                                                    >
</schema>
```

B.1.7 The SMIL Meta Module

```
<!--
XML Schema for the SMIL 2.0 Metainformation functionality.

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Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-meta.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- the RDF namespace needs to be verified -->

    <!-- import rdf:RDF -->
    <!-- fix schemaLocation later -->
    <import namespace="http://www.w3.org/1999/02/22-rdf-syntax-ns#" schemaLocation="rdf.xsd"/>

    <!-- define the meta element prototype -->
    <complexType name="metaPrototype">
        <attribute name="content" type="string" use="required"/>
        <attribute name="name" type="string" use="required"/>
    </complexType>


    <!-- define the metadata element prototype -->
    <complexType name="metadataPrototype">
      <choice minOccurs="0" maxOccurs="unbounded">
        <any namespace="##other" processContents="lax"/>
      </choice>
    </complexType>


    <!-- define the global metainformation elements -->
    <element name="metadata" type="smil20lang:metadataType" substitutionGroup="smil20lang:metadata"/>
    <element name="meta" type="smil20lang:metaType" substitutionGroup="smil20lang:meta"/>

</schema>
```

B.1.8 The SMIL Structure Module

```
<!--
XML Schema for the SMIL 2.0 Structure functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-struct.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:x="http://www.w3.org/XML/1998/namespace"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- import xml:lang -->
    <!-- fix schemaLocation later -->
    <import namespace="http://www.w3.org/XML/1998/namespace" schemaLocation="xml-mod.xsd"/>

    <!-- define the structure module attribute group -->
        <attribute name="id" type="ID" use="optional"/>
        <attribute name="class" type="string" use="optional"/>
        <attribute ref="x:lang" use="optional" />
    </attributeGroup>

    <!-- define the smil element prototype -->
    <complexType name="smilPrototype">
    </complexType>

    <!-- define the head element prototype -->
    <complexType name="headPrototype">
    </complexType>

    <!-- define the body element prototype -->
    <complexType name="bodyPrototype">
    </complexType>

    <!-- declare global elements -->
    <element name="smil" type="smil20lang:smilType" substitutionGroup="smil20lang:smil"/>
    <element name="head" type="smil20lang:headType" substitutionGroup="smil20lang:head"/>
    <element name="body" type="smil20lang:bodyType" substitutionGroup="smil20lang:body"/>

</schema>
```

B.1.9 The SMIL Time manipulation

```
<!--
XML Schema for the SMIL 2.0 Time Manipulations functionality.
```

```
This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-timemanip.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 time manipulation attributes.

-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <attribute name="accelerate" type="smil20:zeroToOneDecimalType"/>
    <attribute name="decelerate" type="smil20:zeroToOneDecimalType"/>
    <attribute name="autoReverse" type="boolean"/>
    <attribute name="speed" type="smil20:nonZeroDecimalType"/>

    <!-- attribute group for time manipulation attributes -->
    <attributeGroup name="timeManipAttrs">
        <attribute name="accelerate" type="smil20:zeroToOneDecimalType" use="optional"  default="0.0"/>
        <attribute name="decelerate" type="smil20:zeroToOneDecimalType" use="optional"  default="0.0"/>
        <attribute name="autoReverse" type="boolean" use="optional"  default="false"/>
        <attribute name="speed" type="smil20:nonZeroDecimalType" use="optional"  default="1.0"/>
    </attributeGroup>

</schema>
```

B.1.10 The SMIL Timing Module

```
<!--
XML Schema for the SMIL 2.0 Timing and Synchronization functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-timing.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Defines both the local and global smil20 timing attributes.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

    <!-- define the begin/end timing attribute group -->
    <!-- other attribute groups require inclusion of this group -->
    <attributeGroup name="beginEndTimingAttrs">
        <attribute name="begin" type="string"/>
        <attribute name="end" type="string"/>
    </attributeGroup>

    <!-- define the dur timing attribute -->
    <attribute name="dur" type="string"/>

    <!-- define the durTimingAttrs attribute group -->
    <attributeGroup name="durTimingAttrs">
        <attribute name="dur" type="string"/>
    </attributeGroup>

    <!-- define the repeat timing attributes -->
    <attribute name="repeatDur" type="string"/>
    <attribute name="repeatCount" type="smil20:nonNegativeDecimalType"/>

    <!-- define the repeatTiming attribute group -->
    <!-- requires inclusion of the basicInlineTimingAttrs group -->
    <attributeGroup name="repeatTimingAttrs">
        <attribute name="repeatDur" type="string"/>
        <attribute name="repeatCount" type="smil20:nonNegativeDecimalType"/>
    </attributeGroup>

    <!-- define the repeat attribute -->
    <attribute name="repeat" type="nonNegativeInteger"/>

    <!-- define the deprecatedRepeatTiming attribute group -->
    <!-- requires inclusion of the basicInlineTimingAttrs group -->
    <attributeGroup name="deprecatedRepeatTiming">
        <attribute name="repeat" type="nonNegativeInteger"/>
    </attributeGroup>

    <!-- define the min, max attributes -->
    <attribute name="min" type="string"/>
    <attribute name="max" type="string"/>

    <!-- define the minMaxTimingAttrs attribute group -->
    <attributeGroup name="minMaxTimingAttrs">
        <attribute name="min" type="string"/>
        <attribute name="max" type="string"/>
    </attributeGroup>

    <!-- define the fillTimingAttrs attribute type -->

        <restriction base="string">
            <enumeration value="remove"/>
            <enumeration value="freeze"/>
            <enumeration value="hold"/>
            <enumeration value="auto"/>
            <enumeration value="default"/>

            <!--
                this value is only legal when transitions are included
```

```
            in the profile. may need a means to separate out this
            attribute value, but not clear whether or how XML Schemas
            provides this.
        -->
        <enumeration value="transition"/>
    </restriction>
</simpleType>

<!-- define the fill attribute -->
<attribute name="fill" type="smil20:fillTimingAttrsType"/>

<!-- define the fillTimingAttrs attribute group -->
<attributeGroup name="fillTimingAttrs">
    <attribute name="fill" type="smil20:fillTimingAttrsType" use="optional"  default="default"/>
</attributeGroup>

<!-- utility type for endsync attribute arg values -->
<simpleType name="endsyncArgType">
    <restriction base="string">
        <enumeration value="first"/>
        <enumeration value="last"/>
        <enumeration value="all"/>
        <enumeration value="media"/>
    </restriction>
</simpleType>

<!-- define the endsyncTimingAttrsType -->
<simpleType name="endsyncTimingAttrsType">
    <union memberTypes="smil20:endsyncArgType IDREF"/>
</simpleType>

<!-- define the endsync attribute-->
<attribute name="endsync" type="smil20:endsyncTimingAttrsType"/>

<!-- define the endsyncTimingAttrs attribute group -->
<attributeGroup name="endsyncTimingAttrs">
    <attribute name="endsync" type="smil20:endsyncTimingAttrsType" use="optional"/>
</attributeGroup>

<!-- define the timeContainerAttrs attribute value types -->
<simpleType name="timeContainerArgType">
    <restriction base="string">
        <enumeration value="par"/>
        <enumeration value="seq"/>
        <enumeration value="excl"/>
        <enumeration value="none"/>
    </restriction>
</simpleType>

<simpleType name="timeActionArgType">
    <restriction base="string">
        <enumeration value="intrinsic"/>
        <enumeration value="display"/>
        <enumeration value="visibility"/>
        <enumeration value="style"/>
        <enumeration value="none"/>
    </restriction>
</simpleType>

<simpleType name="timeActionClassArgType">
    <restriction base="string">
        <pattern value="class:.*"/>
    </restriction>
</simpleType>

<simpleType name="timeActionType">
    <union memberTypes="smil20:timeActionArgType smil20:timeActionClassArgType"/>
</simpleType>

<!-- define the timeContainer attribute -->
<attribute name="timeContainer" type="smil20:timeContainerArgType"/>

<!-- define the timeAction attribute -->
<attribute name="timeAction" type="smil20:timeActionType"/>

<!-- define the timeContainersAttrs attribute group -->
<attributeGroup name="timeContainersAttrs">
    <attribute name="timeContainer" type="smil20:timeContainerArgType" use="optional"  default="none"/>
    <attribute name="timeAction" type="smil20:timeActionType" use="optional"  default="intrinsic"/>
</attributeGroup>

<!-- define the restartTimingAttrs attribute value types -->
<simpleType name="restartTimingType">
    <restriction base="string">
        <enumeration value="never"/>
        <enumeration value="always"/>
        <enumeration value="whenNotActive"/>
        <enumeration value="default"/>
    </restriction>
</simpleType>

<!-- define the restart attribute -->
<attribute name="restart" type="smil20:restartTimingType"/>

<!-- define the restartTimingAttrs attribute group -->
<attributeGroup name="restartTimingAttrs">
    <attribute name="restart" type="smil20:restartTimingType" use="optional"  default="default"/>
</attributeGroup>

<!-- define the syncBehaviorAttrs attribute value types -->
<simpleType name="syncBehaviorType">
    <restriction base="string">
        <enumeration value="canSlip"/>
        <enumeration value="locked"/>
        <enumeration value="independent"/>
        <enumeration value="default"/>
    </restriction>
</simpleType>

<!-- define the syncBehavior attributes -->
<attribute name="syncBehavior" type="smil20:syncBehaviorType"/>
<attribute name="syncTolerance" type="string"/>

<!-- define the syncBehaviorAttrs attribute group -->
<attributeGroup name="syncBehaviorAttrs">
    <attribute name="syncBehavior" type="smil20:syncBehaviorType" use="optional"  default="default"/>
    <attribute name="syncTolerance" type="string" use="optional"/>
</attributeGroup>

<!-- define the syncBehaviorDefault attribute type -->
<simpleType name="syncBehaviorDefaultType">
    <restriction base="string">
        <enumeration value="canSlip"/>
        <enumeration value="locked"/>
        <enumeration value="independent"/>
        <enumeration value="inherit"/>
```

```
    </restriction>
</simpleType>

<!-- define the syncBehaviorDefault attributes -->
<attribute name="syncBehaviorDefault" type="smil20:syncBehaviorDefaultType"/>
<attribute name="syncToleranceDefault" type="string"/>

<!-- define the syncBehaviorDefaultAttrs attribute group -->
<attributeGroup name="syncBehaviorDefaultAttrs">
    <attribute name="syncBehaviorDefault" type="smil20:syncBehaviorDefaultType" use="optional"  default="inherit"/>
    <attribute name="syncToleranceDefault" type="string" use="optional"  default="inherit"/>
</attributeGroup>

<!-- define the syncMaster attribute -->
<attribute name="syncMaster" type="boolean"/>

<!-- define the syncMasterAttrs attribute group -->
<attributeGroup name="syncMasterAttrs">
    <attribute name="syncMaster" type="boolean" use="optional"  default="false"/>
</attributeGroup>

<!-- define the restartDefaultType attribute value type -->
<simpleType name="restartDefaultType">
    <restriction base="string">
        <enumeration value="never"/>
        <enumeration value="always"/>
        <enumeration value="whenNotActive"/>
        <enumeration value="inherit"/>
    </restriction>
</simpleType>

<!-- define the restartDefault attribute -->
<attribute name="restartDefault" type="smil20:restartDefaultType"/>

<!-- define the restartDefaultAttrs attribute group -->
<attributeGroup name="restartDefaultAttrs">
    <attribute name="restartDefault" type="smil20:restartDefaultType" use="optional"  default="inherit"/>
</attributeGroup>

<!-- define the fillDefaultType attribute value type -->
<simpleType name="fillDefaultType">
    <restriction base="string">
        <enumeration value="remove"/>
        <enumeration value="freeze"/>
        <enumeration value="hold"/>
        <enumeration value="auto"/>
        <enumeration value="inherit"/>

        <!--
            this value is only legal when transitions are included
            in the profile. may need a means to separate out this
            attribute value, but not clear whether or how XML Schemas
            provides this.
        -->
        <enumeration value="transition"/>
    </restriction>
</simpleType>

<!-- define the fillDefault attribute -->
<attribute name="fillDefault" type="smil20:fillDefaultType"/>

<!-- define the fillDefaultAttrs attribute group -->
    <attribute name="fillDefault" type="smil20:fillDefaultType" use="optional"  default="inherit"/>
</attributeGroup>

<!-- define the par element prototype -->
<complexType name="parPrototype">
    <attributeGroup ref="smil20:beginEndTimingAttrs"/>
    <attributeGroup ref="smil20:durTimingAttrs"/>
    <attributeGroup ref="smil20:fillTimingAttrs"/>
    <attributeGroup ref="smil20:endsyncTimingAttrs"/>
</complexType>

<!-- define the seq element prototype -->
<complexType name="seqPrototype">
    <attributeGroup ref="smil20:beginEndTimingAttrs"/>
    <attributeGroup ref="smil20:durTimingAttrs"/>
    <attributeGroup ref="smil20:fillTimingAttrs"/>
</complexType>

<!-- define the priorityClass element prototype -->
<complexType name="priorityClassPrototype">
    <attribute name="peers" use="optional"  default="stop">
        <simpleType>
            <restriction base="string">
                <enumeration value="stop"/>
                <enumeration value="pause"/>
                <enumeration value="defer"/>
                <enumeration value="never"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="higher" use="optional"  default="pause">
        <simpleType>
            <restriction base="string">
                <enumeration value="stop"/>
                <enumeration value="pause"/>
            </restriction>
        </simpleType>
    </attribute>

    <attribute name="lower" use="optional"  default="defer">
        <simpleType>
            <restriction base="string">
                <enumeration value="defer"/>
                <enumeration value="never"/>
            </restriction>
        </simpleType>
    </attribute>

        <simpleType>
            <restriction base="string">
                <enumeration value="disable"/>
                <enumeration value="hide"/>
                <enumeration value="show"/>
            </restriction>
        </simpleType>
    </attribute>

</complexType>

<!-- define the excl element prototype -->
```

```
    <complexType name="exclPrototype">
        <attributeGroup ref="smil20:beginEndTimingAttrs"/>
        <attributeGroup ref="smil20:durTimingAttrs"/>
        <attributeGroup ref="smil20:fillTimingAttrs"/>
        <attributeGroup ref="smil20:endsyncTimingAttrs"/>
    </complexType>

    <!-- global timing elements -->
    <element name="par" type="smil20lang:parType" substitutionGroup="smil20lang:par"/>
    <element name="seq" type="smil20lang:seqType" substitutionGroup="smil20lang:seq"/>
    <element name="excl" type="smil20lang:exclType" substitutionGroup="smil20lang:excl"/>
    <element name="priorityClass" type="smil20lang:priorityClassType" substitutionGroup="smil20lang:priorityClass"/>

</schema>
```

B.1.11 The SMIL Transition Module

```
<!--
XML Schema for the SMIL 2.0 Transitions functionality.

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- define global transIn transOut attributes -->
    <attribute name="transIn" type="string"/>
    <attribute name="transOut" type="string"/>

    <!-- define transInOut attributegroup -->
    <attributeGroup name="transInOutAttrs">
        <attribute name="transIn" type="string"/>
        <attribute name="transOut" type="string"/>
    </attributeGroup>

    <!-- define the transitionModifiers attribute group -->
    <attributeGroup name="transitionModifiersAttrs">
        <attribute name="horzRepeat" type="decimal" use="optional"  default="1.0"/>
        <attribute name="vertRepeat" type="decimal" use="optional"  default="1.0"/>
        <attribute name="borderWidth" type="nonNegativeInteger" use="optional"  default="0"/>
        <attribute name="borderColor" type="string" use="optional"  default="black"/>
    </attributeGroup>

    <!-- define transition element prototype -->
    <complexType name="transitionPrototype">
        <attribute name="type" type="string" use="required"/>
        <attribute name="subtype" type="string" use="optional"/>

        <attribute name="mode" use="optional"  default="in">
            <simpleType>
                <restriction base="string">
                    <enumeration value="in"/>
                    <enumeration value="out"/>
                </restriction>
            </simpleType>
        </attribute>

        <attribute name="dur" type="string" use="optional"/>
        <attribute name="startProgress" type="smil20:zeroToOneDecimalType" use="optional"  default="0.0"/>
        <attribute name="endProgress" type="smil20:zeroToOneDecimalType" use="optional"  default="1.0"/>

        <attribute name="direction" use="optional"  default="forward">
            <simpleType>
                <restriction base="string">
                    <enumeration value="forward"/>
                </restriction>
            </simpleType>
        </attribute>

        <attribute name="fadeColor" type="string" use="optional"  default="black"/>
    </complexType>

    <!-- define transitionFilter element prototype -->
    <complexType name="transitionFilterPrototype">
        <attribute name="targetElement" type="IDREF" use="optional"/>
        <attribute name="href" type="anyURI" use="optional"/>

        <attribute name="type" type="string" use="required"/>
        <attribute name="subtype" type="string" use="optional"/>
        <attribute name="dur" type="string" use="optional"/>
        <attribute name="startProgress" type="smil20:zeroToOneDecimalType" use="optional"  default="0.0"/>
        <attribute name="endProgress" type="smil20:zeroToOneDecimalType" use="optional"  default="1.0"/>

        <attribute name="direction">
            <simpleType>
                <restriction base="string">
                    <enumeration value="forward"/>
                    <enumeration value="reverse"/>
                </restriction>
            </simpleType>
        </attribute>

        <attribute name="fadeColor" type="string" use="optional"  default="black"/>

        <attribute name="from" type="smil20:zeroToOneDecimalType" use="optional"  default="0.0"/>
        <attribute name="to" type="smil20:zeroToOneDecimalType" use="optional"  default="1.0"/>
        <attribute name="by" type="smil20:zeroToOneDecimalType" use="optional"/>
        <attribute name="values" type="string" use="optional"/>

        <attribute name="calcMode" use="optional"  default="linear">
            <simpleType>
                <restriction base="string">
                    <enumeration value="discrete"/>
                    <enumeration value="linear"/>
```

```
                <enumeration value="paced"/>
            </restriction>
        </simpleType>
    </attribute>
</complexType>

<!-- define the global transitionFilter element -->
<!-- it is part of the smil20 namespace but not part of the smil20 language -->
<element name="transitionFilter" type="smil20:transitionFilterType"/>
```



```
<complexType name="transitionFilterType">
    <complexContent>
        <extension base="smil20:transitionFilterPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <attributeGroup ref="smil20:transitionModifiersAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- define the global transition element -->
<!-- it is extended in the smil20 namespace from the smil20 language -->
<element name="transition" type="smil20:transitionType"/>
<complexType name="transitionType">
    <complexContent>
        <extension base="smil20:transitionPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <attributeGroup ref="smil20:transitionModifiersAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

</schema>
```

B.2 XML Schema for the SMIL 2.0 Language:

B.2.1 SMIL 2.0 Language Profile



```
<!--
XML Schema for the SMIL 2.0 Language

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-language.xsd
Author: Aaron Michael Cohen (Intel)

Revision: 2001/07/15

Note: <any> wildcard element content is missing from most of the SMIL 2.0 elements because of a conflict
between substitutionGroups and wildcard content.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        targetNamespace="http://www.w3.org/2001/SMIL20/Language"
        elementFormDefault="qualified">

    <!-- import the smil20 namespaces -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- ================================================================= -->
    <!-- CoreAttrs attribute group used on all SMIL2.0 profile elements    -->
    <!-- ================================================================= -->
    <attributeGroup name="CoreAttrs">
        <attributeGroup ref="smil20:structureModuleAttrs"/>
        <attributeGroup ref="smil20:alternateContentAttrs"/>
        <!--
            should have xml:base here, but no schema to refer to.
            not a problem since it will validate anyway because of
            the anyAttribute declarations.
        -->
    </attributeGroup>

    <!-- ================================================================= -->
    <!-- Structure Functionality                                           -->
    <!-- ================================================================= -->

    <!-- ================================================================= -->
    <!-- define the top down structure of a SMIL 2.0 language document.    -->
    <!-- ================================================================= -->

    <!-- top level smil element and content model -->
    <element name="smil" type="smil20lang:smilType"/>
    <complexType name="smilType">
```



```
            <extension base="smil20:smilPrototype">
                <sequence>
                    <element ref="smil20lang:head" minOccurs="0" maxOccurs="1"/>
                    <element ref="smil20lang:body" minOccurs="1" maxOccurs="1"/>
                </sequence>
                <attributeGroup ref="smil20lang:CoreAttrs"/>
                <attributeGroup ref="smil20:systemTestAttrs"/>
                <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
                <anyAttribute namespace="##any" processContents="strict"/>
            </extension>
        </complexContent>
    </complexType>

    <!-- head element and content model -->
    <element name="head" type="smil20lang:headType"/>
    <complexType name="headType">
```

```
    <complexContent>
        <extension base="smil20:headPrototype">
            <sequence>
                <group ref="smil20lang:metaGroup" minOccurs="0" maxOccurs="unbounded"/>

                <sequence minOccurs="0" maxOccurs="1">
                    <group ref="smil20lang:customAttributesGroup" minOccurs="1" maxOccurs="1"/>
                    <group ref="smil20lang:metaGroup" minOccurs="0" maxOccurs="unbounded"/>
                </sequence>

                <sequence minOccurs="0" maxOccurs="1">
                    <group ref="smil20lang:metadataGroup" minOccurs="1" maxOccurs="1"/>
                    <group ref="smil20lang:metaGroup" minOccurs="0" maxOccurs="unbounded"/>
                </sequence>

                <sequence minOccurs="0" maxOccurs="1">
                    <choice minOccurs="1" maxOccurs="1">
                        <group ref="smil20lang:layoutGroup"/>
                        <group ref="smil20lang:switchGroup"/>
                    </choice>
                    <group ref="smil20lang:metaGroup" minOccurs="0" maxOccurs="unbounded"/>
                </sequence>

                <sequence minOccurs="0" maxOccurs="1">
                    <group ref="smil20lang:transitionGroup" minOccurs="1" maxOccurs="unbounded"/>
                    <group ref="smil20lang:metaGroup" minOccurs="0" maxOccurs="unbounded"/>
                </sequence>

            </sequence>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- body element and content model -->
<element name="body" type="smil20lang:bodyType"/>
<complexType name="bodyType">
    <complexContent>
        <extension base="smil20:bodyPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:aElementGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <attributeGroup ref="smil20:regionAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- ================================================================= -->
<!-- Metainformation Functionality                                     -->
<!-- ================================================================= -->
<!-- metadata element and content model -->
<element name="metadata" type="smil20lang:metadataType"/>
<complexType name="metadataType">
    <complexContent>
        <extension base="smil20:metadataPrototype">
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- meta element and content model -->
<element name="meta" type="smil20lang:metaType"/>
<complexType name="metaType">
    <complexContent>
        <extension base="smil20:metaPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##other" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- metainformation groups -->
<group name="metaGroup">
    <choice>
        <element ref="smil20lang:meta"/>
    </choice>
</group>

<group name="metadataGroup">
    <choice>
        <element ref="smil20lang:metadata"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- Layout Functionality                                              -->
<!-- ================================================================= -->

<!-- layout element and content model -->
<!--
    In smil 2.0 as in smil 1.0, the layout element can have almost any content,
    based on the value of the 'type' attribute, but we cannot syntax check that,
    so here we only specify the content model for type="text/smil-basic-layout"
-->
<element name="layout" type="smil20lang:layoutType"/>
<complexType name="layoutType">
    <complexContent>
        <extension base="smil20:layoutPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:regionGroup"/>
                <group ref="smil20lang:topLayoutGroup"/>
                <group ref="smil20lang:root-layoutGroup"/>
                <group ref="smil20lang:regPointGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- root-layout element and content model -->
```

```
<element name="root-layout" type="smil20lang:root-layoutType"/>
<complexType name="root-layoutType">
    <complexContent>
        <extension base="smil20:root-layoutPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- region element and content model -->
<element name="region" type="smil20lang:regionType"/>
<complexType name="regionType">
    <complexContent>
        <extension base="smil20:regionPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <element name="region" type="smil20lang:regionType"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- topLayout element and content model -->
<element name="topLayout" type="smil20lang:topLayoutType"/>
<complexType name="topLayoutType">
    <complexContent>
        <extension base="smil20:topLayoutPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <element name="region" type="smil20lang:regionType"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- regPoint element and content model -->
<element name="regPoint" type="smil20lang:regPointType"/>
<complexType name="regPointType">
    <complexContent>
        <extension base="smil20:regPointPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
```

```
<!-- layout groups -->
<group name="root-layoutGroup">
    <sequence>
        <element ref="smil20lang:root-layout"/>
    </sequence>
</group>

<group name="regionGroup">
    <sequence>
        <element ref="smil20lang:region"/>
    </sequence>
</group>

<group name="topLayoutGroup">
    <sequence>
        <element ref="smil20lang:topLayout"/>
    </sequence>
</group>

<group name="layoutGroup">
    <sequence>
        <element ref="smil20lang:layout"/>
    </sequence>
</group>

<group name="regPointGroup">
    <sequence>
        <element ref="smil20lang:regPoint"/>
    </sequence>
</group>

<!-- ================================================================= -->
<!-- Transition Functionality                                          -->
<!-- ================================================================= -->
<element name="transition" type="smil20lang:transitionType"/>
<complexType name="transitionType">
    <complexContent>
        <extension base="smil20:transitionPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- transition groups -->
<group name="transitionGroup">
    <choice>
        <element ref="smil20lang:transition"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- Content Control Functionality                                     -->
<!-- ================================================================= -->

<!-- customAttributes element and content model -->
<element name="customAttributes" type="smil20lang:customAttributesType"/>
<complexType name="customAttributesType">
    <complexContent>
        <extension base="smil20:customAttributesPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <element name="customTest" type="smil20lang:customTestType"/>
```

```
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- customTest element and content model -->
<element name="customTest" type="smil20lang:customTestType"/>
<complexType name="customTestType">
    <complexContent>
        <extension base="smil20:customTestPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- switch element and content model -->
<element name="switch" type="smil20lang:switchType"/>
<complexType name="switchType">
    <complexContent>
        <extension base="smil20:switchPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:layoutGroup"/>
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:aElementGroup"/>
                <group ref="smil20lang:animationGroup"/>
                <group ref="smil20lang:areaGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- prefetch element and content model -->
<element name="prefetch" type="smil20lang:prefetchType"/>
<complexType name="prefetchType">
    <complexContent>
        <extension base="smil20:prefetchPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <attributeGroup ref="smil20:mediaClippingAttrs"/>
            <attributeGroup ref="smil20:deprecatedMediaClippingAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>


<!-- content control groups -->
<group name="customAttributesGroup">
    <choice>
        <element ref="smil20lang:customAttributes"/>
    </choice>
</group>

<group name="prefetchGroup">
    <choice>
        <element ref="smil20lang:prefetch"/>
    </choice>
</group>

<group name="switchGroup">
    <choice>
        <element ref="smil20lang:switch"/>
    </choice>
</group>

<group name="contentControlGroup">
    <choice minOccurs="0" maxOccurs="unbounded">
        <group ref="smil20lang:switchGroup"/>
        <group ref="smil20lang:prefetchGroup"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- Animation Functionality                                           -->
<!-- ================================================================= -->

<!-- animate element and content model -->
<element name="animate" type="smil20lang:animateType"/>
<complexType name="animateType">
    <complexContent>
        <extension base="smil20:animatePrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:animTargetAttrs"/>
            <attributeGroup ref="smil20:animModeAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- set element and content model -->
<element name="set" type="smil20lang:setType"/>
<complexType name="setType">
    <complexContent>
        <extension base="smil20:setPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
```

```
            <attributeGroup ref="smil20:skipContentAttrs"/>
        </extension>
    </complexContent>
</complexType>

<!-- animateMotion element and content model -->
<element name="animateMotion" type="smil20lang:animateMotionType"/>
<complexType name="animateMotionType">
    <complexContent>
        <extension base="smil20:animateMotionPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:animTargetAttrs"/>
            <attributeGroup ref="smil20:animModeAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- animateColor element and content model -->
<element name="animateColor" type="smil20lang:animateColorType"/>
<complexType name="animateColorType">
    <complexContent>
        <extension base="smil20:animateColorPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:animTargetAttrs"/>
            <attributeGroup ref="smil20:animModeAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- animation groups -->
<group name="animationGroup">
    <choice minOccurs="0" maxOccurs="unbounded">
        <element ref="smil20lang:animate"/>
        <element ref="smil20lang:set"/>
        <element ref="smil20lang:animateMotion"/>
        <element ref="smil20lang:animateColor"/>
    </choice>
</group>

<group name="simpleAnimationGroup">
    <choice minOccurs="0" maxOccurs="unbounded">
        <element ref="smil20lang:animate"/>
        <element ref="smil20lang:set"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- Linking Functionality                                             -->
<!-- ================================================================= -->

<!-- a element and content model -->
<element name="a" type="smil20lang:aType"/>
<complexType name="aType">
    <complexContent>
        <extension base="smil20:aPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:BasicTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- area element and content model -->
<element name="area" type="smil20lang:areaType"/>
<complexType name="areaType">
    <complexContent>
        <extension base="smil20:areaPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:simpleAnimationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:BasicTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <attributeGroup ref="smil20:fragmentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- anchor element and content model -->
<element name="anchor" type="smil20lang:anchorType"/>
<complexType name="anchorType">
    <complexContent>
        <extension base="smil20:areaPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:simpleAnimationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:BasicTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:skipContentAttrs"/>
            <attributeGroup ref="smil20:fragmentAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- linking groups -->
```

```
<group name="aElementGroup">
    <choice>
        <element ref="smil20lang:a"/>
    </choice>
</group>

<group name="areaGroup">
    <choice>
        <element ref="smil20lang:area"/>
        <element ref="smil20lang:anchor"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- Media Functionality                                               -->
<!-- ================================================================= -->

<!-- media elements and content model -->
<element name="text" type="smil20lang:mediaType"/>
<element name="img" type="smil20lang:mediaType"/>
<element name="audio" type="smil20lang:mediaType"/>
<element name="animation" type="smil20lang:mediaType"/>
<element name="video" type="smil20lang:mediaType"/>
<element name="textstream" type="smil20lang:mediaType"/>
<element name="ref" type="smil20lang:mediaType"/>
                                                                    >
    <complexContent>
        <extension base="smil20:mediaPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:paramGroup"/>
                <group ref="smil20lang:areaGroup"/>
                <group ref="smil20lang:switchGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:regionAttrs"/>
            <attributeGroup ref="smil20:eraseMediaAttrs"/>
            <attributeGroup ref="smil20:mediaRepeatAttrs"/>
            <attributeGroup ref="smil20:sensitivityMediaAttrs"/>
            <attributeGroup ref="smil20:transInOutAttrs"/>
            <attributeGroup ref="smil20:tabindexAttrs"/>
            <attributeGroup ref="smil20:mediaClippingAttrs"/>
            <attributeGroup ref="smil20:deprecatedMediaClippingAttrs"/>
            <attributeGroup ref="smil20:mediaAccessAttrs"/>
            <attributeGroup ref="smil20:mediaObjectOverrideAttrs"/>
            <attributeGroup ref="smil20:subregionPositioningAttrs"/>
            <attributeGroup ref="smil20:regPointAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <attributeGroup ref="smil20:endsyncTimingAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- brush element and content model -->
<element name="brush" type="smil20lang:brushType"/>
<complexType name="brushType">
    <complexContent>
        <extension base="smil20:brushPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:paramGroup"/>
                <group ref="smil20lang:areaGroup"/>
                <group ref="smil20lang:switchGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20lang:TimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
                                                                    >
            <attributeGroup ref="smil20:eraseMediaAttrs"/>
            <attributeGroup ref="smil20:sensitivityMediaAttrs"/>
            <attributeGroup ref="smil20:tabindexAttrs"/>
            <attributeGroup ref="smil20:transInOutAttrs"/>
            <attributeGroup ref="smil20:mediaAccessAttrs"/>
            <attributeGroup ref="smil20:mediaObjectOverrideAttrs"/>
            <attributeGroup ref="smil20:subregionPositioningAttrs"/>
            <attributeGroup ref="smil20:regPointAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- param element and content model -->
<element name="param" type="smil20lang:paramType"/>
<complexType name="paramType">
    <complexContent>
        <extension base="smil20:paramPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <any namespace="##other" processContents="lax"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- media groups -->
<group name="mediaContentGroup">
    <choice>
        <element ref="smil20lang:text"/>
        <element ref="smil20lang:img"/>
        <element ref="smil20lang:audio"/>
        <element ref="smil20lang:animation"/>
        <element ref="smil20lang:video"/>
        <element ref="smil20lang:textstream"/>
        <element ref="smil20lang:ref"/>
        <element ref="smil20lang:brush"/>
    </choice>
</group>

<group name="paramGroup">
    <choice>
        <element ref="smil20lang:param"/>
    </choice>
</group>

<!-- ================================================================= -->
<!-- ================================================================= -->
```

```
<attributeGroup name="BasicTimingAttrs">
    <attributeGroup ref="smil20:beginEndTimingAttrs"/>
    <attributeGroup ref="smil20:durTimingAttrs"/>
    <attributeGroup ref="smil20:repeatTimingAttrs"/>
    <attributeGroup ref="smil20:deprecatedRepeatTiming"/>
    <attributeGroup ref="smil20:minMaxTimingAttrs"/>
</attributeGroup>

<attributeGroup name="TimingAttrs">
    <attributeGroup ref="smil20lang:BasicTimingAttrs"/>
    <attributeGroup ref="smil20:syncBehaviorAttrs"/>
    <attributeGroup ref="smil20:syncBehaviorDefaultAttrs"/>
    <attributeGroup ref="smil20:restartTimingAttrs"/>
    <attributeGroup ref="smil20:restartDefaultAttrs"/>
    <attributeGroup ref="smil20:fillTimingAttrs"/>
    <attributeGroup ref="smil20:fillDefaultAttrs"/>
</attributeGroup>

<!-- par element and content model -->
<element name="par" type="smil20lang:parType"/>
<complexType name="parType">
    <complexContent>
        <extension base="smil20:parPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:aElementGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:deprecatedRepeatTiming"/>
            <attributeGroup ref="smil20:minMaxTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <attributeGroup ref="smil20:regionAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- seq element and content model -->
<element name="seq" type="smil20lang:seqType"/>
<complexType name="seqType">
    <complexContent>
        <extension base="smil20:seqPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:aElementGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:deprecatedRepeatTiming"/>
            <attributeGroup ref="smil20:minMaxTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <attributeGroup ref="smil20:regionAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- excl element and content model -->
<element name="excl" type="smil20lang:exclType"/>
<complexType name="exclType">
    <complexContent>
        <extension base="smil20:exclPrototype">
            <choice>
                <group ref="smil20lang:priorityClassGroup" minOccurs="0" maxOccurs="unbounded"/>
                <choice minOccurs="0" maxOccurs="unbounded">
                    <group ref="smil20lang:scheduleGroup"/>
                    <group ref="smil20lang:mediaContentGroup"/>
                    <group ref="smil20lang:contentControlGroup"/>
                    <group ref="smil20lang:aElementGroup"/>
                    <group ref="smil20lang:animationGroup"/>
                </choice>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:deprecatedRepeatTiming"/>
            <attributeGroup ref="smil20:minMaxTimingAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <attributeGroup ref="smil20:regionAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<element name="priorityClass" type="smil20lang:priorityClassType"/>
<complexType name="priorityClassType">
    <complexContent>
        <extension base="smil20:priorityClassPrototype">
            <choice minOccurs="0" maxOccurs="unbounded">
                <group ref="smil20lang:scheduleGroup"/>
                <group ref="smil20lang:mediaContentGroup"/>
                <group ref="smil20lang:contentControlGroup"/>
                <group ref="smil20lang:aElementGroup"/>
                <group ref="smil20lang:animationGroup"/>
            </choice>
            <attributeGroup ref="smil20lang:CoreAttrs"/>
            <attributeGroup ref="smil20:systemTestAttrs"/>
            <attributeGroup ref="smil20:deprecatedSystemTestAttrs"/>
            <attributeGroup ref="smil20:customTestAttrs"/>
            <attributeGroup ref="smil20:mediaAnnotateAttrs"/>
            <anyAttribute namespace="##any" processContents="strict"/>
        </extension>
    </complexContent>
</complexType>

<!-- timing groups -->
<group name="scheduleGroup">
    <choice>
        <element ref="smil20lang:par"/>
        <element ref="smil20lang:seq"/>
        <element ref="smil20lang:excl"/>
    </choice>
```

```
    </group>

    <group name="priorityClassGroup">
        <sequence>
            <element ref="smil20lang:priorityClass"/>
        </sequence>
    </group>

</schema>
```

B.3 XML Schema for the SMIL 2.0 modules:

B.3.1 SMIL 2.0 AccessKeyTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-AccessKeyTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the AccessKeyTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:AccessKeyTiming="http://www.w3.org/2001/SMIL20/AccessKeyTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/AccessKeyTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.2 SMIL 2.0 AudioLayout

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-AudioLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the AudioLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:AudioLayout="http://www.w3.org/2001/SMIL20/AudioLayout"
        targetNamespace="http://www.w3.org/2001/SMIL20/AudioLayout"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="soundLevel" type="smil20:positivePercentageType"/>

</schema>
```

B.3.3 SMIL 2.0 BasicAnimation

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicAnimation.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicAnimation module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:BasicAnimation="http://www.w3.org/2001/SMIL20/BasicAnimation"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicAnimation"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->
```

```
    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="animate" type="smil20lang:animateType" substitutionGroup="smil20lang:animate"/>
    <element name="set" type="smil20lang:setType" substitutionGroup="smil20lang:set"/>
    <element name="animateMotion" type="smil20lang:animateMotionType" substitutionGroup="smil20lang:animateMotion"/>
    <element name="animateColor" type="smil20lang:animateColorType" substitutionGroup="smil20lang:animateColor"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.4 SMIL 2.0 BasicContentControl

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicContentControl.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicContentControl module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicContentControl="http://www.w3.org/2001/SMIL20/BasicContentControl"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicContentControl"
        elementFormDefault="qualified">

    <!-- these URL's may have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="switch" type="smil20lang:switchType" substitutionGroup="smil20lang:switch"/>

    <!-- declare global attributes in this module -->
    <attribute name="systemAudioDesc" type="smil20:onOrOffType"/>
    <attribute name="systemBitrate" type="string"/>
    <attribute name="systemCaptions" type="smil20:onOrOffType"/>
    <attribute name="systemComponent" type="string"/>
    <attribute name="systemCPU" type="NMTOKEN"/>
    <attribute name="systemLanguage" type="string"/>
    <attribute name="systemOperatingSystem" type="NMTOKEN"/>
    <attribute name="systemOverdubOrSubtitle" type="smil20:overdubOrSubtitleType"/>
    <attribute name="systemRequired" type="string"/>
    <attribute name="systemScreenDepth" type="positiveInteger"/>
    <attribute name="systemScreenSize" type="string"/>
    <attribute name="system-bitrate" type="string"/>
    <attribute name="system-captions" type="smil20:onOrOffType"/>
    <attribute name="system-language" type="string"/>
    <attribute name="system-overdub-or-caption" type="smil20:overdubOrCaptionsType"/>
    <attribute name="system-required" type="string"/>
    <attribute name="system-screen-depth" type="positiveInteger"/>
    <attribute name="system-screen-size" type="string"/>

</schema>
```

B.3.5 SMIL 2.0 BasicInlineTiming

```
<!--
XML Schema for the SMIL 2.0 modules

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Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicInlineTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicInlineTiming module namespace
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout


```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->
```

```
    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
```

```
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout


```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>
```

```
    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
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Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
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Author: Aaron Michael Cohen (Intel)
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<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
```

```
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
```

```
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:BasicInlineTiming="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/BasicInlineTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>
    <attribute name="dur" type="string"/>

</schema>
```

B.3.6 SMIL 2.0 BasicLayout

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-BasicLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the BasicLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MediaClipMarkers="http://www.w3.org/2001/SMIL20/MediaClipMarkers"
        targetNamespace="http://www.w3.org/2001/SMIL20/MediaClipMarkers"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="clipBegin" type="string"/>
    <attribute name="clipEnd" type="string"/>
    <attribute name="clip-begin" type="string"/>
    <attribute name="clip-end" type="string"/>
```

```
</schema>
```

B.3.23 SMIL 2.0 MediaClipping

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-MediaClipping.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MediaClipping module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MediaClipping="http://www.w3.org/2001/SMIL20/MediaClipping"
        targetNamespace="http://www.w3.org/2001/SMIL20/MediaClipping"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="clipBegin" type="string"/>
    <attribute name="clipEnd" type="string"/>
    <attribute name="clip-begin" type="string"/>
    <attribute name="clip-end" type="string"/>

</schema>
```

B.3.24 SMIL 2.0 MediaDescription

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-MediaDescription.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MediaDescription module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:MediaDescription="http://www.w3.org/2001/SMIL20/MediaDescription"
        targetNamespace="http://www.w3.org/2001/SMIL20/MediaDescription"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="abstract" type="string"/>
    <attribute name="author" type="string"/>
    <attribute name="copyright" type="string"/>
    <attribute name="title" type="string"/>

</schema>
```

B.3.25 SMIL 2.0 MediaMarkerTiming

```
<!--
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Public URI: http://www.w3.org/2001/SMIL20/smil20-MediaMarkerTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MediaMarkerTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
```

```
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MediaMarkerTiming="http://www.w3.org/2001/SMIL20/MediaMarkerTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.26 SMIL 2.0 MediaParam

```
<!--
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Public URI: http://www.w3.org/2001/SMIL20/smil20-MediaParam.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MediaParam module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MediaParam="http://www.w3.org/2001/SMIL20/MediaParam"
        targetNamespace="http://www.w3.org/2001/SMIL20/MediaParam"
        elementFormDefault="qualified">

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="param" type="smil20lang:paramType" substitutionGroup="smil20lang:param"/>

    <!-- declare global attributes in this module -->
    <attribute name="erase" type="smil20:eraseMediaType"/>
    <attribute name="mediaRepeat" type="smil20:mediaRepeatType"/>
    <attribute name="sensitivity" type="smil20:sensitivityType"/>

</schema>
```

B.3.27 SMIL 2.0 Metainformation

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-Metainformation.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the Metainformation module namespace.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:Metainformation="http://www.w3.org/2001/SMIL20/Metainformation"
        targetNamespace="http://www.w3.org/2001/SMIL20/Metainformation"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->

    <!-- declare global elements in this module -->
    <element name="metadata" type="smil20lang:metadataType" substitutionGroup="smil20lang:metadata"/>
    <element name="meta" type="smil20lang:metaType" substitutionGroup="smil20lang:meta"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.28 SMIL 2.0 MinMaxTiming

```
<!--
XML Schema for the SMIL 2.0 modules
```

```
This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-MinMaxTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MinMaxTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MinMaxTiming="http://www.w3.org/2001/SMIL20/MinMaxTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/MinMaxTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="min" type="string"/>
    <attribute name="max" type="string"/>

</schema>
```

B.3.29 SMIL 2.0 MultiArcTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-MultiArcTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MultiArcTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MultiArcTiming="http://www.w3.org/2001/SMIL20/MultiArcTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/MultiArcTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.30 SMIL 2.0 MultiWindowLayout

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-MultiWindowLayout.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the MultiWindowLayout module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:MultiWindowLayout="http://www.w3.org/2001/SMIL20/MultiWindowLayout"
        targetNamespace="http://www.w3.org/2001/SMIL20/MultiWindowLayout"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="topLayout" type="smil20lang:topLayoutType" substitutionGroup="smil20lang:topLayout"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.31 SMIL 2.0 ObjectLinking

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-ObjectLinking.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the ObjectLinking module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:ObjectLinking="http://www.w3.org/2001/SMIL20/ObjectLinking"
        targetNamespace="http://www.w3.org/2001/SMIL20/ObjectLinking"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="area" type="smil20lang:areaType" substitutionGroup="smil20lang:area"/>
    <element name="anchor" type="smil20lang:anchorType" substitutionGroup="smil20lang:anchor"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.32 SMIL 2.0 PrefetchControl

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-PrefetchControl.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the PrefetchControl module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:PrefetchControl="http://www.w3.org/2001/SMIL20/PrefetchControl"
        targetNamespace="http://www.w3.org/2001/SMIL20/PrefetchControl"
        elementFormDefault="qualified">

    <!-- these URL's may have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="prefetch" type="smil20lang:prefetchType" substitutionGroup="smil20lang:prefetch"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->
</schema>
```

B.3.33 SMIL 2.0 RepeatTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-RepeatTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RepeatTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:RepeatTiming="http://www.w3.org/2001/SMIL20/RepeatTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/RepeatTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->
```

```
    <!-- declare global attributes in this module -->
    <attribute name="repeatDur" type="string"/>
    <attribute name="repeatCount" type="smil20:nonNegativeDecimalType"/>
    <attribute name="repeat" type="nonNegativeInteger"/>

</schema>
```

B.3.34 SMIL 2.0 RepeatValueTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-RepeatValueTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RepeatValueTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:RepeatValueTiming="http://www.w3.org/2001/SMIL20/RepeatValueTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/RepeatValueTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.35 SMIL 2.0 RestartDefault

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-RestartDefault.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RestartDefault module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:RestartDefault="http://www.w3.org/2001/SMIL20/RestartDefault"
        targetNamespace="http://www.w3.org/2001/SMIL20/RestartDefault"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="restartDefault" type="smil20:restartDefaultType"/>

</schema>
```

B.3.36 SMIL 2.0 RestartTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-RestartTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RestartTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
```

```
        xmlns:RestartTiming="http://www.w3.org/2001/SMIL20/RestartTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/RestartTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="restart" type="smil20:restartTimingType"/>

</schema>
```

B.3.37 SMIL 2.0 SkipContentControl

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-SkipContentControl.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the SkipContentControl module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:SkipContentControl="http://www.w3.org/2001/SMIL20/SkipContentControl"
        targetNamespace="http://www.w3.org/2001/SMIL20/SkipContentControl"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="skip-content" type="boolean"/>

</schema>
```

B.3.38 SMIL 2.0 SplineAnimation

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-SplineAnimation.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the SplineAnimation module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:SplineAnimation="http://www.w3.org/2001/SMIL20/SplineAnimation"
        targetNamespace="http://www.w3.org/2001/SMIL20/SplineAnimation"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="animate" type="smil20lang:animateType" substitutionGroup="smil20lang:animate"/>
    <element name="animateMotion" type="smil20lang:animateMotionType" substitutionGroup="smil20lang:animateMotion"/>
    <element name="animateColor" type="smil20lang:animateColorType" substitutionGroup="smil20lang:animateColor"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.39 SMIL 2.0 Structure

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
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```

```
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-Structure.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the Structure module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:Structure="http://www.w3.org/2001/SMIL20/Structure"
        targetNamespace="http://www.w3.org/2001/SMIL20/Structure"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <element name="smil" type="smil20lang:smilType" substitutionGroup="smil20lang:smil"/>
    <element name="head" type="smil20lang:headType" substitutionGroup="smil20lang:head"/>
    <element name="body" type="smil20lang:bodyType" substitutionGroup="smil20lang:body"/>

    <!-- declare global attributes in this module -->
    <!-- (none) -->

</schema>
```

B.3.40 SMIL 2.0 SyncBehavior

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-SyncBehavior.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RestartTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:SyncBehavior="http://www.w3.org/2001/SMIL20/SyncBehavior"
        targetNamespace="http://www.w3.org/2001/SMIL20/SyncBehavior"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="syncBehavior" type="smil20:syncBehaviorType"/>
    <attribute name="syncTolerance" type="string"/>

</schema>
```

B.3.41 SMIL 2.0 SyncBehaviorDefault

```
<!--
XML Schema for the SMIL 2.0 modules

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Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-SyncBehaviorDefault.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the RestartTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:SyncBehaviorDefault="http://www.w3.org/2001/SMIL20/SyncBehaviorDefault"
        targetNamespace="http://www.w3.org/2001/SMIL20/SyncBehaviorDefault"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="syncBehaviorDefault" type="smil20:syncBehaviorDefaultType"/>
    <attribute name="syncToleranceDefault" type="string"/>

</schema>
```

B.3.42 SMIL 2.0 SyncMaster

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-SyncMaster.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the SyncMaster module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:SyncMaster="http://www.w3.org/2001/SMIL20/SyncMaster"
        targetNamespace="http://www.w3.org/2001/SMIL20/SyncMaster"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="syncMaster" type="boolean"/>

</schema>
```

B.3.43 SMIL 2.0 SyncbaseTiming

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-SyncbaseTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the SyncbaseTiming module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:SyncbaseTiming="http://www.w3.org/2001/SMIL20/SyncbaseTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/SyncbaseTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.44 SMIL 2.0 TimeContainerAttributes

```
<!--
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-TimeContainerAttributes.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the TimeContainerAttributes module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:TimeContainerAttributes="http://www.w3.org/2001/SMIL20/TimeContainerAttributes"
        targetNamespace="http://www.w3.org/2001/SMIL20/TimeContainerAttributes"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="timeContainer" type="smil20:timeContainerArgType"/>
    <attribute name="timeAction" type="smil20:timeActionType"/>
    <attribute name="fill" type="smil20:fillTimingAttrsType"/>
    <attribute name="endsync" type="smil20:endsyncTimingAttrsType"/>
```

```
</schema>
```

B.3.45 SMIL 2.0 TimeManipulations

```
<!--
XML Schema for the SMIL 2.0 modules

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Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
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Public URI: http://www.w3.org/2001/SMIL20/smil20-TimeManipulations.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the TimeManipulations module namespace,
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:TimeManipulations="http://www.w3.org/2001/SMIL20/TimeManipulations"
        targetNamespace="http://www.w3.org/2001/SMIL20/TimeManipulations"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="accelerate" type="smil20:zeroToOneDecimalType"/>
    <attribute name="decelerate" type="smil20:zeroToOneDecimalType"/>
    <attribute name="autoReverse" type="boolean"/>
    <attribute name="speed" type="smil20:nonZeroDecimalType"/>

</schema>
```

B.3.46 SMIL 2.0 TransitionModifiers

```
XML Schema for the SMIL 2.0 modules

This is SMIL 2.0
Copyright: 1998-2001 W3C (MIT, INRIA, Keio), All Rights Reserved.
See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-TransitionModifiers.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the TransitionModifiers module namespace.
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:TransitionModifiers="http://www.w3.org/2001/SMIL20/TransitionModifiers"
        targetNamespace="http://www.w3.org/2001/SMIL20/TransitionModifiers"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- import the definitions in the smil20 language namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/Language" schemaLocation="smil20-language.xsd"/>

    <!-- declare global elements in this module -->
    <element name="transitionFilter" type="smil20:transitionFilterType" substitutionGroup="smil20:transitionFilter"/>
    <element name="transition" type="smil20lang:transitionType" substitutionGroup="smil20lang:transition"/>

    <!-- declare global attributes in this module -->
    <attribute name="transIn" type="string"/>
    <attribute name="transOut" type="string"/>

</schema>
```

B.3.47 SMIL 2.0 WallclockTiming

```
<!--
XML Schema for the SMIL 2.0 modules

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Public URI: http://www.w3.org/2001/SMIL20/smil20-WallclockTiming.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31

Schema for the WallclockTiming module namespace,
-->
```

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        xmlns:smil20lang="http://www.w3.org/2001/SMIL20/Language"
        xmlns:WallclockTiming="http://www.w3.org/2001/SMIL20/WallclockTiming"
        targetNamespace="http://www.w3.org/2001/SMIL20/WallclockTiming"
        elementFormDefault="qualified">

    <!-- these URL's will have to be expanded to their full and proper locations -->

    <!-- import the definitions in the smil20 namespace -->
    <import namespace="http://www.w3.org/2001/SMIL20/" schemaLocation="smil20.xsd"/>

    <!-- declare global elements in this module -->
    <!-- (none) -->

    <!-- declare global attributes in this module -->
    <attribute name="begin" type="string"/>
    <attribute name="end" type="string"/>

</schema>
```

B.3.48 SMIL 2.0 utility

```
<!--
XML Schema utility types used by any or all of the schema documents.

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See http://www.w3.org/Consortium/Legal/.

Public URI: http://www.w3.org/2001/SMIL20/smil20-utility.xsd
Author: Aaron Michael Cohen (Intel)
Revision: 2001/07/31
-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:smil20="http://www.w3.org/2001/SMIL20/"
        targetNamespace="http://www.w3.org/2001/SMIL20/"
        elementFormDefault="qualified">

    <!-- utility type for values 0.0 to 1.0 inclusive -->
    <simpleType name="zeroToOneDecimalType">
        <restriction base="decimal">
            <minInclusive value="0.0"/>
            <maxInclusive value="1.0"/>
        </restriction>
    </simpleType>

    <!-- utility types for non-zero values -->
    <simpleType name="greatThanZeroDecimalType">
        <restriction base="decimal">
            <minExclusive value="0.0"/>
        </restriction>
    </simpleType>

    <simpleType name="nonNegativeDecimalType">
        <restriction base="decimal">
            <minInclusive value="0.0"/>
        </restriction>
    </simpleType>

    <simpleType name="lessThanZeroDecimalType">
        <restriction base="decimal">
            <maxExclusive value="0.0"/>
        </restriction>
    </simpleType>

    <simpleType name="nonZeroDecimalType">
        <union memberTypes="smil20:lessThanZeroDecimalType smil20:greaterThanZeroDecimalType"/>
    </simpleType>

    <!-- syntax for positive percentages, zero inclusive -->
    <simpleType name="positivePercentageType">
        <restriction base="string">
            <pattern value="[0-9]*((\.)([0-9])*)?%"/>
        </restriction>
    </simpleType>

</schema>
```

B.3.49 SMIL 2.0 rdf

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
        targetNamespace="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

    <!-- the RDF namespace needs to be verified -->

    <element name="RDF">
        <complexType>
            <sequence>
                <any namespace="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
                     minOccurs="0" maxOccurs="unbounded" processContents="skip"/>
            </sequence>
        </complexType>
    </element>

</schema>
```

B.3.50 SMIL 2.0 xml-mod

```
<schema targetNamespace="http://www.w3.org/XML/1998/namespace"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:x="http://www.w3.org/XML/1998/namespace">

   <attribute name="lang" type="language">
      <annotation>
         <documentation>In due course, we should install the relevant ISO 2- and 3-letter
            codes as the enumerated possible values . . .</documentation>
      </annotation>
   </attribute>

   <attribute name="space" use="optional"  default="preserve">
      <simpleType>
         <restriction base="NCName">
            <enumeration value="default"/>
            <enumeration value="preserve"/>
         </restriction>
      </simpleType>
   </attribute>

   <attributeGroup name="specialAttrs">
      <attribute ref="x:lang"/>
      <attribute ref="x:space"/>
   </attributeGroup>
</schema>
```

Appendix C. Index of Elements

Element Name	specified in
a	Linking Modules
anchor	Linking Modules
animateColor	Animation Modules
animateMotion	Animation Modules
animation	Animation Modules
area	Linking Modules
audio	Media Object Modules
brush	Media Object Modules
body	Structure Module
customAttributes	Content Control Modules
customTest	Content Control Modules
excl	Timing and Synchronization Module
head	Structure Module
img	Media Object Modules
layout	Layout Modules
meta	Metainformation Module
metadata	Metainformation Module
par	Timing and Synchronization Module
param	Media Object Modules
prefetch	Content Control Modules
priorityClass	Content Control Modules
ref	Media Object Modules
region	Layout Modules
regPoint	Layout Modules
root-layout	Layout Modules
seq	Timing and Synchronization Module
set	Animation Modules
smil	Structure Module
switch	Content Control Modules
text	Media Object Modules
textstream	Media Object Modules
topLayout	Layout Modules
transition	Transition Effects Module
transitionFilter	Transition Effects Module
video	Media Object Modules

Appendix D. Index of Attributes

Appendix B: Index of Attributes

Attribute Name	specified in
abstract	Media Object Modules
accelerate	Time Manipulations Module
accesskey	Linking Modules
accumulate	Animation Modules
actuate	Linking Modules
actuate	Animation Modules
additive	Animation Modules
alt	Linking Modules
alt	Media Object Modules
attributeName	Animation Modules
attributeType	Animation Modules
author	Media Object Modules
autoReverse	Time Manipulations Module
background-color	Layout Modules
backgroundColor	Layout Modules (Media elements)
bandwidth	Content Control Modules
begin	Timing and Synchronization Module
begin	Transition Effects Module
borderColor	Transition Effects Module
borderWidth	Transition Effects Module
bottom	Layout Modules
bottom	Layout Modules (RegPoint element)
bottom	Layout Modules (Sub-region positioning)
by	Animation Modules
by	Transition Effects Module
calcMode	Animation Modules
calcMode	Animation Modules (SplineAnimation)
calcMode	Animation Modules (transitionFilter element)
class	Structure Module
clip-begin	Media Object Modules
clipBegin	Media Object Modules
clip-end	Media Object Modules
clipEnd	Media Object Modules
close	Layout Modules (topLayout element)
color	Media Object Modules
content	Metainformation Module
coords	Linking Modules
copyright	Media Object Modules
customTest	Content Control Modules
decelerate	Time Manipulations Module
defaultState	Content Control Modules
destinationPlaystate	Linking Modules
direction	Transition Effects Module
dur	Timing and Synchronization Module
dur	Transition Effects Module (transition element)
dur	Transition Effects Module (transitionFilter element)
end	Timing and Synchronization Module
end	Transition Effects Module (transitionFilter element)
endProgress	Transition Effects Module (transition element)
endsync	Timing and Synchronization Module
erase	Media Object Modules
external	Linking Modules
fadeColor	Transition Effects Module (transitionFilter element)
fadeColor	Transition Effects Module (transition element)
fill	Timing and Synchronization Module
fillDefault	Timing and Synchronization Module
fillTransition	Transition Effects Module
fit	Layout Modules
fragment	Linking Modules
from	Animation Modules
from	Transition Effects Module (transitionFilter element)
height	Layout Modules
height	Layout Modules (root-layout element)
height	Layout Modules (Sub-region positioning)

higher	Timing and Synchronization Module
horzRepeat	Transition Effects Module
href	Linking Modules
href	Animation Modules (animate element)
id	Structure Module
keySplines	Animation Modules
keyTimes	Animation Modules
left	Layout Modules
left	Layout Modules (RegPoint element)
left	Layout Modules (Sub-region positioning)
longdesc	Media Object Modules
lower	Timing and Synchronization Module
max	Timing and Synchronization Module
mediaRepeat	Media Object Modules
mediaSize	Content Control Modules
mediaTime	Content Control Modules
min	Timing and Synchronization Module
mode	Transition Effects Module
name	Metainformation Module
name	Media Object Modules (param element)
nohref	Linking Modules
open	Layout Modules (topLayout element)
origin	Animation Modules
override	Content Control Modules
path	Animation Modules
pauseDisplay	Timing and Synchronization Module
peers	Timing and Synchronization Module
readIndex	Media Object Modules
regAlign	Layout Modules
regAlign	Layout Modules (RegPoint element)
regPoint	Layout Modules
regionName	Layout Modules
repeat	Timing and Synchronization Module
repeatCount	Timing and Synchronization Module
repeatCount	Transition Effects Module (transitionFilter element)
repeatDur	Timing and Synchronization Module
repeatDur	Transition Effects Module (transitionFilter element)
restart	Timing and Synchronization Module
restartDefault	Timing and Synchronization Module
right	Layout Modules
right	Layout Modules (RegPoint element)
right	Layout Modules (Sub-region positioning)
shape	Linking Modules
show	Linking Modules
show	Animation Modules (animate element)
showBackground	Layout Modules
skip-content	Content Control Modules
soundLevel	Layout Modules
sourceLevel	Linking Modules
sourcePlaystate	Linking Modules
speed	Time Manipulations Module
src	Media Object Modules
startProgress	Transition Effects Module
subtype	Transition Effects Module
subtype	Transition Effects Module (transitionFilter element)
syncBehavior	Timing and Synchronization Module
syncBehaviorDefault	Timing and Synchronization Module
syncMaster	Timing and Synchronization Module
syncTolerance	Timing and Synchronization Module
syncToleranceDefault	Timing and Synchronization Module
system-overdub-or-caption	Content Control Modules
systemAudioDesc	Content Control Modules
systemBitrate	Content Control Modules
systemCPU	Content Control Modules
systemCaptions	Content Control Modules
systemComponent	Content Control Modules
systemLanguage	Content Control Modules
systemOperatingSystem	Content Control Modules
systemOverdubOrSubtitle	Content Control Modules
systemRequired	Content Control Modules

systemRequired	Content Control Modules
systemScreenDepth	Content Control Modules
systemScreenSize	Content Control Modules
tabindex	Linking Modules
target	Linking Modules
targetElement	Animation Modules
timeAction	Timing and Synchronization Module
timeContainer	Timing and Synchronization Module
title	Structure Module
to	Animation Modules
to	Animation Modules (set element)
to	Transition Effects Module (transitionFilter element)
top	Layout Modules
top	Layout Modules (Sub-region positioning)
top	Layout Modules (RegPoint element)
transIn	Transition Effects Module
transOut	Transition Effects Module
type	Animation Modules (animate element)
type	Layout Modules
type	Media Object Modules (param element)
type	Media Object Modules (media element)
type	Transition Effects Module (transition element)
type	Transition Effects Module (transitionFilter element)
uid	Content Control Modules
value	Media Object Modules
values	Animation Modules
values	Transition Effects Module (transitionFilter element)
valuetype	Media Object Modules
vertRepeat	Transition Effects Module
width	Layout Modules
width	Layout Modules (root-layout element)
width	Layout Modules (Sub-region positioning)
xml:lang	Structure Module
xmlns	Structure Module
z-index	Layout Modules

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INTERNET ARCHIVE WayBackMachine https://www.ietf.org/rfc/rfc2616.txt Go JUN AUG NOV 02 2001 2002 2003 3,132 captures 15 Aug 2000 - 2 Sep 2023 About this capture

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Request for Comments: 2616
Obsoletes: 2068
Category: Standards Track

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June 1999

Hypertext Transfer Protocol -- HTTP/1.1

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information systems. It is a generic, stateless, protocol which can be used for many tasks beyond its use for hypertext, such as name servers and distributed object management systems, through extension of its request methods, error codes and headers [47]. A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred.

HTTP has been in use by the World-Wide Web global information initiative since 1990. This specification defines the protocol referred to as "HTTP/1.1", and is an update to RFC 2068 [33].

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1 Introduction

1.1 Purpose

The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information systems. HTTP has been in use by the World-Wide Web global information initiative since 1990. The first version of HTTP, referred to as HTTP/0.9, was a simple protocol for raw data transfer across the Internet. HTTP/1.0, as defined by RFC 1945 [6], improved the protocol by allowing messages to be in the format of MIME-like messages, containing metainformation about the data transferred and modifiers on the request/response semantics. However, HTTP/1.0 does not sufficiently take into consideration the effects of hierarchical proxies, caching, the need for persistent connections, or virtual hosts. In addition, the proliferation of incompletely-implemented applications calling themselves "HTTP/1.0" has necessitated a protocol version change in order for two communicating applications to determine each other's true capabilities.

This specification defines the protocol referred to as "HTTP/1.1". This protocol includes more stringent requirements than HTTP/1.0 in order to ensure reliable implementation of its features.

Practical information systems require more functionality than simple retrieval, including search, front-end update, and annotation. HTTP allows an open-ended set of methods and headers that indicate the purpose of a request [47]. It builds on the discipline of reference provided by the Uniform Resource Identifier (URI) [3], as a location (URL) [4] or name (URN) [20], for indicating the resource to which a

method is to be applied. Messages are passed in a format similar to that used by Internet mail [9] as defined by the Multipurpose Internet Mail Extensions (MIME) [7].

HTTP is also used as a generic protocol for communication between user agents and proxies/gateways to other Internet systems, including

those supported by the SMTP [16], NNTP [13], FTP [18], Gopher [2], and WAIS [10] protocols. In this way, HTTP allows basic hypermedia access to resources available from diverse applications.

1.2 Requirements

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [34].

An implementation is not compliant if it fails to satisfy one or more of the MUST or REQUIRED level requirements for the protocols it implements. An implementation that satisfies all the MUST or REQUIRED level and all the SHOULD level requirements for its protocols is said to be "unconditionally compliant"; one that satisfies all the MUST level requirements but not all the SHOULD level requirements for its protocols is said to be "conditionally compliant."

1.3 Terminology

This specification uses a number of terms to refer to the roles played by participants in, and objects of, the HTTP communication.

connection
: A transport layer virtual circuit established between two programs for the purpose of communication.

message
: The basic unit of HTTP communication, consisting of a structured sequence of octets matching the syntax defined in section 4 and transmitted via the connection.

request
: An HTTP request message, as defined in section 5.

response
: An HTTP response message, as defined in section 6.

resource
: A network data object or service that can be identified by a URI, as defined in section 3.2. Resources may be available in multiple representations (e.g. multiple languages, data formats, size, and resolutions) or vary in other ways.

entity
: The information transferred as the payload of a request or response. An entity consists of metainformation in the form of entity-header fields and content in the form of an entity-body, as described in section 7.

representation
: An entity included with a response that is subject to content negotiation, as described in section 12. There may exist multiple representations associated with a particular response status.

content negotiation
: The mechanism for selecting the appropriate representation when servicing a request, as described in section 12. The representation of entities in any response can be negotiated (including error responses).

variant
: A resource may have one, or more than one, representation(s) associated with it at any given instant. Each of these representations is termed a `varriant'. Use of the term `variant' does not necessarily imply that the resource is subject to content negotiation.

client
: A program that establishes connections for the purpose of sending requests.

user agent
: The client which initiates a request. These are often browsers, editors, spiders (web-traversing robots), or other end user tools.

server
: An application program that accepts connections in order to service requests by sending back responses. Any given program may be capable of being both a client and a server; our use of these terms refers only to the role being performed by the program for a particular connection, rather than to the program's capabilities in general. Likewise, any server may act as an origin server, proxy, gateway, or tunnel, switching behavior based on the nature of each request.

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origin server
The server on which a given resource resides or is to be created.

proxy
An intermediary program which acts as both a server and a client for the purpose of making requests on behalf of other clients. Requests are serviced internally or by passing them on, with possible translation, to other servers. A proxy MUST implement both the client and server requirements of this specification. A "transparent proxy" is a proxy that does not modify the request or response beyond what is required for proxy authentication and identification. A "non-transparent proxy" is a proxy that modifies the request or response in order to provide some added service to the user agent, such as group annotation services, media type transformation, protocol reduction, or anonymity filtering. Except where either transparent or non-transparent behavior is explicitly stated, the HTTP proxy requirements apply to both types of proxies.

gateway
A server which acts as an intermediary for some other server. Unlike a proxy, a gateway receives requests as if it were the origin server for the requested resource; the requesting client may not be aware that it is communicating with a gateway.

tunnel
An intermediary program which is acting as a blind relay between two connections. Once active, a tunnel is not considered a party to the HTTP communication, though the tunnel may have been initiated by an HTTP request. The tunnel ceases to exist when both ends of the relayed connections are closed.

cache
A program's local store of response messages and the subsystem that controls its message storage, retrieval, and deletion. A cache stores cacheable responses in order to reduce the response time and network bandwidth consumption on future, equivalent requests. Any client or server may include a cache, though a cache cannot be used by a server that is acting as a tunnel.

cacheable
A response is cacheable if a cache is allowed to store a copy of the response message for use in answering subsequent requests. The rules for determining the cacheability of HTTP responses are defined in section 13. Even if a resource is cacheable, there may be additional constraints on whether a cache can use the cached copy for a particular request.

first-hand
A response is first-hand if it comes directly and without unnecessary delay from the origin server, perhaps via one or more proxies. A response is also first-hand if its validity has just been checked directly with the origin server.

explicit expiration time
The time at which the origin server intends that an entity should no longer be returned by a cache without further validation.

heuristic expiration time
An expiration time assigned by a cache when no explicit expiration time is available.

age
The age of a response is the time since it was sent by, or successfully validated with, the origin server.

freshness lifetime
The length of time between the generation of a response and its expiration time.

fresh
A response is fresh if its age has not yet exceeded its freshness lifetime.

stale
A response is stale if its age has passed its freshness lifetime.

semantically transparent
A cache behaves in a "semantically transparent" manner, with respect to a particular response, when its use affects neither the requesting client nor the origin server, except to improve performance. When a cache is semantically transparent, the client receives exactly the same response (except for hop-by-hop headers) that it would have received had its request been handled directly by the origin server.

validator
A protocol element (e.g., an entity tag or a Last-Modified time) that is used to find out whether a cache entry is an equivalent copy of an entity.

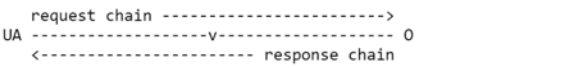
upstream/downstream
Upstream and downstream describe the flow of a message: all messages flow from upstream to downstream.

inbound/outbound
Inbound and outbound refer to the request and response paths for messages: "inbound" means "traveling toward the origin server", and "outbound" means "traveling toward the user agent"

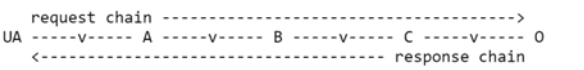
1.4 Overall Operation

The HTTP protocol is a request/response protocol. A client sends a request to the server in the form of a request method, URI, and protocol version, followed by a MIME-like message containing request modifiers, client information, and possible body content over a connection with a server. The server responds with a status line, including the message's protocol version and a success or error code, followed by a MIME-like message containing server information, entity metainformation, and possible entity-body content. The relationship between HTTP and MIME is described in appendix 19.4.

Most HTTP communication is initiated by a user agent and consists of a request to be applied to a resource on some origin server. In the simplest case, this may be accomplished via a single connection (v) between the user agent (UA) and the origin server (O).



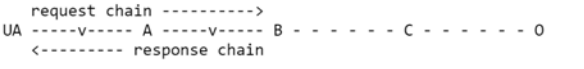
A more complicated situation occurs when one or more intermediaries are present in the request/response chain. There are three common forms of intermediary: proxy, gateway, and tunnel. A proxy is a forwarding agent, receiving requests for a URI in its absolute form, rewriting all or part of the message, and forwarding the reformatted request toward the server identified by the URI. A gateway is a receiving agent, acting as a layer above some other server(s) and, if necessary, translating the requests to the underlying server's protocol. A tunnel acts as a relay point between two connections without changing the messages; tunnels are used when the communication needs to pass through an intermediary (such as a firewall) even when the intermediary cannot understand the contents of the messages.



The figure above shows three intermediaries (A, B, and C) between the user agent and origin server. A request or response message that travels the whole chain will pass through four separate connections. This distinction is important because some HTTP communication options

may apply only to the connection with the nearest, non-tunnel neighbor, only to the end-points of the chain, or to all connections along the chain. Although the diagram is linear, each participant may be engaged in multiple, simultaneous communications. For example, B may be receiving requests from many clients other than A, and/or forwarding requests to servers other than C, at the same time that it is handling A's request.

Any party to the communication which is not acting as a tunnel may employ an internal cache for handling requests. The effect of a cache is that the request/response chain is shortened if one of the participants along the chain has a cached response applicable to that request. The following illustrates the resulting chain if B has a cached copy of an earlier response from O (via C) for a request which has not been cached by UA or A.



Not all responses are usefully cacheable, and some requests may contain modifiers which place special requirements on cache behavior. HTTP requirements for cache behavior and cacheable responses are defined in section 13.

In fact, there are a wide variety of architectures and configurations of caches and proxies currently being experimented with or deployed across the World Wide Web. These systems include national hierarchies of proxy caches to save transoceanic bandwidth, systems that broadcast or multicast cache entries, organizations that distribute subsets of cached data via CD-ROM, and so on. HTTP systems are used in corporate intranets over high-bandwidth links, and for access via PDAs with low-power radio links and intermittent connectivity. The goal of HTTP/1.1 is to support the wide diversity of configurations

goal of HTTP/1.1 is to support the wide diversity of configurations already deployed while introducing protocol constructs that meet the needs of those who build web applications that require high reliability and, failing that, at least reliable indications of failure.

HTTP communication usually takes place over TCP/IP connections. The default port is TCP 80 [19], but other ports can be used. This does not preclude HTTP from being implemented on top of any other protocol on the Internet, or on other networks. HTTP only presumes a reliable transport; any protocol that provides such guarantees can be used; the mapping of the HTTP/1.1 request and response structures onto the transport data units of the protocol in question is outside the scope of this specification.

In HTTP/1.0, most implementations used a new connection for each request/response exchange. In HTTP/1.1, a connection may be used for one or more request/response exchanges, although connections may be closed for a variety of reasons (see section 8.1).

2 Notational Conventions and Generic Grammar

2.1 Augmented BNF

All of the mechanisms specified in this document are described in both prose and an augmented Backus-Naur Form (BNF) similar to that used by RFC 822 [9]. Implementors will need to be familiar with the notation in order to understand this specification. The augmented BNF includes the following constructs:

name = definition
: The name of a rule is simply the name itself (without any enclosing "<" and ">") and is separated from its definition by the equal "=" character. White space is only significant in that indentation of continuation lines is used to indicate a rule definition that spans more than one line. Certain basic rules are in uppercase, such as SP, LWS, HT, CRLF, DIGIT, ALPHA, etc. Angle brackets are used within definitions whenever their presence will facilitate discerning the use of rule names.

"literal"
: Quotation marks surround literal text. Unless stated otherwise, the text is case-insensitive.

rule1 | rule2
: Elements separated by a bar ("|") are alternatives, e.g., "yes | no" will accept yes or no.

(rule1 rule2)
: Elements enclosed in parentheses are treated as a single element. Thus, "(elem (foo | bar) elem)" allows the token sequences "elem foo elem" and "elem bar elem".

*rule
: The character "*" preceding an element indicates repetition. The full form is "<n>*<m>element" indicating at least <n> and at most <m> occurrences of element. Default values are 0 and infinity so that "*(element)" allows any number, including zero; "1*element" requires at least one; and "1*2element" allows one or two.

[rule]
: Square brackets enclose optional elements; "[foo bar]" is equivalent to "*1(foo bar)".

N rule
: Specific repetition: "<n>(element)" is equivalent to "<n>*<n>(element)"; that is, exactly <n> occurrences of (element). Thus 2DIGIT is a 2-digit number, and 3ALPHA is a string of three alphabetic characters.

#rule
: A construct "#" is defined, similar to "*", for defining lists of elements. The full form is "<n>#<m>element" indicating at least <n> and at most <m> elements, each separated by one or more commas (",") and OPTIONAL linear white space (LWS). This makes the usual form of lists very easy; a rule such as

```
( *LWS element *( *LWS "," *LWS element ))
```

can be shown as

```
1#element
```

Wherever this construct is used, null elements are allowed, but do not contribute to the count of elements present. That is, "(element), , (element) " is permitted, but counts as only two elements. Therefore, where at least one element is required, at least one non-null element MUST be present. Default values are 0 and infinity so that "#element" allows any number, including zero; "1#element" requires at least one; and "1#2element" allows one or two.

; comment
A semi-colon, set off some distance to the right of rule text, starts a comment that continues to the end of line. This is a simple way of including useful notes in parallel with the specifications.

implied *LWS
The grammar described by this specification is word-based. Except where noted otherwise, linear white space (LWS) can be included between any two adjacent words (token or quoted-string), and between adjacent words and separators, without changing the interpretation of a field. At least one delimiter (LWS and/or

separators) MUST exist between any two tokens (for the definition of "token" below), since they would otherwise be interpreted as a single token.

2.2 Basic Rules

The following rules are used throughout this specification to describe basic parsing constructs. The US-ASCII coded character set is defined by ANSI X3.4-1986 [21].


```
      OCTET          = <any 8-bit sequence of data>
      CHAR           = <any US-ASCII character (octets 0 - 127)>
      UPALPHA        = <any US-ASCII uppercase letter "A".."Z">
      LOALPHA        = <any US-ASCII lowercase letter "a".."z">
      ALPHA          = UPALPHA | LOALPHA
      DIGIT          = <any US-ASCII digit "0".."9">
      CTL            = <any US-ASCII control character
                       (octets 0 - 31) and DEL (127)>
      CR             = <US-ASCII CR, carriage return (13)>
      LF             = <US-ASCII LF, linefeed (10)>
      SP             = <US-ASCII SP, space (32)>
      HT             = <US-ASCII HT, horizontal-tab (9)>
      <">            = <US-ASCII double-quote mark (34)>
```

HTTP/1.1 defines the sequence CR LF as the end-of-line marker for all protocol elements except the entity-body (see appendix 19.3 for tolerant applications). The end-of-line marker within an entity-body is defined by its associated media type, as described in section 3.7.

```
      CRLF           = CR LF
```

HTTP/1.1 header field values can be folded onto multiple lines if the continuation line begins with a space or horizontal tab. All linear white space, including folding, has the same semantics as SP. A recipient MAY replace any linear white space with a single SP before interpreting the field value or forwarding the message downstream.

```
      LWS            = [CRLF] 1*( SP | HT )
```

The TEXT rule is only used for descriptive field contents and values that are not intended to be interpreted by the message parser. Words of *TEXT MAY contain characters from character sets other than ISO-8859-1 [22] only when encoded according to the rules of RFC 2047 [14].

```
      TEXT           = <any OCTET except CTLs,
                       but including LWS>
```

A CRLF is allowed in the definition of TEXT only as part of a header field continuation. It is expected that the folding LWS will be replaced with a single SP before interpretation of the TEXT value.

Hexadecimal numeric characters are used in several protocol elements.

```
      HEX            = "A" | "B" | "C" | "D" | "E" | "F"
                     | "a" | "b" | "c" | "d" | "e" | "f" | DIGIT
```


Many HTTP/1.1 header field values consist of words separated by LWS or special characters. These special characters MUST be in a quoted string to be used within a parameter value (as defined in section 3.6).

```
      token          = 1*<any CHAR except CTLs or separators>
      separators     = "(" | ")" | "<" | ">" | "@"
                     | "," | ";" | ":" | "\" | <">
                     | "/" | "[" | "]" | "?" | "="
                     | "{" | "}" | SP | HT
```

Comments can be included in some HTTP header fields by surrounding the comment text with parentheses. Comments are only allowed in fields containing "comment" as part of their field value definition.

In all other fields, parentheses are considered part of the field value.

```
comment        = "(" *( ctext | quoted-pair | comment ) ")"
ctext          = <any TEXT excluding "(" and ")">
```

A string of text is parsed as a single word if it is quoted using double-quote marks.

```
quoted-string  = ( <"> *(qdtext | quoted-pair ) <"> )
qdtext         = <any TEXT except <">>
```

The backslash character ("\") MAY be used as a single-character quoting mechanism only within quoted-string and comment constructs.

```
quoted-pair    = "\" CHAR
```

3 Protocol Parameters

3.1 HTTP Version

HTTP uses a "<major>.<minor>" numbering scheme to indicate versions of the protocol. The protocol versioning policy is intended to allow the sender to indicate the format of a message and its capacity for understanding further HTTP communication, rather than the features obtained via that communication. No change is made to the version number for the addition of message components which do not affect communication behavior or which only add to extensible field values. The <minor> number is incremented when the changes made to the protocol add features which do not change the general message parsing algorithm, but which may add to the message semantics and imply additional capabilities of the sender. The <major> number is incremented when the format of a message within the protocol is changed. See RFC 2145 [36] for a fuller explanation.

The version of an HTTP message is indicated by an HTTP-Version field in the first line of the message.

```
HTTP-Version   = "HTTP" "/" 1*DIGIT "." 1*DIGIT
```

Note that the major and minor numbers MUST be treated as separate integers and that each MAY be incremented higher than a single digit. Thus, HTTP/2.4 is a lower version than HTTP/2.13, which in turn is lower than HTTP/12.3. Leading zeros MUST be ignored by recipients and MUST NOT be sent.

An application that sends a request or response message that includes HTTP-Version of "HTTP/1.1" MUST be at least conditionally compliant with this specification. Applications that are at least conditionally compliant with this specification SHOULD use an HTTP-Version of "HTTP/1.1" in their messages, and MUST do so for any message that is not compatible with HTTP/1.0. For more details on when to send specific HTTP-Version values, see RFC 2145 [36].

The HTTP version of an application is the highest HTTP version for which the application is at least conditionally compliant.

Proxy and gateway applications need to be careful when forwarding messages in protocol versions different from that of the application. Since the protocol version indicates the protocol capability of the sender, a proxy/gateway MUST NOT send a message with a version indicator which is greater than its actual version. If a higher version request is received, the proxy/gateway MUST either downgrade the request version, or respond with an error, or switch to tunnel behavior.

Due to interoperability problems with HTTP/1.0 proxies discovered since the publication of RFC 2068[33], caching proxies MUST, gateways MAY, and tunnels MUST NOT upgrade the request to the highest version they support. The proxy/gateway's response to that request MUST be in the same major version as the request.

> Note: Converting between versions of HTTP may involve modification of header fields required or forbidden by the versions involved.

3.2 Uniform Resource Identifiers

URIs have been known by many names: WWW addresses, Universal Document Identifiers, Universal Resource Identifiers [3], and finally the combination of Uniform Resource Locators (URL) [4] and Names (URN) [20]. As far as HTTP is concerned, Uniform Resource Identifiers are simply formatted strings which identify--via name, location, or any other characteristic--a resource.

3.2.1 General Syntax

URIs in HTTP can be represented in absolute form or relative to some known base URI [11], depending upon the context of their use. The two forms are differentiated by the fact that absolute URIs always begin

with a scheme name followed by a colon. For definitive information on URL syntax and semantics, see "Uniform Resource Identifiers (URI): Generic Syntax and Semantics," RFC 2396 [42] (which replaces RFCs 1738 [4] and RFC 1808 [11]). This specification adopts the definitions of "URI-reference", "absoluteURI", "relativeURI", "port", "host","abs_path", "rel_path", and "authority" from that specification.

The HTTP protocol does not place any a priori limit on the length of a URI. Servers MUST be able to handle the URI of any resource they serve, and SHOULD be able to handle URIs of unbounded length if they provide GET-based forms that could generate such URIs. A server SHOULD return 414 (Request-URI Too Long) status if a URI is longer than the server can handle (see section 10.4.15).

Note: Servers ought to be cautious about depending on URI lengths above 255 bytes, because some older client or proxy implementations might not properly support these lengths.

3.2.2 http URL

The "http" scheme is used to locate network resources via the HTTP protocol. This section defines the scheme-specific syntax and semantics for http URLs.

```
http_URL = "http:" "//" host [ ":" port ] [ abs_path [ "?" query ]]
```

If the port is empty or not given, port 80 is assumed. The semantics are that the identified resource is located at the server listening for TCP connections on that port of that host, and the Request-URI for the resource is abs_path (section 5.1.2). The use of IP addresses in URLs SHOULD be avoided whenever possible (see RFC 1900 [24]). If the abs_path is not present in the URL, it MUST be given as "/" when used as a Request-URI for a resource (section 5.1.2). If a proxy receives a host name which is not a fully qualified domain name, it MAY add its domain to the host name it received. If a proxy receives a fully qualified domain name, the proxy MUST NOT change the host name.

3.2.3 URI Comparison

When comparing two URIs to decide if they match or not, a client SHOULD use a case-sensitive octet-by-octet comparison of the entire URIs, with these exceptions:

- A port that is empty or not given is equivalent to the default port for that URI-reference;
- Comparisons of host names MUST be case-insensitive;
- Comparisons of scheme names MUST be case-insensitive;
- An empty abs_path is equivalent to an abs_path of "/".

Characters other than those in the "reserved" and "unsafe" sets (see RFC 2396 [42]) are equivalent to their ""%" HEX HEX" encoding.

For example, the following three URIs are equivalent:

```
http://abc.com:80/~smith/home.html
http://ABC.com/%7Esmith/home.html
http://ABC.com:/%7esmith/home.html
```

3.3 Date/Time Formats

3.3.1 Full Date

HTTP applications have historically allowed three different formats for the representation of date/time stamps:

```
Sun, 06 Nov 1994 08:49:37 GMT  ; RFC 822, updated by RFC 1123
Sunday, 06-Nov-94 08:49:37 GMT ; RFC 850, obsoleted by RFC 1036
Sun Nov  6 08:49:37 1994       ; ANSI C's asctime() format
```

The first format is preferred as an Internet standard and represents a fixed-length subset of that defined by RFC 1123 [8] (an update to RFC 822 [9]). The second format is in common use, but is based on the obsolete RFC 850 [12] date format and lacks a four-digit year. HTTP/1.1 clients and servers that parse the date value MUST accept all three formats (for compatibility with HTTP/1.0), though they MUST only generate the RFC 1123 format for representing HTTP-date values in header fields. See section 19.3 for further information.

Note: Recipients of date values are encouraged to be robust in accepting date values that may have been sent by non-HTTP applications, as is sometimes the case when retrieving or posting messages via proxies/gateways to SMTP or NNTP.

All HTTP date/time stamps MUST be represented in Greenwich Mean Time (GMT), without exception. For the purposes of HTTP, GMT is exactly equal to UTC (Coordinated Universal Time). This is indicated in the first two formats by the inclusion of "GMT" as the three-letter abbreviation for time zone, and MUST be assumed when reading the asctime format. HTTP-date is case sensitive and MUST NOT include additional LWS beyond that specifically included as SP in the grammar.

```
    HTTP-date    = rfc1123-date | rfc850-date | asctime-date
    rfc1123-date = wkday "," SP date1 SP time SP "GMT"
    rfc850-date  = weekday "," SP date2 SP time SP "GMT"
    asctime-date = wkday SP date3 SP time SP 4DIGIT
    date1        = 2DIGIT SP month SP 4DIGIT
                   ; day month year (e.g., 02 Jun 1982)
    date2        = 2DIGIT "-" month "-" 2DIGIT
                   ; day-month-year (e.g., 02-Jun-82)
    date3        = month SP ( 2DIGIT | ( SP 1DIGIT ))
                   ; month day (e.g., Jun  2)
    time         = 2DIGIT ":" 2DIGIT ":" 2DIGIT
                   ; 00:00:00 - 23:59:59
    wkday        = "Mon" | "Tue" | "Wed"
                 | "Thu" | "Fri" | "Sat" | "Sun"
    weekday      = "Monday" | "Tuesday" | "Wednesday"
                 | "Thursday" | "Friday" | "Saturday" | "Sunday"
    month        = "Jan" | "Feb" | "Mar" | "Apr"
                 | "May" | "Jun" | "Jul" | "Aug"
                 | "Sep" | "Oct" | "Nov" | "Dec"
```

Note: HTTP requirements for the date/time stamp format apply only to their usage within the protocol stream. Clients and servers are not required to use these formats for user presentation, request logging, etc.

3.3.2 Delta Seconds

Some HTTP header fields allow a time value to be specified as an integer number of seconds, represented in decimal, after the time that the message was received.

```
    delta-seconds  = 1*DIGIT
```

3.4 Character Sets

HTTP uses the same definition of the term "character set" as that described for MIME:

The term "character set" is used in this document to refer to a method used with one or more tables to convert a sequence of octets into a sequence of characters. Note that unconditional conversion in the other direction is not required, in that not all characters may be available in a given character set and a character set may provide more than one sequence of octets to represent a particular character. This definition is intended to allow various kinds of character encoding, from simple single-table mappings such as US-ASCII to complex table switching methods such as those that use ISO-2022's techniques. However, the definition associated with a MIME character set name MUST fully specify the mapping to be performed from octets to characters. In particular, use of external profiling information to determine the exact mapping is not permitted.

Note: This use of the term "character set" is more commonly referred to as a "character encoding." However, since HTTP and MIME share the same registry, it is important that the terminology also be shared.

HTTP character sets are identified by case-insensitive tokens. The complete set of tokens is defined by the IANA Character Set registry [19].

```
    charset = token
```

Although HTTP allows an arbitrary token to be used as a charset value, any token that has a predefined value within the IANA Character Set registry [19] MUST represent the character set defined by that registry. Applications SHOULD limit their use of character sets to those defined by the IANA registry.

Implementors should be aware of IETF character set requirements [38] [41].

3.4.1 Missing Charset

Some HTTP/1.0 software has interpreted a Content-Type header without charset parameter incorrectly to mean "recipient should guess." Senders wishing to defeat this behavior MAY include a charset parameter even when the charset is ISO-8859-1 and SHOULD do so when it is known that it will not confuse the recipient.

Unfortunately, some older HTTP/1.0 clients did not deal properly with an explicit charset parameter. HTTP/1.1 recipients MUST respect the charset label provided by the sender; and those user agents that have a provision to "guess" a charset MUST use the charset from the

content-type field if they support that charset, rather than the recipient's preference, when initially displaying a document. See section 3.7.1.

3.5 Content Codings

Content coding values indicate an encoding transformation that has been or can be applied to an entity. Content codings are primarily used to allow a document to be compressed or otherwise usefully transformed without losing the identity of its underlying media type and without loss of information. Frequently, the entity is stored in coded form, transmitted directly, and only decoded by the recipient.

```
    content-coding   = token
```

All content-coding values are case-insensitive. HTTP/1.1 uses content-coding values in the Accept-Encoding (section 14.3) and Content-Encoding (section 14.11) header fields. Although the value describes the content-coding, what is more important is that it indicates what decoding mechanism will be required to remove the encoding.

The Internet Assigned Numbers Authority (IANA) acts as a registry for content-coding value tokens. Initially, the registry contains the following tokens:

gzip An encoding format produced by the file compression program "gzip" (GNU zip) as described in RFC 1952 [25]. This format is a Lempel-Ziv coding (LZ77) with a 32 bit CRC.

compress
The encoding format produced by the common UNIX file compression program "compress". This format is an adaptive Lempel-Ziv-Welch coding (LZW).

Use of program names for the identification of encoding formats is not desirable and is discouraged for future encodings. Their use here is representative of historical practice, not good design. For compatibility with previous implementations of HTTP, applications SHOULD consider "x-gzip" and "x-compress" to be equivalent to "gzip" and "compress" respectively.

deflate
The "zlib" format defined in RFC 1950 [31] in combination with the "deflate" compression mechanism described in RFC 1951 [29].

identity
The default (identity) encoding; the use of no transformation whatsoever. This content-coding is used only in the Accept-Encoding header, and SHOULD NOT be used in the Content-Encoding header.

New content-coding value tokens SHOULD be registered; to allow interoperability between clients and servers, specifications of the content coding algorithms needed to implement a new value SHOULD be publicly available and adequate for independent implementation, and conform to the purpose of content coding defined in this section.

3.6 Transfer Codings

Transfer-coding values are used to indicate an encoding transformation that has been, can be, or may need to be applied to an entity-body in order to ensure "safe transport" through the network. This differs from a content coding in that the transfer-coding is a property of the message, not of the original entity.

```
    transfer-coding         = "chunked" | transfer-extension
    transfer-extension      = token *( ";" parameter )
```

Parameters are in the form of attribute/value pairs.

```
    parameter               = attribute "=" value
    attribute               = token
    value                   = token | quoted-string
```

All transfer-coding values are case-insensitive. HTTP/1.1 uses transfer-coding values in the TE header field (section 14.39) and in the Transfer-Encoding header field (section 14.41).

Whenever a transfer-coding is applied to a message-body, the set of transfer-codings MUST include "chunked", unless the message is terminated by closing the connection. When the "chunked" transfer-coding is used, it MUST be the last transfer-coding applied to the message-body. The "chunked" transfer-coding MUST NOT be applied more than once to a message-body. These rules allow the recipient to determine the transfer-length of the message (section 4.4).

Transfer-codings are analogous to the Content-Transfer-Encoding values of MIME [7], which were designed to enable safe transport of binary data over a 7-bit transport service. However, safe transport has a different focus for an 8bit-clean transfer protocol. In HTTP, the only unsafe characteristic of message-bodies is the difficulty in determining the exact body length (section 7.2.2), or the desire to encrypt data over a shared transport.

The Internet Assigned Numbers Authority (IANA) acts as a registry for transfer-coding value tokens. Initially, the registry contains the following tokens: "chunked" (section 3.6.1), "identity" (section 3.6.2), "gzip" (section 3.5), "compress" (section 3.5), and "deflate" (section 3.5).

New transfer-coding value tokens SHOULD be registered in the same way as new content-coding value tokens (section 3.5).

A server which receives an entity-body with a transfer-coding it does not understand SHOULD return 501 (Unimplemented), and close the connection. A server MUST NOT send transfer-codings to an HTTP/1.0 client.

3.6.1 Chunked Transfer Coding

The chunked encoding modifies the body of a message in order to transfer it as a series of chunks, each with its own size indicator, followed by an OPTIONAL trailer containing entity-header fields. This allows dynamically produced content to be transferred along with the information necessary for the recipient to verify that it has received the full message.

```
    Chunked-Body   = *chunk
                     last-chunk
                     trailer
                     CRLF

    chunk          = chunk-size [ chunk-extension ] CRLF
                     chunk-data CRLF
    chunk-size     = 1*HEX
    last-chunk     = 1*("0") [ chunk-extension ] CRLF

    chunk-extension= *( ";" chunk-ext-name [ "=" chunk-ext-val ] )
    chunk-ext-name = token
    chunk-ext-val  = token | quoted-string
    chunk-data     = chunk-size(OCTET)
    trailer        = *(entity-header CRLF)
```

The chunk-size field is a string of hex digits indicating the size of the chunk. The chunked encoding is ended by any chunk whose size is zero, followed by the trailer, which is terminated by an empty line.

The trailer allows the sender to include additional HTTP header fields at the end of the message. The Trailer header field can be used to indicate which header fields are included in a trailer (see section 14.40).

A server using chunked transfer-coding in a response MUST NOT use the trailer for any header fields unless at least one of the following is true:

a)the request included a TE header field that indicates "trailers" is acceptable in the transfer-coding of the response, as described in section 14.39; or,

b)the server is the origin server for the response, the trailer fields consist entirely of optional metadata, and the recipient could use the message (in a manner acceptable to the origin server) without receiving this metadata. In other words, the origin server is willing to accept the possibility that the trailer fields might be silently discarded along the path to the client.

This requirement prevents an interoperability failure when the message is being received by an HTTP/1.1 (or later) proxy and forwarded to an HTTP/1.0 recipient. It avoids a situation where compliance with the protocol would have necessitated a possibly infinite buffer on the proxy.

An example process for decoding a Chunked-Body is presented in appendix 19.4.6.

appendix 19.4.6.

All HTTP/1.1 applications MUST be able to receive and decode the "chunked" transfer-coding, and MUST ignore chunk-extension extensions they do not understand.

3.7 Media Types

HTTP uses Internet Media Types [17] in the Content-Type (section 14.17) and Accept (section 14.1) header fields in order to provide open and extensible data typing and type negotiation.

```
media-type     = type "/" subtype *( ";" parameter )
type           = token
subtype        = token
```

Parameters MAY follow the type/subtype in the form of attribute/value pairs (as defined in section 3.6).

The type, subtype, and parameter attribute names are case-insensitive. Parameter values might or might not be case-sensitive, depending on the semantics of the parameter name. Linear white space (LWS) MUST NOT be used between the type and subtype, nor between an attribute and its value. The presence or absence of a parameter might be significant to the processing of a media-type, depending on its definition within the media type registry.

Note that some older HTTP applications do not recognize media type parameters. When sending data to older HTTP applications, implementations SHOULD only use media type parameters when they are required by that type/subtype definition.

Media-type values are registered with the Internet Assigned Number Authority (IANA [19]). The media type registration process is outlined in RFC 1590 [17]. Use of non-registered media types is discouraged.

3.7.1 Canonicalization and Text Defaults

Internet media types are registered with a canonical form. An entity-body transferred via HTTP messages MUST be represented in the appropriate canonical form prior to its transmission except for "text" types, as defined in the next paragraph.

When in canonical form, media subtypes of the "text" type use CRLF as the text line break. HTTP relaxes this requirement and allows the transport of text media with plain CR or LF alone representing a line break when it is done consistently for an entire entity-body. HTTP applications MUST accept CRLF, bare CR, and bare LF as being representative of a line break in text media received via HTTP. In addition, if the text is represented in a character set that does not use octets 13 and 10 for CR and LF respectively, as is the case for some multi-byte character sets, HTTP allows the use of whatever octet sequences are defined by that character set to represent the equivalent of CR and LF for line breaks. This flexibility regarding line breaks applies only to text media in the entity-body; a bare CR or LF MUST NOT be substituted for CRLF within any of the HTTP control structures (such as header fields and multipart boundaries).

If an entity-body is encoded with a content-coding, the underlying data MUST be in a form defined above prior to being encoded.

The "charset" parameter is used with some media types to define the character set (section 3.4) of the data. When no explicit charset parameter is provided by the sender, media subtypes of the "text" type are defined to have a default charset value of "ISO-8859-1" when received via HTTP. Data in character sets other than "ISO-8859-1" or its subsets MUST be labeled with an appropriate charset value. See section 3.4.1 for compatibility problems.

3.7.2 Multipart Types

MIME provides for a number of "multipart" types -- encapsulations of one or more entities within a single message-body. All multipart types share a common syntax, as defined in section 5.1.1 of RFC 2046

[40], and MUST include a boundary parameter as part of the media type value. The message body is itself a protocol element and MUST therefore use only CRLF to represent line breaks between body-parts. Unlike in RFC 2046, the epilogue of any multipart message MUST be empty; HTTP applications MUST NOT transmit the epilogue (even if the original multipart contains an epilogue). These restrictions exist in order to preserve the self-delimiting nature of a multipart message-body, wherein the "end" of the message-body is indicated by the ending multipart boundary.

In general, HTTP treats a multipart message-body no differently than any other media type: strictly as payload. The one exception is the "multipart/byteranges" type (appendix 19.2) when it appears in a 206

(Partial Content) response, which will be interpreted by some HTTP caching mechanisms as described in sections 13.5.4 and 14.16. In all other cases, an HTTP user agent SHOULD follow the same or similar behavior as a MIME user agent would upon receipt of a multipart type. The MIME header fields within each body-part of a multipart message-body do not have any significance to HTTP beyond that defined by their MIME semantics.

In general, an HTTP user agent SHOULD follow the same or similar behavior as a MIME user agent would upon receipt of a multipart type. If an application receives an unrecognized multipart subtype, the application MUST treat it as being equivalent to "multipart/mixed".

Note: The "multipart/form-data" type has been specifically defined for carrying form data suitable for processing via the POST request method, as described in RFC 1867 [15].

3.8 Product Tokens

Product tokens are used to allow communicating applications to identify themselves by software name and version. Most fields using product tokens also allow sub-products which form a significant part of the application to be listed, separated by white space. By convention, the products are listed in order of their significance for identifying the application.

```
product         = token ["/" product-version]
product-version = token
```

Examples:

```
User-Agent: CERN-LineMode/2.15 libwww/2.17b3
Server: Apache/0.8.4
```


Product tokens SHOULD be short and to the point. They MUST NOT be used for advertising or other non-essential information. Although any token character MAY appear in a product-version, this token SHOULD only be used for a version identifier (i.e., successive versions of the same product SHOULD only differ in the product-version portion of the product value).

3.9 Quality Values

HTTP content negotiation (section 12) uses short "floating point" numbers to indicate the relative importance ("weight") of various negotiable parameters. A weight is normalized to a real number in the range 0 through 1, where 0 is the minimum and 1 the maximum value. If a parameter has a quality value of 0, then content with this parameter is `not acceptable' for the client. HTTP/1.1 applications MUST NOT generate more than three digits after the decimal point. User configuration of these values SHOULD also be limited in this fashion.

```
qvalue         = ( "0" [ "." 0*3DIGIT ] )
               | ( "1" [ "." 0*3("0") ] )
```

"Quality values" is a misnomer, since these values merely represent relative degradation in desired quality.

3.10 Language Tags

A language tag identifies a natural language spoken, written, or otherwise conveyed by human beings for communication of information to other human beings. Computer languages are explicitly excluded. HTTP uses language tags within the Accept-Language and Content-Language fields.

The syntax and registry of HTTP language tags is the same as that defined by RFC 1766 [1]. In summary, a language tag is composed of 1 or more parts: A primary language tag and a possibly empty series of subtags:

```
language-tag  = primary-tag *( "-" subtag )
primary-tag   = 1*8ALPHA
subtag        = 1*8ALPHA
```

White space is not allowed within the tag and all tags are case-insensitive. The name space of language tags is administered by the IANA. Example tags include:

```
en, en-US, en-cockney, i-cherokee, x-pig-latin
```


where any two-letter primary-tag is an ISO-639 language abbreviation and any two-letter initial subtag is an ISO-3166 country code. (The last three tags above are not registered tags; all but the last are examples of tags which could be registered in future.)

examples of tags which could be registered in future.)

3.11 Entity Tags

Entity tags are used for comparing two or more entities from the same requested resource. HTTP/1.1 uses entity tags in the ETag (section 14.19), If-Match (section 14.24), If-None-Match (section 14.26), and If-Range (section 14.27) header fields. The definition of how they are used and compared as cache validators is in section 13.3.3. An entity tag consists of an opaque quoted string, possibly prefixed by a weakness indicator.

```
entity-tag = [ weak ] opaque-tag
weak       = "W/"
opaque-tag = quoted-string
```

A "strong entity tag" MAY be shared by two entities of a resource only if they are equivalent by octet equality.

A "weak entity tag," indicated by the "W/" prefix, MAY be shared by two entities of a resource only if the entities are equivalent and could be substituted for each other with no significant change in semantics. A weak entity tag can only be used for weak comparison.

An entity tag MUST be unique across all versions of all entities associated with a particular resource. A given entity tag value MAY be used for entities obtained by requests on different URIs. The use of the same entity tag value in conjunction with entities obtained by requests on different URIs does not imply the equivalence of those entities.

3.12 Range Units

HTTP/1.1 allows a client to request that only part (a range of) the response entity be included within the response. HTTP/1.1 uses range units in the Range (section 14.35) and Content-Range (section 14.16) header fields. An entity can be broken down into subranges according to various structural units.

```
range-unit       = bytes-unit | other-range-unit
bytes-unit       = "bytes"
other-range-unit = token
```

The only range unit defined by HTTP/1.1 is "bytes". HTTP/1.1 implementations MAY ignore ranges specified using other units.

HTTP/1.1 has been designed to allow implementations of applications that do not depend on knowledge of ranges.

4 HTTP Message

4.1 Message Types

HTTP messages consist of requests from client to server and responses from server to client.

```
HTTP-message   = Request | Response     ; HTTP/1.1 messages
```

Request (section 5) and Response (section 6) messages use the generic message format of RFC 822 [9] for transferring entities (the payload of the message). Both types of message consist of a start-line, zero or more header fields (also known as "headers"), an empty line (i.e., a line with nothing preceding the CRLF) indicating the end of the header fields, and possibly a message-body.

```
generic-message = start-line
                  *(message-header CRLF)
                  CRLF
                  [ message-body ]
start-line      = Request-Line | Status-Line
```

In the interest of robustness, servers SHOULD ignore any empty line(s) received where a Request-Line is expected. In other words, if the server is reading the protocol stream at the beginning of a message and receives a CRLF first, it should ignore the CRLF.

Certain buggy HTTP/1.0 client implementations generate extra CRLF's after a POST request. To restate what is explicitly forbidden by the BNF, an HTTP/1.1 client MUST NOT preface or follow a request with an extra CRLF.

4.2 Message Headers

HTTP header fields, which include general-header (section 4.5), request-header (section 5.3), response-header (section 6.2), and entity-header (section 7.1) fields, follow the same generic format as that given in Section 3.1 of RFC 822 [9]. Each header field consists of a name followed by a colon (":") and the field value. Field names are case-insensitive. The field value MAY be preceded by any amount of LWS, though a single SP is preferred. Header fields can be extended over multiple lines by preceding each extra line with at least one SP or HT. Applications ought to follow "common form", where one is known or indicated, when generating HTTP constructs, since there might exist some implementations that fail to accept anything

beyond the common forms.

```
message-header = field-name ":" [ field-value ]
field-name     = token
field-value    = *( field-content | LWS )
field-content  = <the OCTETs making up the field-value
                 and consisting of either *TEXT or combinations
                 of token, separators, and quoted-string>
```

The field-content does not include any leading or trailing LWS: linear white space occurring before the first non-whitespace character of the field-value or after the last non-whitespace character of the field-value. Such leading or trailing LWS MAY be removed without changing the semantics of the field value. Any LWS that occurs between field-content MAY be replaced with a single SP before interpreting the field value or forwarding the message downstream.

The order in which header fields with differing field names are received is not significant. However, it is "good practice" to send general-header fields first, followed by request-header or response-header fields, and ending with the entity-header fields.

Multiple message-header fields with the same field-name MAY be present in a message if and only if the entire field-value for that header field is defined as a comma-separated list [i.e., #(values)]. It MUST be possible to combine the multiple header fields into one "field-name: field-value" pair, without changing the semantics of the message, by appending each subsequent field-value to the first, each separated by a comma. The order in which header fields with the same field-name are received is therefore significant to the interpretation of the combined field value, and thus a proxy MUST NOT change the order of these field values when a message is forwarded.

4.3 Message Body

The message-body (if any) of an HTTP message is used to carry the entity-body associated with the request or response. The message-body differs from the entity-body only when a transfer-coding has been applied, as indicated by the Transfer-Encoding header field (section 14.41).

```
message-body = entity-body
             | <entity-body encoded as per Transfer-Encoding>
```

Transfer-Encoding MUST be used to indicate any transfer-codings applied by an application to ensure safe and proper transfer of the message. Transfer-Encoding is a property of the message, not of the

entity, and thus MAY be added or removed by any application along the request/response chain. (However, section 3.6 places restrictions on when certain transfer-codings may be used.)

The rules for when a message-body is allowed in a message differ for requests and responses.

The presence of a message-body in a request is signaled by the inclusion of a Content-Length or Transfer-Encoding header field in the request's message-headers. A message-body MUST NOT be included in a request if the specification of the request method (section 5.1.1) does not allow sending an entity-body in requests. A server SHOULD read and forward a message-body on any request; if the request method does not include defined semantics for an entity-body, then the message-body SHOULD be ignored when handling the request.

For response messages, whether or not a message-body is included with a message is dependent on both the request method and the response status code (section 6.1.1). All responses to the HEAD request method MUST NOT include a message-body, even though the presence of entity-header fields might lead one to believe they do. All 1xx (informational), 204 (no content), and 304 (not modified) responses MUST NOT include a message-body. All other responses do include a message-body, although it MAY be of zero length.

4.4 Message Length

The transfer-length of a message is the length of the message-body as it appears in the message; that is, after any transfer-codings have been applied. When a message-body is included with a message, the transfer-length of that body is determined by one of the following (in order of precedence):

1. Any response message which "MUST NOT" include a message-body (such as the 1xx, 204, and 304 responses and any response to a HEAD request) is always terminated by the first empty line after the header fields, regardless of the entity-header fields present in the message.

2. If a Transfer-Encoding header field (section 14.41) is present and

has any value other than "identity", then the transfer-length is defined by use of the "chunked" transfer-coding (section 3.6), unless the message is terminated by closing the connection.

3. If a Content-Length header field (section 14.13) is present, its decimal value in OCTETs represents both the entity-length and the transfer-length. The Content-Length header field MUST NOT be sent if these two lengths are different (i.e., if a Transfer-Encoding

header field is present). If a message is received with both a Transfer-Encoding header field and a Content-Length header field, the latter MUST be ignored.

4. If the message uses the media type "multipart/byteranges", and the ransfer-length is not otherwise specified, then this self-elimiting media type defines the transfer-length. This media type UST NOT be used unless the sender knows that the recipient can arse it; the presence in a request of a Range header with ultiple byte-range specifiers from a 1.1 client implies that the lient can parse multipart/byteranges responses.

   A range header might be forwarded by a 1.0 proxy that does not understand multipart/byteranges; in this case the server MUST delimit the message using methods defined in items 1,3 or 5 of this section.

5. By the server closing the connection. (Closing the connection cannot be used to indicate the end of a request body, since that would leave no possibility for the server to send back a response.)

For compatibility with HTTP/1.0 applications, HTTP/1.1 requests containing a message-body MUST include a valid Content-Length header field unless the server is known to be HTTP/1.1 compliant. If a request contains a message-body and a Content-Length is not given, the server SHOULD respond with 400 (bad request) if it cannot determine the length of the message, or with 411 (length required) if it wishes to insist on receiving a valid Content-Length.

All HTTP/1.1 applications that receive entities MUST accept the "chunked" transfer-coding (section 3.6), thus allowing this mechanism to be used for messages when the message length cannot be determined in advance.

Messages MUST NOT include both a Content-Length header field and a non-identity transfer-coding. If the message does include a non-identity transfer-coding, the Content-Length MUST be ignored.

When a Content-Length is given in a message where a message-body is allowed, its field value MUST exactly match the number of OCTETs in the message-body. HTTP/1.1 user agents MUST notify the user when an invalid length is received and detected.

4.5 General Header Fields

There are a few header fields which have general applicability for both request and response messages, but which do not apply to the entity being transferred. These header fields apply only to the

message being transmitted.

```
    general-header = Cache-Control            ; Section 14.9
                   | Connection               ; Section 14.10
                   | Date                     ; Section 14.18
                   | Pragma                   ; Section 14.32
                   | Trailer                  ; Section 14.40
                   | Transfer-Encoding        ; Section 14.41
                   | Upgrade                  ; Section 14.42
                   | Via                      ; Section 14.45
                   | Warning                  ; Section 14.46
```

General-header field names can be extended reliably only in combination with a change in the protocol version. However, new or experimental header fields may be given the semantics of general header fields if all parties in the communication recognize them to be general-header fields. Unrecognized header fields are treated as entity-header fields.

5 Request

A request message from a client to a server includes, within the first line of that message, the method to be applied to the resource, the identifier of the resource, and the protocol version in use.

```
     Request       = Request-Line              ; Section 5.1
                     *(( general-header        ; Section 4.5
                      | request-header         ; Section 5.3
                      | entity-header ) CRLF)  ; Section 7.1
                     CRLF
                     [ message-body ]          ; Section 4.3
```

5.1 Request-Line

The Request-Line begins with a method token, followed by the Request-URI and the protocol version, and ending with CRLF. The elements are separated by SP characters. No CR or LF is allowed except in the final CRLF sequence.

```
Request-Line   = Method SP Request-URI SP HTTP-Version CRLF
```


5.1.1 Method

The Method token indicates the method to be performed on the resource identified by the Request-URI. The method is case-sensitive.

```
Method         = "OPTIONS"                ; Section 9.2
               | "GET"                    ; Section 9.3
               | "HEAD"                   ; Section 9.4
               | "POST"                   ; Section 9.5
               | "PUT"                    ; Section 9.6
               | "DELETE"                 ; Section 9.7
               | "TRACE"                  ; Section 9.8
               | "CONNECT"                ; Section 9.9
               | extension-method
extension-method = token
```

The list of methods allowed by a resource can be specified in an Allow header field (section 14.7). The return code of the response always notifies the client whether a method is currently allowed on a resource, since the set of allowed methods can change dynamically. An origin server SHOULD return the status code 405 (Method Not Allowed) if the method is known by the origin server but not allowed for the requested resource, and 501 (Not Implemented) if the method is unrecognized or not implemented by the origin server. The methods GET and HEAD MUST be supported by all general-purpose servers. All other methods are OPTIONAL; however, if the above methods are implemented, they MUST be implemented with the same semantics as those specified in section 9.

5.1.2 Request-URI

The Request-URI is a Uniform Resource Identifier (section 3.2) and identifies the resource upon which to apply the request.

```
Request-URI    = "*" | absoluteURI | abs_path | authority
```

The four options for Request-URI are dependent on the nature of the request. The asterisk "*" means that the request does not apply to a particular resource, but to the server itself, and is only allowed when the method used does not necessarily apply to a resource. One example would be

```
OPTIONS * HTTP/1.1
```

The absoluteURI form is REQUIRED when the request is being made to a proxy. The proxy is requested to forward the request or service it from a valid cache, and return the response. Note that the proxy MAY forward the request on to another proxy or directly to the server

specified by the absoluteURI. In order to avoid request loops, a proxy MUST be able to recognize all of its server names, including any aliases, local variations, and the numeric IP address. An example Request-Line would be:

```
GET http://www.w3.org/pub/WWW/TheProject.html HTTP/1.1
```

To allow for transition to absoluteURIs in all requests in future versions of HTTP, all HTTP/1.1 servers MUST accept the absoluteURI form in requests, even though HTTP/1.1 clients will only generate them in requests to proxies.

The authority form is only used by the CONNECT method (section 9.9).

The most common form of Request-URI is that used to identify a resource on an origin server or gateway. In this case the absolute path of the URI MUST be transmitted (see section 3.2.1, abs_path) as the Request-URI, and the network location of the URI (authority) MUST be transmitted in a Host header field. For example, a client wishing to retrieve the resource above directly from the origin server would create a TCP connection to port 80 of the host "www.w3.org" and send

the lines:

```
GET /pub/WWW/TheProject.html HTTP/1.1
Host: www.w3.org
```

followed by the remainder of the Request. Note that the absolute path cannot be empty; if none is present in the original URI, it MUST be given as "/" (the server root).

The Request-URI is transmitted in the format specified in section 3.2.1. If the Request-URI is encoded using the "% HEX HEX" encoding [42], the origin server MUST decode the Request-URI in order to properly interpret the request. Servers SHOULD respond to invalid Request-URIs with an appropriate status code.

A transparent proxy MUST NOT rewrite the "abs_path" part of the received Request-URI when forwarding it to the next inbound server, except as noted above to replace a null abs_path with "/".

> Note: The "no rewrite" rule prevents the proxy from changing the meaning of the request when the origin server is improperly using a non-reserved URI character for a reserved purpose. Implementors should be aware that some pre-HTTP/1.1 proxies have been known to rewrite the Request-URI.

5.2 The Resource Identified by a Request

The exact resource identified by an Internet request is determined by examining both the Request-URI and the Host header field.

An origin server that does not allow resources to differ by the requested host MAY ignore the Host header field value when determining the resource identified by an HTTP/1.1 request. (But see section 19.6.1.1 for other requirements on Host support in HTTP/1.1.)

An origin server that does differentiate resources based on the host requested (sometimes referred to as virtual hosts or vanity host names) MUST use the following rules for determining the requested resource on an HTTP/1.1 request:

1. If Request-URI is an absoluteURI, the host is part of the Request-URI. Any Host header field value in the request MUST be ignored.

2. If the Request-URI is not an absoluteURI, and the request includes a Host header field, the host is determined by the Host header field value.

3. If the host as determined by rule 1 or 2 is not a valid host on the server, the response MUST be a 400 (Bad Request) error message.

Recipients of an HTTP/1.0 request that lacks a Host header field MAY attempt to use heuristics (e.g., examination of the URI path for something unique to a particular host) in order to determine what exact resource is being requested.

5.3 Request Header Fields

The request-header fields allow the client to pass additional information about the request, and about the client itself, to the server. These fields act as request modifiers, with semantics equivalent to the parameters on a programming language method invocation.

```
request-header = Accept                   ; Section 14.1
               | Accept-Charset           ; Section 14.2
               | Accept-Encoding          ; Section 14.3
               | Accept-Language          ; Section 14.4
               | Authorization            ; Section 14.8
               | Expect                   ; Section 14.20
               | From                     ; Section 14.22
               | Host                     ; Section 14.23
               | If-Match                 ; Section 14.24
```



```
               | If-Modified-Since        ; Section 14.25
               | If-None-Match            ; Section 14.26
               | If-Range                 ; Section 14.27
               | If-Unmodified-Since      ; Section 14.28
               | Max-Forwards             ; Section 14.31
               | Proxy-Authorization      ; Section 14.34
               | Range                    ; Section 14.35
               | Referer                  ; Section 14.36
               | TE                       ; Section 14.39
               | User-Agent               ; Section 14.43
```

Request-header field names can be extended reliably only in

Request-header field names can be extended reliably only in combination with a change in the protocol version. However, new or experimental header fields MAY be given the semantics of request-header fields if all parties in the communication recognize them to be request-header fields. Unrecognized header fields are treated as entity-header fields.

6 Response

After receiving and interpreting a request message, a server responds with an HTTP response message.

```
    Response      = Status-Line               ; Section 6.1
                    *(( general-header        ; Section 4.5
                     | response-header        ; Section 6.2
                     | entity-header ) CRLF)  ; Section 7.1
                    CRLF
                    [ message-body ]          ; Section 7.2
```

6.1 Status-Line

The first line of a Response message is the Status-Line, consisting of the protocol version followed by a numeric status code and its associated textual phrase, with each element separated by SP characters. No CR or LF is allowed except in the final CRLF sequence.

```
    Status-Line = HTTP-Version SP Status-Code SP Reason-Phrase CRLF
```

6.1.1 Status Code and Reason Phrase

The Status-Code element is a 3-digit integer result code of the attempt to understand and satisfy the request. These codes are fully defined in section 10. The Reason-Phrase is intended to give a short textual description of the Status-Code. The Status-Code is intended for use by automata and the Reason-Phrase is intended for the human user. The client is not required to examine or display the Reason-Phrase.

The first digit of the Status-Code defines the class of response. The last two digits do not have any categorization role. There are 5 values for the first digit:

- 1xx: Informational - Request received, continuing process
- 2xx: Success - The action was successfully received, understood, and accepted
- 3xx: Redirection - Further action must be taken in order to complete the request
- 4xx: Client Error - The request contains bad syntax or cannot be fulfilled
- 5xx: Server Error - The server failed to fulfill an apparently valid request

The individual values of the numeric status codes defined for HTTP/1.1, and an example set of corresponding Reason-Phrase's, are presented below. The reason phrases listed here are only recommendations -- they MAY be replaced by local equivalents without affecting the protocol.

```
    Status-Code    =
          "100"  ; Section 10.1.1: Continue
        | "101"  ; Section 10.1.2: Switching Protocols
        | "200"  ; Section 10.2.1: OK
        | "201"  ; Section 10.2.2: Created
        | "202"  ; Section 10.2.3: Accepted
        | "203"  ; Section 10.2.4: Non-Authoritative Information
        | "204"  ; Section 10.2.5: No Content
        | "205"  ; Section 10.2.6: Reset Content
        | "206"  ; Section 10.2.7: Partial Content
        | "300"  ; Section 10.3.1: Multiple Choices
        | "301"  ; Section 10.3.2: Moved Permanently
        | "302"  ; Section 10.3.3: Found
        | "303"  ; Section 10.3.4: See Other
        | "304"  ; Section 10.3.5: Not Modified
        | "305"  ; Section 10.3.6: Use Proxy
        | "307"  ; Section 10.3.8: Temporary Redirect
        | "400"  ; Section 10.4.1: Bad Request
        | "401"  ; Section 10.4.2: Unauthorized
        | "402"  ; Section 10.4.3: Payment Required
        | "403"  ; Section 10.4.4: Forbidden
        | "404"  ; Section 10.4.5: Not Found
        | "405"  ; Section 10.4.6: Method Not Allowed
        | "406"  ; Section 10.4.7: Not Acceptable
```



```
        | "407"  ; Section 10.4.8: Proxy Authentication Required
        | "408"  ; Section 10.4.9: Request Time-out
```

```
        | "409"  ; Section 10.4.10: Conflict
        | "410"  ; Section 10.4.11: Gone
        | "411"  ; Section 10.4.12: Length Required
        | "412"  ; Section 10.4.13: Precondition Failed
        | "413"  ; Section 10.4.14: Request Entity Too Large
        | "414"  ; Section 10.4.15: Request-URI Too Large
        | "415"  ; Section 10.4.16: Unsupported Media Type
        | "416"  ; Section 10.4.17: Requested range not satisfiable
        | "417"  ; Section 10.4.18: Expectation Failed
        | "500"  ; Section 10.5.1: Internal Server Error
        | "501"  ; Section 10.5.2: Not Implemented
        | "502"  ; Section 10.5.3: Bad Gateway
        | "503"  ; Section 10.5.4: Service Unavailable
        | "504"  ; Section 10.5.5: Gateway Time-out
        | "505"  ; Section 10.5.6: HTTP Version not supported
        | extension-code

     extension-code = 3DIGIT
     Reason-Phrase  = *<TEXT, excluding CR, LF>
```

HTTP status codes are extensible. HTTP applications are not required to understand the meaning of all registered status codes, though such understanding is obviously desirable. However, applications MUST understand the class of any status code, as indicated by the first digit, and treat any unrecognized response as being equivalent to the x00 status code of that class, with the exception that an unrecognized response MUST NOT be cached. For example, if an unrecognized status code of 431 is received by the client, it can safely assume that there was something wrong with its request and treat the response as if it had received a 400 status code. In such cases, user agents SHOULD present to the user the entity returned with the response, since that entity is likely to include human-readable information which will explain the unusual status.

6.2 Response Header Fields

The response-header fields allow the server to pass additional information about the response which cannot be placed in the Status-Line. These header fields give information about the server and about further access to the resource identified by the Request-URI.

```
     response-header = Accept-Ranges           ; Section 14.5
                     | Age                     ; Section 14.6
                     | ETag                    ; Section 14.19
                     | Location                ; Section 14.30
                     | Proxy-Authenticate      ; Section 14.33
```



```
                     | Retry-After             ; Section 14.37
                     | Server                  ; Section 14.38
                     | Vary                    ; Section 14.44
                     | WWW-Authenticate        ; Section 14.47
```

Response-header field names can be extended reliably only in combination with a change in the protocol version. However, new or experimental header fields MAY be given the semantics of response-header fields if all parties in the communication recognize them to be response-header fields. Unrecognized header fields are treated as entity-header fields.

7 Entity

Request and Response messages MAY transfer an entity if not otherwise restricted by the request method or response status code. An entity consists of entity-header fields and an entity-body, although some responses will only include the entity-headers.

In this section, both sender and recipient refer to either the client or the server, depending on who sends and who receives the entity.

7.1 Entity Header Fields

Entity-header fields define metainformation about the entity-body or, if no body is present, about the resource identified by the request. Some of this metainformation is OPTIONAL; some might be REQUIRED by portions of this specification.

```
     entity-header  = Allow                    ; Section 14.7
                    | Content-Encoding         ; Section 14.11
                    | Content-Language         ; Section 14.12
                    | Content-Length           ; Section 14.13
                    | Content-Location         ; Section 14.14
                    | Content-MD5              ; Section 14.15
                    | Content-Range            ; Section 14.16
                    | Content-Type             ; Section 14.17
                    | Expires                  ; Section 14.21
                    | Last-Modified            ; Section 14.29
                    | extension-header

     extension-header = message-header
```

The extension-header mechanism allows additional entity-header fields to be defined without changing the protocol, but these fields cannot be assumed to be recognizable by the recipient. Unrecognized header fields SHOULD be ignored by the recipient and MUST be forwarded by transparent proxies.

7.2 Entity Body

The entity-body (if any) sent with an HTTP request or response is in a format and encoding defined by the entity-header fields.

```
entity-body    = *OCTET
```

An entity-body is only present in a message when a message-body is present, as described in section 4.3. The entity-body is obtained from the message-body by decoding any Transfer-Encoding that might have been applied to ensure safe and proper transfer of the message.

7.2.1 Type

When an entity-body is included with a message, the data type of that body is determined via the header fields Content-Type and Content-Encoding. These define a two-layer, ordered encoding model:

```
entity-body := Content-Encoding( Content-Type( data ) )
```

Content-Type specifies the media type of the underlying data. Content-Encoding may be used to indicate any additional content codings applied to the data, usually for the purpose of data compression, that are a property of the requested resource. There is no default encoding.

Any HTTP/1.1 message containing an entity-body SHOULD include a Content-Type header field defining the media type of that body. If and only if the media type is not given by a Content-Type field, the recipient MAY attempt to guess the media type via inspection of its content and/or the name extension(s) of the URI used to identify the resource. If the media type remains unknown, the recipient SHOULD treat it as type "application/octet-stream".

7.2.2 Entity Length

The entity-length of a message is the length of the message-body before any transfer-codings have been applied. Section 4.4 defines how the transfer-length of a message-body is determined.

8 Connections

8.1 Persistent Connections

8.1.1 Purpose

Prior to persistent connections, a separate TCP connection was established to fetch each URL, increasing the load on HTTP servers and causing congestion on the Internet. The use of inline images and other associated data often require a client to make multiple requests of the same server in a short amount of time. Analysis of these performance problems and results from a prototype implementation are available [26] [30]. Implementation experience and measurements of actual HTTP/1.1 (RFC 2068) implementations show good results [39]. Alternatives have also been explored, for example, T/TCP [27].

Persistent HTTP connections have a number of advantages:

- By opening and closing fewer TCP connections, CPU time is saved in routers and hosts (clients, servers, proxies, gateways, tunnels, or caches), and memory used for TCP protocol control blocks can be saved in hosts.

- HTTP requests and responses can be pipelined on a connection. Pipelining allows a client to make multiple requests without waiting for each response, allowing a single TCP connection to be used much more efficiently, with much lower elapsed time.

- Network congestion is reduced by reducing the number of packets caused by TCP opens, and by allowing TCP sufficient time to determine the congestion state of the network.

- Latency on subsequent requests is reduced since there is no time spent in TCP's connection opening handshake.

- HTTP can evolve more gracefully, since errors can be reported without the penalty of closing the TCP connection. Clients using future versions of HTTP might optimistically try a new feature,

but if communicating with an older server, retry with old semantics after an error is reported.

HTTP implementations SHOULD implement persistent connections.

8.1.2 Overall Operation

A significant difference between HTTP/1.1 and earlier versions of HTTP is that persistent connections are the default behavior of any HTTP connection. That is, unless otherwise indicated, the client SHOULD assume that the server will maintain a persistent connection, even after error responses from the server.

Persistent connections provide a mechanism by which a client and a server can signal the close of a TCP connection. This signaling takes place using the Connection header field (section 14.10). Once a close has been signaled, the client MUST NOT send any more requests on that connection.

8.1.2.1 Negotiation

An HTTP/1.1 server MAY assume that a HTTP/1.1 client intends to maintain a persistent connection unless a Connection header including the connection-token "close" was sent in the request. If the server chooses to close the connection immediately after sending the response, it SHOULD send a Connection header including the connection-token close.

An HTTP/1.1 client MAY expect a connection to remain open, but would decide to keep it open based on whether the response from a server contains a Connection header with the connection-token close. In case the client does not want to maintain a connection for more than that request, it SHOULD send a Connection header including the connection-token close.

If either the client or the server sends the close token in the Connection header, that request becomes the last one for the connection.

Clients and servers SHOULD NOT assume that a persistent connection is maintained for HTTP versions less than 1.1 unless it is explicitly signaled. See section 19.6.2 for more information on backward compatibility with HTTP/1.0 clients.

In order to remain persistent, all messages on the connection MUST have a self-defined message length (i.e., one not defined by closure of the connection), as described in section 4.4.

8.1.2.2 Pipelining

A client that supports persistent connections MAY "pipeline" its requests (i.e., send multiple requests without waiting for each response). A server MUST send its responses to those requests in the same order that the requests were received.

Clients which assume persistent connections and pipeline immediately after connection establishment SHOULD be prepared to retry their connection if the first pipelined attempt fails. If a client does such a retry, it MUST NOT pipeline before it knows the connection is persistent. Clients MUST also be prepared to resend their requests if the server closes the connection before sending all of the corresponding responses.

Clients SHOULD NOT pipeline requests using non-idempotent methods or non-idempotent sequences of methods (see section 9.1.2). Otherwise, a premature termination of the transport connection could lead to indeterminate results. A client wishing to send a non-idempotent request SHOULD wait to send that request until it has received the response status for the previous request.

8.1.3 Proxy Servers

It is especially important that proxies correctly implement the properties of the Connection header field as specified in section 14.10.

The proxy server MUST signal persistent connections separately with its clients and the origin servers (or other proxy servers) that it

its clients and the origin servers (or other proxy servers) that it connects to. Each persistent connection applies to only one transport link.

A proxy server MUST NOT establish a HTTP/1.1 persistent connection with an HTTP/1.0 client (but see RFC 2068 [33] for information and discussion of the problems with the Keep-Alive header implemented by many HTTP/1.0 clients).

8.1.4 Practical Considerations

Servers will usually have some time-out value beyond which they will no longer maintain an inactive connection. Proxy servers might make this a higher value since it is likely that the client will be making more connections through the same server. The use of persistent connections places no requirements on the length (or existence) of this time-out for either the client or the server.

When a client or server wishes to time-out it SHOULD issue a graceful close on the transport connection. Clients and servers SHOULD both constantly watch for the other side of the transport close, and respond to it as appropriate. If a client or server does not detect the other side's close promptly it could cause unnecessary resource drain on the network.

A client, server, or proxy MAY close the transport connection at any time. For example, a client might have started to send a new request at the same time that the server has decided to close the "idle" connection. From the server's point of view, the connection is being closed while it was idle, but from the client's point of view, a request is in progress.

This means that clients, servers, and proxies MUST be able to recover from asynchronous close events. Client software SHOULD reopen the transport connection and retransmit the aborted sequence of requests without user interaction so long as the request sequence is idempotent (see section 9.1.2). Non-idempotent methods or sequences MUST NOT be automatically retried, although user agents MAY offer a human operator the choice of retrying the request(s). Confirmation by user-agent software with semantic understanding of the application MAY substitute for user confirmation. The automatic retry SHOULD NOT be repeated if the second sequence of requests fails.

Servers SHOULD always respond to at least one request per connection, if at all possible. Servers SHOULD NOT close a connection in the middle of transmitting a response, unless a network or client failure is suspected.

Clients that use persistent connections SHOULD limit the number of simultaneous connections that they maintain to a given server. A single-user client SHOULD NOT maintain more than 2 connections with any server or proxy. A proxy SHOULD use up to 2*N connections to another server or proxy, where N is the number of simultaneously active users. These guidelines are intended to improve HTTP response times and avoid congestion.

8.2 Message Transmission Requirements

8.2.1 Persistent Connections and Flow Control

HTTP/1.1 servers SHOULD maintain persistent connections and use TCP's flow control mechanisms to resolve temporary overloads, rather than terminating connections with the expectation that clients will retry. The latter technique can exacerbate network congestion.

8.2.2 Monitoring Connections for Error Status Messages

An HTTP/1.1 (or later) client sending a message-body SHOULD monitor the network connection for an error status while it is transmitting the request. If the client sees an error status, it SHOULD immediately cease transmitting the body. If the body is being sent using a "chunked" encoding (section 3.6), a zero length chunk and empty trailer MAY be used to prematurely mark the end of the message. If the body was preceded by a Content-Length header, the client MUST close the connection.

8.2.3 Use of the 100 (Continue) Status

The purpose of the 100 (Continue) status (see section 10.1.1) is to allow a client that is sending a request message with a request body to determine if the origin server is willing to accept the request (based on the request headers) before the client sends the request body. In some cases, it might either be inappropriate or highly inefficient for the client to send the body if the server will reject the message without looking at the body.

Requirements for HTTP/1.1 clients:

- If a client will wait for a 100 (Continue) response before sending the request body, it MUST send an Expect request-header field (section 14.20) with the "100-continue" expectation.

- A client MUST NOT send an Expect request-header field (section 14.20) with the "100-continue" expectation if it does not intend to send a request body.

Because of the presence of older implementations, the protocol allows ambiguous situations in which a client may send "Expect: 100-continue" without receiving either a 417 (Expectation Failed) status or a 100 (Continue) status. Therefore, when a client sends this header field to an origin server (possibly via a proxy) from which it has never seen a 100 (Continue) status, the client SHOULD NOT wait for an indefinite period before sending the request body.

Requirements for HTTP/1.1 origin servers:

- Upon receiving a request which includes an Expect request-header field with the "100-continue" expectation, an origin server MUST either respond with 100 (Continue) status and continue to read from the input stream, or respond with a final status code. The origin server MUST NOT wait for the request body before sending the 100 (Continue) response. If it responds with a final status code, it MAY close the transport connection or it MAY continue

to read and discard the rest of the request. It MUST NOT perform the requested method if it returns a final status code.

- An origin server SHOULD NOT send a 100 (Continue) response if the request message does not include an Expect request-header field with the "100-continue" expectation, and MUST NOT send a 100 (Continue) response if such a request comes from an HTTP/1.0 (or earlier) client. There is an exception to this rule: for compatibility with RFC 2068, a server MAY send a 100 (Continue) status in response to an HTTP/1.1 PUT or POST request that does not include an Expect request-header field with the "100-continue" expectation. This exception, the purpose of which is to minimize any client processing delays associated with an undeclared wait for 100 (Continue) status, applies only to HTTP/1.1 requests, and not to requests with any other HTTP-version value.

- An origin server MAY omit a 100 (Continue) response if it has already received some or all of the request body for the corresponding request.

- An origin server that sends a 100 (Continue) response MUST ultimately send a final status code, once the request body is received and processed, unless it terminates the transport connection prematurely.

- If an origin server receives a request that does not include an Expect request-header field with the "100-continue" expectation, the request includes a request body, and the server responds with a final status code before reading the entire request body from the transport connection, then the server SHOULD NOT close the transport connection until it has read the entire request, or until the client closes the connection. Otherwise, the client might not reliably receive the response message. However, this requirement is not be construed as preventing a server from defending itself against denial-of-service attacks, or from badly broken client implementations.

Requirements for HTTP/1.1 proxies:

- If a proxy receives a request that includes an Expect request-header field with the "100-continue" expectation, and the proxy either knows that the next-hop server complies with HTTP/1.1 or higher, or does not know the HTTP version of the next-hop server, it MUST forward the request, including the Expect header field.

- If the proxy knows that the version of the next-hop server is HTTP/1.0 or lower, it MUST NOT forward the request, and it MUST respond with a 417 (Expectation Failed) status.

- Proxies SHOULD maintain a cache recording the HTTP version numbers received from recently-referenced next-hop servers.

- A proxy MUST NOT forward a 100 (Continue) response if the request message was received from an HTTP/1.0 (or earlier) client and did not include an Expect request-header field with

the "100-continue" expectation. This requirement overrides the general rule for forwarding of 1xx responses (see section 10.1).

8.2.4 Client Behavior if Server Prematurely Closes Connection

If an HTTP/1.1 client sends a request which includes a request body, but which does not include an Expect request-header field with the "100-continue" expectation, and if the client is not directly connected to an HTTP/1.1 origin server, and if the client sees the connection close before receiving any status from the server, the client SHOULD retry the request. If the client does retry this request, it MAY use the following "binary exponential backoff" algorithm to be assured of obtaining a reliable response:

1. Initiate a new connection to the server
2. Transmit the request-headers
3. Initialize a variable R to the estimated round-trip time to the server (e.g., based on the time it took to establish the connection), or to a constant value of 5 seconds if the round-trip time is not available.
4. Compute T = R * (2**N), where N is the number of previous retries of this request.
5. Wait either for an error response from the server, or for T seconds (whichever comes first)
6. If no error response is received, after T seconds transmit the body of the request.
7. If client sees that the connection is closed prematurely, repeat from step 1 until the request is accepted, an error response is received, or the user becomes impatient and terminates the retry process.

If at any point an error status is received, the client

- SHOULD NOT continue and
- SHOULD close the connection if it has not completed sending the request message.

9 Method Definitions

The set of common methods for HTTP/1.1 is defined below. Although this set can be expanded, additional methods cannot be assumed to share the same semantics for separately extended clients and servers.

The Host request-header field (section 14.23) MUST accompany all HTTP/1.1 requests.

9.1 Safe and Idempotent Methods

9.1.1 Safe Methods

Implementors should be aware that the software represents the user in their interactions over the Internet, and should be careful to allow the user to be aware of any actions they might take which may have an unexpected significance to themselves or others.

In particular, the convention has been established that the GET and HEAD methods SHOULD NOT have the significance of taking an action other than retrieval. These methods ought to be considered "safe". This allows user agents to represent other methods, such as POST, PUT and DELETE, in a special way, so that the user is made aware of the fact that a possibly unsafe action is being requested.

Naturally, it is not possible to ensure that the server does not generate side-effects as a result of performing a GET request; in fact, some dynamic resources consider that a feature. The important distinction here is that the user did not request the side-effects, so therefore cannot be held accountable for them.

9.1.2 Idempotent Methods

Methods can also have the property of "idempotence" in that (aside from error or expiration issues) the side-effects of N > 0 identical requests is the same as for a single request. The methods GET, HEAD, PUT and DELETE share this property. Also, the methods OPTIONS and TRACE SHOULD NOT have side effects, and so are inherently idempotent.

However, it is possible that a sequence of several requests is non-

idempotent, even if all of the methods executed in that sequence are idempotent. (A sequence is idempotent if a single execution of the entire sequence always yields a result that is not changed by a reexecution of all, or part, of that sequence.) For example, a sequence is non-idempotent if its result depends on a value that is later modified in the same sequence.

A sequence that never has side effects is idempotent, by definition (provided that no concurrent operations are being executed on the same set of resources).

9.2 OPTIONS

The OPTIONS method represents a request for information about the communication options available on the request/response chain identified by the Request-URI. This method allows the client to determine the options and/or requirements associated with a resource, or the capabilities of a server, without implying a resource action or initiating a resource retrieval.

Responses to this method are not cacheable.

If the OPTIONS request includes an entity-body (as indicated by the presence of Content-Length or Transfer-Encoding), then the media type MUST be indicated by a Content-Type field. Although this specification does not define any use for such a body, future extensions to HTTP might use the OPTIONS body to make more detailed queries on the server. A server that does not support such an extension MAY discard the request body.

If the Request-URI is an asterisk ("*"), the OPTIONS request is intended to apply to the server in general rather than to a specific resource. Since a server's communication options typically depend on the resource, the "*" request is only useful as a "ping" or "no-op" type of method; it does nothing beyond allowing the client to test the capabilities of the server. For example, this can be used to test a proxy for HTTP/1.1 compliance (or lack thereof).

If the Request-URI is not an asterisk, the OPTIONS request applies only to the options that are available when communicating with that resource.

A 200 response SHOULD include any header fields that indicate optional features implemented by the server and applicable to that resource (e.g., Allow), possibly including extensions not defined by this specification. The response body, if any, SHOULD also include information about the communication options. The format for such a

body is not defined by this specification, but might be defined by future extensions to HTTP. Content negotiation MAY be used to select the appropriate response format. If no response body is included, the response MUST include a Content-Length field with a field-value of "0".

The Max-Forwards request-header field MAY be used to target a specific proxy in the request chain. When a proxy receives an OPTIONS request on an absoluteURI for which request forwarding is permitted, the proxy MUST check for a Max-Forwards field. If the Max-Forwards field-value is zero ("0"), the proxy MUST NOT forward the message; instead, the proxy SHOULD respond with its own communication options. If the Max-Forwards field-value is an integer greater than zero, the proxy MUST decrement the field-value when it forwards the request. If no Max-Forwards field is present in the request, then the forwarded request MUST NOT include a Max-Forwards field.

9.3 GET

The GET method means retrieve whatever information (in the form of an entity) is identified by the Request-URI. If the Request-URI refers to a data-producing process, it is the produced data which shall be returned as the entity in the response and not the source text of the process, unless that text happens to be the output of the process.

The semantics of the GET method change to a "conditional GET" if the request message includes an If-Modified-Since, If-Unmodified-Since, If-Match, If-None-Match, or If-Range header field. A conditional GET method requests that the entity be transferred only under the circumstances described by the conditional header field(s). The conditional GET method is intended to reduce unnecessary network usage by allowing cached entities to be refreshed without requiring multiple requests or transferring data already held by the client.

The semantics of the GET method change to a "partial GET" if the request message includes a Range header field. A partial GET requests that only part of the entity be transferred, as described in section 14.35. The partial GET method is intended to reduce unnecessary network usage by allowing partially-retrieved entities to be completed without transferring data already held by the client.

The response to a GET request is cacheable if and only if it meets the requirements for HTTP caching described in section 13.

See section 15.1.3 for security considerations when used for forms.

9.4 HEAD

The HEAD method is identical to GET except that the server MUST NOT return a message-body in the response. The metainformation contained in the HTTP headers in response to a HEAD request SHOULD be identical to the information sent in response to a GET request. This method can be used for obtaining metainformation about the entity implied by the request without transferring the entity-body itself. This method is often used for testing hypertext links for validity, accessibility, and recent modification.

The response to a HEAD request MAY be cacheable in the sense that the information contained in the response MAY be used to update a previously cached entity from that resource. If the new field values indicate that the cached entity differs from the current entity (as would be indicated by a change in Content-Length, Content-MD5, ETag or Last-Modified), then the cache MUST treat the cache entry as stale.

9.5 POST

The POST method is used to request that the origin server accept the entity enclosed in the request as a new subordinate of the resource identified by the Request-URI in the Request-Line. POST is designed to allow a uniform method to cover the following functions:

- Annotation of existing resources;
- Posting a message to a bulletin board, newsgroup, mailing list, or similar group of articles;
- Providing a block of data, such as the result of submitting a form, to a data-handling process;
- Extending a database through an append operation.

The actual function performed by the POST method is determined by the server and is usually dependent on the Request-URI. The posted entity is subordinate to that URI in the same way that a file is subordinate to a directory containing it, a news article is subordinate to a newsgroup to which it is posted, or a record is subordinate to a database.

The action performed by the POST method might not result in a resource that can be identified by a URI. In this case, either 200 (OK) or 204 (No Content) is the appropriate response status, depending on whether or not the response includes an entity that describes the result.

If a resource has been created on the origin server, the response SHOULD be 201 (Created) and contain an entity which describes the status of the request and refers to the new resource, and a Location header (see section 14.30).

Responses to this method are not cacheable, unless the response includes appropriate Cache-Control or Expires header fields. However, the 303 (See Other) response can be used to direct the user agent to retrieve a cacheable resource.

POST requests MUST obey the message transmission requirements set out in section 8.2.

See section 15.1.3 for security considerations.

9.6 PUT

The PUT method requests that the enclosed entity be stored under the supplied Request-URI. If the Request-URI refers to an already existing resource, the enclosed entity SHOULD be considered as a modified version of the one residing on the origin server. If the Request-URI does not point to an existing resource, and that URI is capable of being defined as a new resource by the requesting user agent, the origin server can create the resource with that URI. If a new resource is created, the origin server MUST inform the user agent via the 201 (Created) response. If an existing resource is modified, either the 200 (OK) or 204 (No Content) response codes SHOULD be sent to indicate successful completion of the request. If the resource could not be created or modified with the Request-URI, an appropriate error response SHOULD be given that reflects the nature of the problem. The recipient of the entity MUST NOT ignore any Content-* (e.g. Content-Range) headers that it does not understand or implement and MUST return a 501 (Not Implemented) response in such cases.

If the request passes through a cache and the Request-URI identifies one or more currently cached entities, those entries SHOULD be treated as stale. Responses to this method are not cacheable.

The fundamental difference between the POST and PUT requests is reflected in the different meaning of the Request-URI. The URI in a POST request identifies the resource that will handle the enclosed entity. That resource might be a data-accepting process, a gateway to some other protocol, or a separate entity that accepts annotations. In contrast, the URI in a PUT request identifies the entity enclosed with the request -- the user agent knows what URI is intended and the server MUST NOT attempt to apply the request to some other resource. If the server desires that the request be applied to a different URI,

it MUST send a 301 (Moved Permanently) response; the user agent MAY then make its own decision regarding whether or not to redirect the request.

A single resource MAY be identified by many different URIs. For example, an article might have a URI for identifying "the current version" which is separate from the URI identifying each particular version. In this case, a PUT request on a general URI might result in several other URIs being defined by the origin server.

HTTP/1.1 does not define how a PUT method affects the state of an origin server.

PUT requests MUST obey the message transmission requirements set out in section 8.2.

Unless otherwise specified for a particular entity-header, the entity-headers in the PUT request SHOULD be applied to the resource created or modified by the PUT.

9.7 DELETE

The DELETE method requests that the origin server delete the resource identified by the Request-URI. This method MAY be overridden by human intervention (or other means) on the origin server. The client cannot be guaranteed that the operation has been carried out, even if the status code returned from the origin server indicates that the action has been completed successfully. However, the server SHOULD NOT indicate success unless, at the time the response is given, it intends to delete the resource or move it to an inaccessible location.

A successful response SHOULD be 200 (OK) if the response includes an entity describing the status, 202 (Accepted) if the action has not yet been enacted, or 204 (No Content) if the action has been enacted but the response does not include an entity.

If the request passes through a cache and the Request-URI identifies one or more currently cached entities, those entries SHOULD be treated as stale. Responses to this method are not cacheable.

9.8 TRACE

The TRACE method is used to invoke a remote, application-layer loop-back of the request message. The final recipient of the request SHOULD reflect the message received back to the client as the entity-body of a 200 (OK) response. The final recipient is either the

origin server or the first proxy or gateway to receive a Max-Forwards value of zero (0) in the request (see section 14.31). A TRACE request MUST NOT include an entity.

TRACE allows the client to see what is being received at the other end of the request chain and use that data for testing or diagnostic information. The value of the Via header field (section 14.45) is of particular interest, since it acts as a trace of the request chain. Use of the Max-Forwards header field allows the client to limit the length of the request chain, which is useful for testing a chain of proxies forwarding messages in an infinite loop.

If the request is valid, the response SHOULD contain the entire request message in the entity-body, with a Content-Type of "message/http". Responses to this method MUST NOT be cached.

9.9 CONNECT

This specification reserves the method name CONNECT for use with a proxy that can dynamically switch to being a tunnel (e.g. SSL tunneling [44]).

10 Status Code Definitions

Each Status-Code is described below, including a description of which method(s) it can follow and any metainformation required in the response.

10.1 Informational 1xx

This class of status code indicates a provisional response, consisting only of the Status-Line and optional headers, and is terminated by an empty line. There are no required headers for this class of status code. Since HTTP/1.0 did not define any 1xx status codes, servers MUST NOT send a 1xx response to an HTTP/1.0 client except under experimental conditions.

A client MUST be prepared to accept one or more 1xx status responses prior to a regular response, even if the client does not expect a 100 (Continue) status message. Unexpected 1xx status responses MAY be ignored by a user agent.

Proxies MUST forward 1xx responses, unless the connection between the proxy and its client has been closed, or unless the proxy itself requested the generation of the 1xx response. (For example, if a

proxy adds a "Expect: 100-continue" field when it forwards a request, then it need not forward the corresponding 100 (Continue) response(s).)

10.1.1 100 Continue

The client SHOULD continue with its request. This interim response is used to inform the client that the initial part of the request has been received and has not yet been rejected by the server. The client SHOULD continue by sending the remainder of the request or, if the request has already been completed, ignore this response. The server MUST send a final response after the request has been completed. See section 8.2.3 for detailed discussion of the use and handling of this status code.

10.1.2 101 Switching Protocols

The server understands and is willing to comply with the client's request, via the Upgrade message header field (section 14.42), for a change in the application protocol being used on this connection. The server will switch protocols to those defined by the response's Upgrade header field immediately after the empty line which terminates the 101 response.

The protocol SHOULD be switched only when it is advantageous to do so. For example, switching to a newer version of HTTP is advantageous over older versions, and switching to a real-time, synchronous protocol might be advantageous when delivering resources that use such features.

10.2 Successful 2xx

This class of status code indicates that the client's request was successfully received, understood, and accepted.

10.2.1 200 OK

The request has succeeded. The information returned with the response is dependent on the method used in the request, for example:

GET an entity corresponding to the requested resource is sent in the response;

HEAD the entity-header fields corresponding to the requested resource are sent in the response without any message-body;

POST an entity describing or containing the result of the action;

TRACE an entity containing the request message as received by the end server.

10.2.2 201 Created

The request has been fulfilled and resulted in a new resource being created. The newly created resource can be referenced by the URI(s) returned in the entity of the response, with the most specific URI for the resource given by a Location header field. The response SHOULD include an entity containing a list of resource characteristics and location(s) from which the user or user agent can choose the one most appropriate. The entity format is specified by the media type given in the Content-Type header field. The origin server MUST create the resource before returning the 201 status code. If the action cannot be carried out immediately, the server SHOULD respond with 202 (Accepted) response instead.

A 201 response MAY contain an ETag response header field indicating the current value of the entity tag for the requested variant just

the current value of the entity tag for the requested variant just created, see section 14.19.

10.2.3 202 Accepted

The request has been accepted for processing, but the processing has not been completed. The request might or might not eventually be acted upon, as it might be disallowed when processing actually takes place. There is no facility for re-sending a status code from an asynchronous operation such as this.

The 202 response is intentionally non-committal. Its purpose is to allow a server to accept a request for some other process (perhaps a batch-oriented process that is only run once per day) without requiring that the user agent's connection to the server persist until the process is completed. The entity returned with this response SHOULD include an indication of the request's current status and either a pointer to a status monitor or some estimate of when the user can expect the request to be fulfilled.

10.2.4 203 Non-Authoritative Information

The returned metainformation in the entity-header is not the definitive set as available from the origin server, but is gathered from a local or a third-party copy. The set presented MAY be a subset or superset of the original version. For example, including local annotation information about the resource might result in a superset of the metainformation known by the origin server. Use of this response code is not required and is only appropriate when the response would otherwise be 200 (OK).

10.2.5 204 No Content

The server has fulfilled the request but does not need to return an entity-body, and might want to return updated metainformation. The response MAY include new or updated metainformation in the form of entity-headers, which if present SHOULD be associated with the requested variant.

If the client is a user agent, it SHOULD NOT change its document view from that which caused the request to be sent. This response is primarily intended to allow input for actions to take place without causing a change to the user agent's active document view, although any new or updated metainformation SHOULD be applied to the document currently in the user agent's active view.

The 204 response MUST NOT include a message-body, and thus is always terminated by the first empty line after the header fields.

10.2.6 205 Reset Content

The server has fulfilled the request and the user agent SHOULD reset the document view which caused the request to be sent. This response is primarily intended to allow input for actions to take place via user input, followed by a clearing of the form in which the input is given so that the user can easily initiate another input action. The response MUST NOT include an entity.

10.2.7 206 Partial Content

The server has fulfilled the partial GET request for the resource. The request MUST have included a Range header field (section 14.35) indicating the desired range, and MAY have included an If-Range header field (section 14.27) to make the request conditional.

The response MUST include the following header fields:

- Either a Content-Range header field (section 14.16) indicating the range included with this response, or a multipart/byteranges Content-Type including Content-Range fields for each part. If a Content-Length header field is present in the response, its value MUST match the actual number of OCTETs transmitted in the message-body.

- Date

- ETag and/or Content-Location, if the header would have been sent in a 200 response to the same request

- Expires, Cache-Control, and/or Vary, if the field-value might differ from that sent in any previous response for the same variant

If the 206 response is the result of an If-Range request that used a strong cache validator (see section 13.3.3), the response SHOULD NOT include other entity-headers. If the response is the result of an If-Range request that used a weak validator, the response MUST NOT include other entity-headers; this prevents inconsistencies between

cached entity-bodies and updated headers. Otherwise, the response MUST include all of the entity-headers that would have been returned with a 200 (OK) response to the same request.

A cache MUST NOT combine a 206 response with other previously cached content if the ETag or Last-Modified headers do not match exactly, see 13.5.4.

A cache that does not support the Range and Content-Range headers MUST NOT cache 206 (Partial) responses.

10.3 Redirection 3xx

This class of status code indicates that further action needs to be taken by the user agent in order to fulfill the request. The action required MAY be carried out by the user agent without interaction with the user if and only if the method used in the second request is GET or HEAD. A client SHOULD detect infinite redirection loops, since such loops generate network traffic for each redirection.

> Note: previous versions of this specification recommended a maximum of five redirections. Content developers should be aware that there might be clients that implement such a fixed limitation.

10.3.1 300 Multiple Choices

The requested resource corresponds to any one of a set of representations, each with its own specific location, and agent-driven negotiation information (section 12) is being provided so that the user (or user agent) can select a preferred representation and redirect its request to that location.

Unless it was a HEAD request, the response SHOULD include an entity containing a list of resource characteristics and location(s) from which the user or user agent can choose the one most appropriate. The entity format is specified by the media type given in the Content-Type header field. Depending upon the format and the capabilities of

the user agent, selection of the most appropriate choice MAY be performed automatically. However, this specification does not define any standard for such automatic selection.

If the server has a preferred choice of representation, it SHOULD include the specific URI for that representation in the Location field; user agents MAY use the Location field value for automatic redirection. This response is cacheable unless indicated otherwise.

10.3.2 301 Moved Permanently

The requested resource has been assigned a new permanent URI and any future references to this resource SHOULD use one of the returned URIs. Clients with link editing capabilities ought to automatically re-link references to the Request-URI to one or more of the new references returned by the server, where possible. This response is cacheable unless indicated otherwise.

The new permanent URI SHOULD be given by the Location field in the response. Unless the request method was HEAD, the entity of the response SHOULD contain a short hypertext note with a hyperlink to the new URI(s).

If the 301 status code is received in response to a request other than GET or HEAD, the user agent MUST NOT automatically redirect the request unless it can be confirmed by the user, since this might change the conditions under which the request was issued.

> Note: When automatically redirecting a POST request after receiving a 301 status code, some existing HTTP/1.0 user agents will erroneously change it into a GET request.

10.3.3 302 Found

The requested resource resides temporarily under a different URI. Since the redirection might be altered on occasion, the client SHOULD continue to use the Request-URI for future requests. This response is only cacheable if indicated by a Cache-Control or Expires header field.

The temporary URI SHOULD be given by the Location field in the response. Unless the request method was HEAD, the entity of the response SHOULD contain a short hypertext note with a hyperlink to the new URI(s).

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If the 302 status code is received in response to a request other than GET or HEAD, the user agent MUST NOT automatically redirect the request unless it can be confirmed by the user, since this might change the conditions under which the request was issued.

Note: RFC 1945 and RFC 2068 specify that the client is not allowed to change the method on the redirected request. However, most existing user agent implementations treat 302 as if it were a 303 response, performing a GET on the Location field-value regardless of the original request method. The status codes 303 and 307 have been added for servers that wish to make unambiguously clear which kind of reaction is expected of the client.

10.3.4 303 See Other

The response to the request can be found under a different URI and SHOULD be retrieved using a GET method on that resource. This method exists primarily to allow the output of a POST-activated script to redirect the user agent to a selected resource. The new URI is not a substitute reference for the originally requested resource. The 303 response MUST NOT be cached, but the response to the second (redirected) request might be cacheable.

The different URI SHOULD be given by the Location field in the response. Unless the request method was HEAD, the entity of the response SHOULD contain a short hypertext note with a hyperlink to the new URI(s).

Note: Many pre-HTTP/1.1 user agents do not understand the 303 status. When interoperability with such clients is a concern, the 302 status code may be used instead, since most user agents react to a 302 response as described here for 303.

10.3.5 304 Not Modified

If the client has performed a conditional GET request and access is allowed, but the document has not been modified, the server SHOULD respond with this status code. The 304 response MUST NOT contain a message-body, and thus is always terminated by the first empty line after the header fields.

The response MUST include the following header fields:

- Date, unless its omission is required by section 14.18.1

If a clockless origin server obeys these rules, and proxies and clients add their own Date to any response received without one (as already specified by [RFC 2068], section 14.19), caches will operate correctly.

- ETag and/or Content-Location, if the header would have been sent in a 200 response to the same request

- Expires, Cache-Control, and/or Vary, if the field-value might differ from that sent in any previous response for the same variant

If the conditional GET used a strong cache validator (see section 13.3.3), the response SHOULD NOT include other entity-headers. Otherwise (i.e., the conditional GET used a weak validator), the response MUST NOT include other entity-headers; this prevents inconsistencies between cached entity-bodies and updated headers.

If a 304 response indicates an entity not currently cached, then the cache MUST disregard the response and repeat the request without the conditional.

If a cache uses a received 304 response to update a cache entry, the cache MUST update the entry to reflect any new field values given in the response.

10.3.6 305 Use Proxy

The requested resource MUST be accessed through the proxy given by the Location field. The Location field gives the URI of the proxy. The recipient is expected to repeat this single request via the proxy. 305 responses MUST only be generated by origin servers.

Note: RFC 2068 was not clear that 305 was intended to redirect a single request, and to be generated by origin servers only. Not observing these limitations has significant security consequences.

10.3.7 306 (Unused)

The 306 status code was used in a previous version of the specification, is no longer used, and the code is reserved.

10.3.8 307 Temporary Redirect

The requested resource resides temporarily under a different URI. Since the redirection MAY be altered on occasion, the client SHOULD continue to use the Request-URI for future requests. This response is only cacheable if indicated by a Cache-Control or Expires header field.

The temporary URI SHOULD be given by the Location field in the response. Unless the request method was HEAD, the entity of the response SHOULD contain a short hypertext note with a hyperlink to the new URI(s) , since many pre-HTTP/1.1 user agents do not understand the 307 status. Therefore, the note SHOULD contain the information necessary for a user to repeat the original request on the new URI.

If the 307 status code is received in response to a request other than GET or HEAD, the user agent MUST NOT automatically redirect the request unless it can be confirmed by the user, since this might change the conditions under which the request was issued.

10.4 Client Error 4xx

The 4xx class of status code is intended for cases in which the client seems to have erred. Except when responding to a HEAD request, the server SHOULD include an entity containing an explanation of the error situation, and whether it is a temporary or permanent condition. These status codes are applicable to any request method. User agents SHOULD display any included entity to the user.

If the client is sending data, a server implementation using TCP SHOULD be careful to ensure that the client acknowledges receipt of the packet(s) containing the response, before the server closes the input connection. If the client continues sending data to the server after the close, the server's TCP stack will send a reset packet to the client, which may erase the client's unacknowledged input buffers before they can be read and interpreted by the HTTP application.

10.4.1 400 Bad Request

The request could not be understood by the server due to malformed syntax. The client SHOULD NOT repeat the request without modifications.

10.4.2 401 Unauthorized

The request requires user authentication. The response MUST include a WWW-Authenticate header field (section 14.47) containing a challenge applicable to the requested resource. The client MAY repeat the request with a suitable Authorization header field (section 14.8). If the request already included Authorization credentials, then the 401 response indicates that authorization has been refused for those credentials. If the 401 response contains the same challenge as the prior response, and the user agent has already attempted authentication at least once, then the user SHOULD be presented the entity that was given in the response, since that entity might include relevant diagnostic information. HTTP access authentication is explained in "HTTP Authentication: Basic and Digest Access Authentication" [43].

10.4.3 402 Payment Required

This code is reserved for future use.

10.4.4 403 Forbidden

The server understood the request, but is refusing to fulfill it. Authorization will not help and the request SHOULD NOT be repeated. If the request method was not HEAD and the server wishes to make public why the request has not been fulfilled, it SHOULD describe the reason for the refusal in the entity. If the server does not wish to make this information available to the client, the status code 404 (Not Found) can be used instead.

10.4.5 404 Not Found

The server has not found anything matching the Request-URI. No indication is given of whether the condition is temporary or permanent. The 410 (Gone) status code SHOULD be used if the server knows, through some internally configurable mechanism, that an old

resource is permanently unavailable and has no forwarding address. This status code is commonly used when the server does not wish to reveal exactly why the request has been refused, or when no other response is applicable.

10.4.6 405 Method Not Allowed

The method specified in the Request-Line is not allowed for the resource identified by the Request-URI. The response MUST include an Allow header containing a list of valid methods for the requested resource.

10.4.7 406 Not Acceptable

The resource identified by the request is only capable of generating response entities which have content characteristics not acceptable according to the accept headers sent in the request.

Unless it was a HEAD request, the response SHOULD include an entity containing a list of available entity characteristics and location(s) from which the user or user agent can choose the one most appropriate. The entity format is specified by the media type given in the Content-Type header field. Depending upon the format and the capabilities of the user agent, selection of the most appropriate choice MAY be performed automatically. However, this specification does not define any standard for such automatic selection.

> Note: HTTP/1.1 servers are allowed to return responses which are not acceptable according to the accept headers sent in the request. In some cases, this may even be preferable to sending a 406 response. User agents are encouraged to inspect the headers of an incoming response to determine if it is acceptable.

If the response could be unacceptable, a user agent SHOULD temporarily stop receipt of more data and query the user for a decision on further actions.

10.4.8 407 Proxy Authentication Required

This code is similar to 401 (Unauthorized), but indicates that the client must first authenticate itself with the proxy. The proxy MUST return a Proxy-Authenticate header field (section 14.33) containing a challenge applicable to the proxy for the requested resource. The client MAY repeat the request with a suitable Proxy-Authorization header field (section 14.34). HTTP access authentication is explained in "HTTP Authentication: Basic and Digest Access Authentication" [43].

10.4.9 408 Request Timeout

The client did not produce a request within the time that the server was prepared to wait. The client MAY repeat the request without modifications at any later time.

10.4.10 409 Conflict

The request could not be completed due to a conflict with the current state of the resource. This code is only allowed in situations where it is expected that the user might be able to resolve the conflict and resubmit the request. The response body SHOULD include enough

information for the user to recognize the source of the conflict. Ideally, the response entity would include enough information for the user or user agent to fix the problem; however, that might not be possible and is not required.

Conflicts are most likely to occur in response to a PUT request. For example, if versioning were being used and the entity being PUT included changes to a resource which conflict with those made by an earlier (third-party) request, the server might use the 409 response to indicate that it can't complete the request. In this case, the response entity would likely contain a list of the differences between the two versions in a format defined by the response Content-Type.

10.4.11 410 Gone

The requested resource is no longer available at the server and no forwarding address is known. This condition is expected to be considered permanent. Clients with link editing capabilities SHOULD delete references to the Request-URI after user approval. If the server does not know, or has no facility to determine, whether or not the condition is permanent, the status code 404 (Not Found) SHOULD be used instead. This response is cacheable unless indicated otherwise.

The 410 response is primarily intended to assist the task of web maintenance by notifying the recipient that the resource is intentionally unavailable and that the server owners desire that

remote links to that resource be removed. Such an event is common for limited-time, promotional services and for resources belonging to individuals no longer working at the server's site. It is not necessary to mark all permanently unavailable resources as "gone" or to keep the mark for any length of time -- that is left to the discretion of the server owner.

10.4.12 411 Length Required

The server refuses to accept the request without a defined Content-Length. The client MAY repeat the request if it adds a valid Content-Length header field containing the length of the message-body in the request message.

10.4.13 412 Precondition Failed

The precondition given in one or more of the request-header fields evaluated to false when it was tested on the server. This response code allows the client to place preconditions on the current resource metainformation (header field data) and thus prevent the requested method from being applied to a resource other than the one intended.

10.4.14 413 Request Entity Too Large

The server is refusing to process a request because the request entity is larger than the server is willing or able to process. The server MAY close the connection to prevent the client from continuing the request.

If the condition is temporary, the server SHOULD include a Retry-After header field to indicate that it is temporary and after what time the client MAY try again.

10.4.15 414 Request-URI Too Long

The server is refusing to service the request because the Request-URI is longer than the server is willing to interpret. This rare condition is only likely to occur when a client has improperly converted a POST request to a GET request with long query information, when the client has descended into a URI "black hole" of redirection (e.g., a redirected URI prefix that points to a suffix of itself), or when the server is under attack by a client attempting to exploit security holes present in some servers using fixed-length buffers for reading or manipulating the Request-URI.

10.4.16 415 Unsupported Media Type

The server is refusing to service the request because the entity of the request is in a format not supported by the requested resource for the requested method.

10.4.17 416 Requested Range Not Satisfiable

A server SHOULD return a response with this status code if a request included a Range request-header field (section 14.35), and none of the range-specifier values in this field overlap the current extent of the selected resource, and the request did not include an If-Range request-header field. (For byte-ranges, this means that the first-byte-pos of all of the byte-range-spec values were greater than the current length of the selected resource.)

When this status code is returned for a byte-range request, the response SHOULD include a Content-Range entity-header field specifying the current length of the selected resource (see section 14.16). This response MUST NOT use the multipart/byteranges content-type.

10.4.18 417 Expectation Failed

The expectation given in an Expect request-header field (see section 14.20) could not be met by this server, or, if the server is a proxy, the server has unambiguous evidence that the request could not be met by the next-hop server.

10.5 Server Error 5xx

Response status codes beginning with the digit "5" indicate cases in which the server is aware that it has erred or is incapable of performing the request. Except when responding to a HEAD request, the server SHOULD include an entity containing an explanation of the error situation, and whether it is a temporary or permanent condition. User agents SHOULD display any included entity to the user. These response codes are applicable to any request method.

10.5.1 500 Internal Server Error

The server encountered an unexpected condition which prevented it from fulfilling the request.

10.5.2 501 Not Implemented

The server does not support the functionality required to fulfill the request. This is the appropriate response when the server does not recognize the request method and is not capable of supporting it for any resource.

10.5.3 502 Bad Gateway

The server, while acting as a gateway or proxy, received an invalid response from the upstream server it accessed in attempting to fulfill the request.

10.5.4 503 Service Unavailable

The server is currently unable to handle the request due to a temporary overloading or maintenance of the server. The implication is that this is a temporary condition which will be alleviated after some delay. If known, the length of the delay MAY be indicated in a Retry-After header. If no Retry-After is given, the client SHOULD handle the response as it would for a 500 response.

> Note: The existence of the 503 status code does not imply that a server must use it when becoming overloaded. Some servers may wish to simply refuse the connection.

10.5.5 504 Gateway Timeout

The server, while acting as a gateway or proxy, did not receive a timely response from the upstream server specified by the URI (e.g. HTTP, FTP, LDAP) or some other auxiliary server (e.g. DNS) it needed to access in attempting to complete the request.

> Note: Note to implementors: some deployed proxies are known to return 400 or 500 when DNS lookups time out.

10.5.6 505 HTTP Version Not Supported

The server does not support, or refuses to support, the HTTP protocol version that was used in the request message. The server is indicating that it is unable or unwilling to complete the request using the same major version as the client, as described in section 3.1, other than with this error message. The response SHOULD contain an entity describing why that version is not supported and what other protocols are supported by that server.

11 Access Authentication

HTTP provides several OPTIONAL challenge-response authentication mechanisms which can be used by a server to challenge a client request and by a client to provide authentication information. The general framework for access authentication, and the specification of "basic" and "digest" authentication, are specified in "HTTP Authentication: Basic and Digest Access Authentication" [43]. This specification adopts the definitions of "challenge" and "credentials" from that specification.

12 Content Negotiation

Most HTTP responses include an entity which contains information for interpretation by a human user. Naturally, it is desirable to supply the user with the "best available" entity corresponding to the request. Unfortunately for servers and caches, not all users have the same preferences for what is "best," and not all user agents are equally capable of rendering all entity types. For that reason, HTTP has provisions for several mechanisms for "content negotiation" -- the process of selecting the best representation for a given response when there are multiple representations available.

> Note: This is not called "format negotiation" because the alternate representations may be of the same media type, but use different capabilities of that type, be in different languages, etc.

Any response containing an entity-body MAY be subject to negotiation, including error responses.

There are two kinds of content negotiation which are possible in HTTP: server-driven and agent-driven negotiation. These two kinds of negotiation are orthogonal and thus may be used separately or in combination. One method of combination, referred to as transparent negotiation, occurs when a cache uses the agent-driven negotiation

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negotiation, occurs when a cache uses the agent-driven negotiation information provided by the origin server in order to provide server-driven negotiation for subsequent requests.

12.1 Server-driven Negotiation

If the selection of the best representation for a response is made by an algorithm located at the server, it is called server-driven negotiation. Selection is based on the available representations of the response (the dimensions over which it can vary; e.g. language, content-coding, etc.) and the contents of particular header fields in the request message or on other information pertaining to the request (such as the network address of the client).

Server-driven negotiation is advantageous when the algorithm for selecting from among the available representations is difficult to describe to the user agent, or when the server desires to send its "best guess" to the client along with the first response (hoping to avoid the round-trip delay of a subsequent request if the "best guess" is good enough for the user). In order to improve the server's guess, the user agent MAY include request header fields (Accept, Accept-Language, Accept-Encoding, etc.) which describe its preferences for such a response.

Server-driven negotiation has disadvantages:

1. It is impossible for the server to accurately determine what might be "best" for any given user, since that would require complete knowledge of both the capabilities of the user agent and the intended use for the response (e.g., does the user want to view it on screen or print it on paper?).

2. Having the user agent describe its capabilities in every request can be both very inefficient (given that only a small percentage of responses have multiple representations) and a potential violation of the user's privacy.

3. It complicates the implementation of an origin server and the algorithms for generating responses to a request.

4. It may limit a public cache's ability to use the same response for multiple user's requests.

HTTP/1.1 includes the following request-header fields for enabling server-driven negotiation through description of user agent capabilities and user preferences: Accept (section 14.1), Accept-Charset (section 14.2), Accept-Encoding (section 14.3), Accept-Language (section 14.4), and User-Agent (section 14.43). However, an origin server is not limited to these dimensions and MAY vary the response based on any aspect of the request, including information outside the request-header fields or within extension header fields not defined by this specification.

The Vary header field can be used to express the parameters the server uses to select a representation that is subject to server-driven negotiation. See section 13.6 for use of the Vary header field by caches and section 14.44 for use of the Vary header field by servers.

12.2 Agent-driven Negotiation

With agent-driven negotiation, selection of the best representation for a response is performed by the user agent after receiving an initial response from the origin server. Selection is based on a list of the available representations of the response included within the header fields or entity-body of the initial response, with each representation identified by its own URI. Selection from among the representations may be performed automatically (if the user agent is capable of doing so) or manually by the user selecting from a generated (possibly hypertext) menu.

Agent-driven negotiation is advantageous when the response would vary over commonly-used dimensions (such as type, language, or encoding), when the origin server is unable to determine a user agent's capabilities from examining the request, and generally when public caches are used to distribute server load and reduce network usage.

Agent-driven negotiation suffers from the disadvantage of needing a second request to obtain the best alternate representation. This second request is only efficient when caching is used. In addition, this specification does not define any mechanism for supporting automatic selection, though it also does not prevent any such mechanism from being developed as an extension and used within HTTP/1.1.

HTTP/1.1 defines the 300 (Multiple Choices) and 406 (Not Acceptable) status codes for enabling agent-driven negotiation when the server is unwilling or unable to provide a varying response using server-driven negotiation.

12.3 Transparent Negotiation

Transparent negotiation is a combination of both server-driven and agent-driven negotiation. When a cache is supplied with a form of the list of available representations of the response (as in agent-driven negotiation) and the dimensions of variance are completely understood by the cache, then the cache becomes capable of performing server-driven negotiation on behalf of the origin server for subsequent requests on that resource.

Transparent negotiation has the advantage of distributing the negotiation work that would otherwise be required of the origin server and also removing the second request delay of agent-driven negotiation when the cache is able to correctly guess the right response.

This specification does not define any mechanism for transparent negotiation, though it also does not prevent any such mechanism from being developed as an extension that could be used within HTTP/1.1.

13 Caching in HTTP

HTTP is typically used for distributed information systems, where performance can be improved by the use of response caches. The HTTP/1.1 protocol includes a number of elements intended to make caching work as well as possible. Because these elements are inextricable from other aspects of the protocol, and because they interact with each other, it is useful to describe the basic caching design of HTTP separately from the detailed descriptions of methods, headers, response codes, etc.

Caching would be useless if it did not significantly improve performance. The goal of caching in HTTP/1.1 is to eliminate the need to send requests in many cases, and to eliminate the need to send full responses in many other cases. The former reduces the number of network round-trips required for many operations; we use an "expiration" mechanism for this purpose (see section 13.2). The latter reduces network bandwidth requirements; we use a "validation" mechanism for this purpose (see section 13.3).

Requirements for performance, availability, and disconnected operation require us to be able to relax the goal of semantic transparency. The HTTP/1.1 protocol allows origin servers, caches,

and clients to explicitly reduce transparency when necessary. However, because non-transparent operation may confuse non-expert users, and might be incompatible with certain server applications (such as those for ordering merchandise), the protocol requires that transparency be relaxed

- only by an explicit protocol-level request when relaxed by client or origin server
- only with an explicit warning to the end user when relaxed by cache or client

Therefore, the HTTP/1.1 protocol provides these important elements:

1. Protocol features that provide full semantic transparency when this is required by all parties.
2. Protocol features that allow an origin server or user agent to explicitly request and control non-transparent operation.
3. Protocol features that allow a cache to attach warnings to responses that do not preserve the requested approximation of semantic transparency.

A basic principle is that it must be possible for the clients to detect any potential relaxation of semantic transparency.

> Note: The server, cache, or client implementor might be faced with design decisions not explicitly discussed in this specification. If a decision might affect semantic transparency, the implementor ought to err on the side of maintaining transparency unless a careful and complete analysis shows significant benefits in breaking transparency.

13.1.1 Cache Correctness

A correct cache MUST respond to a request with the most up-to-date response held by the cache that is appropriate to the request (see sections 13.2.5, 13.2.6, and 13.12) which meets one of the following conditions:

1. It has been checked for equivalence with what the origin server would have returned by revalidating the response with the origin server (section 13.3);

2. It is "fresh enough" (see section 13.2). In the default case, this means it meets the least restrictive freshness requirement of the client, origin server, and cache (see section 14.9); if the origin server so specifies, it is the freshness requirement of the origin server alone.

   If a stored response is not "fresh enough" by the most restrictive freshness requirement of both the client and the origin server, in carefully considered circumstances the cache MAY still return the response with the appropriate Warning header (see section 13.1.5 and 14.46), unless such a response is prohibited (e.g., by a "no-store" cache-directive, or by a "no-cache" cache-request-directive; see section 14.9).

3. It is an appropriate 304 (Not Modified), 305 (Proxy Redirect), or error (4xx or 5xx) response message.

If the cache can not communicate with the origin server, then a correct cache SHOULD respond as above if the response can be correctly served from the cache; if not it MUST return an error or warning indicating that there was a communication failure.

If a cache receives a response (either an entire response, or a 304 (Not Modified) response) that it would normally forward to the requesting client, and the received response is no longer fresh, the cache SHOULD forward it to the requesting client without adding a new Warning (but without removing any existing Warning headers). A cache SHOULD NOT attempt to revalidate a response simply because that response became stale in transit; this might lead to an infinite loop. A user agent that receives a stale response without a Warning MAY display a warning indication to the user.

13.1.2 Warnings

Whenever a cache returns a response that is neither first-hand nor "fresh enough" (in the sense of condition 2 in section 13.1.1), it MUST attach a warning to that effect, using a Warning general-header. The Warning header and the currently defined warnings are described in section 14.46. The warning allows clients to take appropriate action.

Warnings MAY be used for other purposes, both cache-related and otherwise. The use of a warning, rather than an error status code, distinguish these responses from true failures.

Warnings are assigned three digit warn-codes. The first digit indicates whether the Warning MUST or MUST NOT be deleted from a stored cache entry after a successful revalidation:

1xx Warnings that describe the freshness or revalidation status of the response, and so MUST be deleted after a successful revalidation. 1XX warn-codes MAY be generated by a cache only when validating a cached entry. It MUST NOT be generated by clients.

2xx Warnings that describe some aspect of the entity body or entity headers that is not rectified by a revalidation (for example, a lossy compression of the entity bodies) and which MUST NOT be deleted after a successful revalidation.

See section 14.46 for the definitions of the codes themselves.

HTTP/1.0 caches will cache all Warnings in responses, without deleting the ones in the first category. Warnings in responses that are passed to HTTP/1.0 caches carry an extra warning-date field, which prevents a future HTTP/1.1 recipient from believing an erroneously cached Warning.

Warnings also carry a warning text. The text MAY be in any appropriate natural language (perhaps based on the client's Accept headers), and include an OPTIONAL indication of what character set is used.

Multiple warnings MAY be attached to a response (either by the origin server or by a cache), including multiple warnings with the same code number. For example, a server might provide the same warning with texts in both English and Basque.

When multiple warnings are attached to a response, it might not be practical or reasonable to display all of them to the user. This version of HTTP does not specify strict priority rules for deciding which warnings to display and in what order, but does suggest some heuristics.

13.1.3 Cache-control Mechanisms

The basic cache mechanisms in HTTP/1.1 (server-specified expiration times and validators) are implicit directives to caches. In some cases, a server or client might need to provide explicit directives to the HTTP caches. We use the Cache-Control header for this purpose.

The Cache-Control header allows a client or server to transmit a variety of directives in either requests or responses. These directives typically override the default caching algorithms. As a general rule, if there is any apparent conflict between header values, the most restrictive interpretation is applied (that is, the one that is most likely to preserve semantic transparency). However,

in some cases, cache-control directives are explicitly specified as weakening the approximation of semantic transparency (for example, "max-stale" or "public").

The cache-control directives are described in detail in section 14.9.

13.1.4 Explicit User Agent Warnings

Many user agents make it possible for users to override the basic caching mechanisms. For example, the user agent might allow the user to specify that cached entities (even explicitly stale ones) are never validated. Or the user agent might habitually add "Cache-Control: max-stale=3600" to every request. The user agent SHOULD NOT default to either non-transparent behavior, or behavior that results in abnormally ineffective caching, but MAY be explicitly configured to do so by an explicit action of the user.

If the user has overridden the basic caching mechanisms, the user agent SHOULD explicitly indicate to the user whenever this results in the display of information that might not meet the server's transparency requirements (in particular, if the displayed entity is known to be stale). Since the protocol normally allows the user agent to determine if responses are stale or not, this indication need only be displayed when this actually happens. The indication need not be a dialog box; it could be an icon (for example, a picture of a rotting fish) or some other indicator.

If the user has overridden the caching mechanisms in a way that would abnormally reduce the effectiveness of caches, the user agent SHOULD continually indicate this state to the user (for example, by a display of a picture of currency in flames) so that the user does not inadvertently consume excess resources or suffer from excessive latency.

13.1.5 Exceptions to the Rules and Warnings

In some cases, the operator of a cache MAY choose to configure it to return stale responses even when not requested by clients. This decision ought not be made lightly, but may be necessary for reasons of availability or performance, especially when the cache is poorly connected to the origin server. Whenever a cache returns a stale response, it MUST mark it as such (using a Warning header) enabling the client software to alert the user that there might be a potential problem.

It also allows the user agent to take steps to obtain a first-hand or fresh response. For this reason, a cache SHOULD NOT return a stale response if the client explicitly requests a first-hand or fresh one, unless it is impossible to comply for technical or policy reasons.

13.1.6 Client-controlled Behavior

While the origin server (and to a lesser extent, intermediate caches, by their contribution to the age of a response) are the primary source of expiration information, in some cases the client might need to control a cache's decision about whether to return a cached response without validating it. Clients do this using several directives of the Cache-Control header.

A client's request MAY specify the maximum age it is willing to accept of an unvalidated response; specifying a value of zero forces the cache(s) to revalidate all responses. A client MAY also specify the minimum time remaining before a response expires. Both of these options increase constraints on the behavior of caches, and so cannot further relax the cache's approximation of semantic transparency.

A client MAY also specify that it will accept stale responses, up to some maximum amount of staleness. This loosens the constraints on the caches, and so might violate the origin server's specified constraints on semantic transparency, but might be necessary to support disconnected operation, or high availability in the face of

support disconnected operation, or high availability in the face of poor connectivity.

13.2 Expiration Model

13.2.1 Server-Specified Expiration

HTTP caching works best when caches can entirely avoid making requests to the origin server. The primary mechanism for avoiding requests is for an origin server to provide an explicit expiration time in the future, indicating that a response MAY be used to satisfy subsequent requests. In other words, a cache can return a fresh response without first contacting the server.

Our expectation is that servers will assign future explicit expiration times to responses in the belief that the entity is not likely to change, in a semantically significant way, before the expiration time is reached. This normally preserves semantic transparency, as long as the server's expiration times are carefully chosen.

The expiration mechanism applies only to responses taken from a cache and not to first-hand responses forwarded immediately to the requesting client.

If an origin server wishes to force a semantically transparent cache to validate every request, it MAY assign an explicit expiration time in the past. This means that the response is always stale, and so the cache SHOULD validate it before using it for subsequent requests. See section 14.9.4 for a more restrictive way to force revalidation.

If an origin server wishes to force any HTTP/1.1 cache, no matter how it is configured, to validate every request, it SHOULD use the "must-revalidate" cache-control directive (see section 14.9).

Servers specify explicit expiration times using either the Expires header, or the max-age directive of the Cache-Control header.

An expiration time cannot be used to force a user agent to refresh its display or reload a resource; its semantics apply only to caching mechanisms, and such mechanisms need only check a resource's expiration status when a new request for that resource is initiated. See section 13.13 for an explanation of the difference between caches and history mechanisms.

13.2.2 Heuristic Expiration

Since origin servers do not always provide explicit expiration times, HTTP caches typically assign heuristic expiration times, employing algorithms that use other header values (such as the Last-Modified time) to estimate a plausible expiration time. The HTTP/1.1 specification does not provide specific algorithms, but does impose worst-case constraints on their results. Since heuristic expiration times might compromise semantic transparency, they ought to used cautiously, and we encourage origin servers to provide explicit expiration times as much as possible.

13.2.3 Age Calculations

In order to know if a cached entry is fresh, a cache needs to know if its age exceeds its freshness lifetime. We discuss how to calculate the latter in section 13.2.4; this section describes how to calculate the age of a response or cache entry.

In this discussion, we use the term "now" to mean "the current value of the clock at the host performing the calculation." Hosts that use HTTP, but especially hosts running origin servers and caches, SHOULD use NTP [28] or some similar protocol to synchronize their clocks to a globally accurate time standard.

HTTP/1.1 requires origin servers to send a Date header, if possible, with every response, giving the time at which the response was generated (see section 14.18). We use the term "date_value" to denote the value of the Date header, in a form appropriate for arithmetic operations.

HTTP/1.1 uses the Age response-header to convey the estimated age of the response message when obtained from a cache. The Age field value is the cache's estimate of the amount of time since the response was generated or revalidated by the origin server.

In essence, the Age value is the sum of the time that the response has been resident in each of the caches along the path from the origin server, plus the amount of time it has been in transit along network paths.

We use the term "age_value" to denote the value of the Age header, in a form appropriate for arithmetic operations.

A response's age can be calculated in two entirely independent ways:

1. now minus date_value, if the local clock is reasonably well synchronized to the origin server's clock. If the result is negative, the result is replaced by zero.

2. age_value, if all of the caches along the response path implement HTTP/1.1.

Given that we have two independent ways to compute the age of a response when it is received, we can combine these as

```
corrected_received_age = max(now - date_value, age_value)
```

and as long as we have either nearly synchronized clocks or all-HTTP/1.1 paths, one gets a reliable (conservative) result.

Because of network-imposed delays, some significant interval might pass between the time that a server generates a response and the time it is received at the next outbound cache or client. If uncorrected, this delay could result in improperly low ages.

Because the request that resulted in the returned Age value must have been initiated prior to that Age value's generation, we can correct for delays imposed by the network by recording the time at which the request was initiated. Then, when an Age value is received, it MUST be interpreted relative to the time the request was initiated, not

the time that the response was received. This algorithm results in conservative behavior no matter how much delay is experienced. So, we compute:

```
corrected_initial_age = corrected_received_age
                      + (now - request_time)
```

where "request_time" is the time (according to the local clock) when the request that elicited this response was sent.

Summary of age calculation algorithm, when a cache receives a response:

```
/*
 * age_value
 *      is the value of Age: header received by the cache with
 *              this response.
 * date_value
 *      is the value of the origin server's Date: header
 * request_time
 *      is the (local) time when the cache made the request
 *              that resulted in this cached response
 * response_time
 *      is the (local) time when the cache received the
 *              response
 * now
 *      is the current (local) time
 */

apparent_age = max(0, response_time - date_value);
corrected_received_age = max(apparent_age, age_value);
response_delay = response_time - request_time;
corrected_initial_age = corrected_received_age + response_delay;
resident_time = now - response_time;
current_age   = corrected_initial_age + resident_time;
```

The current_age of a cache entry is calculated by adding the amount of time (in seconds) since the cache entry was last validated by the origin server to the corrected_initial_age. When a response is generated from a cache entry, the cache MUST include a single Age header field in the response with a value equal to the cache entry's current_age.

The presence of an Age header field in a response implies that a response is not first-hand. However, the converse is not true, since the lack of an Age header field in a response does not imply that the

response is first-hand unless all caches along the request path are compliant with HTTP/1.1 (i.e., older HTTP caches did not implement the Age header field).

13.2.4 Expiration Calculations

In order to decide whether a response is fresh or stale, we need to compare its freshness lifetime to its age. The age is calculated as described in section 13.2.3; this section describes how to calculate the freshness lifetime, and to determine if a response has expired. In the discussion below, the values can be represented in any form appropriate for arithmetic operations.

We use the term "expires_value" to denote the value of the Expires header. We use the term "max_age_value" to denote an appropriate value of the number of seconds carried by the "max-age" directive of the Cache-Control header in a response (see section 14.9.3).

The max-age directive takes priority over Expires, so if max-age is present in a response, the calculation is simply:

```
freshness_lifetime = max_age_value
```

Otherwise, if Expires is present in the response, the calculation is:

```
freshness_lifetime = expires_value - date_value
```

Note that neither of these calculations is vulnerable to clock skew, since all of the information comes from the origin server.

If none of Expires, Cache-Control: max-age, or Cache-Control: s-maxage (see section 14.9.3) appears in the response, and the response does not include other restrictions on caching, the cache MAY compute a freshness lifetime using a heuristic. The cache MUST attach Warning 113 to any response whose age is more than 24 hours if such warning has not already been added.

Also, if the response does have a Last-Modified time, the heuristic expiration value SHOULD be no more than some fraction of the interval since that time. A typical setting of this fraction might be 10%.

The calculation to determine if a response has expired is quite simple:

```
response_is_fresh = (freshness_lifetime > current_age)
```


13.2.5 Disambiguating Expiration Values

Because expiration values are assigned optimistically, it is possible for two caches to contain fresh values for the same resource that are different.

If a client performing a retrieval receives a non-first-hand response for a request that was already fresh in its own cache, and the Date header in its existing cache entry is newer than the Date on the new response, then the client MAY ignore the response. If so, it MAY retry the request with a "Cache-Control: max-age=0" directive (see section 14.9), to force a check with the origin server.

If a cache has two fresh responses for the same representation with different validators, it MUST use the one with the more recent Date header. This situation might arise because the cache is pooling responses from other caches, or because a client has asked for a reload or a revalidation of an apparently fresh cache entry.

13.2.6 Disambiguating Multiple Responses

Because a client might be receiving responses via multiple paths, so that some responses flow through one set of caches and other responses flow through a different set of caches, a client might receive responses in an order different from that in which the origin server sent them. We would like the client to use the most recently generated response, even if older responses are still apparently fresh.

Neither the entity tag nor the expiration value can impose an ordering on responses, since it is possible that a later response intentionally carries an earlier expiration time. The Date values are ordered to a granularity of one second.

When a client tries to revalidate a cache entry, and the response it receives contains a Date header that appears to be older than the one for the existing entry, then the client SHOULD repeat the request unconditionally, and include

```
    Cache-Control: max-age=0
```

to force any intermediate caches to validate their copies directly with the origin server, or

```
    Cache-Control: no-cache
```

to force any intermediate caches to obtain a new copy from the origin server.

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If the Date values are equal, then the client MAY use either response (or MAY, if it is being extremely prudent, request a new response). Servers MUST NOT depend on clients being able to choose deterministically between responses generated during the same second, if their expiration times overlap.

13.3 Validation Model

When a cache has a stale entry that it would like to use as a response to a client's request, it first has to check with the origin server (or possibly an intermediate cache with a fresh response) to see if its cached entry is still usable. We call this "validating" the cache entry. Since we do not want to have to pay the overhead of retransmitting the full response if the cached entry is good, and we do not want to pay the overhead of an extra round trip if the cached entry is invalid, the HTTP/1.1 protocol supports the use of conditional methods.

The key protocol features for supporting conditional methods are those concerned with "cache validators." When an origin server generates a full response, it attaches some sort of validator to it, which is kept with the cache entry. When a client (user agent or proxy cache) makes a conditional request for a resource for which it has a cache entry, it includes the associated validator in the request.

The server then checks that validator against the current validator for the entity, and, if they match (see section 13.3.3), it responds with a special status code (usually, 304 (Not Modified)) and no entity-body. Otherwise, it returns a full response (including entity-body). Thus, we avoid transmitting the full response if the validator matches, and we avoid an extra round trip if it does not match.

In HTTP/1.1, a conditional request looks exactly the same as a normal request for the same resource, except that it carries a special header (which includes the validator) that implicitly turns the method (usually, GET) into a conditional.

The protocol includes both positive and negative senses of cache-validating conditions. That is, it is possible to request either that a method be performed if and only if a validator matches or if and only if no validators match.

> Note: a response that lacks a validator may still be cached, and served from cache until it expires, unless this is explicitly prohibited by a cache-control directive. However, a cache cannot do a conditional retrieval if it does not have a validator for the entity, which means it will not be refreshable after it expires.

13.3.1 Last-Modified Dates

The Last-Modified entity-header field value is often used as a cache validator. In simple terms, a cache entry is considered to be valid if the entity has not been modified since the Last-Modified value.

13.3.2 Entity Tag Cache Validators

The ETag response-header field value, an entity tag, provides for an "opaque" cache validator. This might allow more reliable validation in situations where it is inconvenient to store modification dates, where the one-second resolution of HTTP date values is not sufficient, or where the origin server wishes to avoid certain paradoxes that might arise from the use of modification dates.

Entity Tags are described in section 3.11. The headers used with entity tags are described in sections 14.19, 14.24, 14.26 and 14.44.

13.3.3 Weak and Strong Validators

Since both origin servers and caches will compare two validators to decide if they represent the same or different entities, one normally would expect that if the entity (the entity-body or any entity-headers) changes in any way, then the associated validator would change as well. If this is true, then we call this validator a "strong validator."

However, there might be cases when a server prefers to change the validator only on semantically significant changes, and not when insignificant aspects of the entity change. A validator that does not always change when the resource changes is a "weak validator."

Entity tags are normally "strong validators," but the protocol provides a mechanism to tag an entity tag as "weak." One can think of a strong validator as one that changes whenever the bits of an entity changes, while a weak value changes whenever the meaning of an entity changes. Alternatively, one can think of a strong validator as part