                    The Model Primary Content Type for
                    Multipurpose Internet Mail Extensions

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.

Introduction

   The purpose of this memo is to propose an update to Internet RFC 2045
   to include a new primary content-type to be known as "model". RFC
   2045 [1] describes mechanisms for specifying and describing the
   format of Internet Message Bodies via content-type/subtype pairs. We
   believe that "model" defines a fundamental type of content with
   unique presentational, hardware, and processing aspects. Various
   subtypes of this primary type are immediately anticipated but will be
   covered under separate documents.

Table of Contents

1. Overview

   This document will outline what a model is, show examples of models,
   and discuss the benefits of grouping models together. This document
   will not directly deal with the intended subtypes since those will be
   covered by their separate registrations. Some immediately expected
   subtypes are listed in section 7.

   This document is a discussion document for an agreed definition,
   intended eventually to form a standard accepted extension to RFC
   2045. We are also targeting developers of input/output filters,
   viewer software and hardware, those involved in MIME transport, and
   decoders.

2. Definition of a model

   A model primary MIME type is an electronically exchangeable
   behavioral or physical representation within a given domain. Each
   subtype in the model structure has unique features, just as does each
   subtype in the other primary types. The important fact is that these
   various subtypes can be converted between each other with less loss
   of information then to that of other primary types. This fact groups
   these subtypes together into the model primary type. All of the
   expected subtypes have several features in common and that are unique
   to this primary type.

   To loosely summarize: models are multidimensional structures composed
   of one or more objects. If there are multiple objects then one
   object defines the arrangement/setting/relationship of the others.
   These objects all have calibrated coordinate systems but these
   systems need not be in the same units nor need they have the same
   dimensionality. In detail:

   1. have 3 or more dimensions which are bases of the system and
      form an orthogonal system (any orthogonal system is sufficient).

      This system is specifically defined in terms of an orthogonal
      set of basis functions [for a subspace of the L^2 function space]
      over a coordinate system of dimension 3 or more. Note that this
      does not preclude regular skewed systems, elliptical coordinates,
      different vector spaces, etc.

   2. contain a structural relationship between model elements.

   3. have scaling or calibration factors which are related to physical
      units (force, momentum, time, velocity, acceleration, size, etc.).
      Thus, an IGES file will specify a building of non-arbitrary size,
      computational meshes and VRML models will have real spatial/

temporal units. This allows for differing elements to be combined
non-arbitrarily.

4. Models can be single objects or composed of a collection of
   objects. These normally independent objects are arranged
   in a master/slave scenario so that one object acts as the
   reference, or primary object, which defines how the other
   objects interrelate and behave. This allows for the creation
   of mathematical, physical, economic, behavioral, etc. models
   which typically are composed of different elements. The key is
   in the description: these types describe how something
   "behaves"; contrasted to typical data types which describe
   how something "is".

   The inclusion of this "collective" system works similar to the
   Email system's multipart/related type which defines the actions
   of the individual parts. Further specification of the model/*
   subtypes utilizing these properties is left to the subtype
   authors.

With these assumptions:

a. the default dimensionality will be spatial and temporal (but
   any are allowed).

b. it is presumed that models will contain underlying structure
   which may or may not be immediately available to the
   user. (fluid dynamics vector fields, electromagnetic
   propagation, interrelated IGES dimensional specifiers, VRML
   materials and operators, etc.)

c. it is assumed that basis set conversion between model domains
   is lossless. The interpretation of the data may change but
   the specification will not. i.e. convert the model of the
   U.S.A. Gross Domestic Product into a VRML model and navigate
   it to explore the variances and interrelationships. The model
   has many dimensions but also "passages" and "corridors"
   linking different parts of it. A similar situation is true
   for meshes and CAD files. The key is identifying the basis set
   conversion which makes sense.

d. models are grouped to assure LESS loss of information between
   the model subtypes than to subtypes of other primary
   types. (i.e. converting a chemical model into an image is
   more lossy than concerting it into a VRML model).

   Items c and d above define the grouping for model similar to the way
   that "images" and "videos" are grouped together; to assure less loss
   of information. Obviously converting from a GIF image to a JPEG
   image looses less information than converting from a GIF image to an
   AU audio file.

3. Consultation Mechanisms

   Before proposing a subtype for the model/* primary type, it is
   suggested that the subtype author examine the definition (above) of
   what a model/* is and the listing (below) of what a model/* is not.
   Additional consultations with the authors of the existing model/*
   subtypes is also suggested.

   Copies of RFCs are available on:

                      ftp://ftp.isi.edu/in-notes/

   Copies of Internet-Drafts are available on:

                    ftp://ftp.ietf.org/internet-drafts/

   Similarly, the VRML discussion list has been archived as:

                      http://vrml.wired.com/arch/

   and discussions on the comp.mail.mime group may be of interest.
   Discussion digests for the existing model/* subtypes may be
   referenced in the respective documents.

   The mesh community presently has numerous different mesh geometries
   as part of different packages. Freely available libraries need to be
   advertised more than they have been in the past to spur the
   development of interoperable packages. It is hoped that by following
   the example of the VRML community and creating a freely available
   comprehensive library of input/output functions for meshes [11] that
   this problem will be alleviated for the mesh community. A freely
   available mesh viewer conforming to these standards is available now
   for various platforms. Consulations with the authors of the mesh
   system,

           http://www-dsed.llnl.gov/documents/tests/mesh.html

   will be beneficial.

   The IGES community has a suite of tests and conformance utilities to
   gauge the conformance to specifications and software authors are
   encouraged to seek those out from NIST [14].

4. Encoding and Transport

   a. Unrecognized subtypes of model should at a minimum be treated
      as "application/octet-stream". Implementations may optionally
      elect to pass subtypes of model that they do not specifically
      recognize to a robust general-purpose model viewing
      application, if such an application is available.

   b. Different subtypes of model may be encoded as textual
      representations or as binary data. Unless noted in the
      subtype registration, subtypes of model should be assumed to
      contain binary data, implying a content encoding of base64 for
      email and binary transfer for ftp and http.

   c. The formal syntax for the subtypes of the model primary type
      should look like this:

      Media type name: model
      Media subtype name: xxxxxxxx
      Required parameters: none
      Optional parameters: dimensionality, state
                                  (see below)
      Encoding considerations: base64 encoding is recommended when
                                  transmitting model/* documents through
                                  MIME electronic mail.
      Security considerations: see section 5 below
      Published specification: This document.
                                  See Appendix B for references to some of
                                  the expected subtypes.
      Person and email address to contact for further information:
                                  Scott D. Nelson <nelson18@llnl.gov>
                                  7000 East Ave.
                                  Lawrence Livermore National Laboratory
                                  Livermore, CA 94550

   The optional parameters consist of starting conditions and variable
   values used as part of the subtypes. A base set is listed here for
   illustration purposes only and will be covered in detail as part of
   the respective subtypes:

  dimension := string ; a number indicating the number of dimensions.
                        This is used as a "hint" in selecting
                        applicable viewer programs.

```
state      := string ; "static" or "dynamic".  In "static", the
                        observer may move about, thus effecting
                        translations, rotations, pans, zooms, etc.
                        but the data does not change.  In "dynamic",
                        the data itself is manipulated via
                        skews, elongations, scales, etc.  Note that
                        time evolution is still a static operation
                        since it is just a translation along one of
                        the principal dimensions while the elongation
                        of a cube or object deformation are dynamic
                        operations.
```

Note that this optional parameter list does not limit those
specified by the various subtypes.

d. The specific issues relating to the various subtypes are covered
   as part of the description of those specific subtypes. The
   following is an example of a typical MIME header used for mail
   transport purposes:

```
To:    you@some.org
From: nelson18@llnl.gov
Date: Fri, 30 Aug 96 13:33:19 -0700
Content-Type: model/mesh; dimension="4"; state="static"
Content-Transfer-Encoding: base64
MIME-Version: 1.0
Subject: model data file
```

```
I1ZSTUwgVjEuMCBhc2NpaQojIFRoaXMgZmlsZSB3YXMgIGdlbmVyY...
byBDb21tdW5pY2F0aW9ucwojIGh0dHA6Ly93d3cuY2hhY28uY29tdC...
IyB1c2VkIGluIHJvb20gMTkyICh0ZXN0IHJvb20pCiAgIAojIFRvc...
.
.
.
```

5.   Security Considerations Section

Note that the data files are "read-only" and do not contain file
system modifiers or batch/macro commands. The transported data is
not self-modifying but may contain interrelationships. The data
files may however contain a "default view" which is added by the
author at file creation time. This "default view" may manipulate
viewer variables, default look angle, lighting, visualization
options, etc. This visualization may also involve the computation of
variables or values for display based on the given raw data. For
motorized equipment, this may change the position from the hardware's
rest state to the object's starting orientation.

   The internal structure of the data files may direct agents to access
   additional data from the network (i.e. inclusions); the security
   limits of whom are not pre-supposed. Actions based on these
   inclusions are left to the security definitions of the inclusions.
   Further comments about the security considerations for the subtypes
   will be contained in each subtype's registration.

6. Authors' Addresses

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7. Expected subtypes

   Table 1 lists some of the expected model sub-type names. Suggested 3
   letter extensions are also provided for DOS compatibility but their
   need is hopefully diminished by the use of more robust operating
   systems on PC platforms. The "silo" extension is provided for
   backwards compatibility. Mesh has an extensive list of hints since
   the present variability is so great. In the future, the need for
   these hints will diminish since the files are self describing. This
   document is not registering these subtypes. They will be handled
   under separate documents.

Table 1.

Primary/sub-type	Suggested extension(s)	Reference
model/iges	igs,iges	[8]
model/vrml	wrl	[9]
model/mesh	msh, mesh, silo	[10]

It is expected that model/mesh will also make use of a number of
parameters which will help the end user determine the data type
without examine the data. However, note that mesh files are self-
describing.

   regular+static, unstructed+static, unstructured+dynamic,
   conformal+static, conformal+dynamic, isoparametric+static,
   isoparametric+dynamic

The sub-types listed above are some of the anticipated types that are
already in use. Notice that the IGES type is already registered as
"application/iges" and that RFC states that a more appropriate type
is desired. Note that the author of "application/iges" is one of the
authors of this "model" submission and application/iges will be re-
registered as model/iges at the appropriate time.

The VRML type is gaining wide acceptance and has numerous parallel
development efforts for different platforms. These efforts are
fueled by the release of the QvLib library for reading VRML files;
without which the VRML effort would be less further along. This has
allowed for a consistent data type and has by defacto established a
set of standards. Further VRML efforts include interfaces to other
kinds of hardware (beyond just visual displays) and it is proposed by
those involved in the VRML effort to encompass more of the five
senses. Unlike other kinds of "reality modeling" schemes, VRML is
not proprietary to any one vendor and should experience similar
growth as do other open standards.

The mesh type is an offshoot of existing computational meshing
efforts and, like VRML, builds on a freely available library set.
Also like VRML, there are other proprietary meshing systems but there
are converters which will convert from those closed systems to the
mesh type. Meshes in general have an association feature so that the
connectivity between nodes is maintained. It should be noted that
most modern meshes are derived from CAD solids files.

8. Appendices

8.1 Appendix A -- extraneous details about expected subtypes

 VRML Data Types

   The 3D modeling and CAD communities use a number of file formats to
   represent 3D models, these formats are widely used to exchange
   information, and full, or lossy, converters between the formats exist
   both independently and integrated into widely used applications. The
   VRML format is rapidly becoming a standard for the display of 3D
   information on the WWW.

 Mesh Data Types

   For many decades, finite element and finite difference time domain
   codes have generated mesh structures which attempt to use the
   physical geometry of the structures in connection with various
   physics packages to generate real world simulations of events
   including electromagnetic wave propagation, fluid dynamics, motor
   design, etc. The resulting output data is then post processed to
   examine the results in a variety of forms. This proposed mesh
   subtype will include both geometry and scalar/vector/tensor results
   data. An important point to note is that many modern meshes are
   generated from solids constructed using CAD packages.

   Motivation for mesh grew out of discussions with other communities
   about their design requirements. Many CAD or scene descriptions are
   composed of a small number of complex objects while computational
   meshes are composed of large numbers of simple objects. A 1,000,000
   element 3D mesh is small. A 100,000,000 element 3D structured mesh
   is large. Each object can also have an arbitrary amount of
   associated data and the mesh connectivity information is important in
   optimizing usage of the mesh. Also, the mesh itself is usually
   uninteresting but postprocessing packages may act on the underlying
   data or a computational engine may process the data as input.

   Meshes differ principally from other kinds of scenes in that meshes
   are composed of a large number of simple objects which may contain
   arbitrary non-spatial parameters, not all of whom need be visible,
   and who have an implicit connectivity and neighbor list. This latter
   point is the key feature of a mesh. It should be noted that most
   meshes are generated from CAD files however. The mesh type has
   association functions because the underlying physics was used to
   calculate the interaction (if you crash a car into a telephone pole,
   you get a crumpled car and a bent pole). Most interesting
   computational meshes are 4D with additional multidimensional results
   components.

IGES CAD Data Types

(The following text, reproduced for reference purposes only, is from
"U.S. Product Data Association and IGES/PDES Organization Reference
Manual," June 1995; by permission.)

IGES, the Initial Graphics Exchange Specification, defines a neutral
data format that allows for the digital exchange of information among
computer-aided design (CAD) systems.

CAD systems are in use today in increasing numbers for applications
in all phases of the design, analysis, and manufacture and testing of
products. Since the designer may use one supplier's system while the
contractor and subcontractor may use other systems, there is a need
to be able to exchange data digitally among all CAD systems.

The databases of CAD systems from different vendors often represent
the same CAD constructs differently. A circular arc on one system may
be defined by a center point, its starting point and end point, while
on another it is defined by its center, its diameter starting and
ending angle. IGES enables the exchange of such data by providing, in
the public domain, a neutral definition and format for the exchange
of such data.

Using IGES, the user can exchange product data models in the form of
wireframe, surface, or solid representations as well as surface
representations. Translators convert a vendor's proprietary internal
database format into the neutral IGES format and from the IGES format
into another vendor's internal database. The translators, called pre-
and post-processors, are usually available from vendors as part of
their product lines.

Applications supported by IGES include traditional engineering
drawings as well as models for analysis and/or various manufacturing
functions. In addition to the general specification, IGES also
includes application protocols in which the standard is interpreted
to meet discipline specific requirements.

IGES technology assumes that a person is available on the receiving
end to interpret the meaning of the product model data. For instance,
a person is needed to determine how many holes are in the part
because the hole itself is not defined. It is represented in IGES by
its component geometry and therefore, is indistinguishable from the
circular edges of a rod.

The IGES format has been registered with the Internet Assigned
Numbers Authority (IANA) as a Multipurpose Internet Mail Extension
(MIME) type "application/iges". The use of the message type/subtype

in Internet messages facilitates the uniform recognition of an IGES file for routing to a viewer or translator.

Version 1.0 of the specification was adopted as an American National Standards (ANS Y14.26M-1981) in November of 1981. Versions 3.0 and 4.0 of the specification have subsequently been approved by ANSI. The current version of IGES 5.2 was approved by ANSI under the new guidelines of the U.S. Product Data Association. Under these guidelines, the IGES/PDES Organization (IPO) became the accredited standards body for product data exchange standards. This latest standard is USPRO/IPO-100-1993.

8.2 Appendix B -- References and Citations

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8.3 Appendix C -- hardware

   Numerous kinds of hardware already exist which can process some of
   the expected model data types and are listed here for illustration
   purposes only:

      stereo glasses, 3D lithography machines, automated manufacturing
      systems, data gloves (with feedback), milling machines,
      aromascopes, treadmills.

8.4 Appendix D -- Examples

   This section contains a collection of various pointers to examples of
   what the model type encompasses:

   Example mesh model objects can be found on this mesh page:
      http://www-dsed.llnl.gov/documents/tests/mesh.html

   Various IGES compliant test objects:
      http://www.eeel.nist.gov/iges/specfigures/index.html

   VRML Test Suite:
      http://www.chaco.com/vrml/test/

   An image of a model of a shipping cage crashing into the ground:
      http://www.llnl.gov/liv_comp/meiko/apps/dyna3d/cagefig2.gif

   An image of a 100,000,000 zone mesh:
      http://www.llnl.gov/liv_comp/meiko/apps/hardin/PMESH.gif

   A video of a seismic wave propagation through a computational mesh:
      http://www.llnl.gov/liv_comp/meiko/apps/larsen/movie.mpg

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   this document is based. That document updated an IETF Internet Draft
   in which the initial chemical submission was made, incorporated
   suggestions received during the subsequent discussion period, and
   indicated scientific support for and uptake of a higher level
   document incorporating physical sciences[2-7]. This Model submission
   benefited greatly from the previous groundwork laid, and the
   continued interest by, those communities.

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