GEOMETRIC MODELING AND ITS RELATIONSHIP TO F.E. MODELING

Background:

Goal of FEA is to solve some set of partial differential equations over a given domain

Geometric model is computerized representation of domain

State-of-the-art:

Several technologies to support the complete and unique computerized definition available

Range of geometry types available is constantly improving - NURBS are becoming standard

Geometric modeling systems providing better support for applications

Geometric modeling systems integral part of the engineering design process

Geometric models used form conceptual design through manufacturing

TERMINOLOGY

Geometric Modeling - Collection of procedures and representations for construction and description of the shape and spatial relations of objects

Wireframe Modeling - Collection of curve definitions for the edges that bound an object

Surface Modeling - Collection of curve and surface definitions for the edges and faces that bound an object

Solid Modeling - Complete & unambiguous computerized representation of objects. There are six known families of unambiguous schemes

Constructive Solid Geometry (CSG) - Solid modeling approach where object is constructed by Boolean set operators

Boundary Representations (B-reps) - Solid modeling approach where the boundary, along with sufficient associatively information are stored

Topology (with respect to geometric modeling) - An abstract representation of the associations of the objects boundary entities

Manifold (2-manifold) Solid Representations - Every point on a surface has a neighborhood which is homeomorphic to a two-dimensional disk

Non-Manifold Geometric Modeling - Allows situations which are not 2-manifold. Allows wire edges, dangling surfaces, and more than two faces to an edge

APPROACHES TO THE INTEGRATION OF MESH GENERATION AND GEOMETRIC MODELING

No Interface - Generate geometry in the finite element modeling system

Static Geometric Interface - Standard file format used for the geometry

Dynamic Geometric Interface - The functionality of the geometric modeling system used by the application programs

No interface forces the re-definition of desired geometry

A static interface provides geometry, but the mesh generator must reproduce the needed geometric modeling functions. Also lose control of geometric approximation issues

DYNAMIC INTERFACE

Directly provides the geometric modeling functionality needed

Supports both geometric interrogation and geometric modification

Can support geometric approximation issues

Topological entities and associativities provide ideal means for coordinating a dynamic interface

Boundary topology provides:

- A shape independent abstraction
- A unique representation
- A natural method since most focus is on the object's boundary

INTEGRATION OF APPLICATIONS WITH GEOMETRIC MODELER

Data exchange standards provide substantial capability

Dynamic interfaces required to effectively support applications like automatic mesh generation

Need the combination of PDES/STEP and the CAM-I Applications Interface Specification

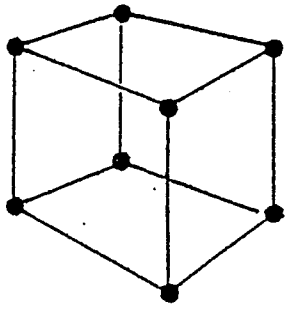
EXAMPLE DYNAMIC INTEGRATION: FINITE OCTREE

Finite Octree:

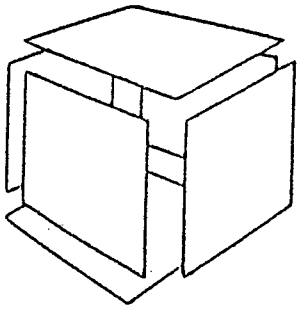
- Automatic 3-D mesh generator
- Integrates with a geometric modeler via 21 operators - no knowledge of modeler data used
- Approx. 1/2 the operators request topological adjacencies - e.g. the vertices of an edge
- Approx. 1/2 are pointwise interrogations - e.g. line/surface intersection, surface normal

Finite Octree has been linked with systems including Parasolids, Shapes and ACIS

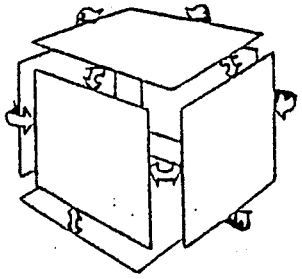
Modeling system supported a library with needed interrogations



WIREFRAME

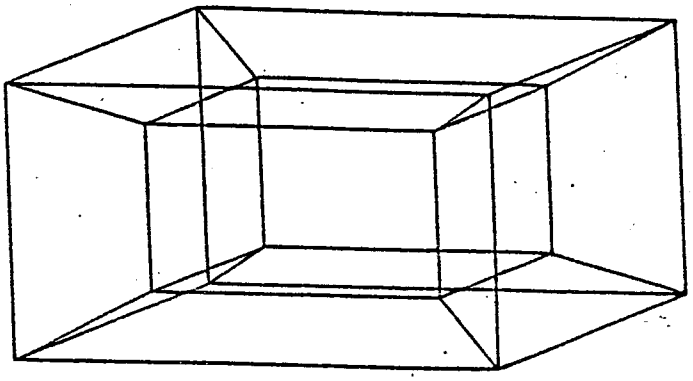


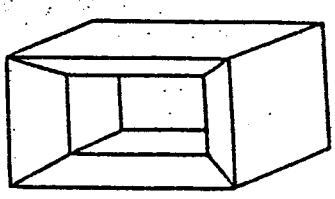
SURFACE

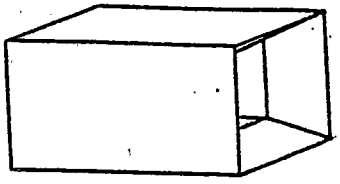


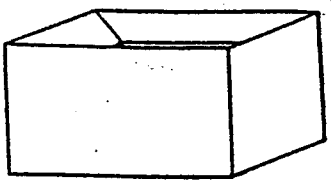
SOLID

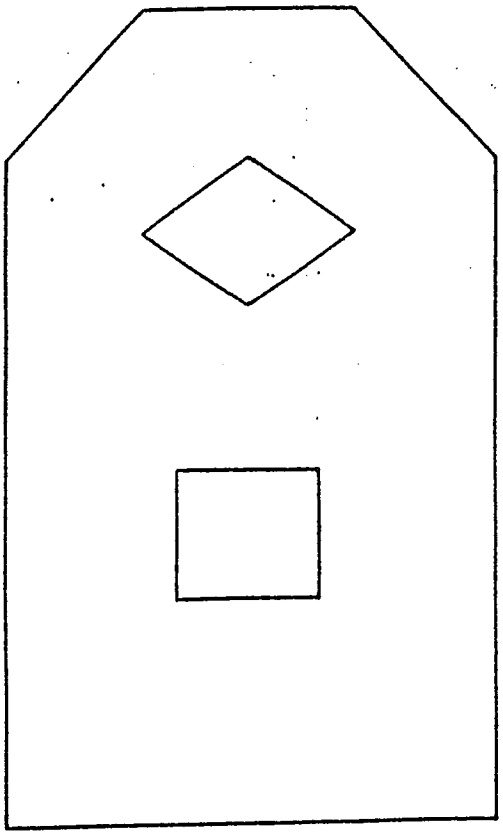
Ambiguous Geometry

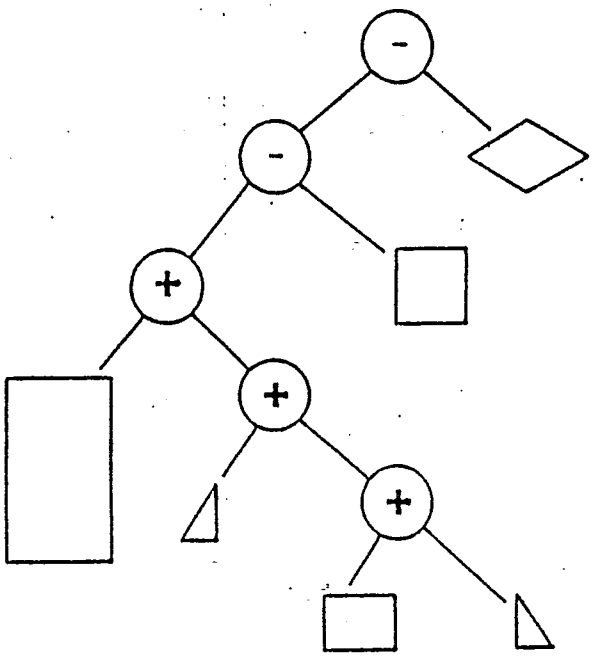




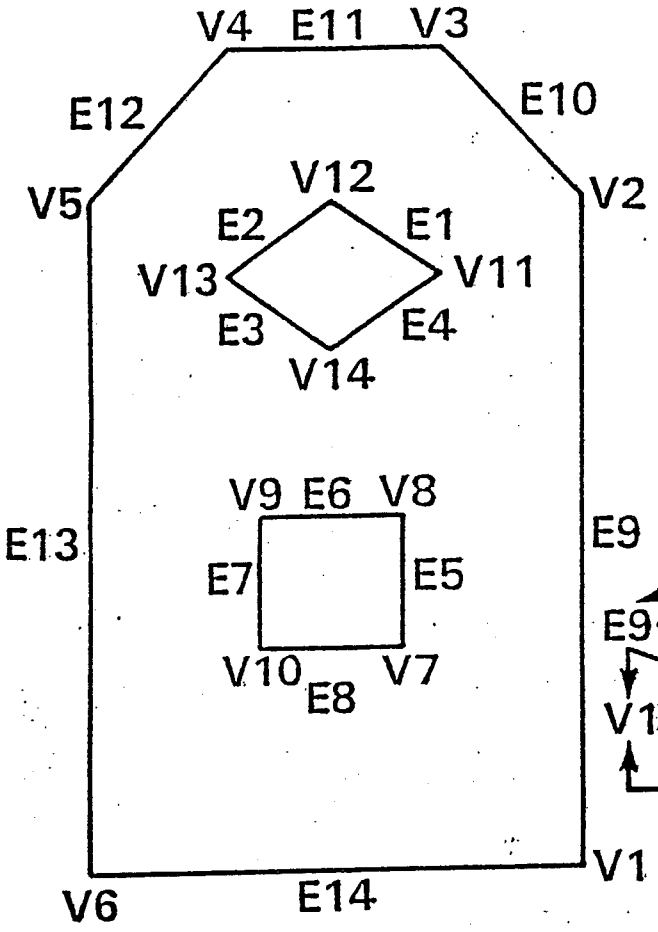


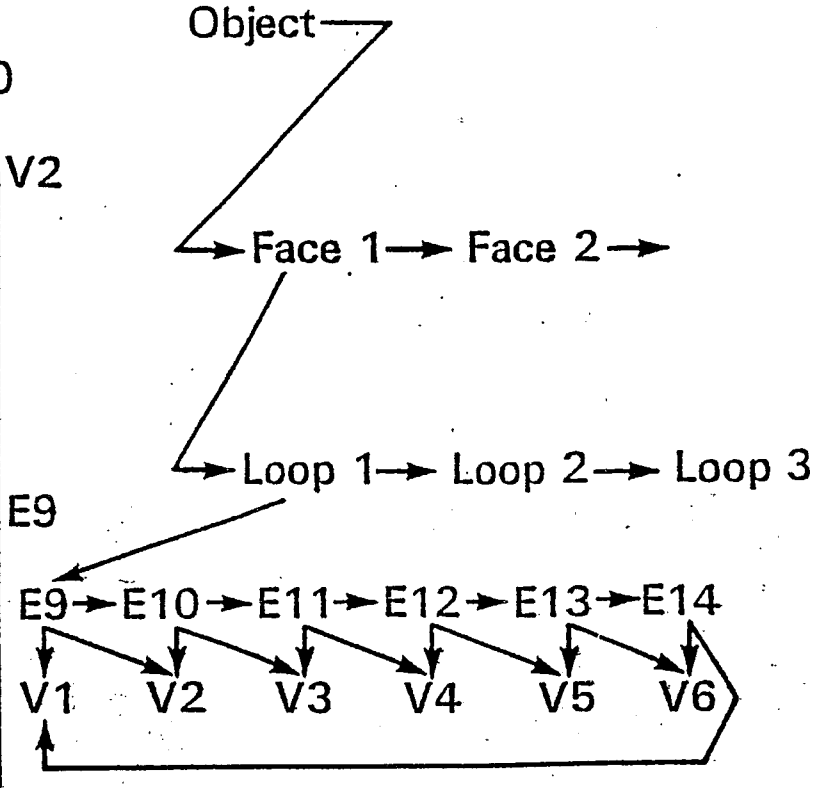




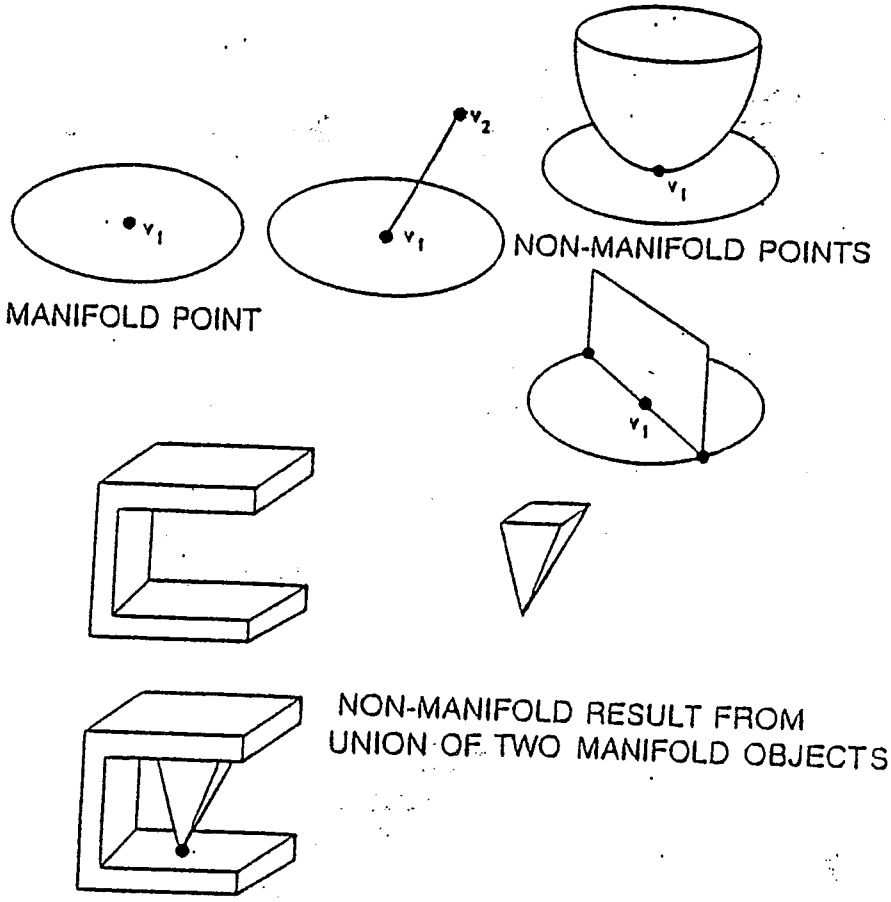


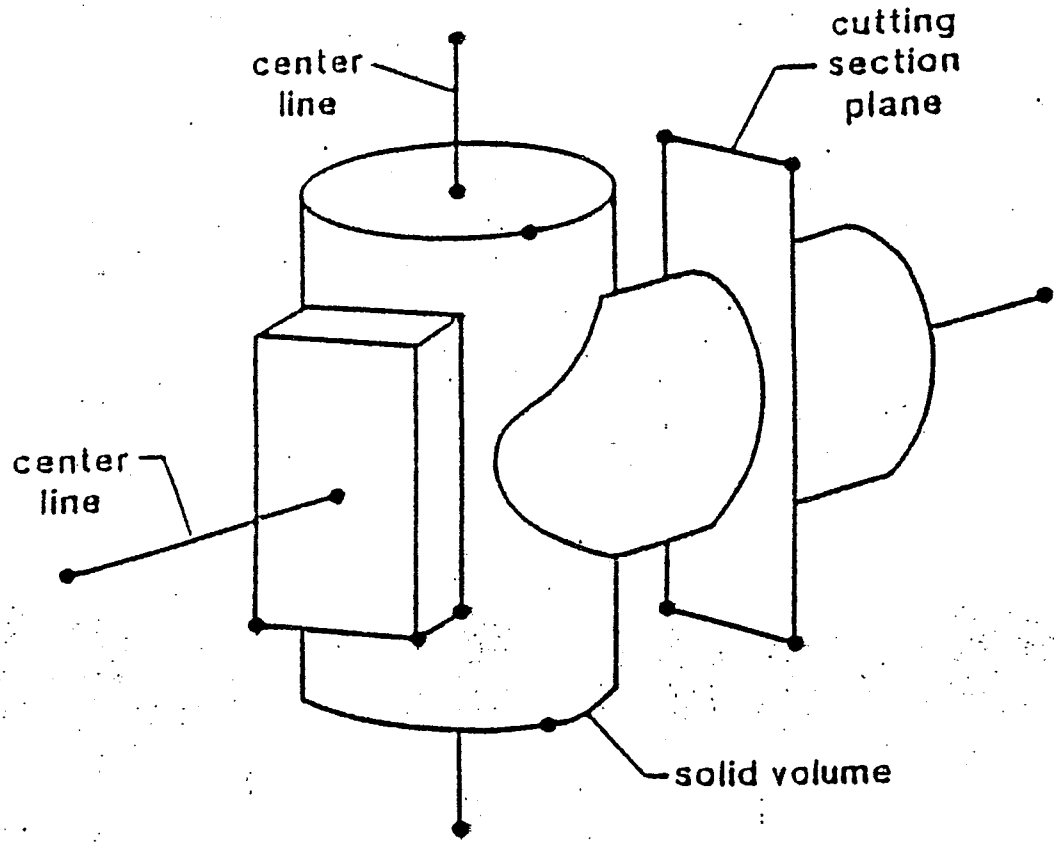
CONSTRUCTIVE SOLID GEOMETRY



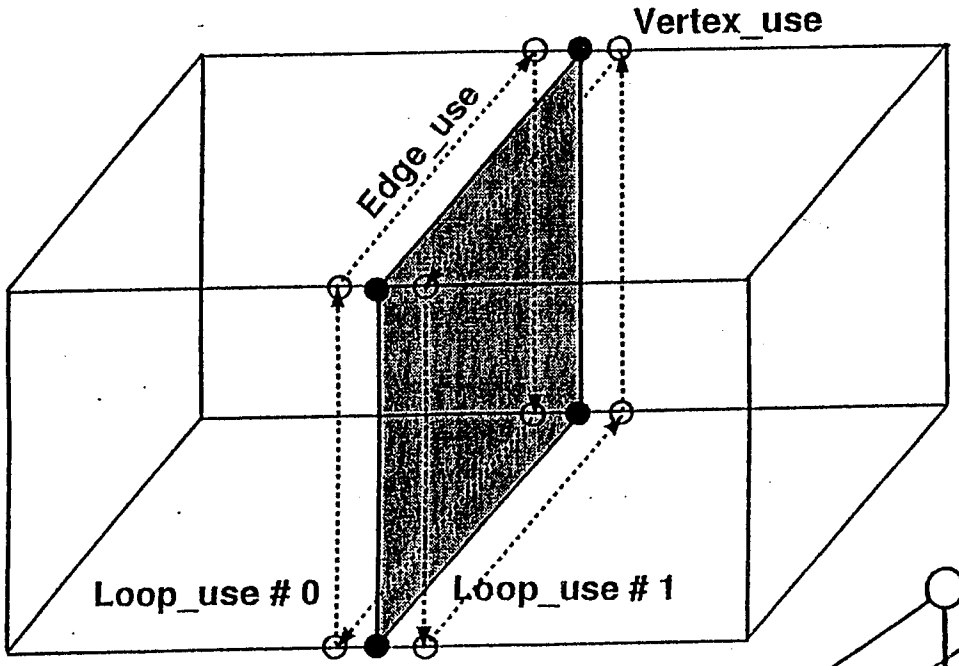


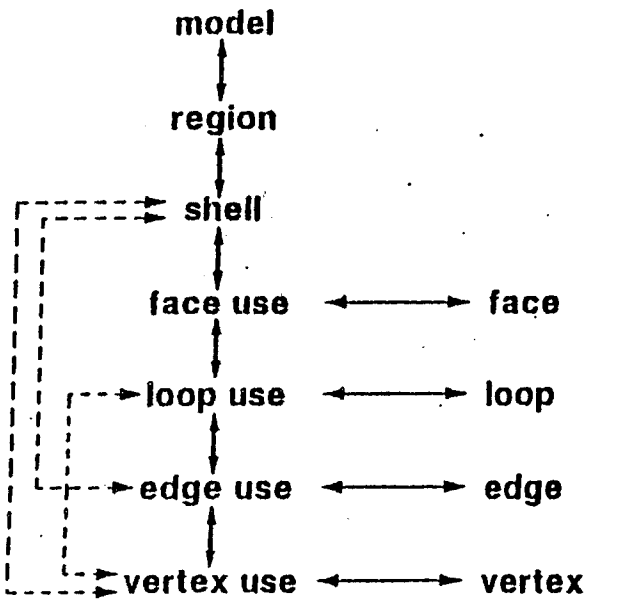
BOUNDARY REPRESENTATIONS


v_1
v_2
v_1
v_1
MANIFOLD POINT
NON-MANIFOLD POINTS
NON-MANIFOLD RESULT FROM
UNION OF TWO MANIFOLD OBJECTS

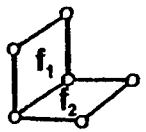

center
line
cutting
section
plane
center
line
solid volume

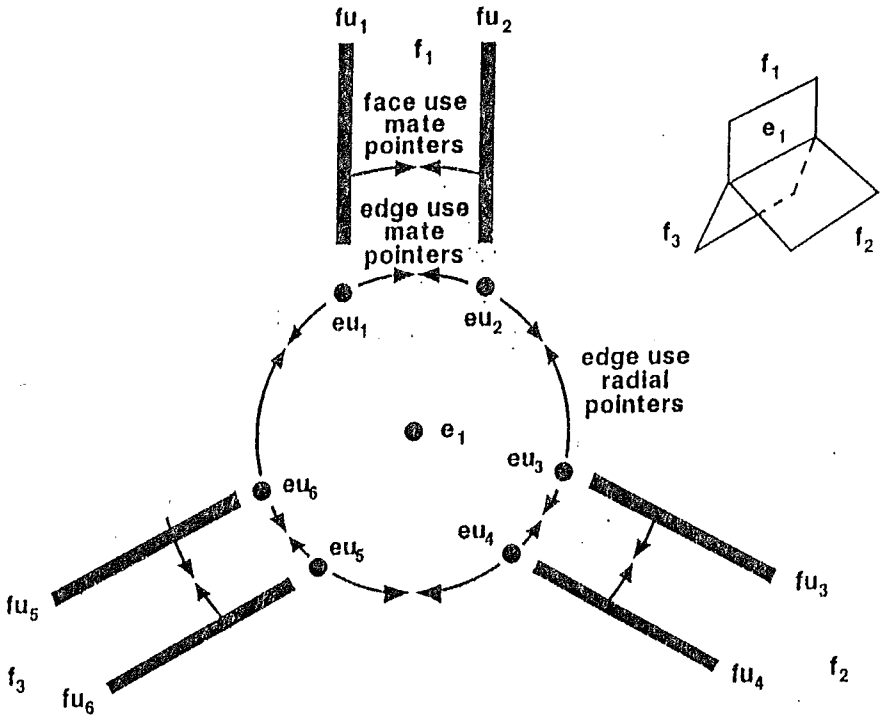
Non-manifold topological representation

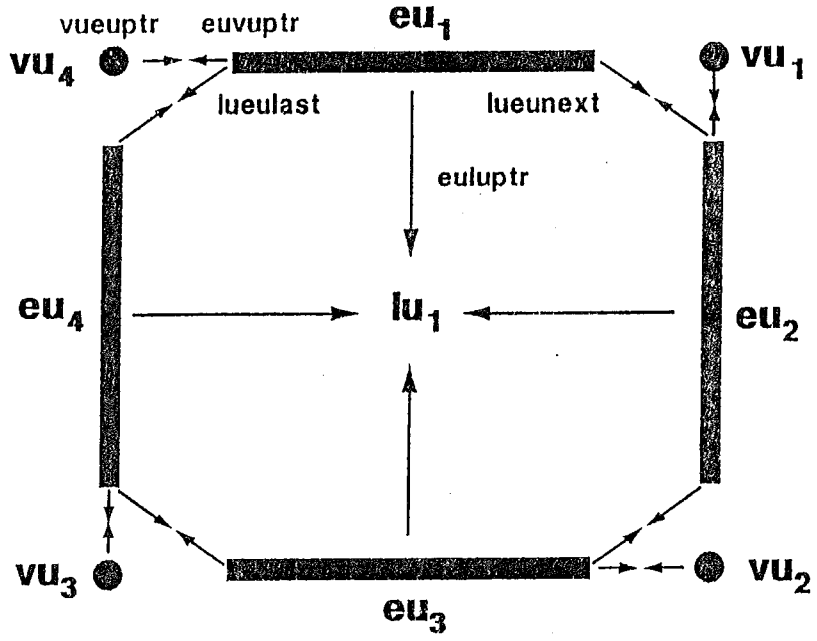




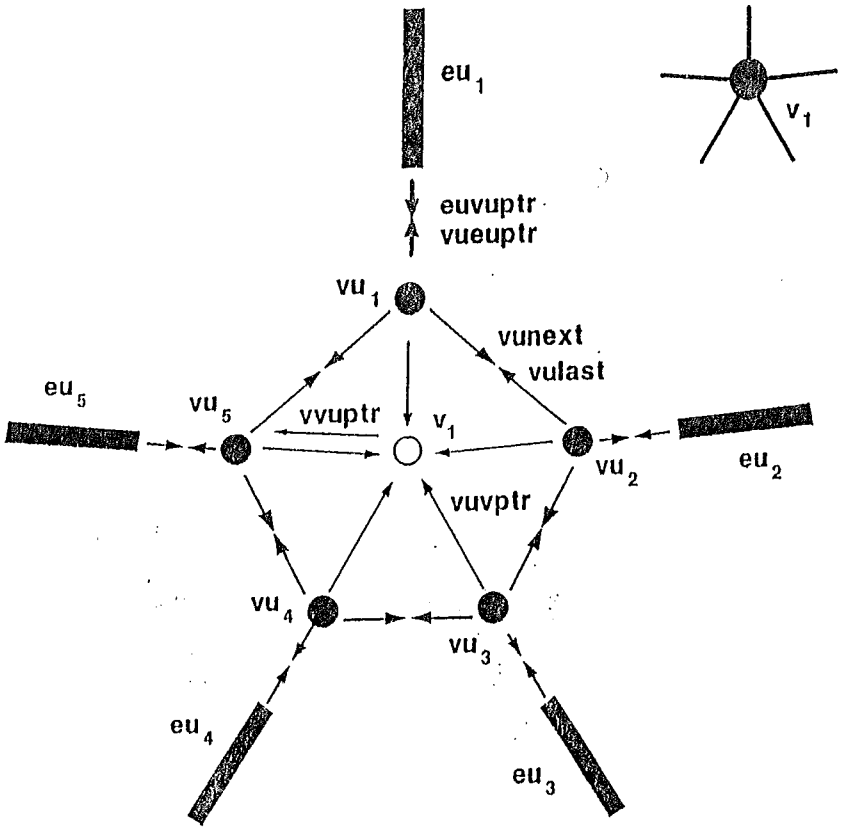
Radial Edge structure relationships







Plan view of a loop of edges in the Radial Edge structure



MESH DATA HIERARCHY	ASSOCIATED MODEL ENTITY
FINITE ELEMENT	REGION
FE-FACE	REGION or FACE
FE-EDGE	REGION, FACE or EDGE
FE-NODE	REGION, FACE EDGE or VERTEX

or
or
or

FIG. 4 HIERARCHIC MESH DATA STRUCTURE