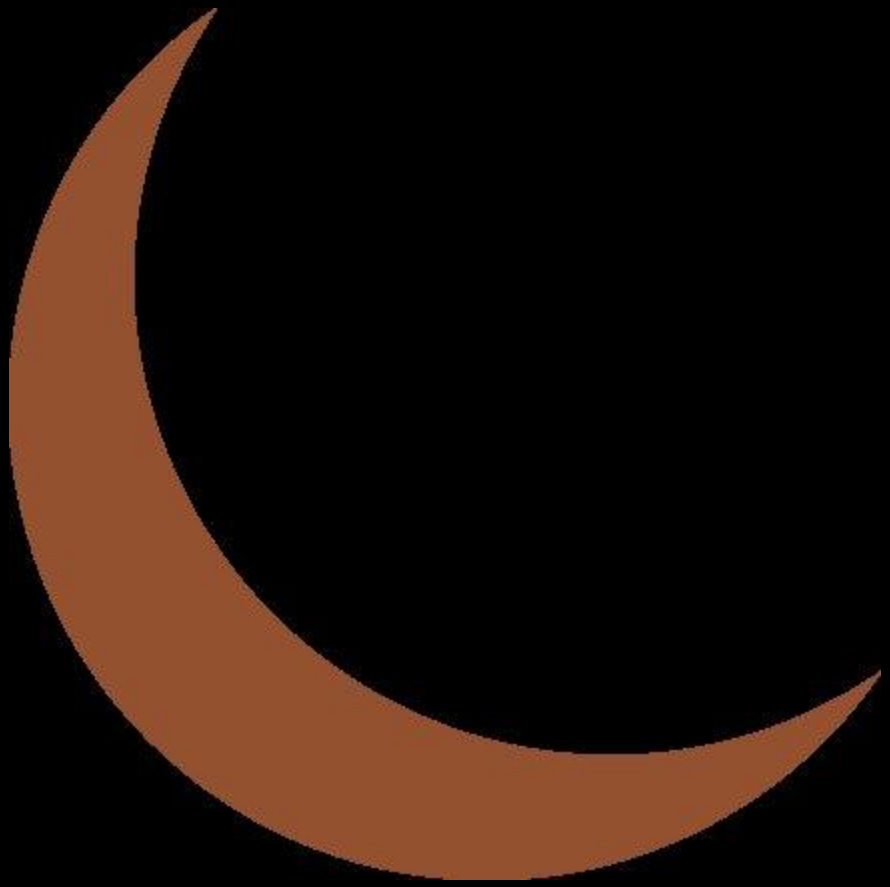


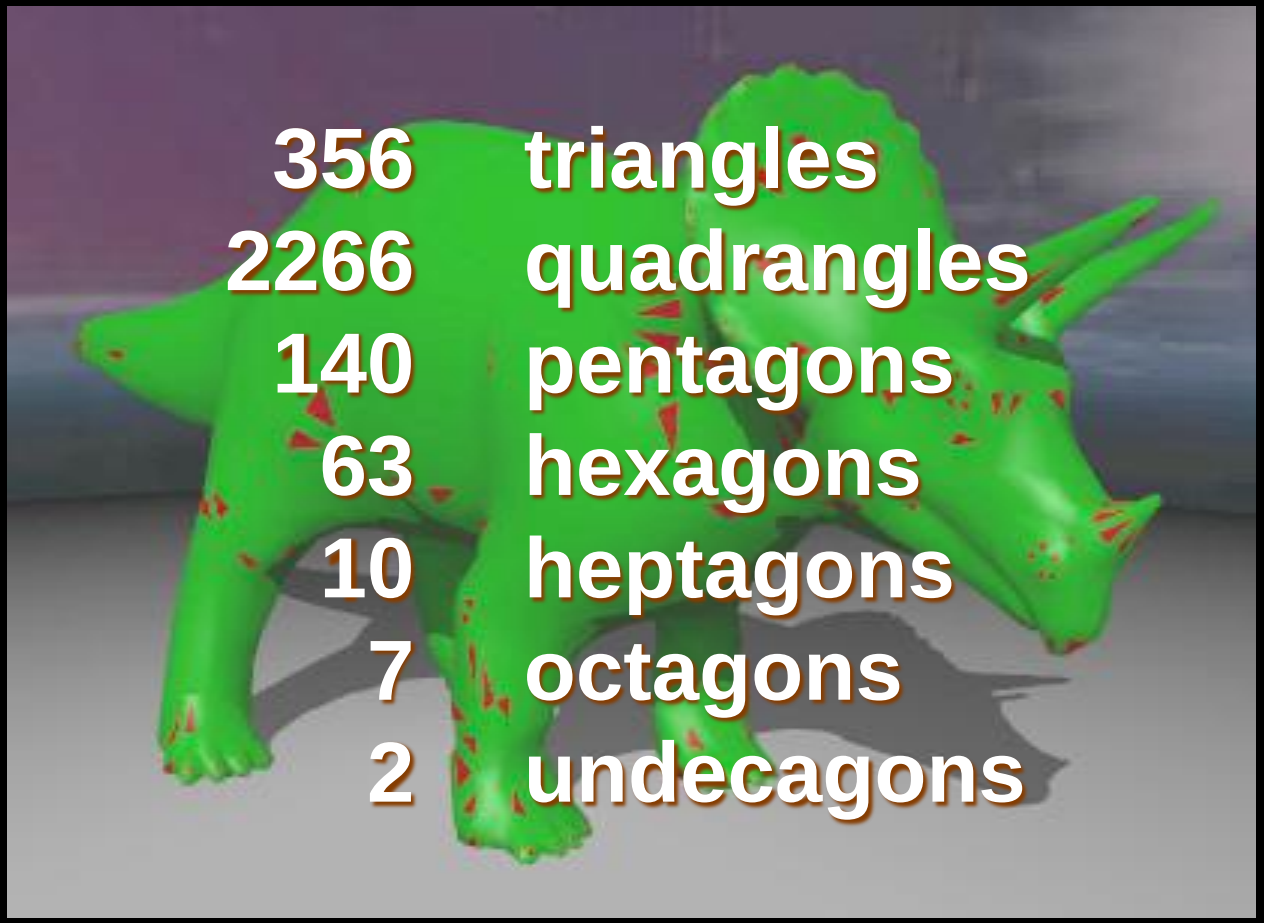
Face Fixer

Compressing Polygon Meshes with Properties

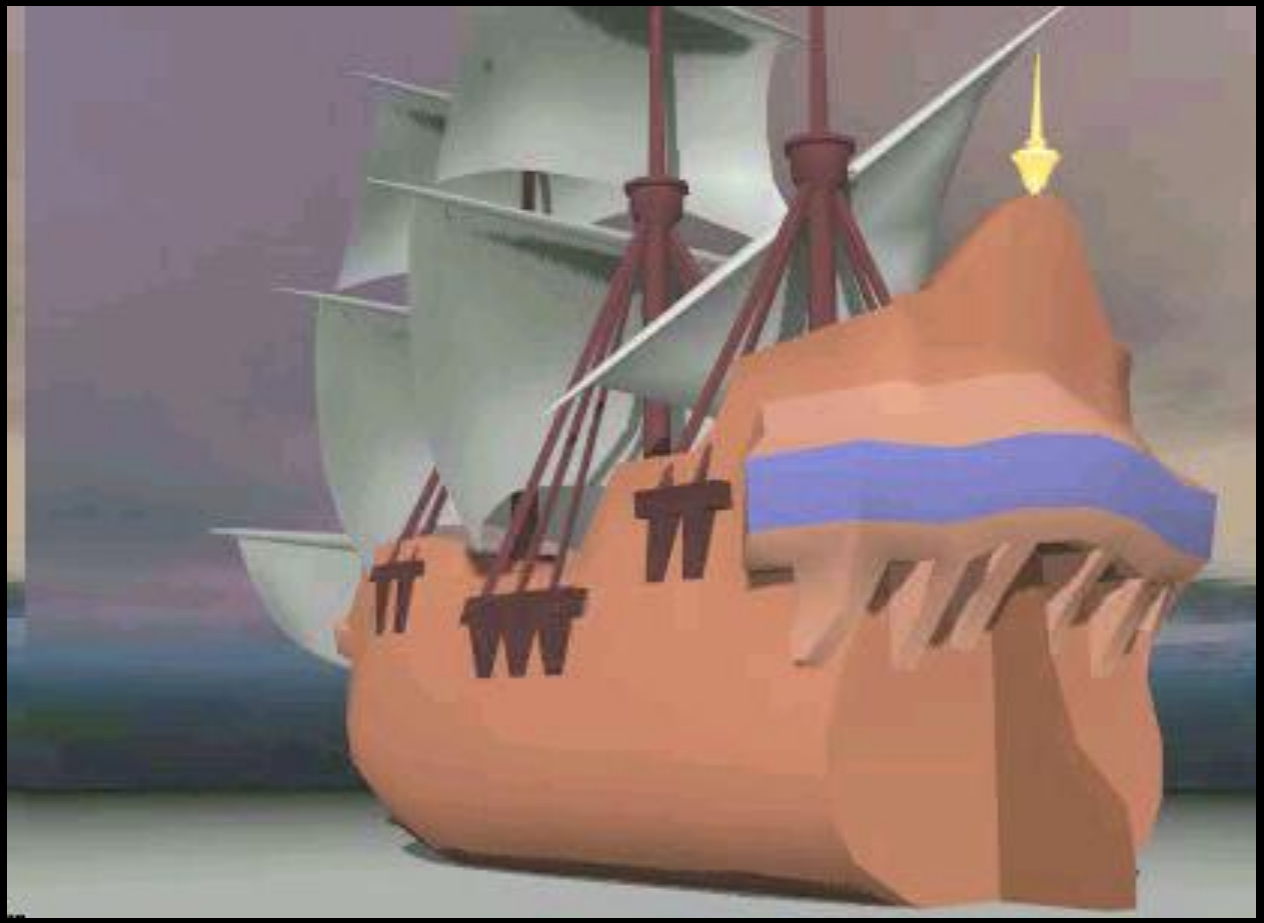
Martin Isenburg Jack Snoeyink

University of North Carolina at Chapel Hill

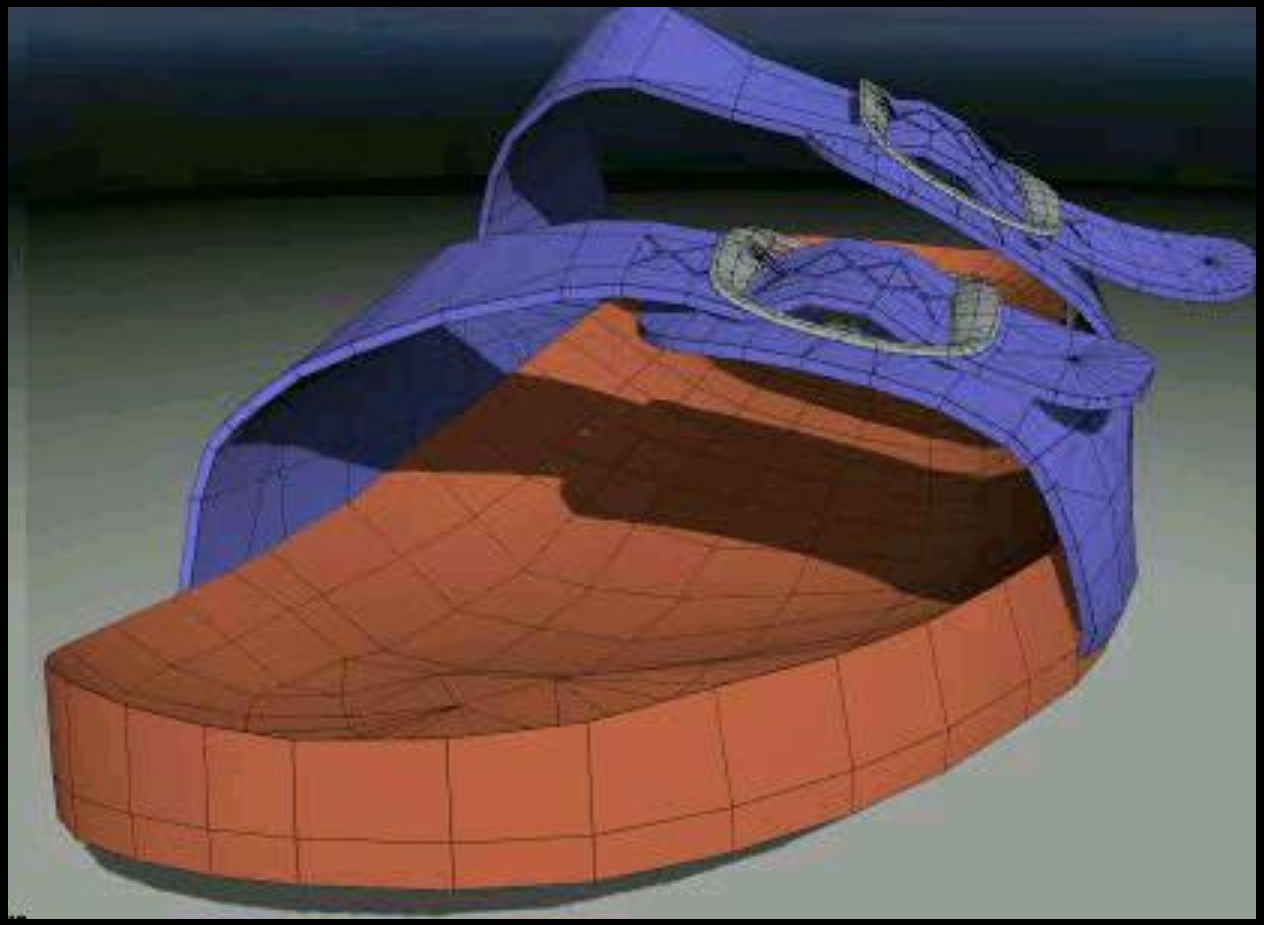
Polygon Models: Triceratops



Polygon Models: Others



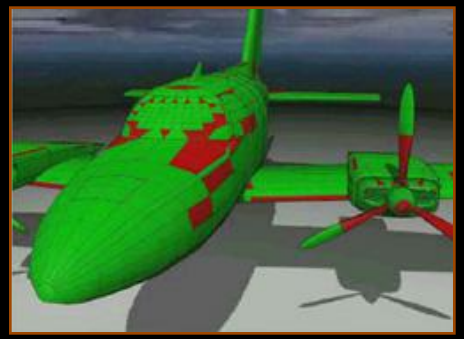
Faces and Corners: Sandal



Do not triangulate!

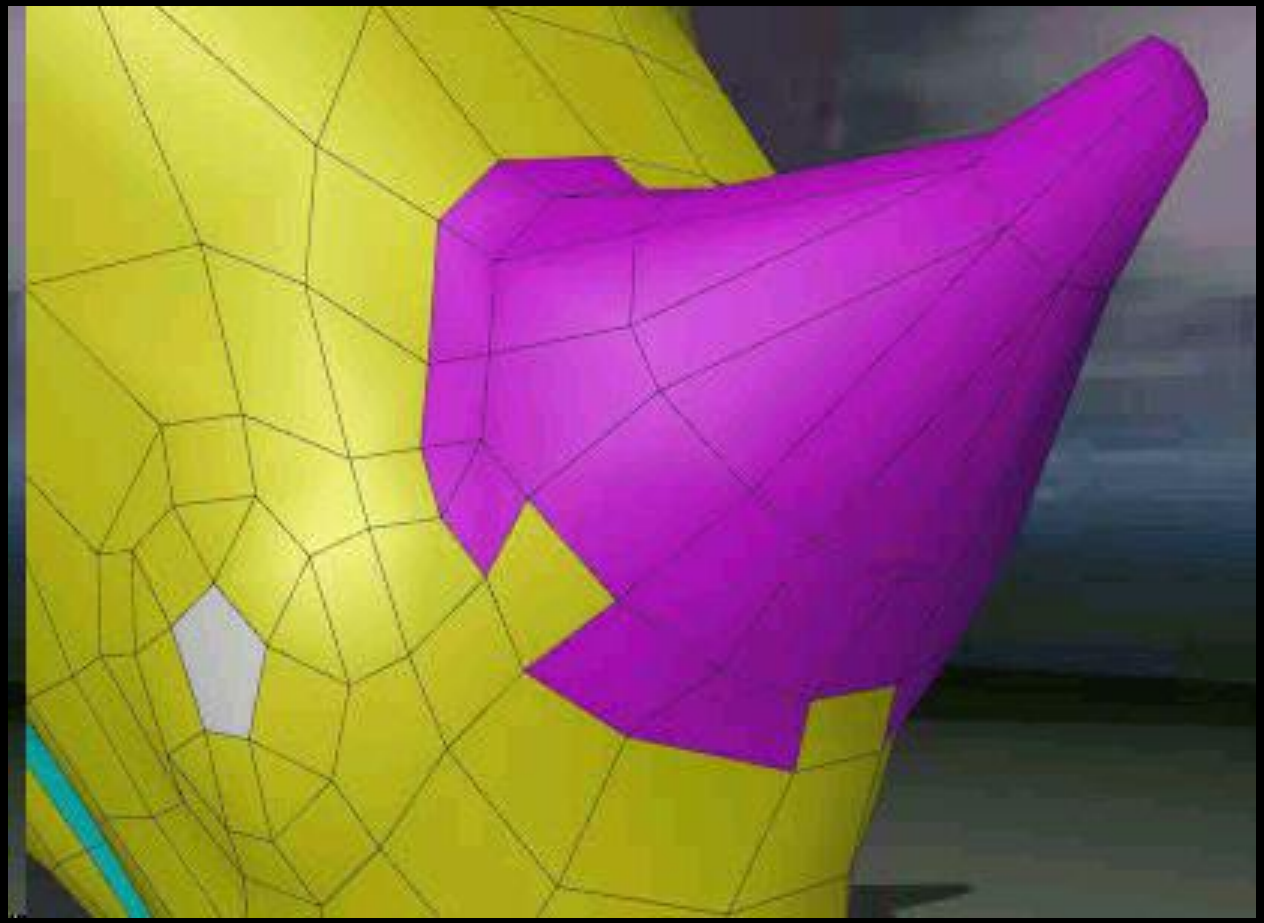
- Fewer polygons
  - ➔ less connectivity information
- Polygons tend to be planar & convex
  - ➔ better geometry prediction
- Better triangle strips





Group Structures: Teapot & Cow

Group Structures: Others



Overview

- **Do not triangulate!**
- **Connectivity Compression for Manifold Polygon Meshes**
  - Compact mesh representations
  - Simple implementation
  - Beyond Faces: Quadrilateral grids
- **Capture Structures!**

Previous Work

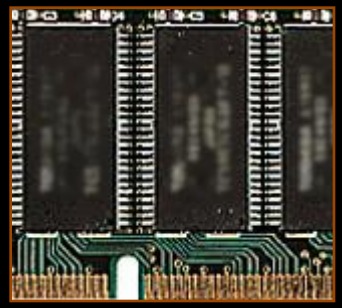
Previous Work

- Fast Rendering
- Progressive Transmission
- Maximum Compression

Previous Work

- **Fast Rendering**
- Progressive Transmission
- Maximum Compression

main memory



graphics board

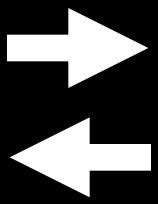
Previous Work

- **Fast Rendering**
- **Progressive Transmission**
- **Maximum Compression**
  - Triangle Strips [?]
  - Generalized Triangle Mesh [Deering]
  - Transparent Vertex Caching [Hoppe, *n*VIDIA]

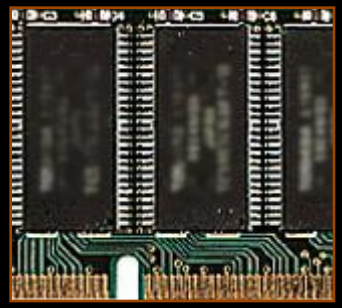
Previous Work

- Fast Rendering
- **Progressive Transmission**
- **Maximum Compression**

storage / network



main memory



Previous Work

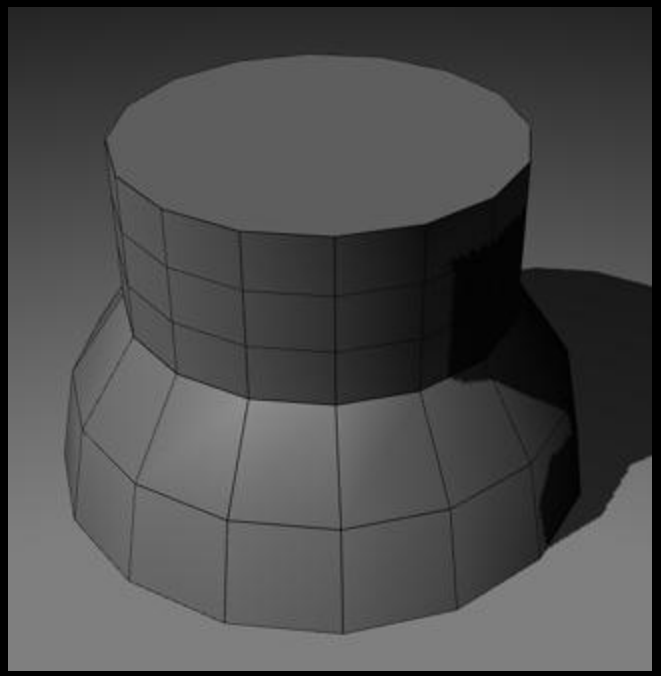
- Fast Rendering
- **Progressive Transmission**
- Maximum Compression

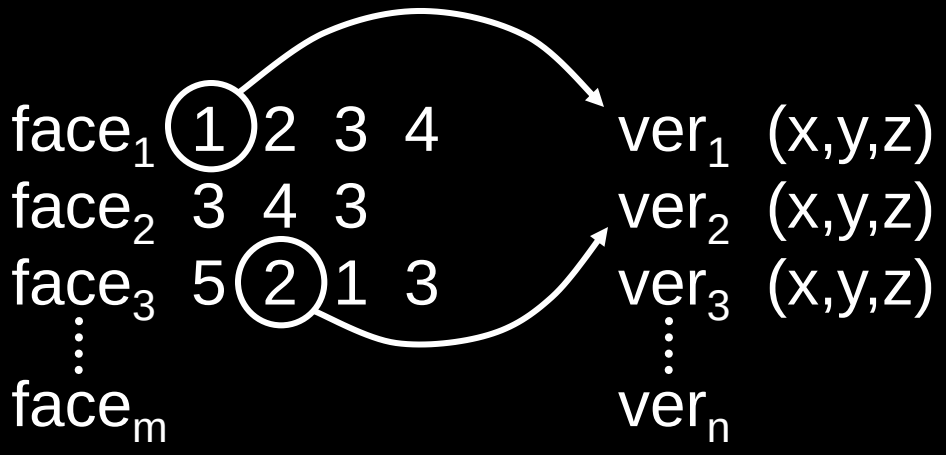
  - Progressive Meshes [Hoppe]
  - Progressive Forest Split [Taubin et]
  - Compressed Progressive Meshes [Pajarola et]
  - Progressive Geometry Compression

Previous Work

- Fast Rendering
- Progressive Transmission
- **Maximum Compression**
  - Topological Surgery [Taubin, Rossignac]
  - Triangle Mesh Compression [Costa, Gotsman]
  - Edgebreaker [Rossignac, King et]
  - Cut-border Machine [Gumhold, Strasser]

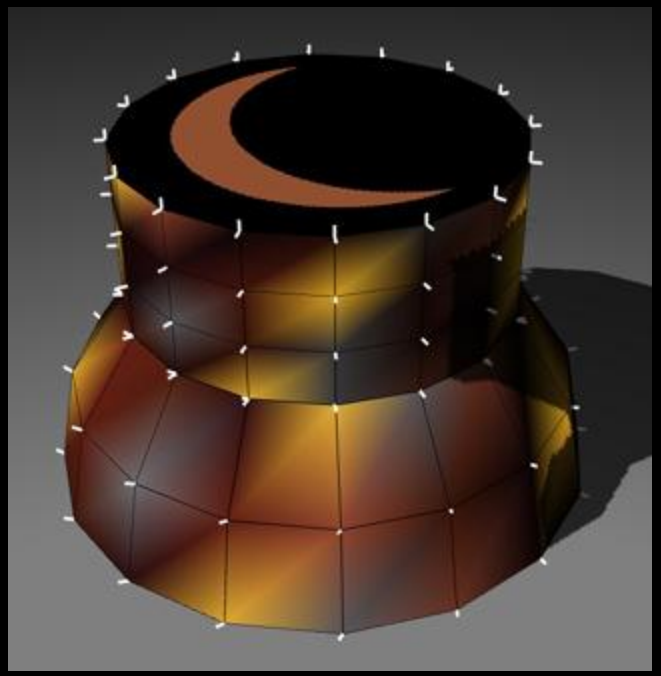
Standard Mesh Representation





	connectivity	geometry
n = 10,000	66 KB	60 KB
n = 100,000	830 KB	600 KB
n = 1,000,000	10 MB	6 MB

Standard Mesh Representation



$face_1$ 1 2 3 4
$face_2$ 3 4 3
$face_3$ 5 2 1 3
⋮
$face_m$

ver_1 (x,y,z)
ver_2 (x,y,z)
ver_3 (x,y,z)
⋮
ver_n

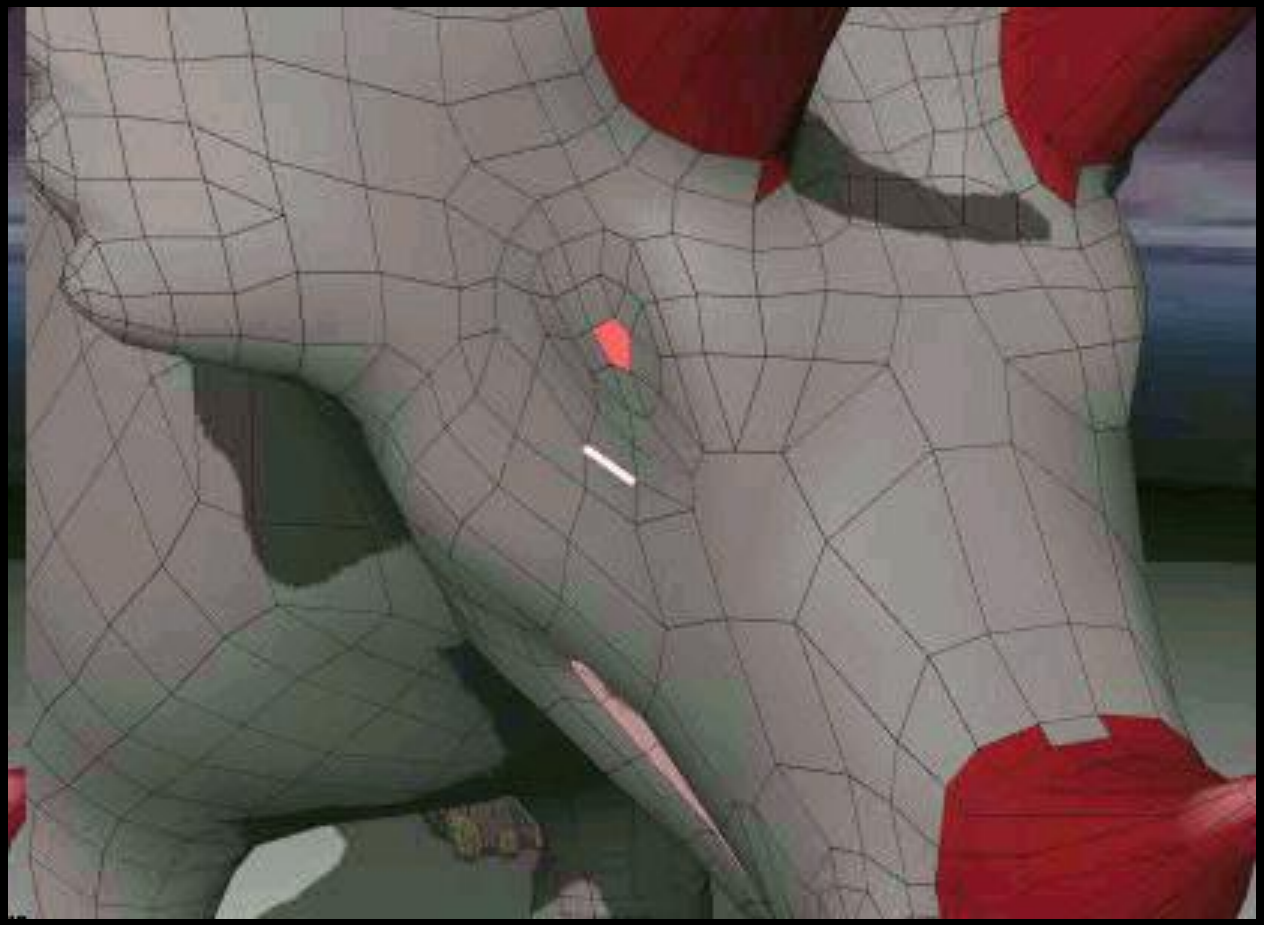
nor_1 (x,y,z)
nor_2 (x,y,z)
nor_3 (x,y,z)
⋮
nor_i

tex_1 (u,v)
tex_2 (u,v)
tex_3 (u,v)
⋮
tex_k

col_1 (r,g,b)
col_2 (r,g,b)
col_3 (r,g,b)
⋮
col_j

Face Fixer

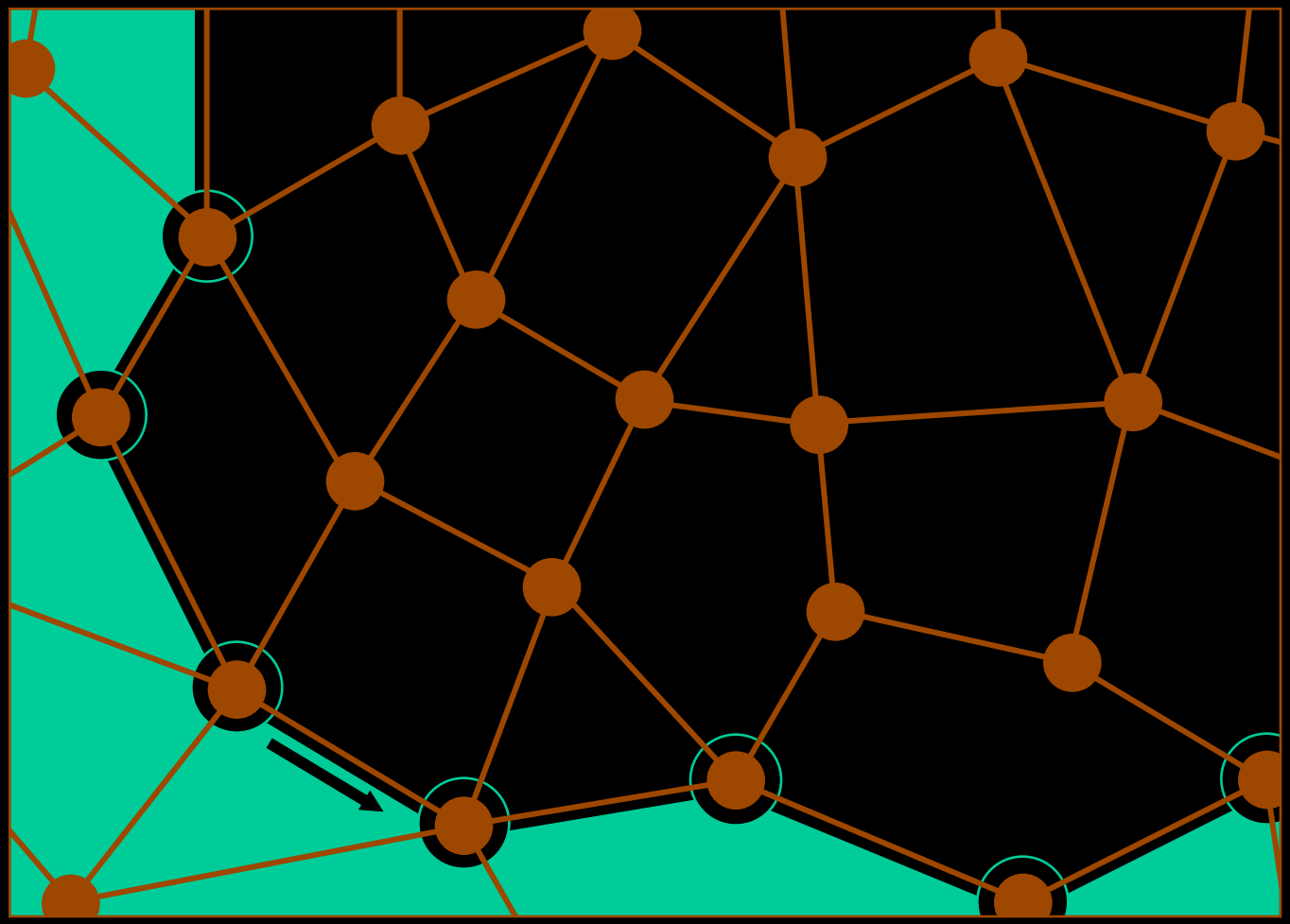
Face Fixer



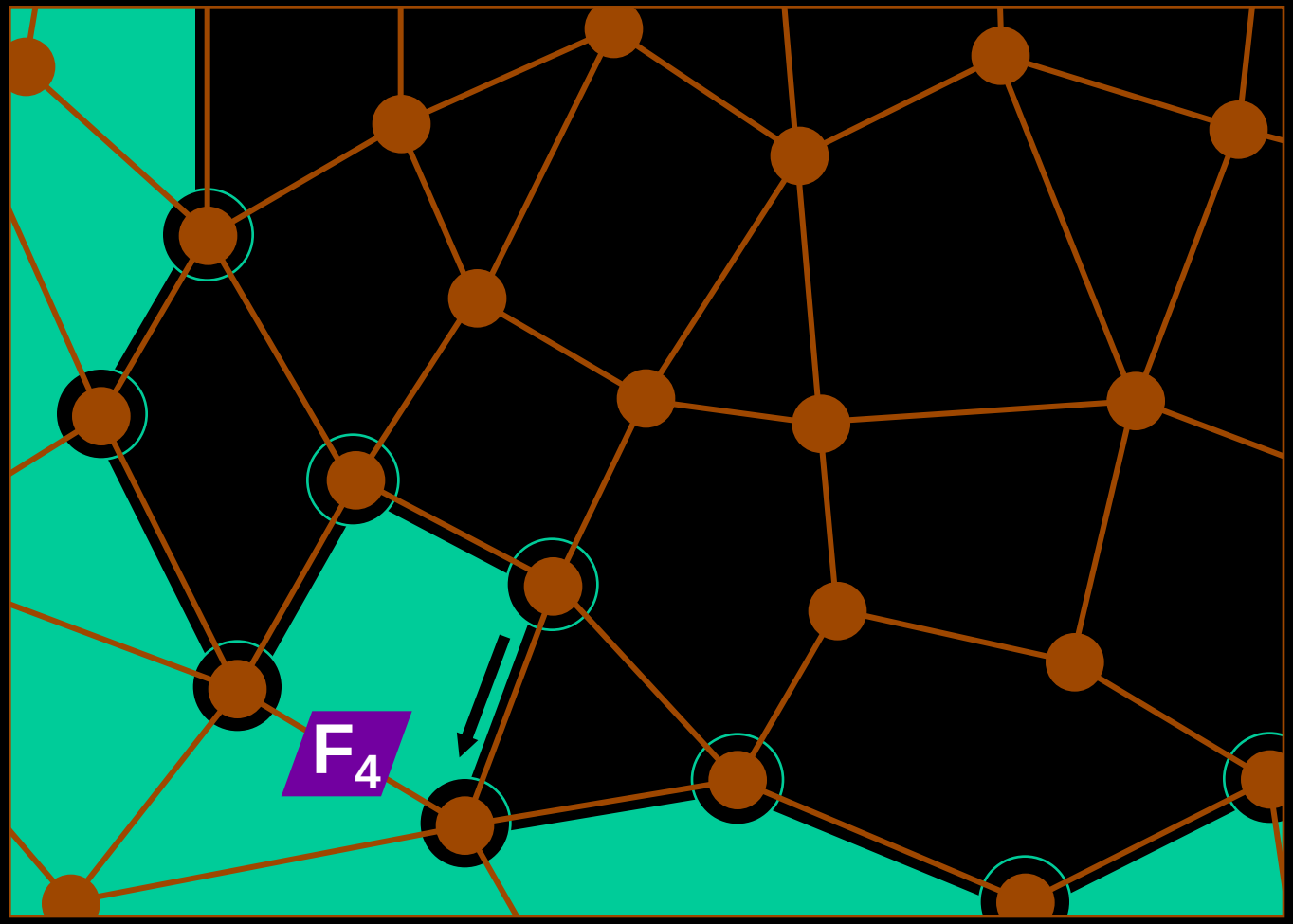
Face Fixer

- **encoding is a sequence of labels:**
  - one label  . . . . per face
  - one label  per hole
  - one label  per handle
  - labels  fix it all together
- **number of labels = number of edges**
- **reverse decoding**

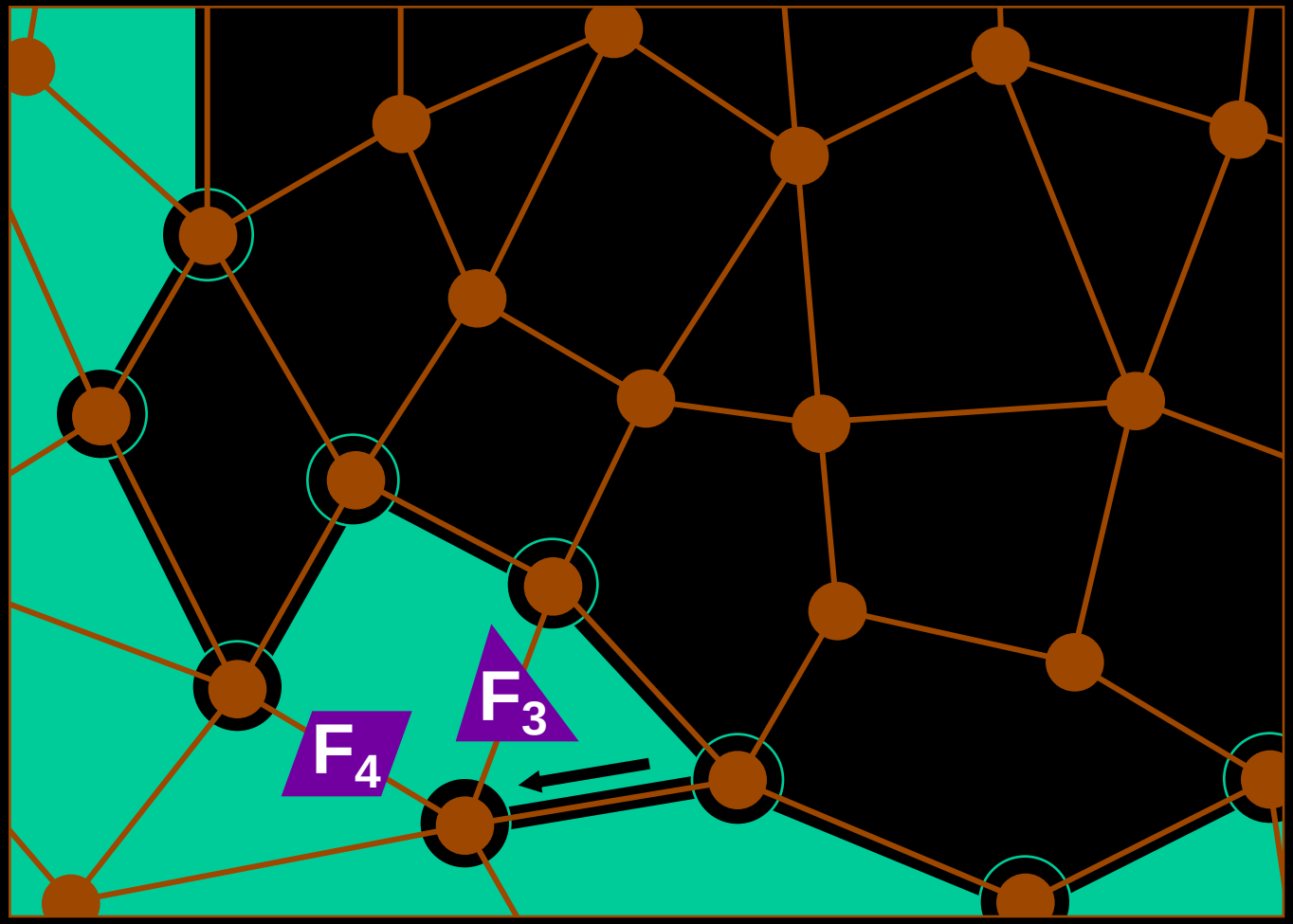
Encoding



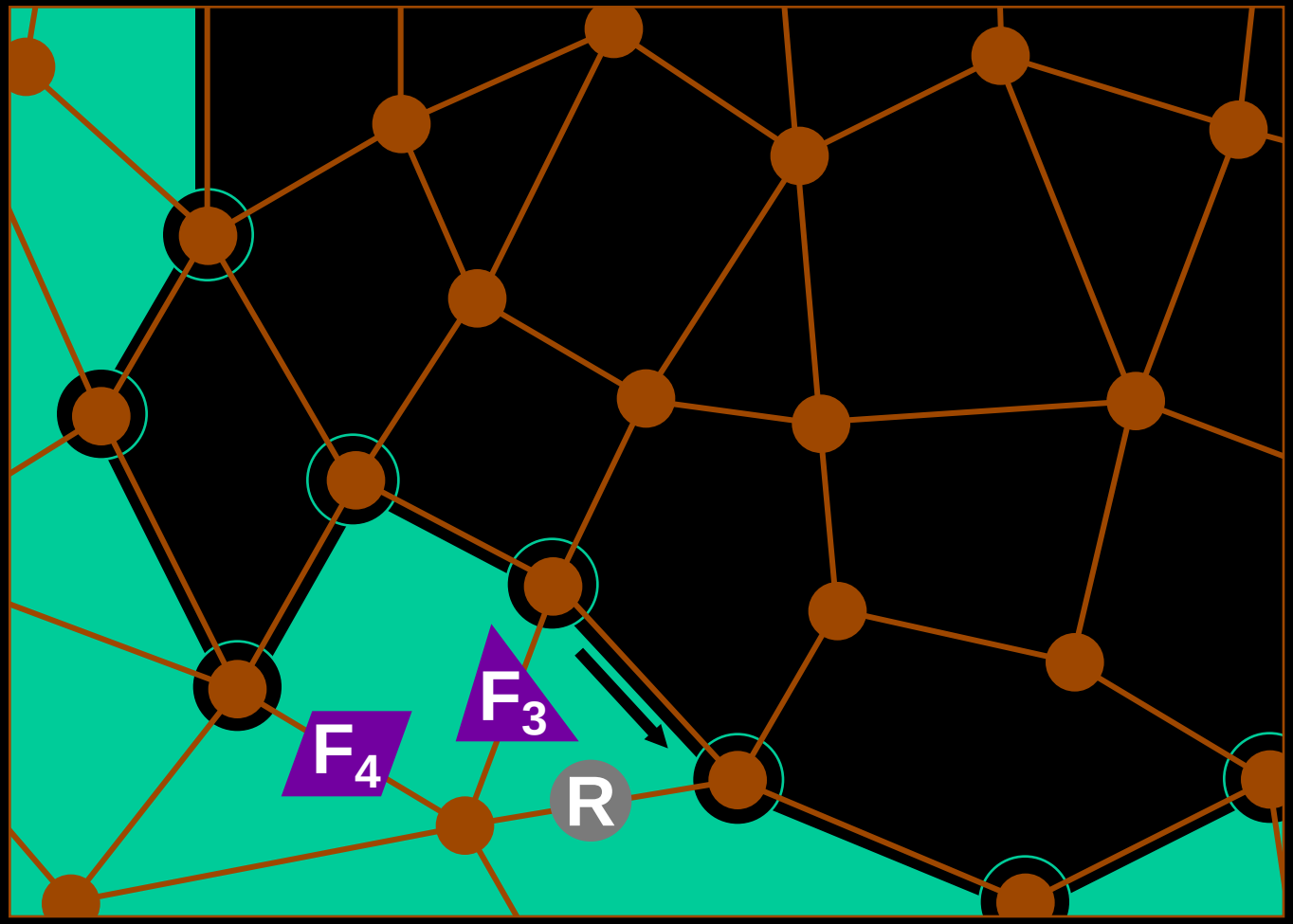
Encoding



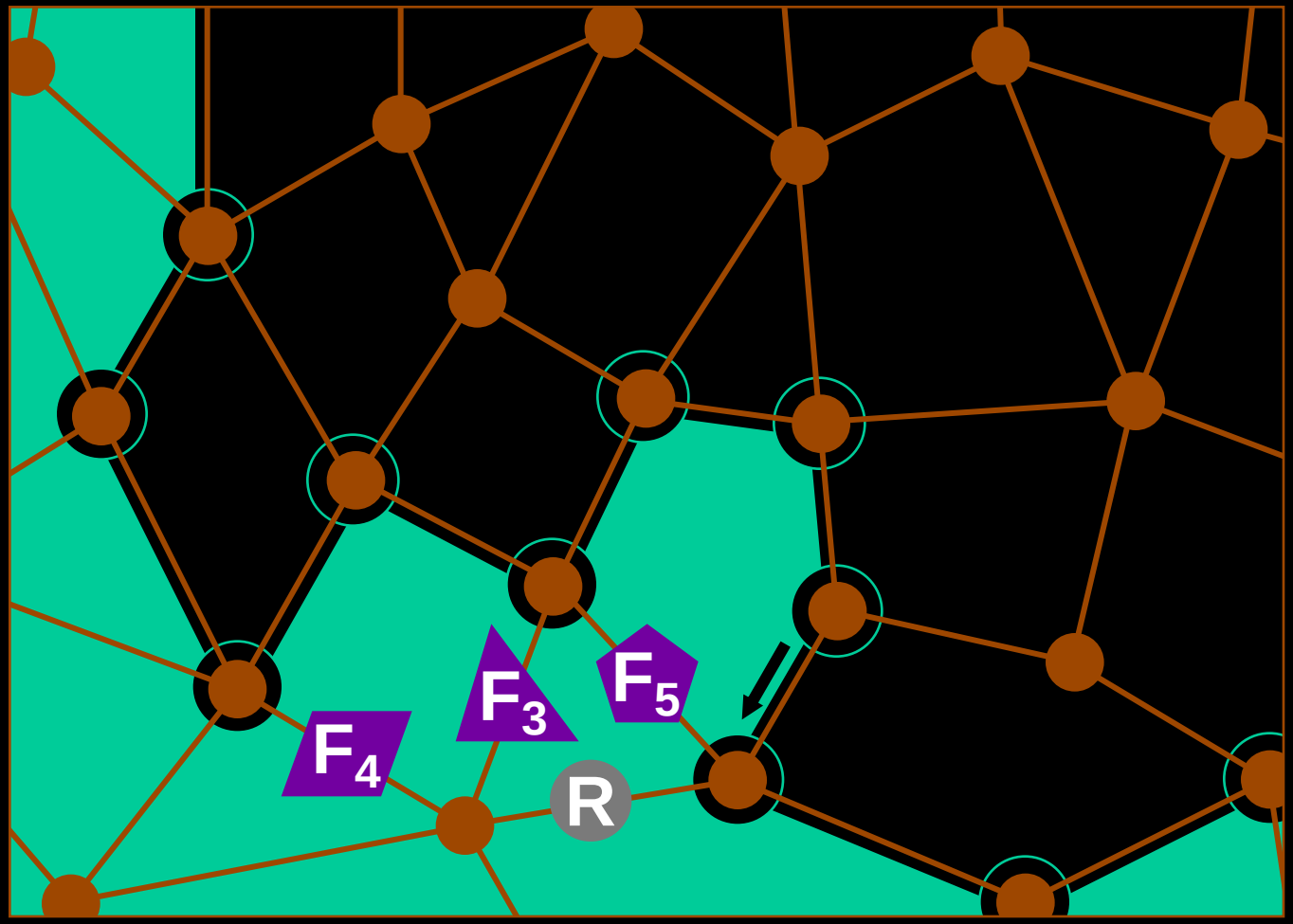
Encoding



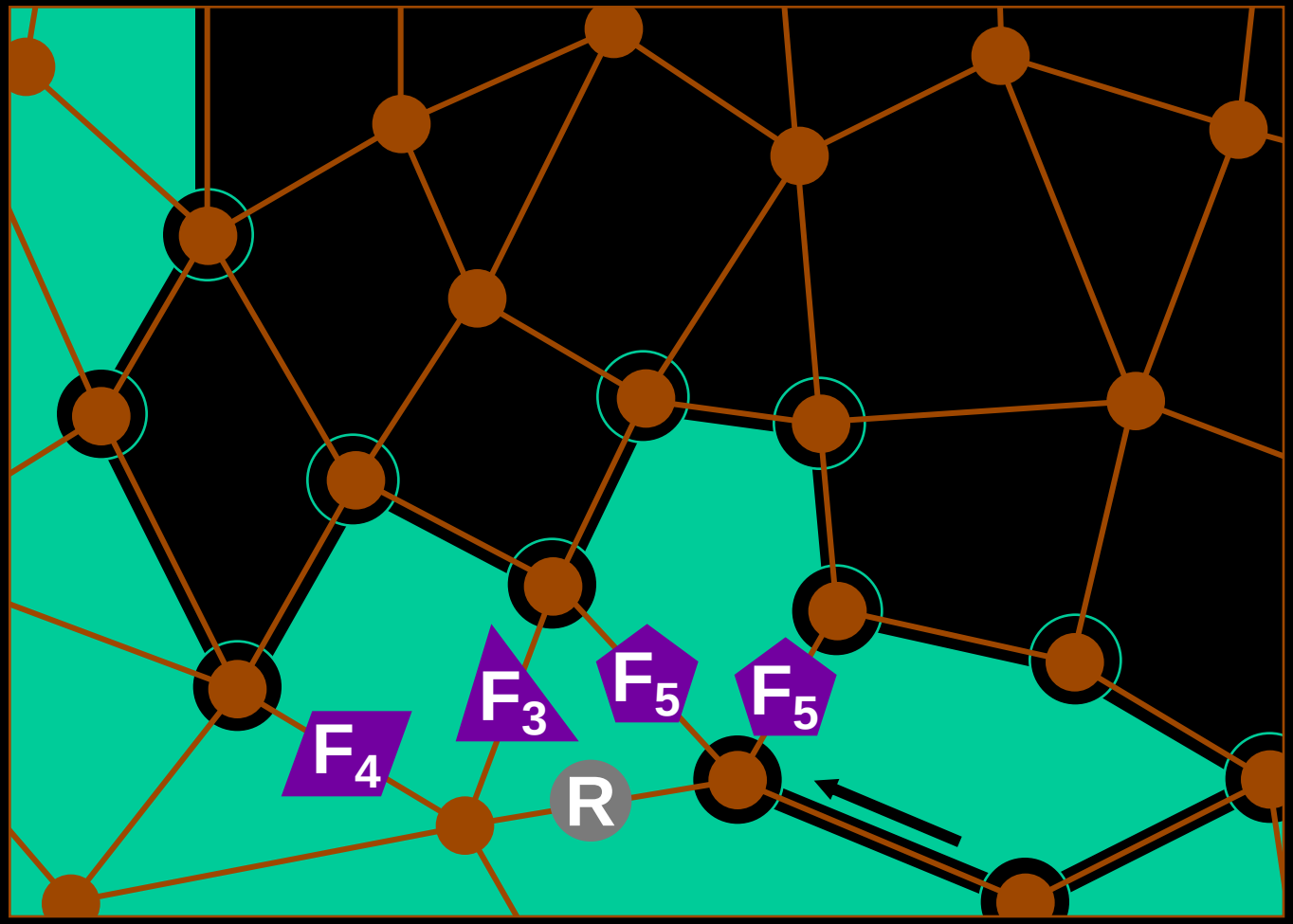
Encoding



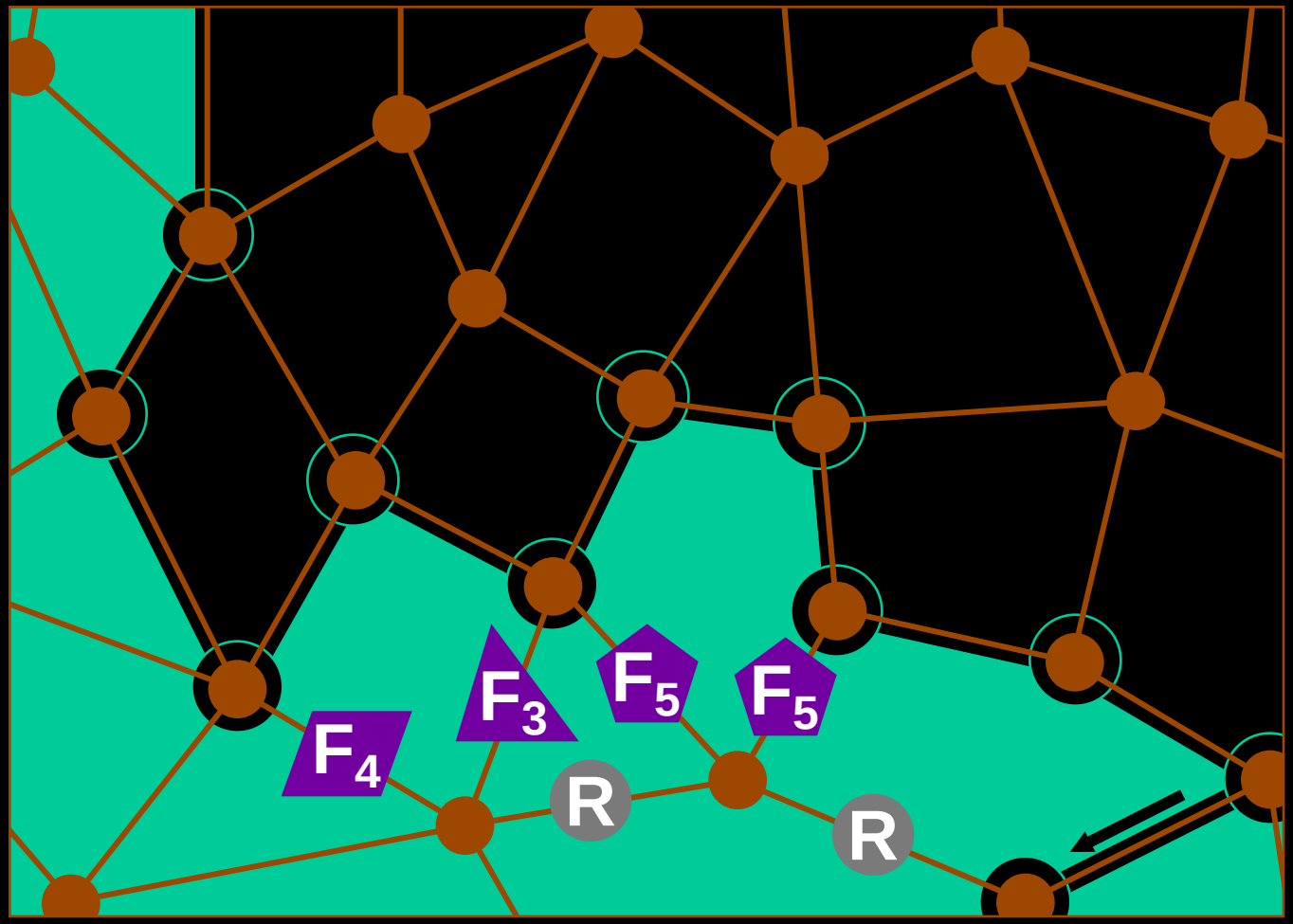
Encoding



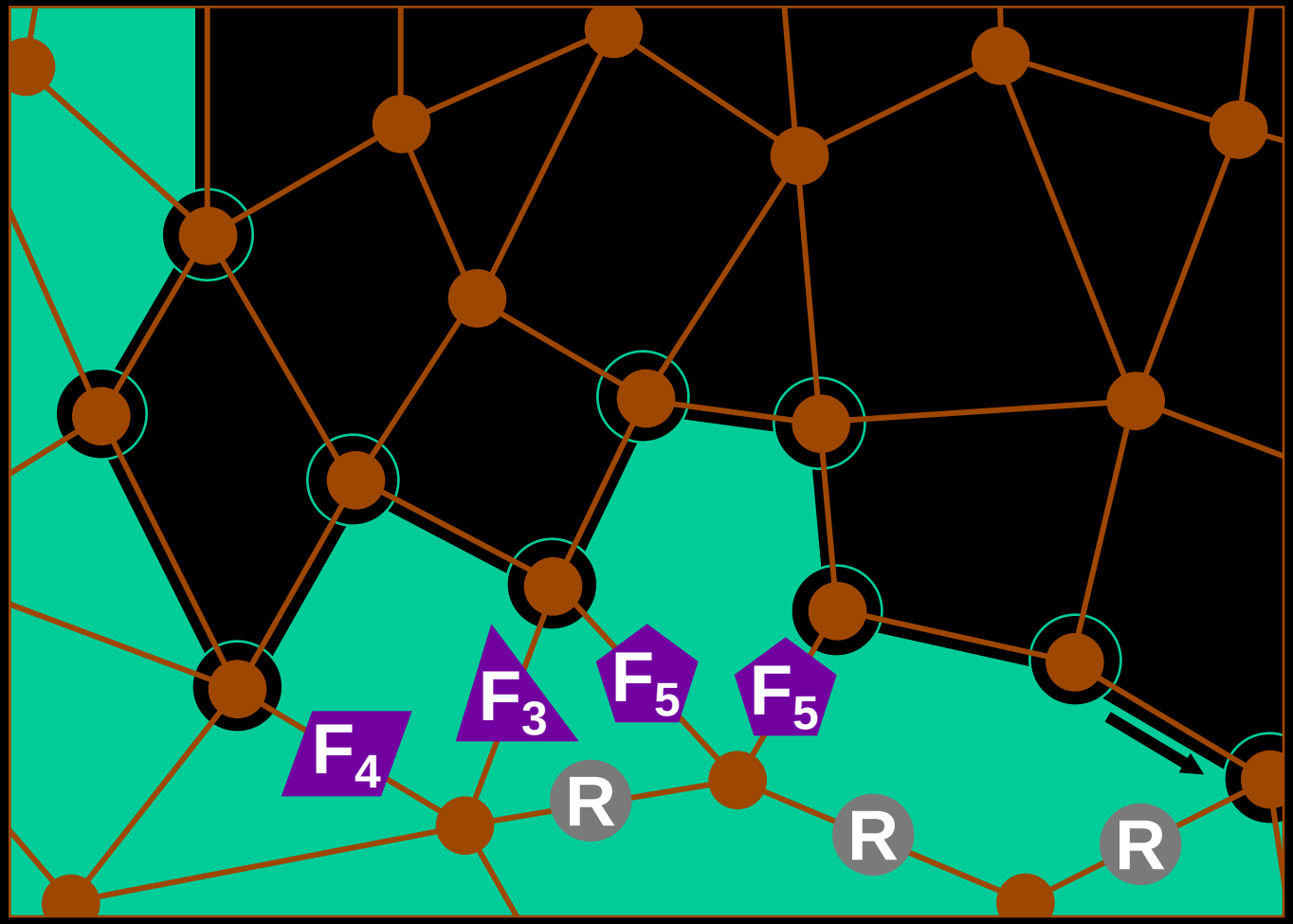
Encoding



Encoding



Encoding

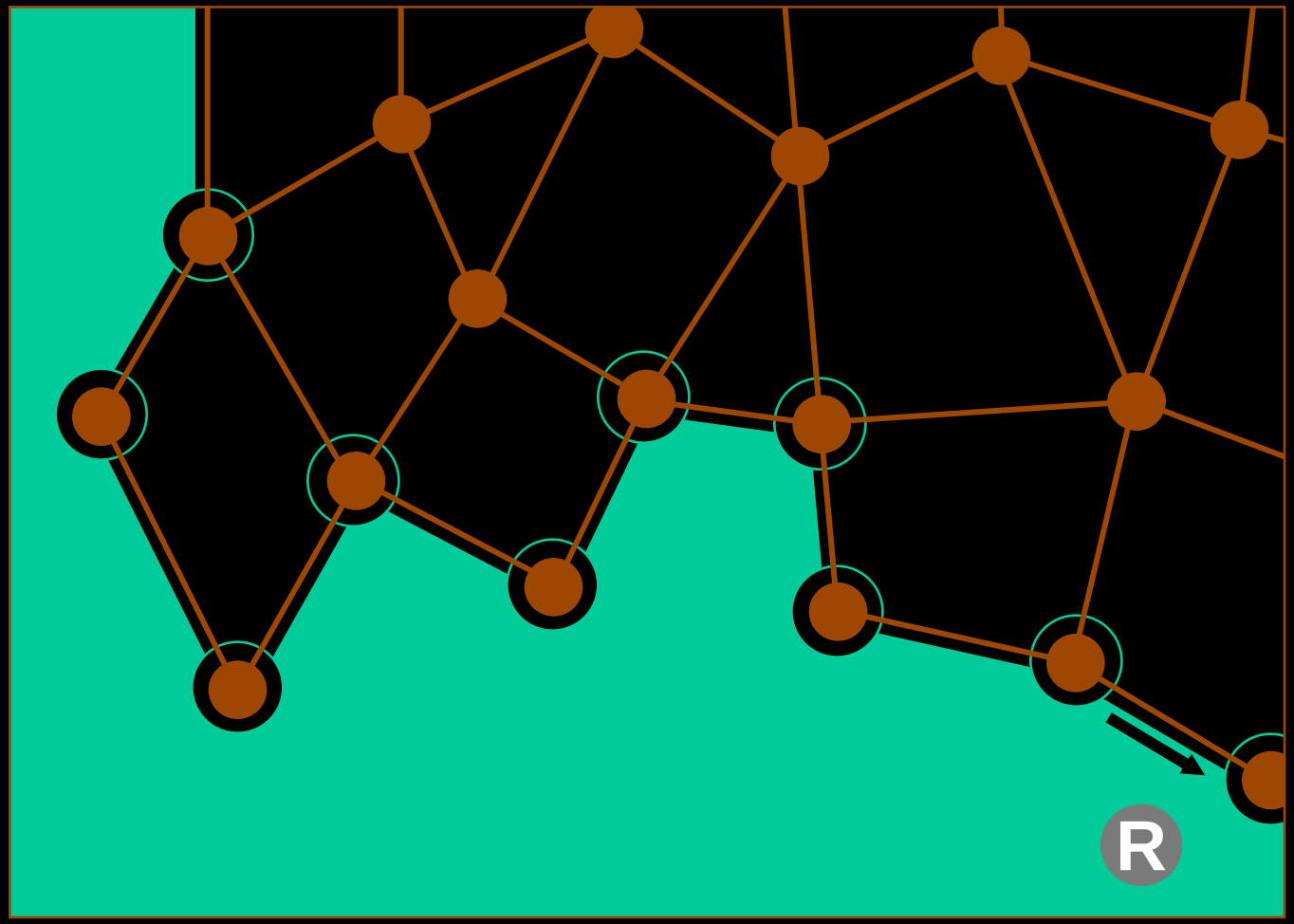


Compressing

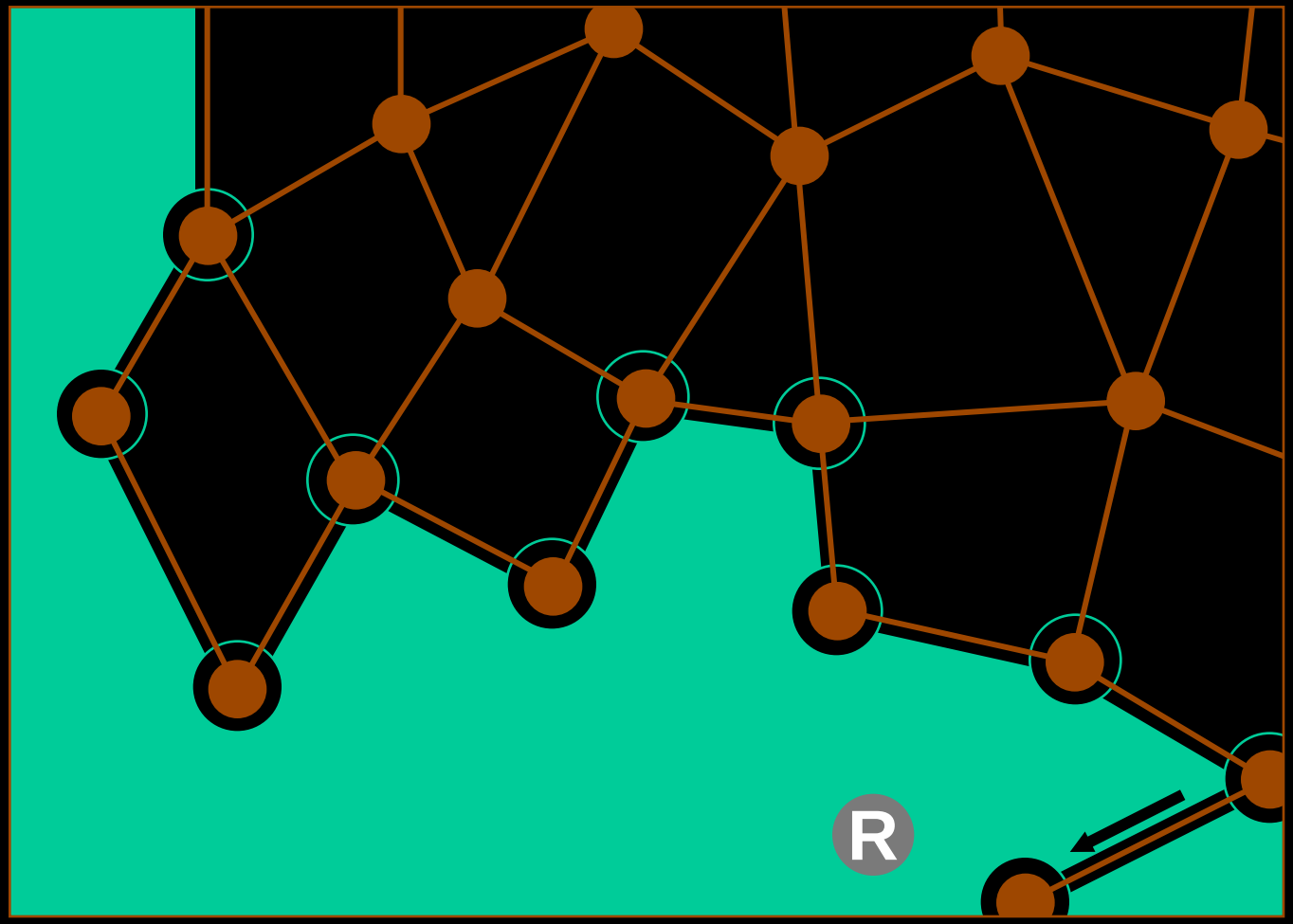
- **Resulting label sequence:**

  - non-uniform label frequencies
  - correlation among subsequent labels
- **Adaptive order-3 arithmetic coding**
  - Compact probability tables
  - Fast bit-operations

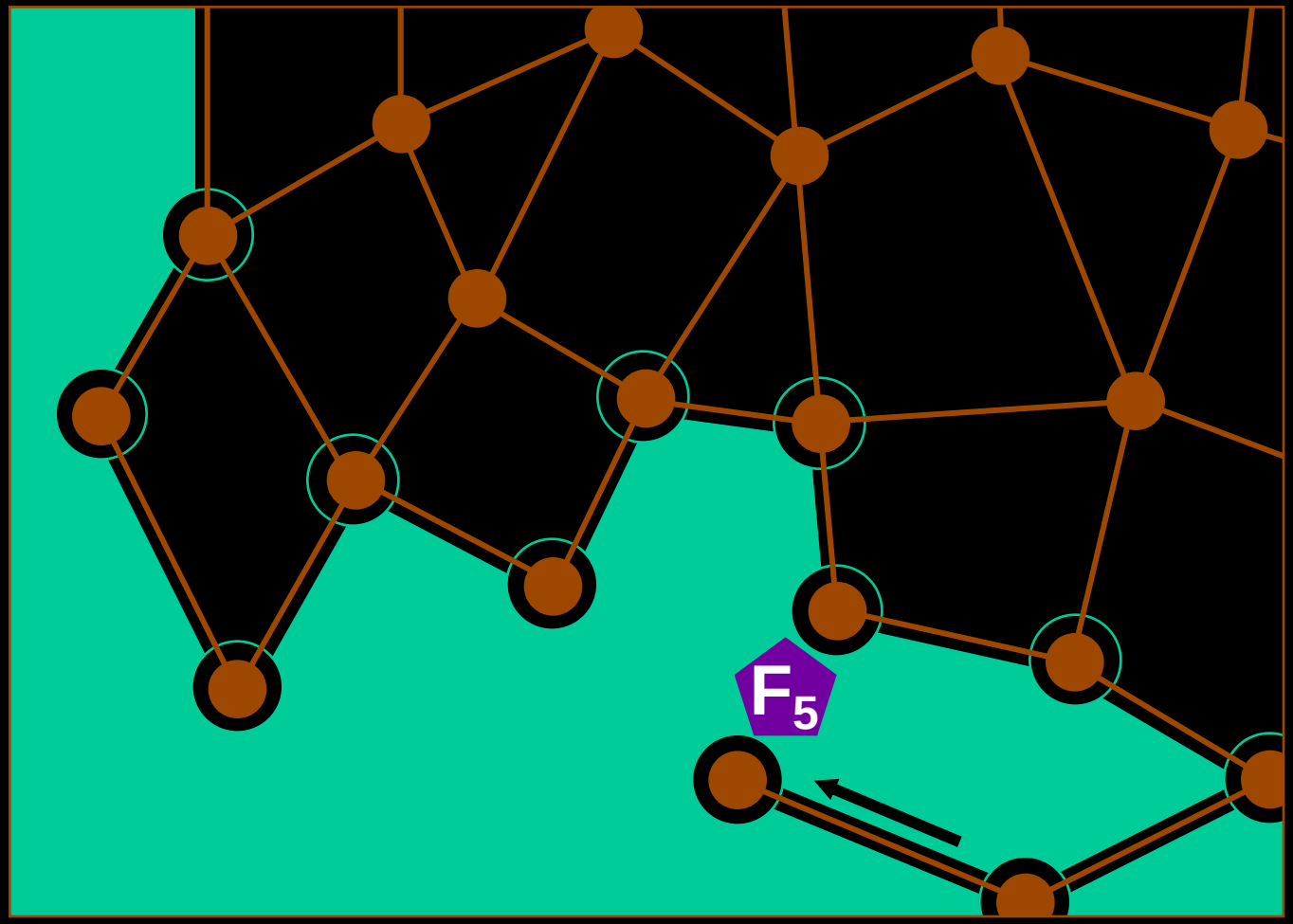
Decoding



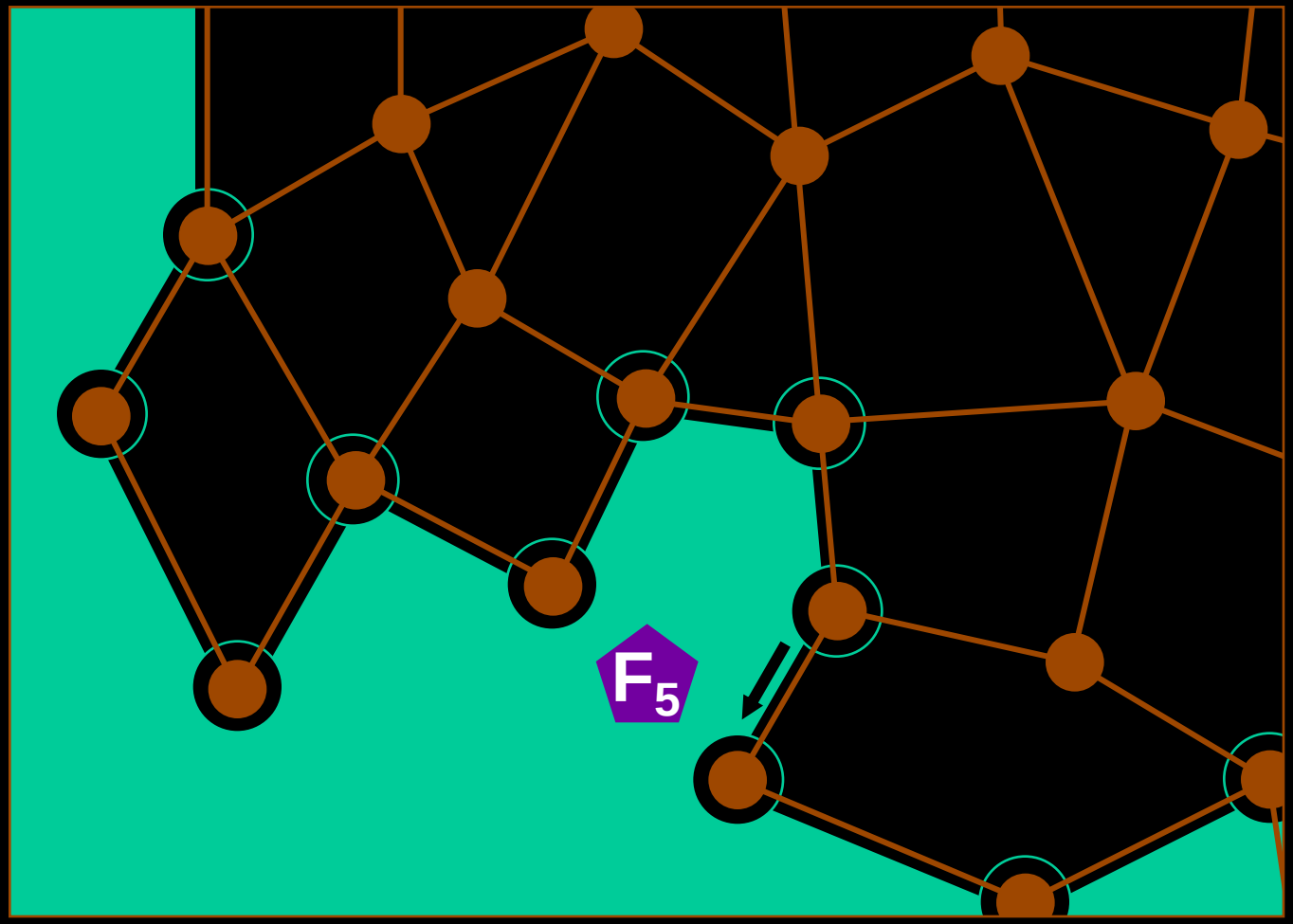
Decoding



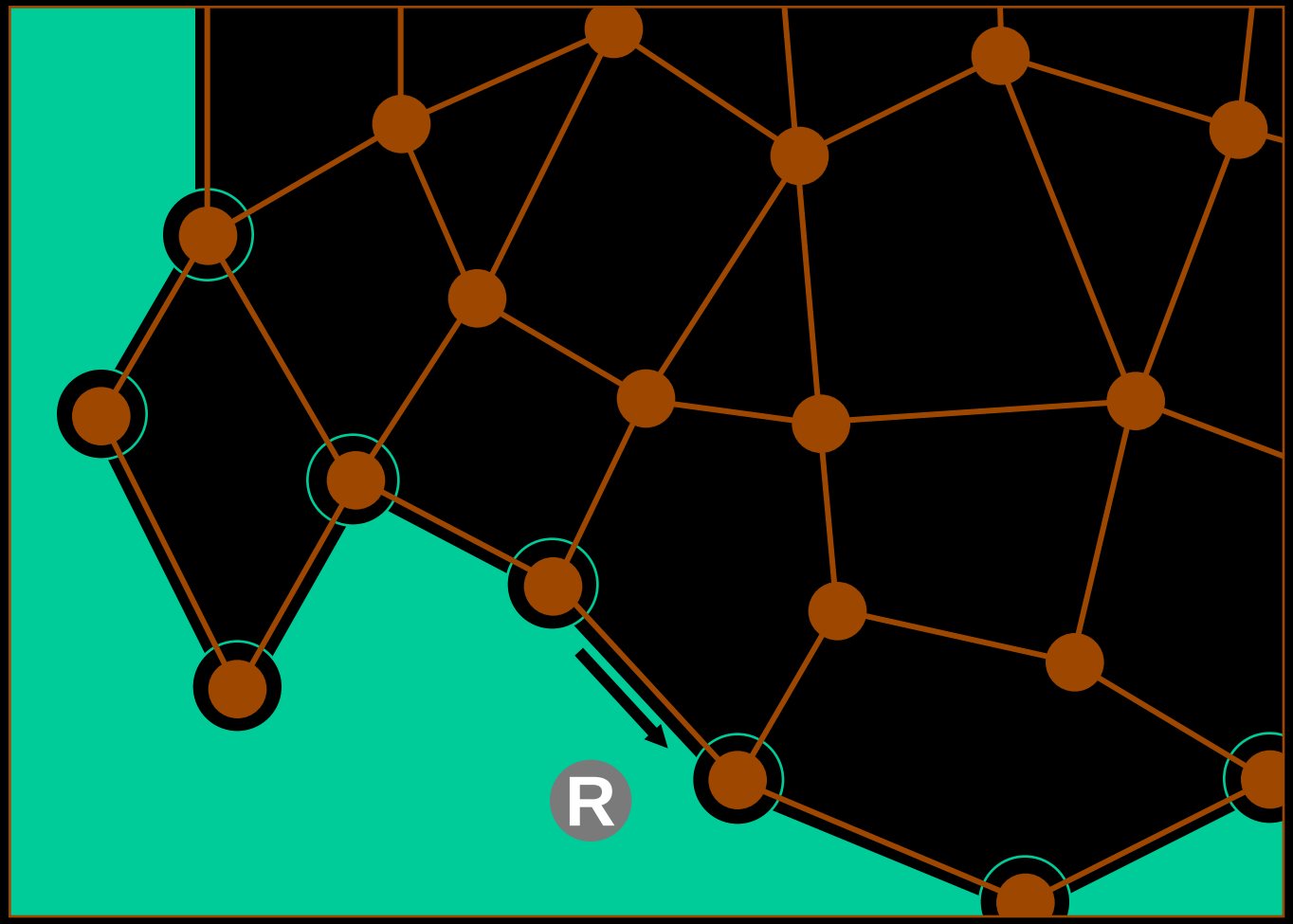
Decoding



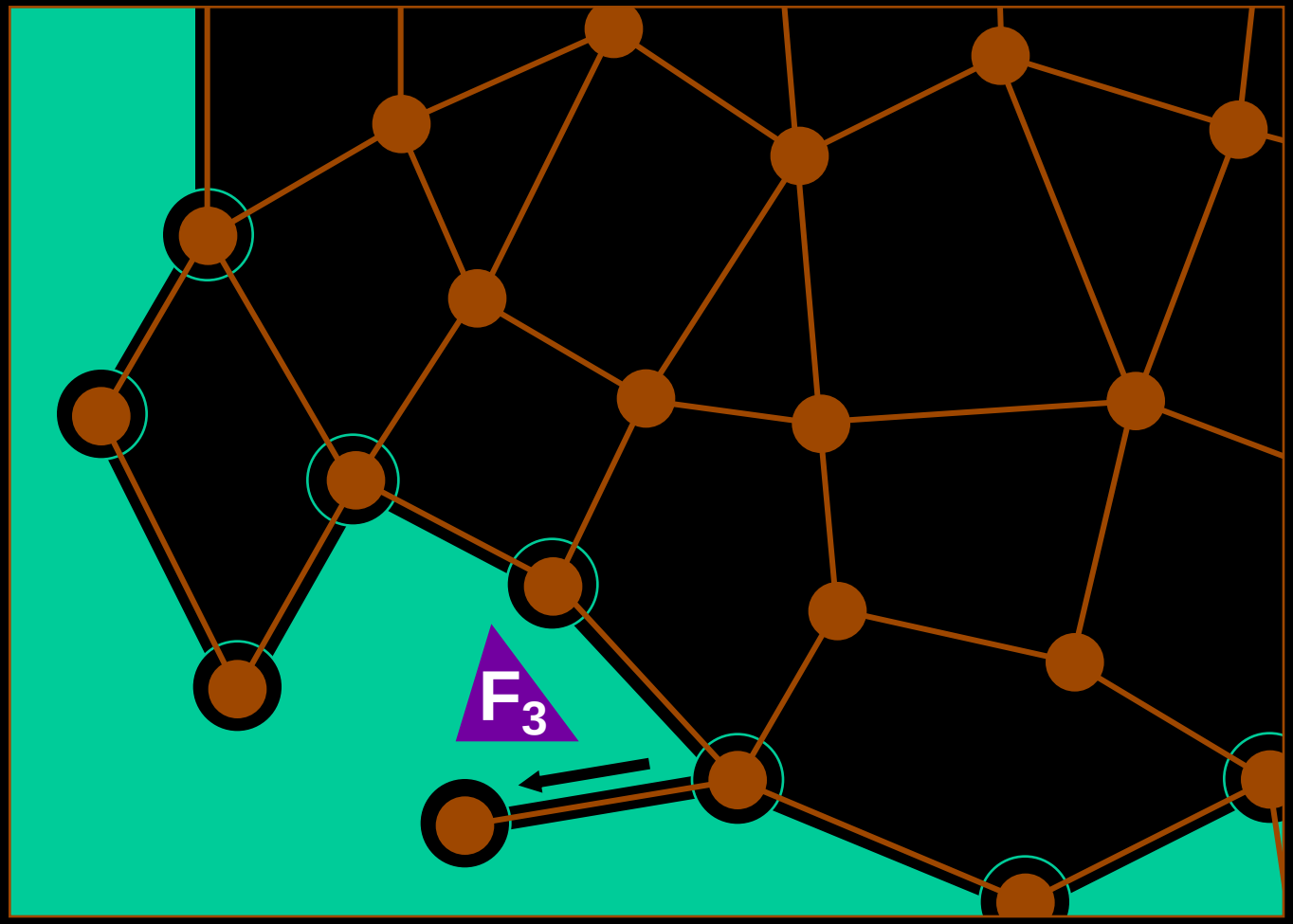
Decoding



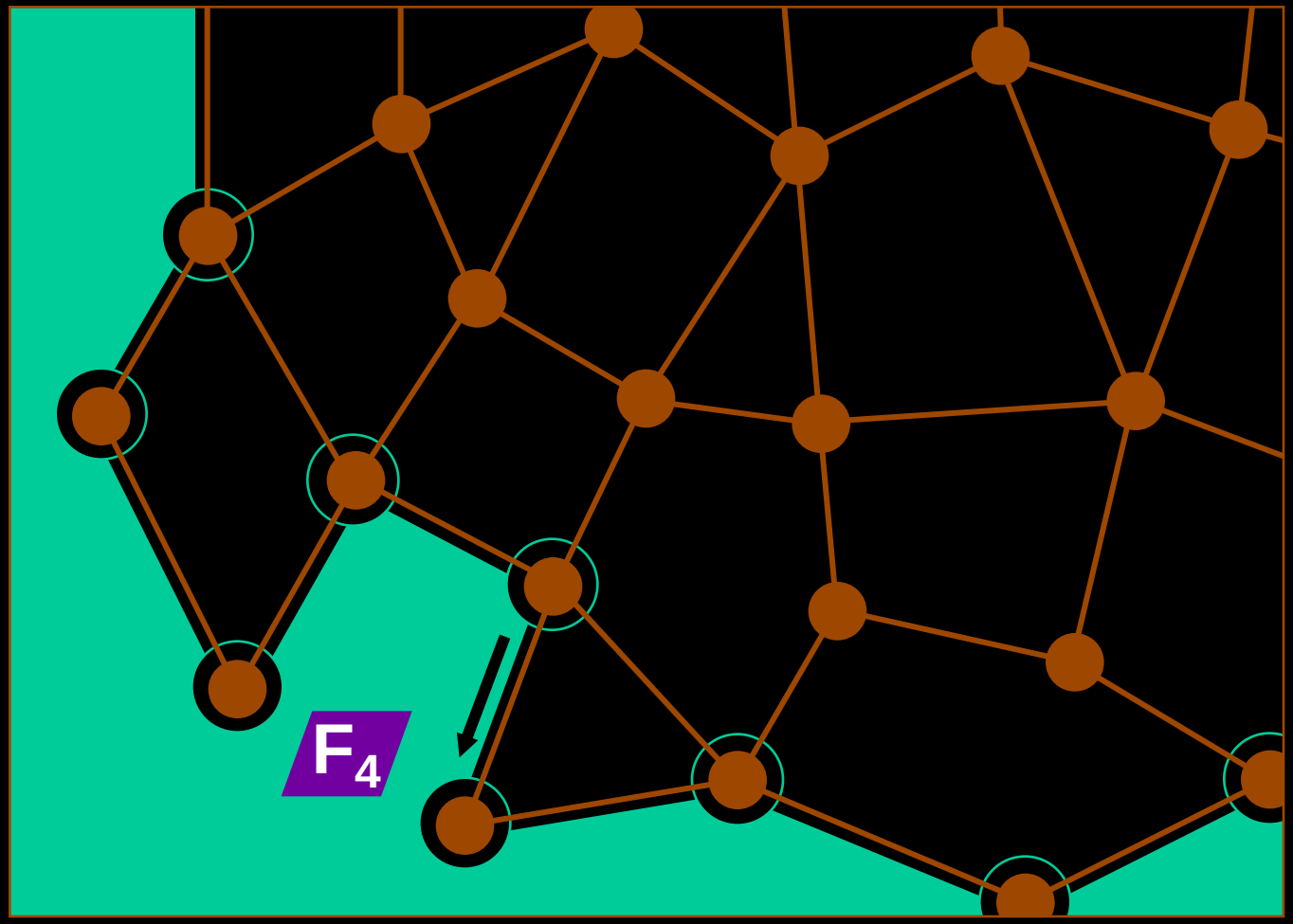
Decoding



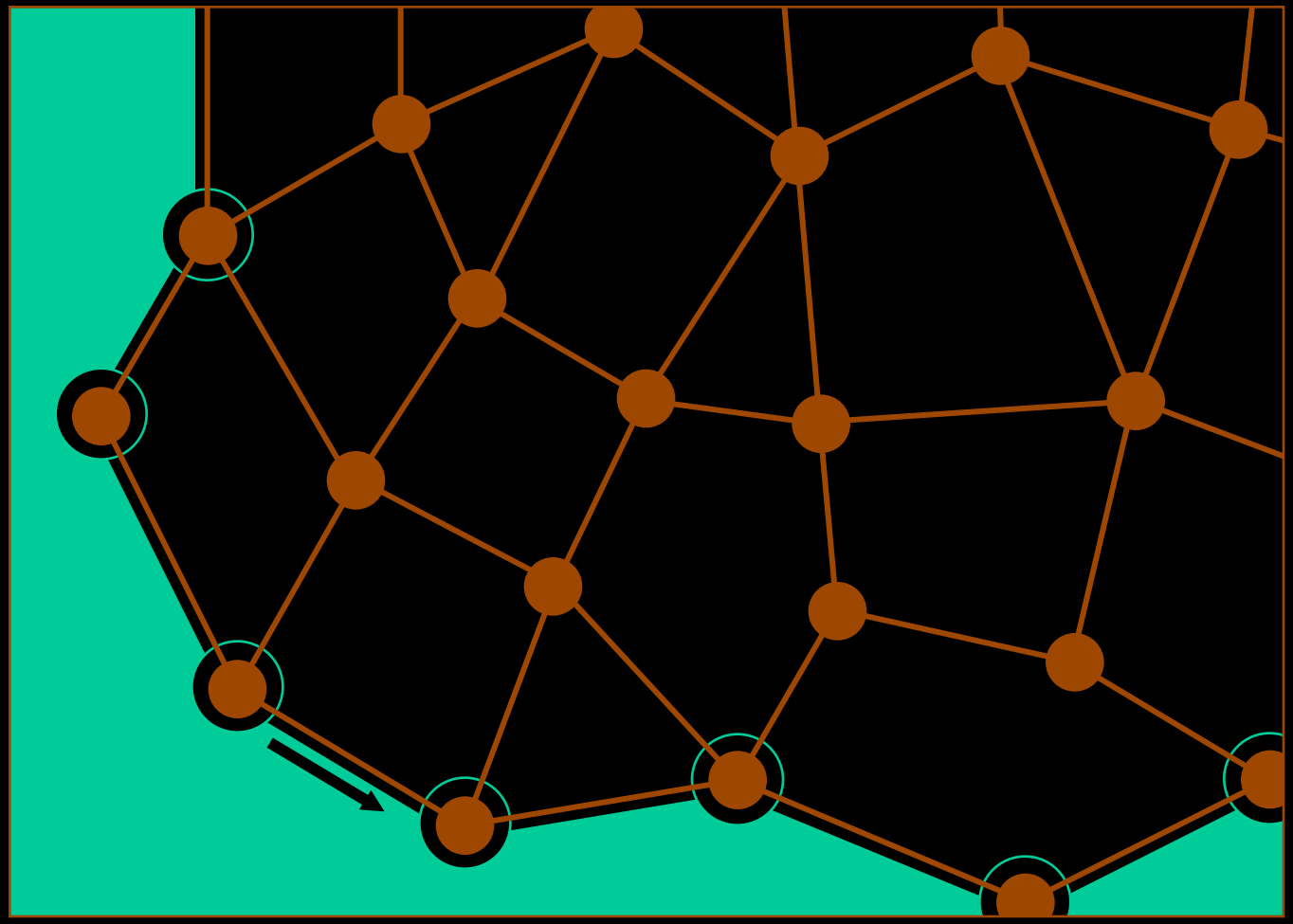
Decoding



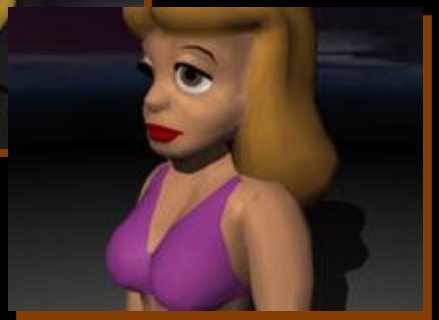
Decoding



Decoding

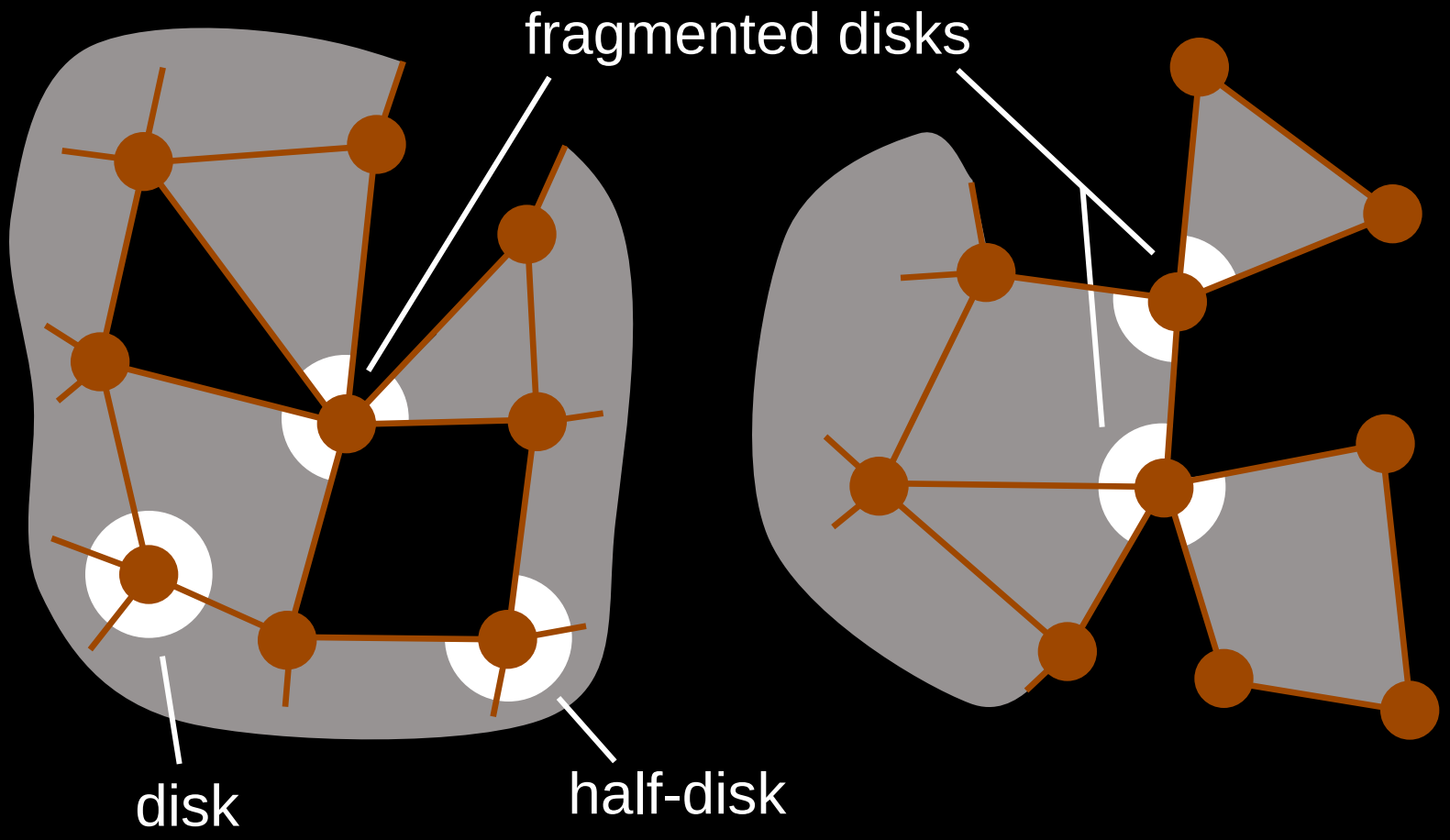


Compression Results

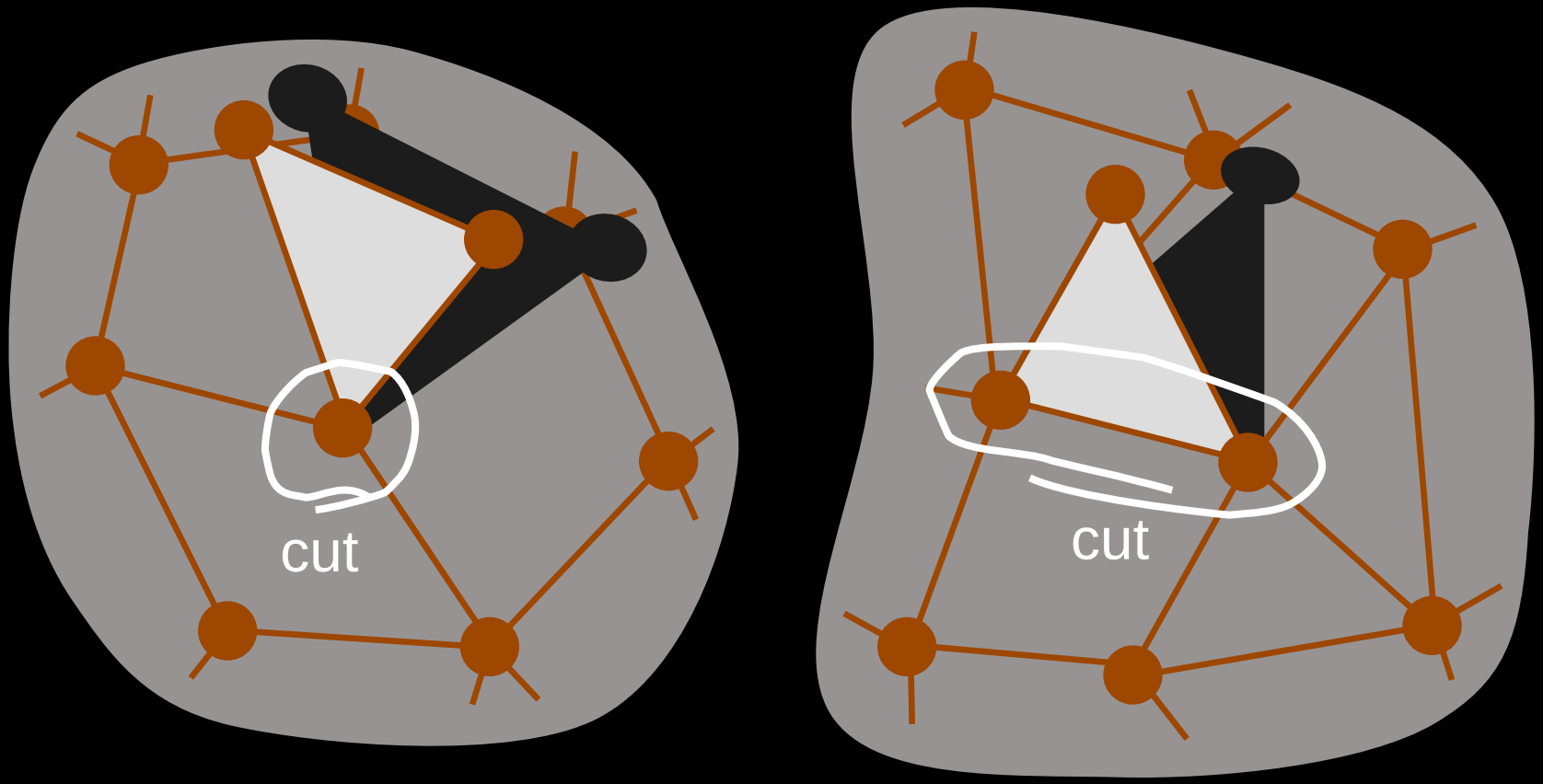


model	bits / vertex	TG	
Triceratops	2.1	2.2	+2.0
Galleon	2.6		
Cessna	2.8		
Beethoven	2.9	2.4	+2.0
Shark	1.7		
Cupie	2.3		

Non-Manifold Meshes (1)



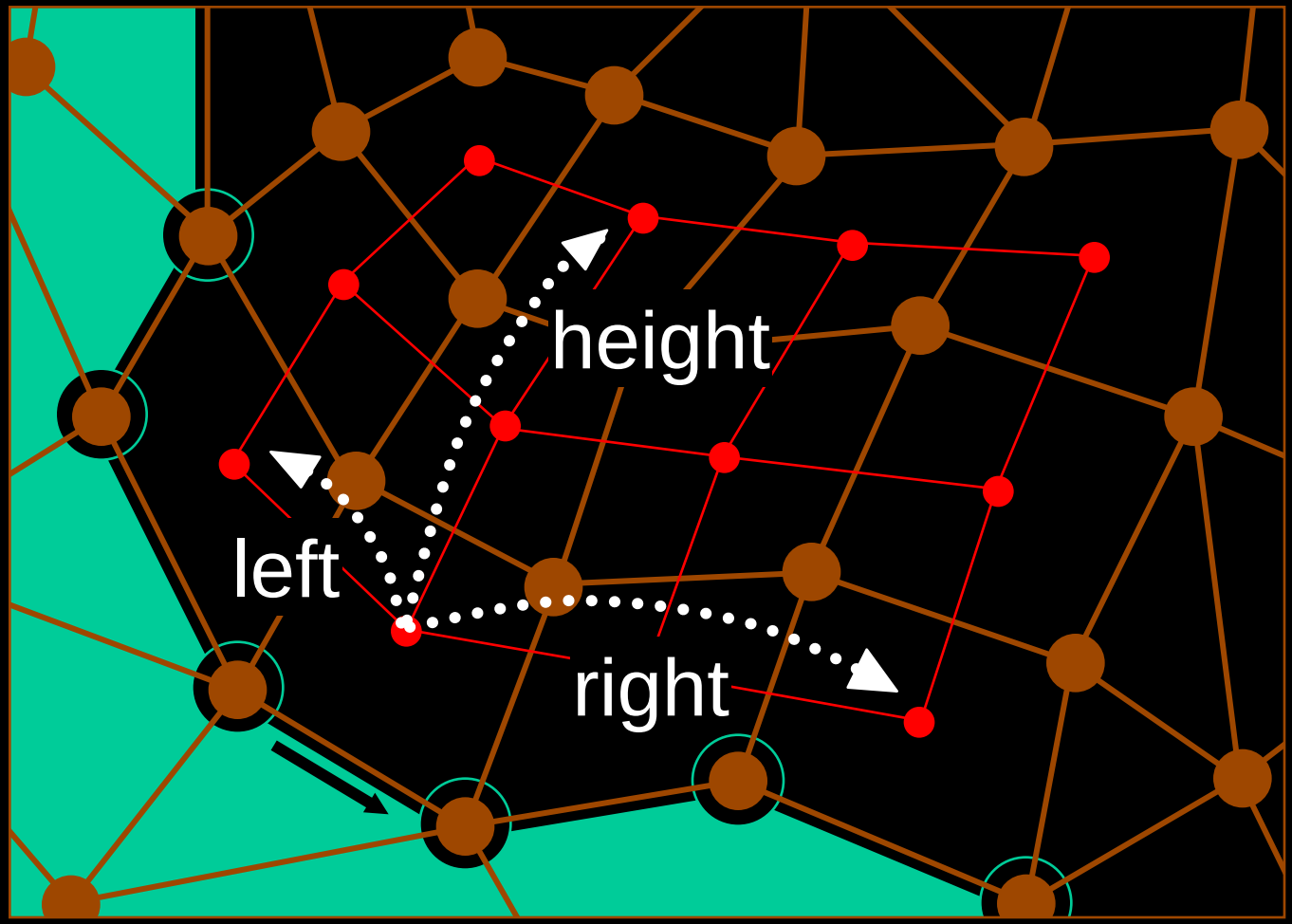
Non-Manifold Meshes (2)



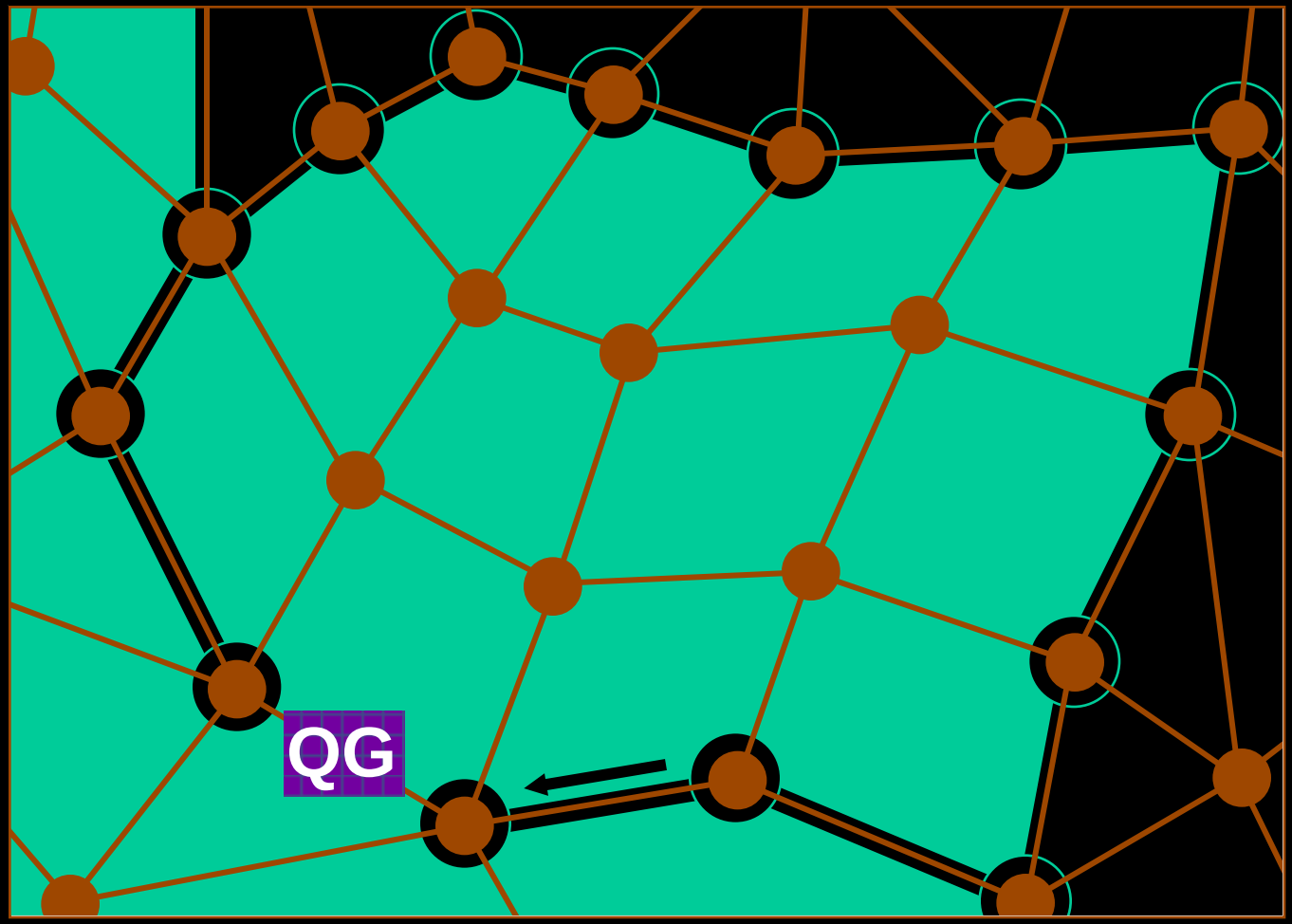
Beyond Faces

Extension: Quadrilateral Grids

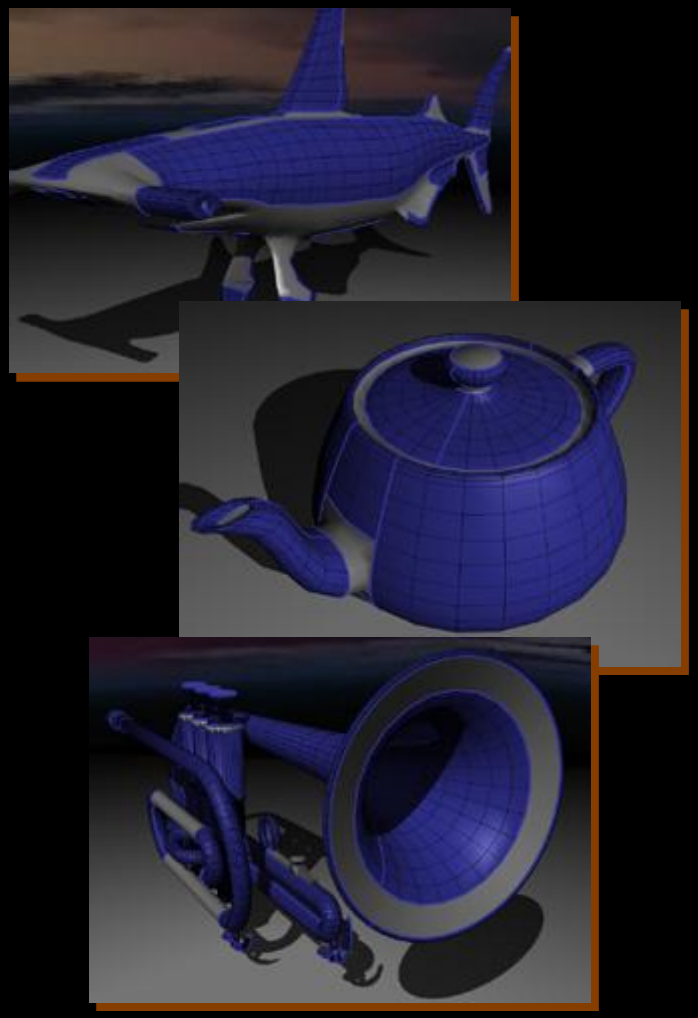
Encoding a Quad Grid



Encoding a Quad Grid



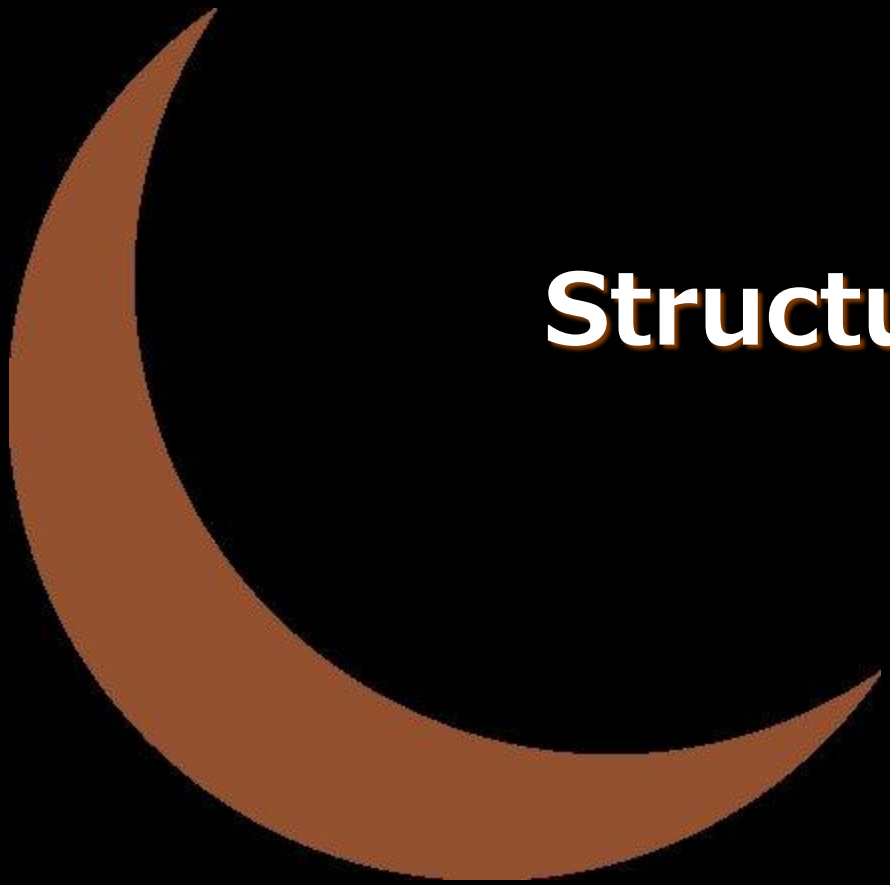
Compression with Quad Grids



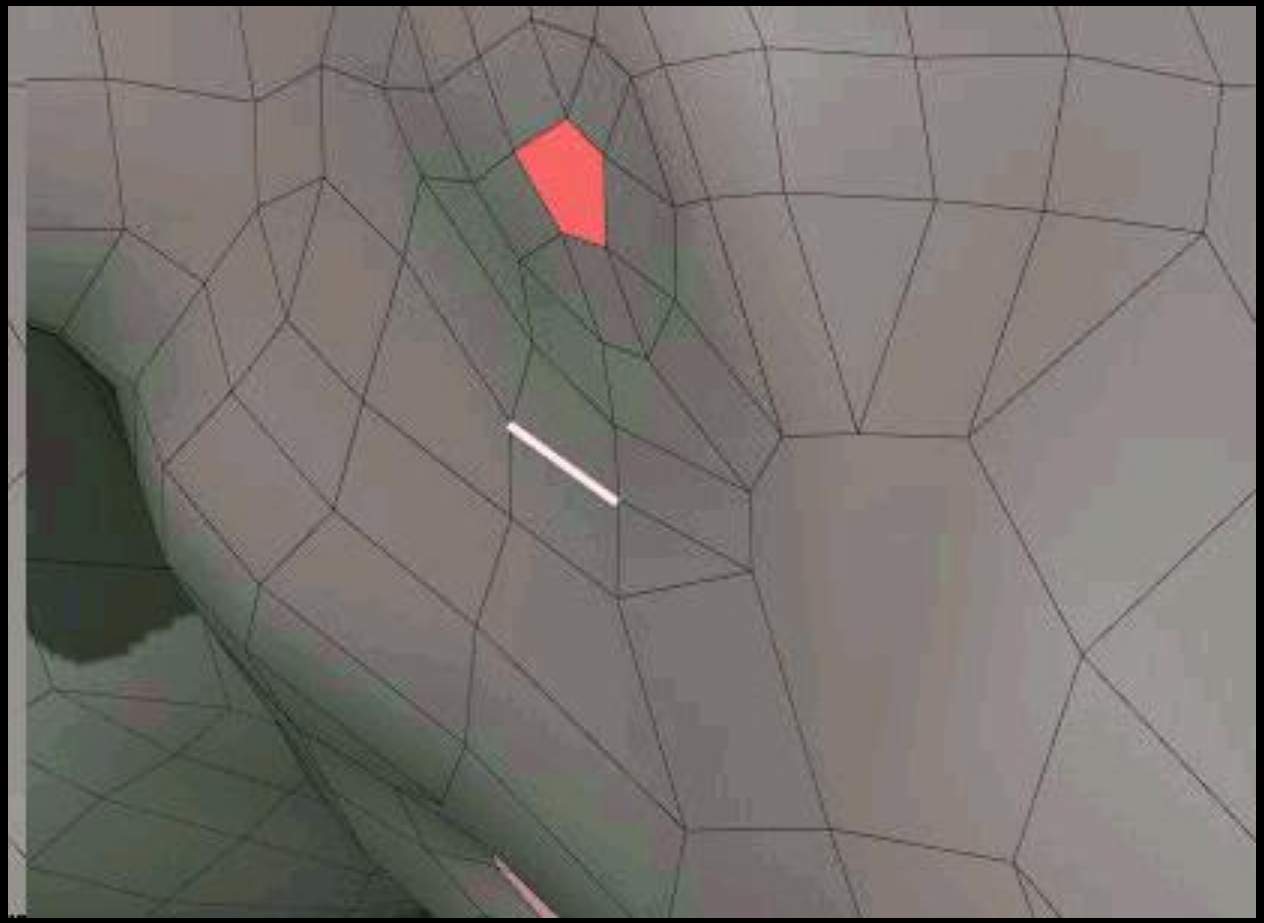
model	bits / vertex	diff
Triceratops	1.9	-0.2
Galleon	2.2	-0.4
Beethoven	2.6	-0.3
Shark	1.4	-0.3
Teapot	1.1	-0.6
Trumpet	0.6	-0.5

Extension: Repeated Patches

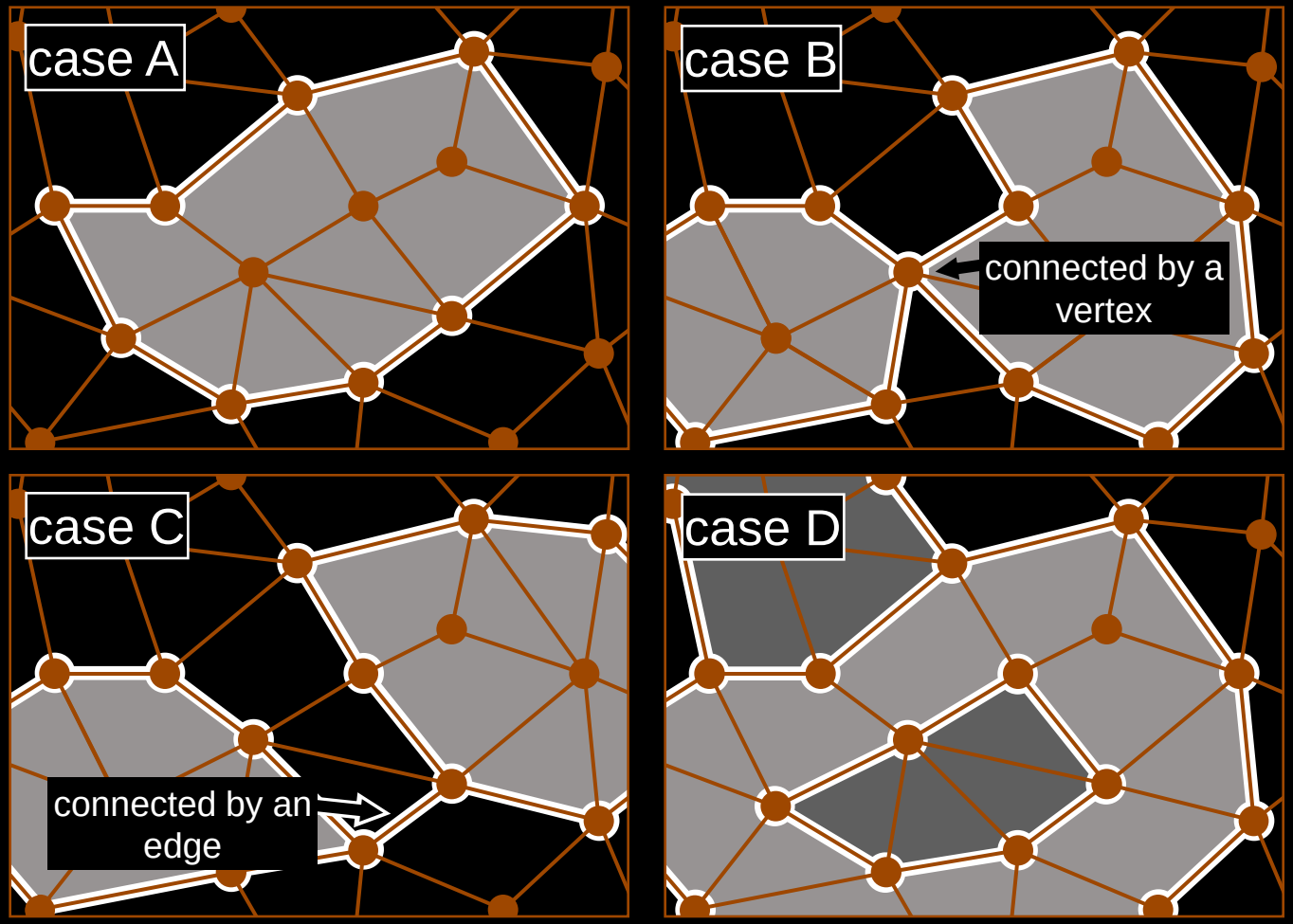
Structures



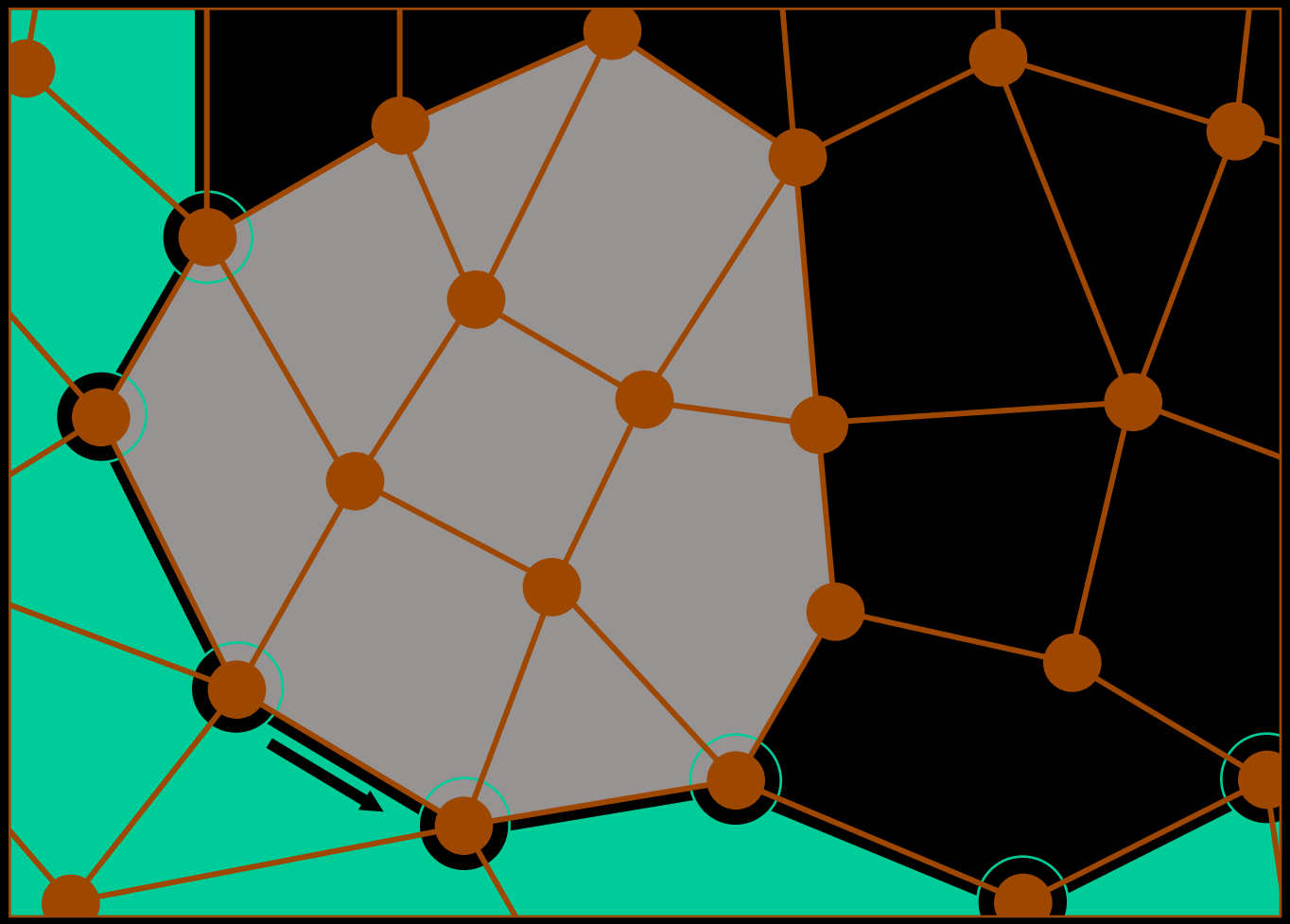
Extension: Structures



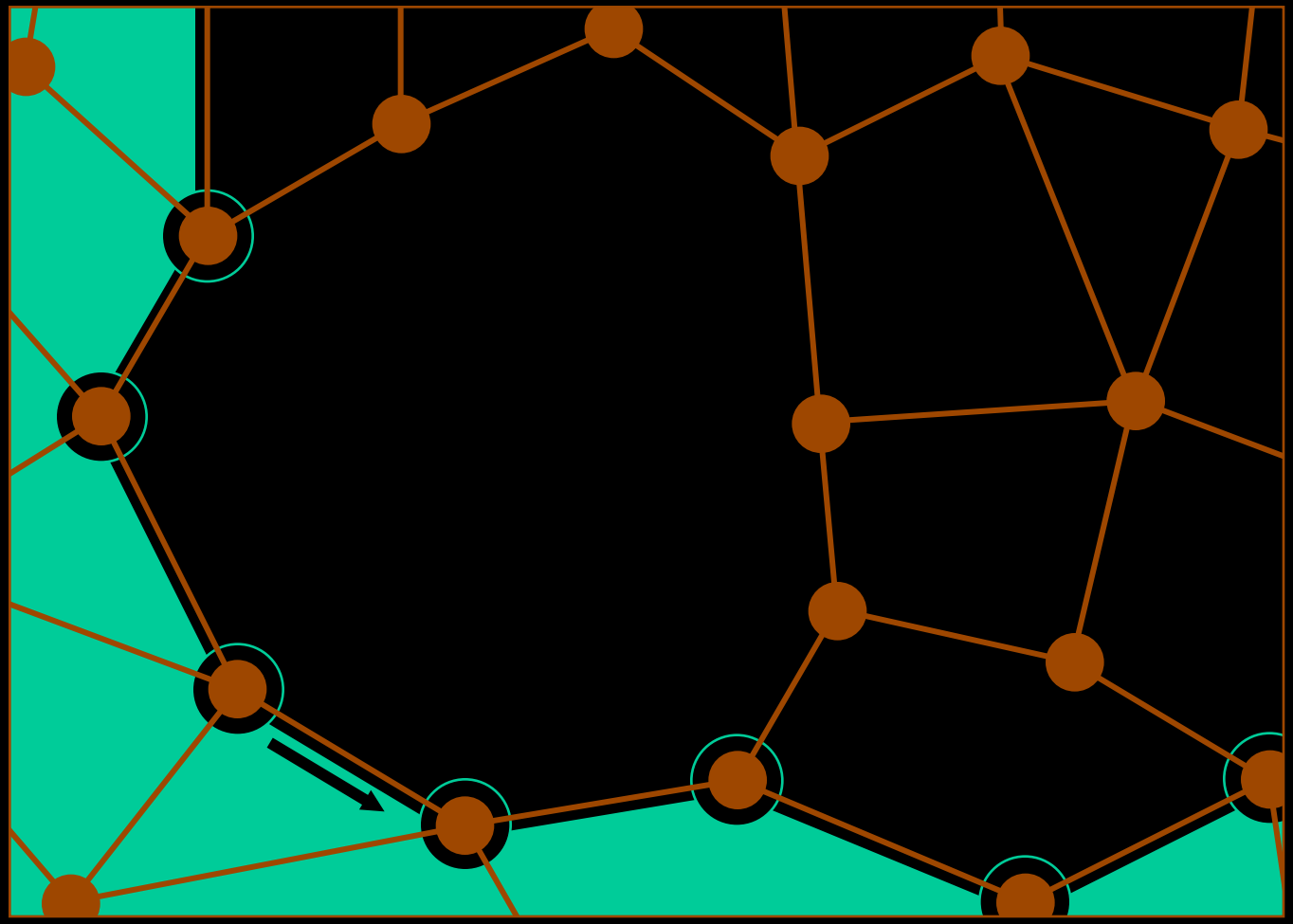
Super Faces


case A
case B
connected by a vertex
case C
connected by an edge
case D

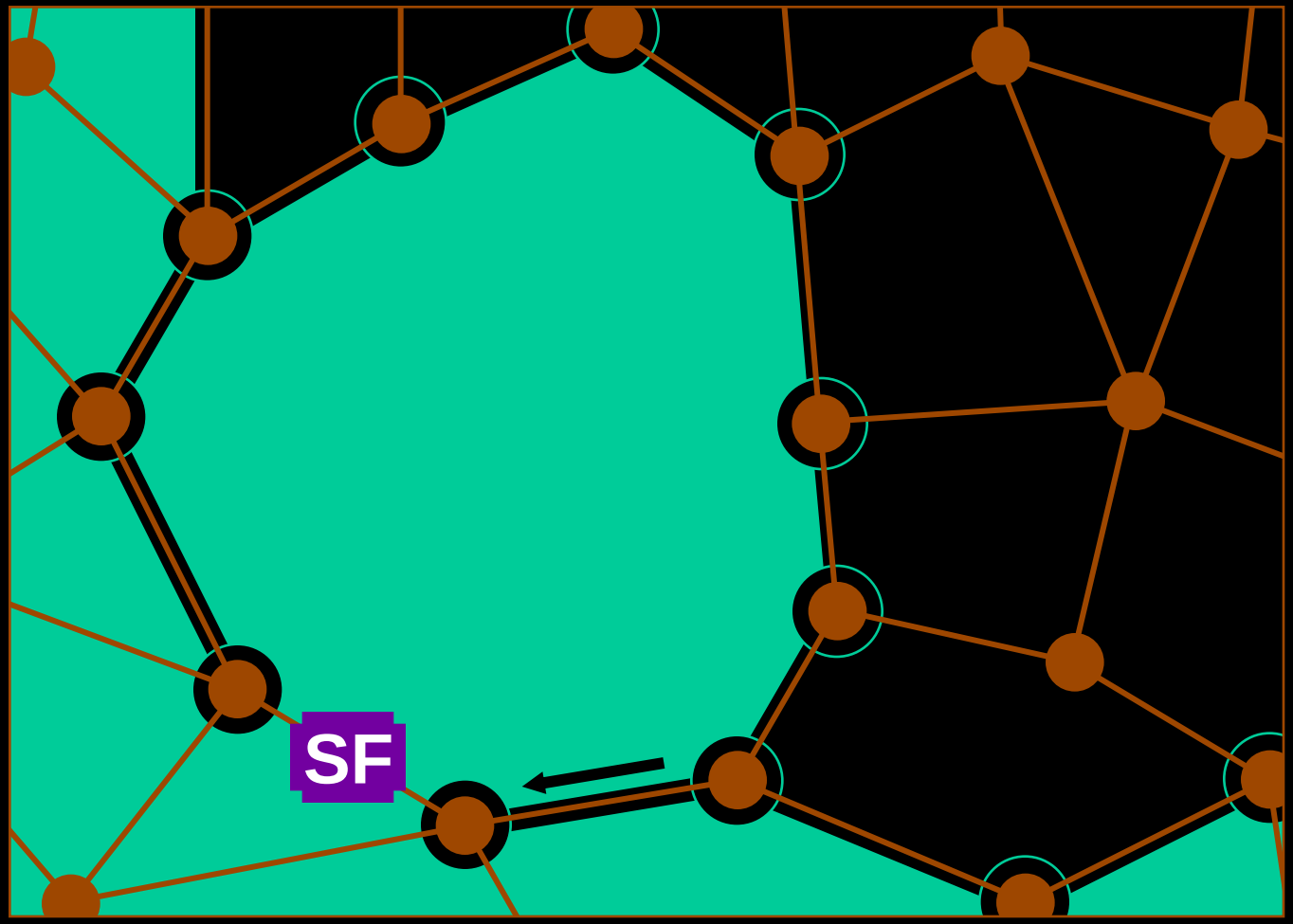
Encoding a Super Face



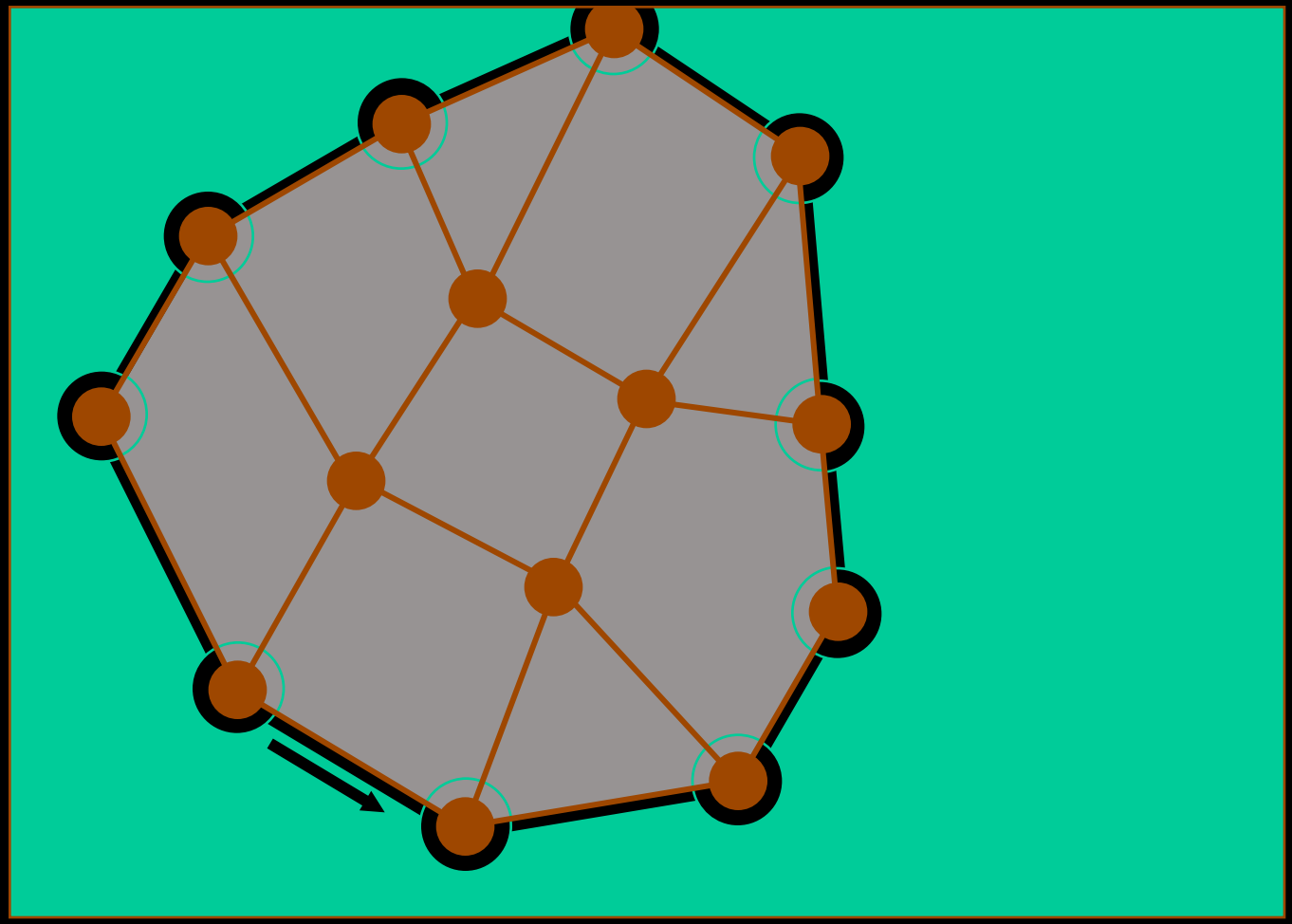
Encoding a Super Face



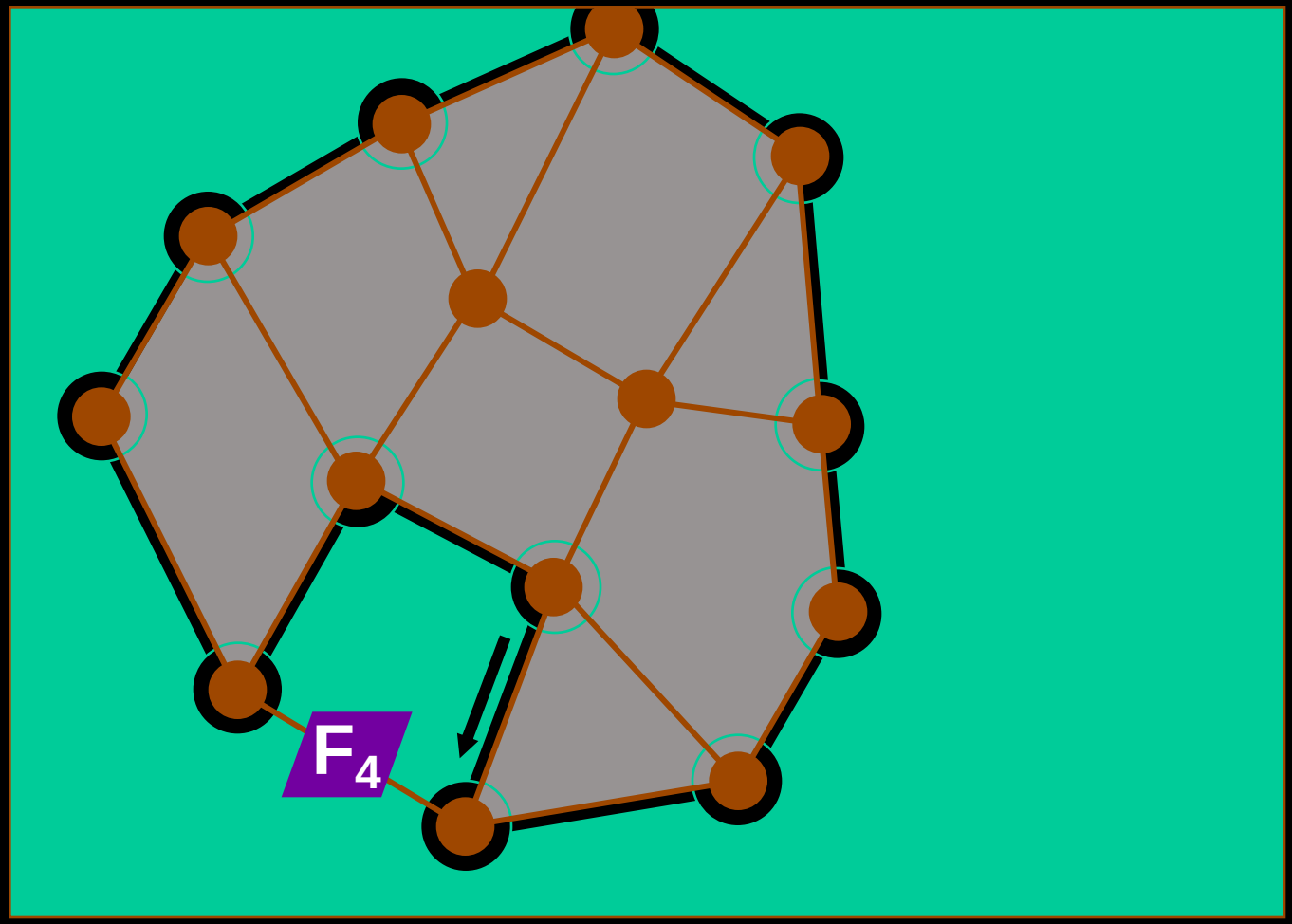
Encoding a Super Face



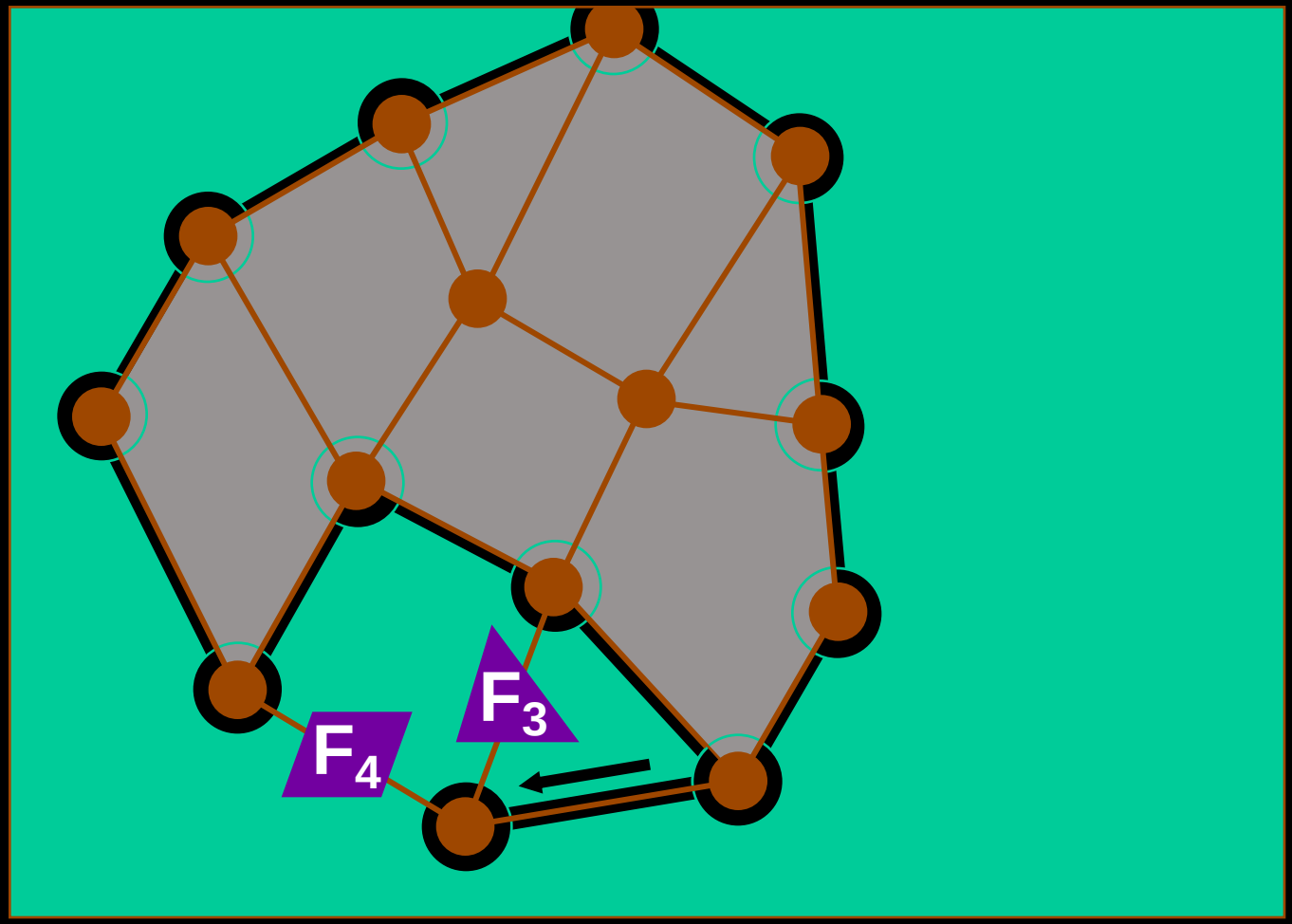
Encoding a Super Face



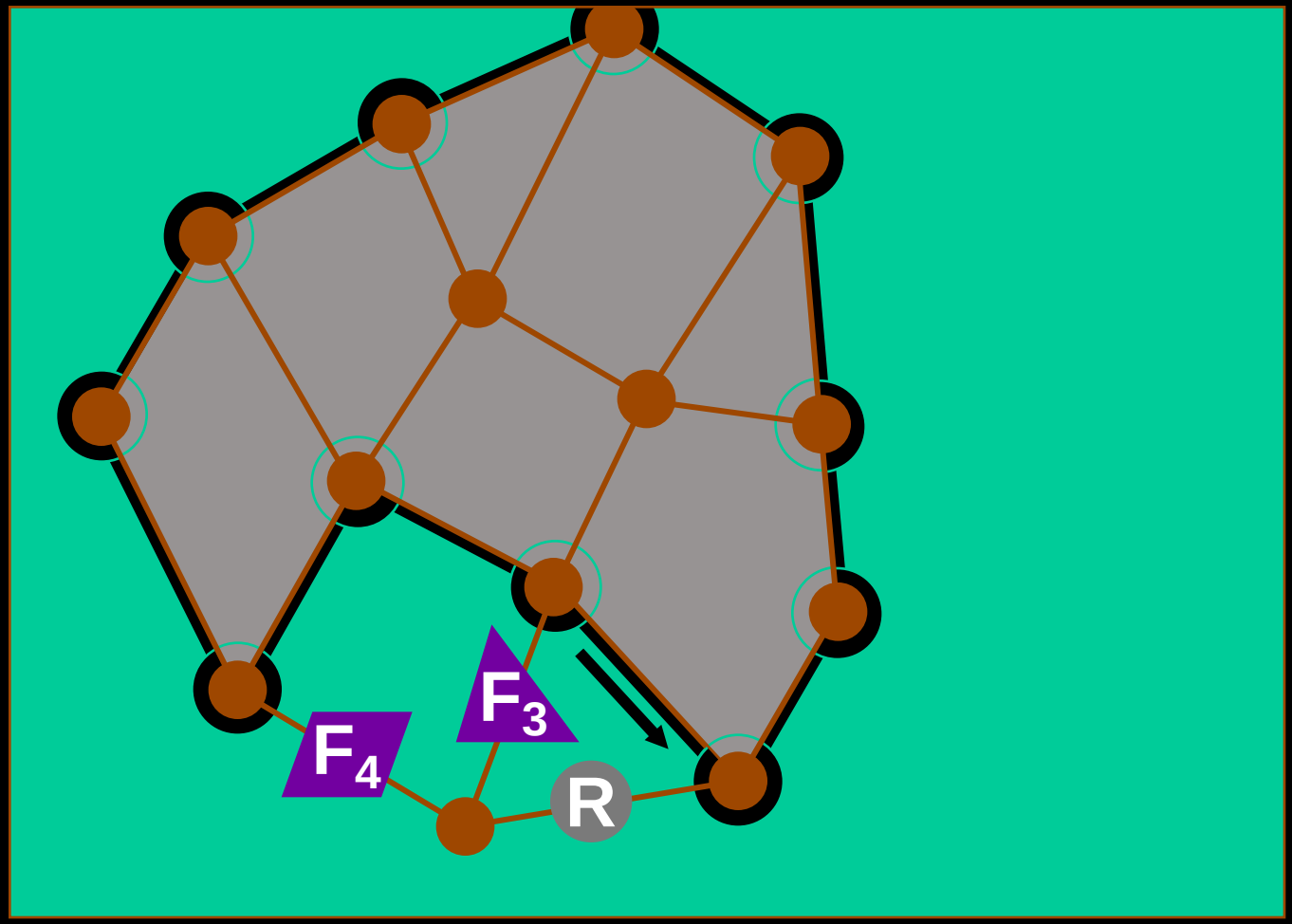
Encoding a Super Face



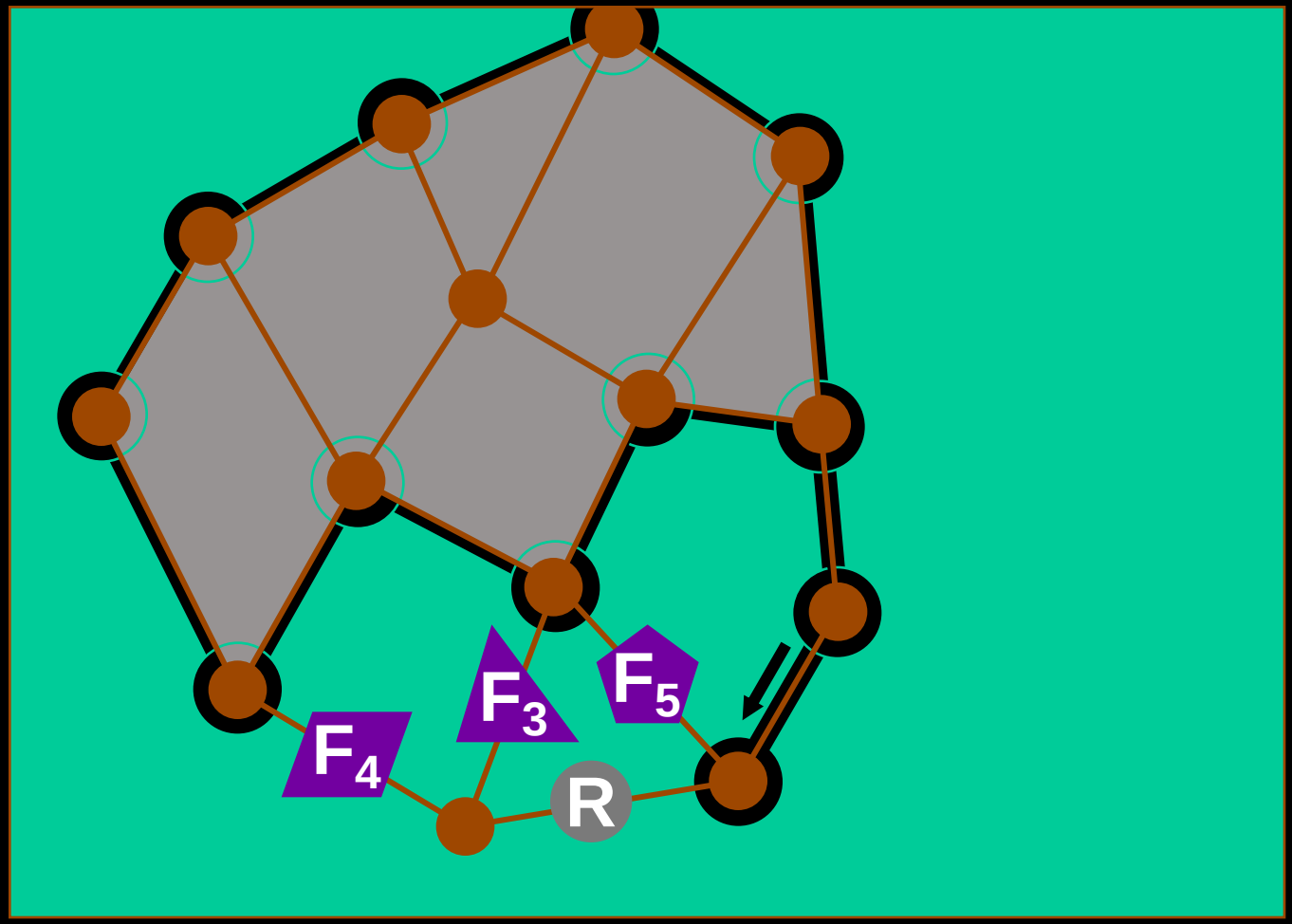
Encoding a Super Face



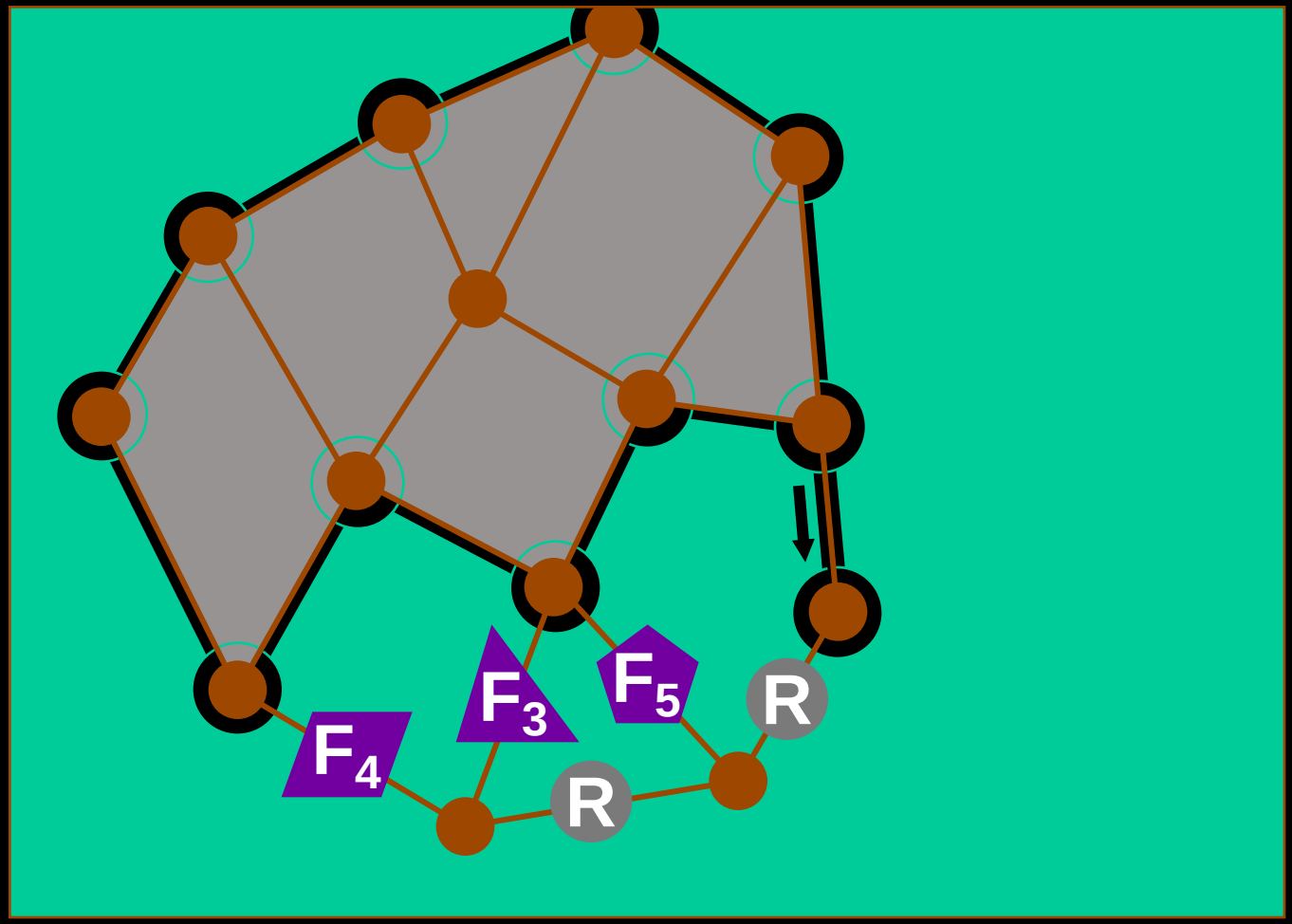
Encoding a Super Face



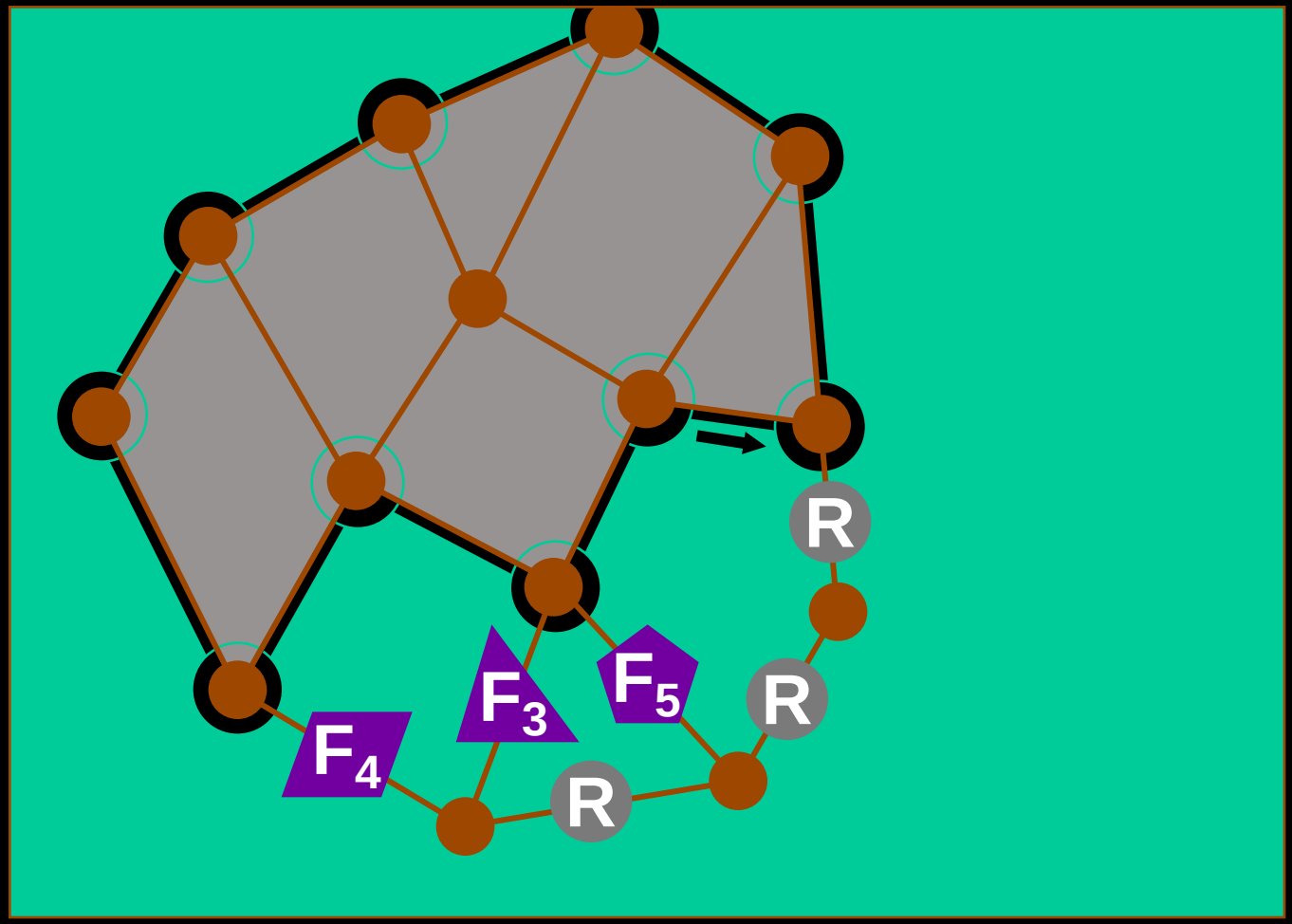
Encoding a Super Face



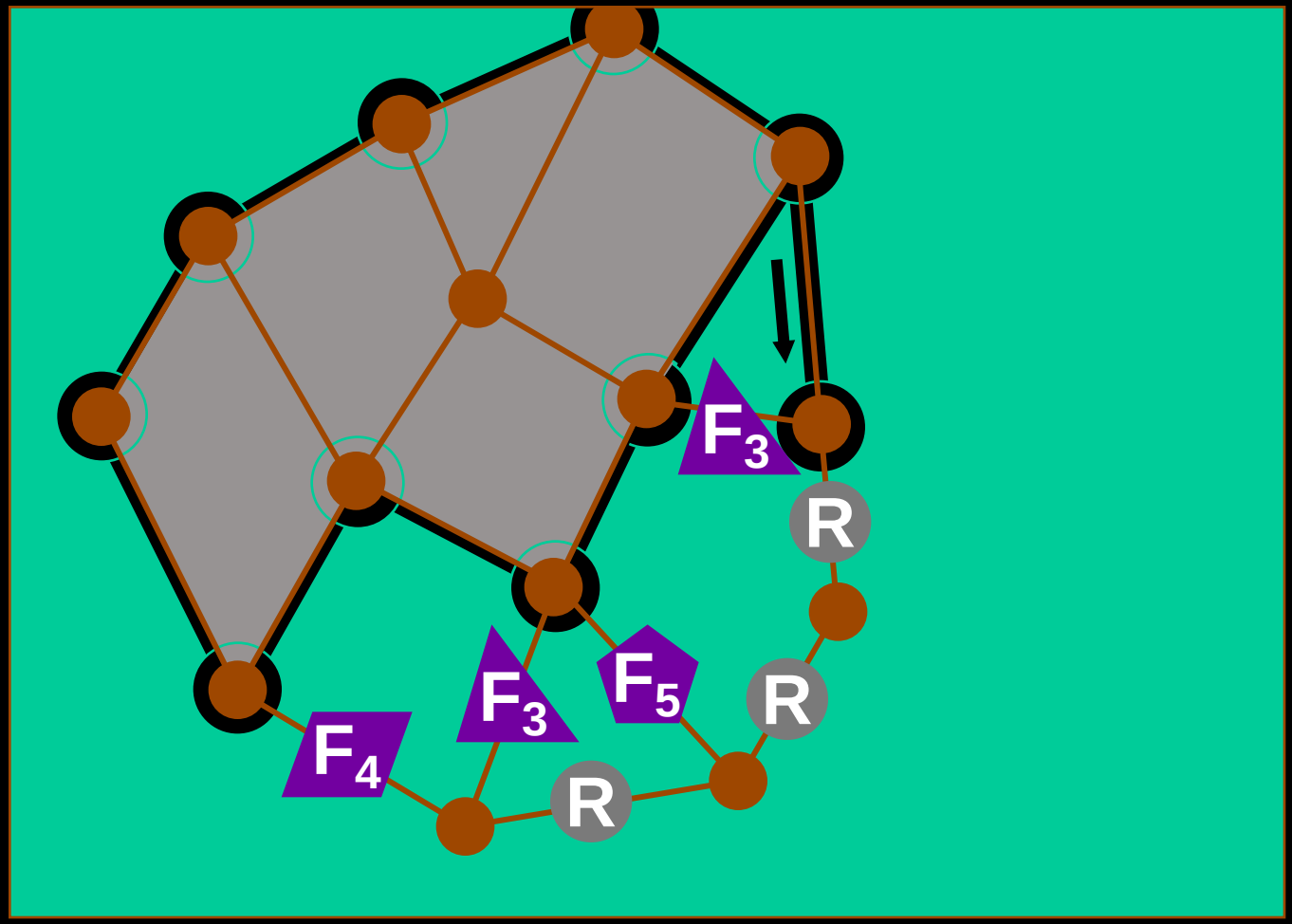
Encoding a Super Face



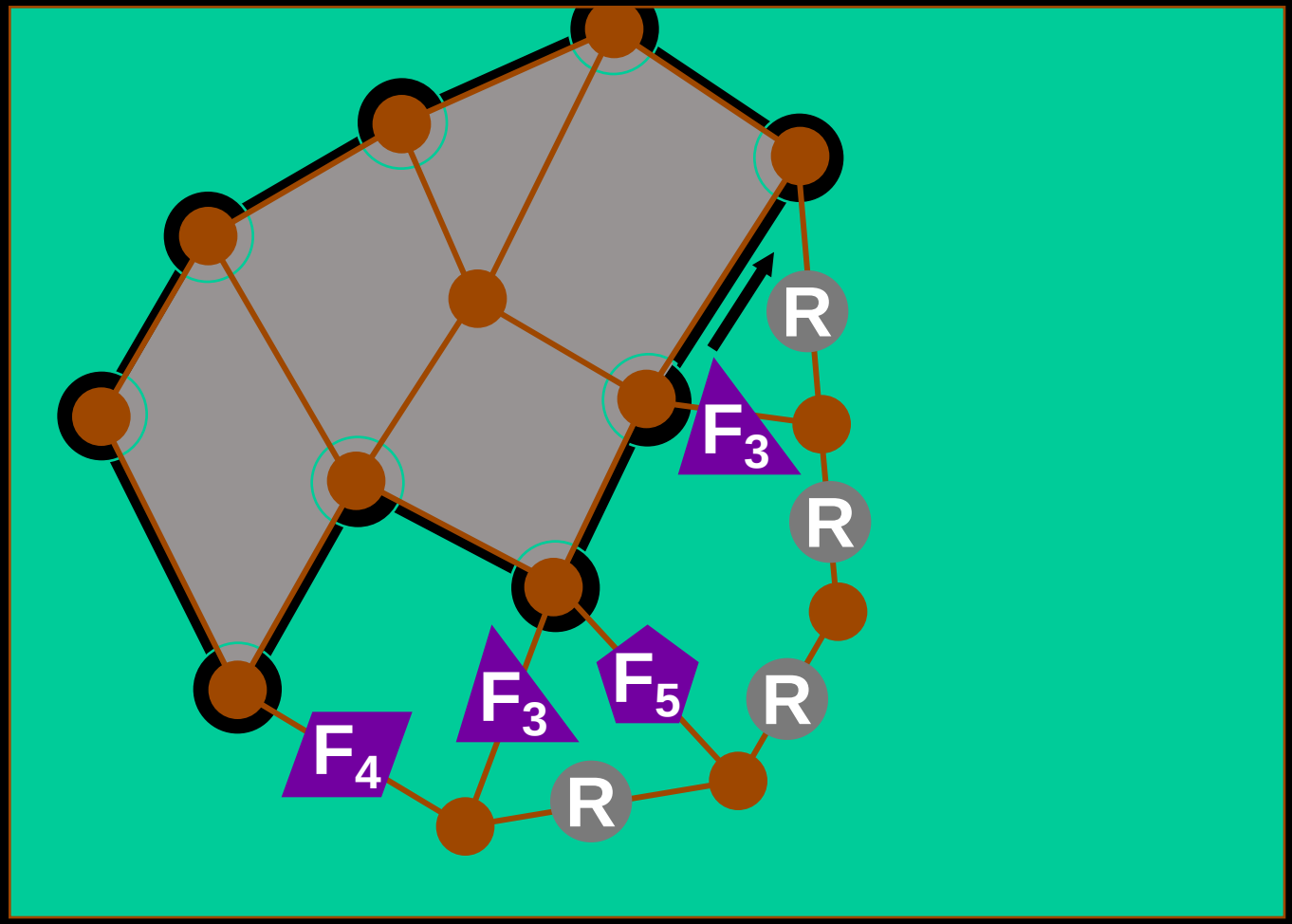
Encoding a Super Face



Encoding a Super Face



Encoding a Super Face



Compression with Structures

model	bits / vertex	diff	
Triceratops	2.4	+0.3	+0.1
Galleon	2.7	+0.1	+0.1
Cessna	3.5	+0.7	+0.2
Beethoven	3.0	+0.1	+0.1
Shark	2.0	+0.3	+0.0
Cupie	2.3	+0.1	+0.1

Summary

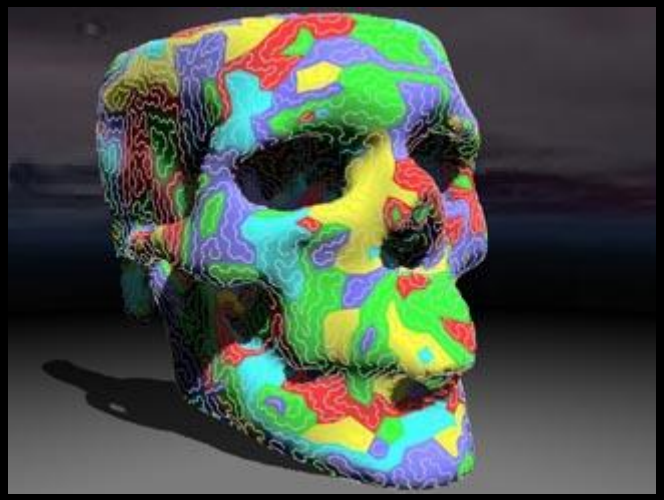
Summary of Contributions

- **Compress polygonal connectivity**
  - simpler, more compact, extensions
- **Capture structural information**
  - face groupings
  - mesh partitions
  - discontinuity curves
- **Model Libraries**
  - “rich” meshes
  - storage / network transmission

Current and Future Work

- **Triangle Strip Compression**

  Graphics Interface 2000



- **Tetrahedral and Hexahedral meshes → "cell fixer"**

Acknowledgements

Davis King
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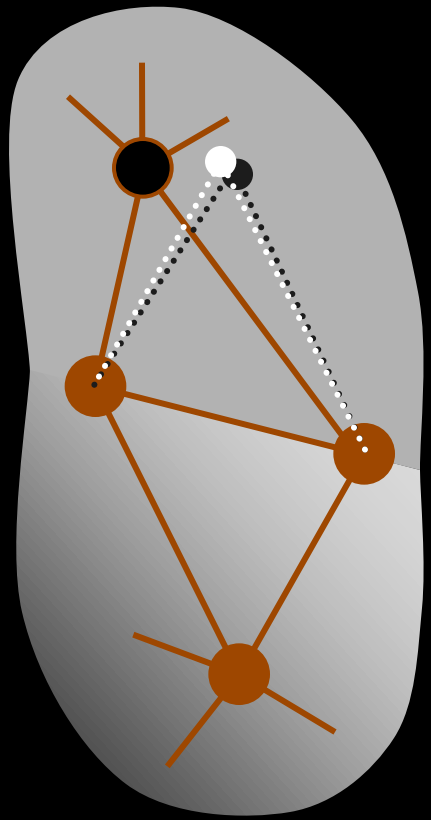
Stefan Gumhold
S6
Viewpoint Datalabs

Thank you.

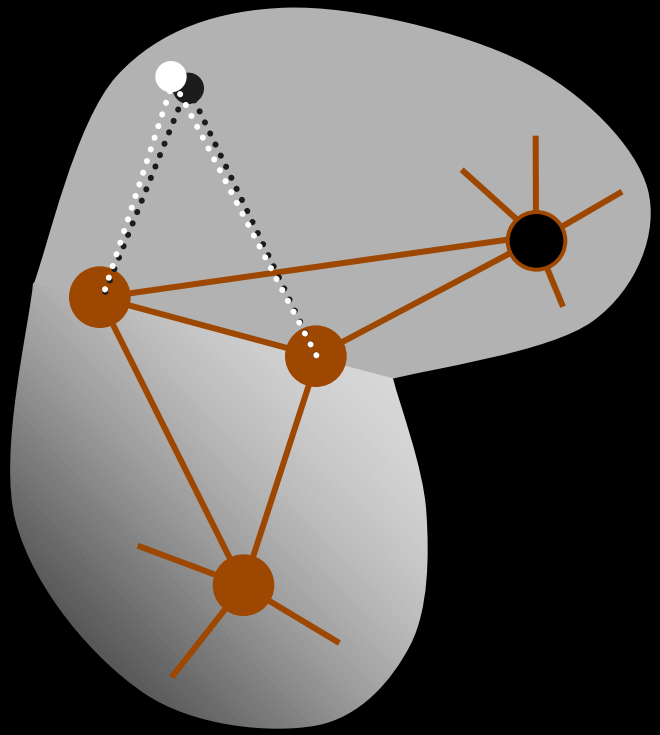
Regular ↔ Irregular Connectivity

- **Re-meshable**
  - Bunnies, Horses, various Roman Statues, …
  - Highly detailed, dense, scanned data sets
- **Not Re-meshable**
  - Cessnas, Spanish Galleons, Sandals, …
  - Careful designed meshes with sharp features
  - CAD models, Viewpoint models

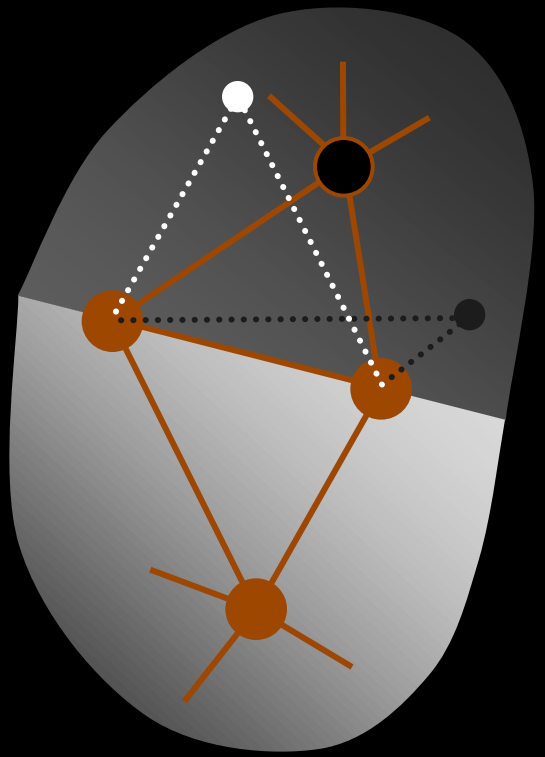
Predictive Coding



good



not convex ➔ bad



not planar ➔ bad

Attaching Geometry