Polylog6: Pioneering Dynamic Equilateral Polyform Discovery

Polylog6 redefines geometric data management, transitioning from static compression to a dynamic, hierarchical discovery process. Our node-based architecture is engineered for the precise assembly, validation, and exploration of an expansive universe of polyforms, from fundamental Johnson and Archimedean solids to complex, novel compound structures. The system's core capabilities, including dynamic validation, face merging, and closure detection, unlock unparalleled geometric accuracy and facilitate the discovery of new forms.

The Four Pillars of Polylog6 Geometry – Enabling Novel Discovery:

Uniform Edge Lengths

All polygons maintain **identical unit edge lengths**, ensuring foundational consistency across all constructions, from simple Johnson solids to complex compounds.

Exact Edge Connections

Connections are strictly **vertex-to-vertex, edge-to-edge**, preserving inherent symmetry and structural integrity in forms like the Cuboctahedron.

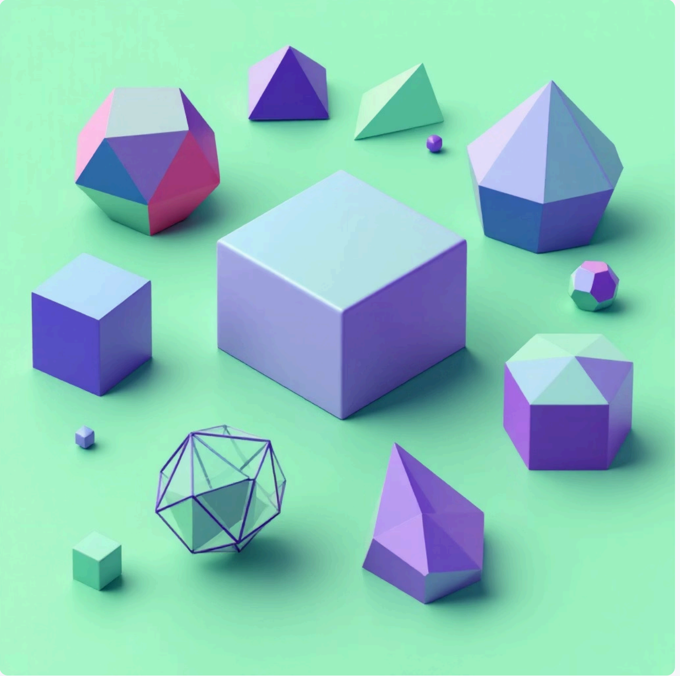
Scaling by Edge Count

Larger forms are created by **more unit-length edges**, not longer ones, allowing scalable and geometrically accurate combination of polyforms.

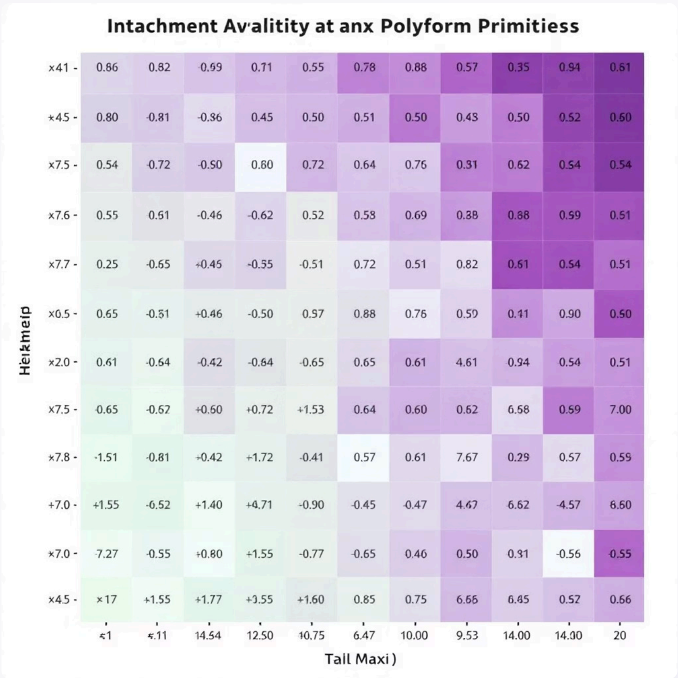
Undeformed Folding

Folding occurs **only at shared edges**, with no internal deformation, critical for maintaining geometric integrity in structures like the Snub Cube.

These principles guide our system in constructing and categorizing polyforms. Our full system inherently maintains the geometric relationships and symmetry that define these structures, facilitating both accurate digital representations and the discovery of new, geometrically sound forms.



The Polylog6 system relies on a sophisticated 18x18 Attachment Matrix to define all possible valid connections between its primitive polyforms. This matrix acts as the foundational rule-set for ensuring geometric integrity during polyform assembly and discovery. With full system capabilities, this matrix becomes dynamic, enabling real-time validation and new discoveries.



Dynamic Validation

Moving beyond static lookups to real-time verification of polyform assemblies, ensuring geometric accuracy for 2,916 symbols.

Face Merging

Intelligent identification and combination of coplanar faces within complex polyforms, simplifying topology and reducing data redundancy.

Closure Detection

Automated algorithms to confirm that complex polyform structures are fully enclosed and geometrically sound, essential for novel discovery.

System Evolution: From Foundation to Full Discovery

Foundational MVP (Phase 1)

- **18** Primitives
- **97** Polyhedra
- Static Matrix Lookup
- View-Only API with LOD Rendering

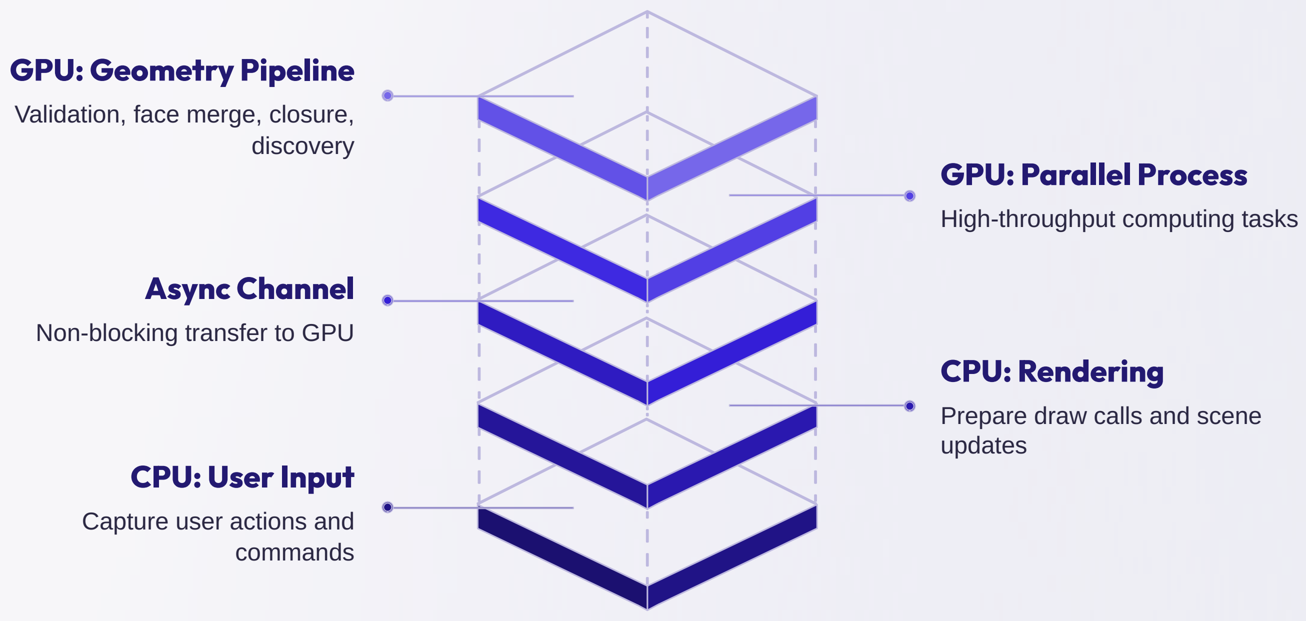
A robust starting point establishing core geometric integrity.

Full System (Phases 2-7+)

- **2,916** Symbols
- **110+** Polyhedra
- Dynamic Validation, Face Merging, Closure Detection
- User Assembly & Novel Discovery

The complete vision for generative polyform exploration and engineering.

The architecture supporting this evolution spans both local processing for user interaction and powerful server-side computation for complex validation and discovery, utilizing asynchronous channels for optimal data flow.



Performance Metrics & Targets for Full System:

99.9%

Geometric Accuracy

Target for structural integrity and connection precision in all generated polyforms.

<100ms

Validation Latency

Average time for dynamic geometric validation of new polyform assemblies.

100x

Discovery Speed

Factor increase in the rate of novel polyform discovery compared to manual methods.

2,916+

Polyform Capacity

Total number of unique polyform symbols the system can dynamically manage and generate.

This innovative approach moves beyond simple compression to a comprehensive system for building and exploring complex equilateral polyform compositions with unparalleled efficiency and unwavering geometric accuracy.

Explore the Technology | View Research Paper

For a comprehensive transformation including the detailed technical slides (Edge Matching Matrix, Edge Matching Flow, Face Topology, Closure Detection, System Architecture, Implementation Roadmap), please submit follow-up requests for each specific slide you wish to create. This current card provides a high-level overview and clarifies the core geometric principles and system states.

Polylog6: Core Insight - Equilateral Polyform Reducibility and Novel Discovery

Our system's foundation is built on the inherent reducibility of complex polyforms into standardized, perfectly equilateral polygon nodes, enabling both precise construction and the discovery of novel structures within a powerful, dynamic framework.

Rigid Equilateral Principles

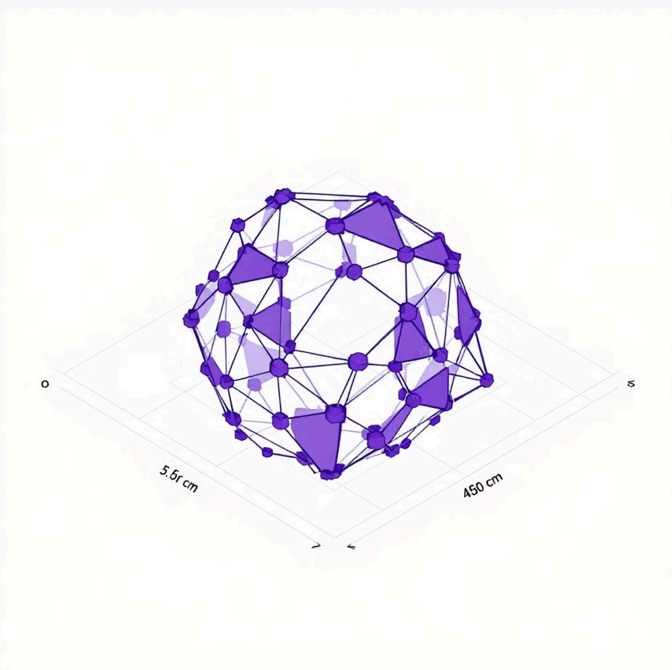
- Built from perfectly equilateral polygons (triangles, squares, hexagons, etc.).
- Identical unit edge length for all edges in the workspace.
- Precise edge-to-edge attachment ensures compatibility.
- Undeformed folding only at shared edges; individual polygons remain pristine.
- Naturally preserves geometric symmetry of forms like Johnson and Archimedean solids.

Dynamic Node-Based Discovery (Phases 2-7+)

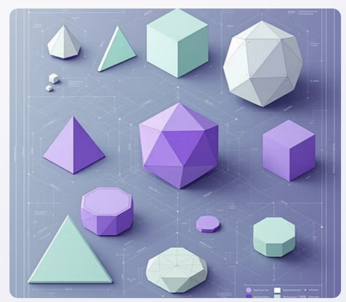
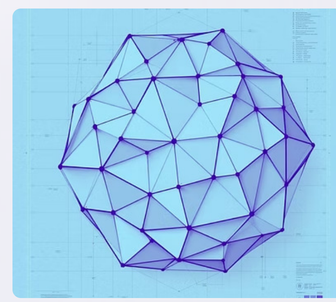
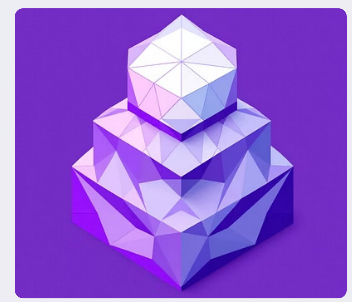
- Each equilateral polygon acts as a standardized node for assembly.
- Enables efficient hierarchical encoding and novel polyform discovery.
- Scalable building block approach: Larger polyforms are composed of more unit-length edges, not longer ones.
- Supports the generation of 2,916 distinct polyform symbols and 110+ complex polyhedra.
- Facilitates user assembly and the creation of new compound polyforms.

Validated & Applied Representation

- GPU/CPU architecture ensures strict geometric validation, face merging, and closure detection.
- Transforms polyforms into efficient, string-based representations for tiered classification.
- Guarantees adherence to geometric regularity, non-deformation, and inherent symmetry.
- Precisely models forms like the cuboctahedron and snub cube, maintaining integrity through unit edge and angular rules.



Complex polyhedral structures, like Johnson or Archimedean solids, are formed by perfectly equilateral polygons with identical unit edge lengths, connected strictly edge-to-edge without deformation. This node-based system allows efficient encoding and maintains inherent symmetry.

The gallery illustrates basic equilateral polygons and their hierarchical assembly into complex forms. Strict edge-to-edge attachment and folding rules are maintained, ensuring perfect geometric regularity and symmetry. Larger polygons are larger due to a greater number of identical unit edges, facilitating scalable compound polyforms and their dynamic discovery.

Polylog6: Tier 0 Primitives – Foundation for Advanced Polyform Discovery

The foundational "Tier 0" of Polylog6 defines the universal vocabulary of primitive **equilateral polyforms**. Each is rigorously defined for geometric consistency and efficient encoding, forming the bedrock for our current MVP (18 primitives) and enabling the full vision of **2,916+ fundamental symbols**, dynamic validation, and novel polyform discovery.

Strict Geometric Consistency

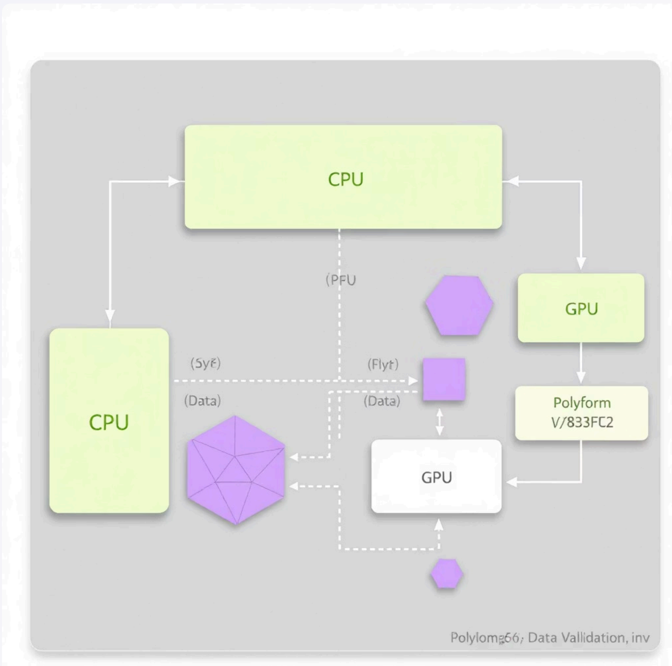
All edges are of identical unit length across the entire workspace (e.g., triangle, square, hexagon edges are precisely the same length). Each polygon maintains its perfect geometric shape with equal internal angles.

Strict Edge-to-Edge Attachment

Polygons connect seamlessly without deformation or overlap, enabling robust hierarchical encoding and symbolic representation crucial for dynamic validation and assembly.

This standardization is critical for the full Polylog6 vision, ensuring accurate construction and representation of complex structures like **Johnson solids** (e.g., square pyramids) and **Archimedean solids** (e.g., cuboctahedron).

Intended System Vision (Phases 2-7+): Dynamic Discovery & Validation



Our intended system architecture leverages both CPU and GPU for parallel processing. Asynchronous channels facilitate rapid data flow for geometric validation, face merging, and closure detection, essential for dynamic user assembly and novel polyform discovery.

Core Principle: Node-Based Equilateral System

SquareSquare: identical unit edge length and equal right angles; joins precisely edge-to-edge to triangles and hexagons, larger than a triangle due to more unit edges, not longer edges.

TriangleEquilateral triangle: identical unit edge length and equal internal angles; connects edge-to-edge without deformation to form composite shapes.

HexagonRegular hexagon: identical unit edge length and equal internal angles; connects seamlessly edge-to-edge to build larger lattices—larger than square by edge count, not edge length.

Polylog6 prevents arbitrary shape manipulation or deformation. Folding occurs **ONLY** at shared edges **between distinct polygons**, maintaining perfect geometric integrity within each individual polygon. This is critical for generating and validating complex structures like cuboctahedra and snub cubes.

Rigorous Geometric Integrity & Folding Rules

- **Identical Unit Length for All Edges:** Consistently applied across the entire workspace.
- **Equal Internal Angles:** Ensures **perfect geometric consistency** of each polygon.
- **Strict Edge-to-Edge Attachment:** From vertex to vertex **between separate equilateral polygons**, preventing deformation or arbitrary bending.

This allows complex forms like **Archimedean solids** while guaranteeing each **equilateral polygon remains a perfect, undeformed shape**, paving the way for dynamic construction and validation.

Expanded Unicode Encoding & Dynamic Validation (Phases 2-7+)

- **Identical unit edge length** and **equal internal angles** facilitate discrete Unicode symbols (e.g., Ω_1, Ω_2, Δ) for each primitive **equilateral polyform**.
- **Compressed Representation:** Efficient storage and transmission of 3D data, crucial for large-scale discovery.
- **Dynamic** $O(1)$ **Validation:** Folding exclusively at shared edges between distinct polygons enables rapid and real-time validation of user-assembled polyforms.
- **Face Merging & Closure Detection:** Automated identification and resolution of merged faces and detection of closed polyform structures for novel discovery.

This capability is crucial for encoding structures from simple **compound polyforms** to complex **Johnson solids**, preserving their inherent symmetry and enabling programmatic exploration.

Polylog6 Tier 0 Roadmap: From Foundational MVP to Comprehensive Discovery

Intended Vision (Phases 2-7+)

2,916+ Symbols

- **36 Single Polygons:** All regular, convex polygons up to N edges.
- **288 Equilateral Polyform Pairs:** Stable 2-polygon combinations.
- **1,944 Equilateral Polyform Chains:** Stable 3-polygon sequences.
- **648+ Advanced Combinations:** Higher-order and specialized forms.
- **Dynamic Validation:** Real-time geometric integrity checks for user assembly.
- **Face Merging & Closure Detection:** Automated processes for new polyform discovery.

This comprehensive vocabulary enables dynamic validation, user assembly, and extensive novel polyform discovery, pushing the boundaries of geometric exploration.

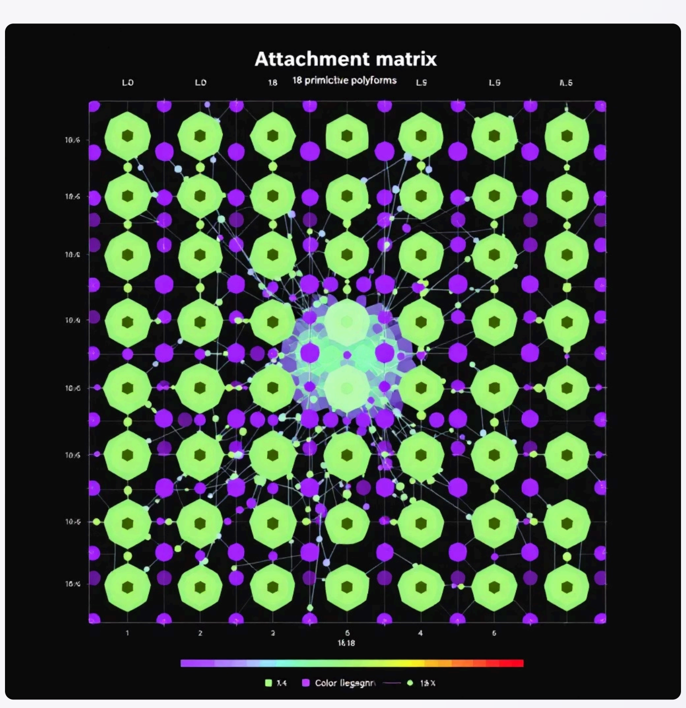
Current MVP (Phase 1)

18 Primitives

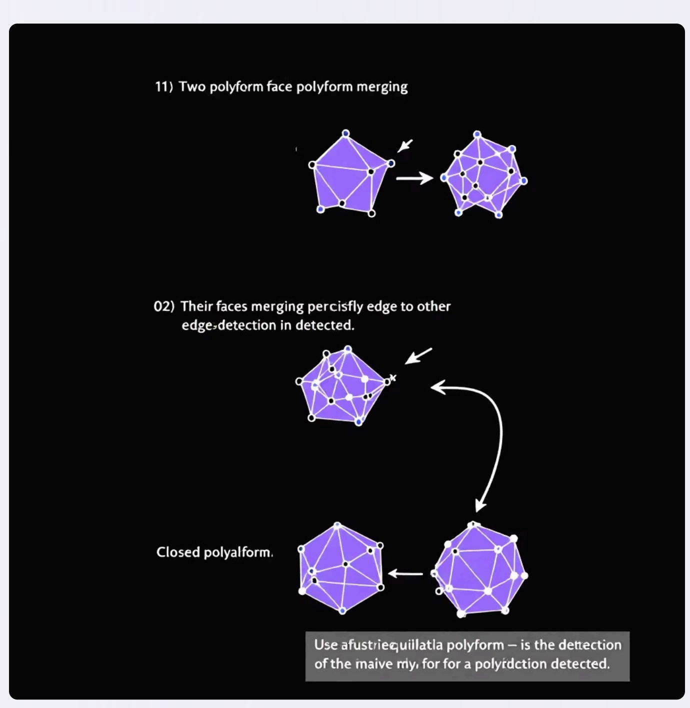
- **3 Base Polygons:** Triangle, Square, Hexagon
- **15 Derived Polyforms:** Stable combinations up to 3 connected polygons.

Focuses on essential building blocks for static matrix lookup and view-only functionalities, laying the groundwork for future expansion.

This robust, expanding vocabulary forms the backbone for constructing all higher-tier polyforms within the Polylog6 system. It emphasizes geometric precision, **equilateral polygon**-based assembly where all edges are identical unit length, and symbolic compression. This foundation is critical for enabling the full vision of dynamic assembly, validation, and novel discovery, ensuring the preservation of intrinsic symmetry and geometric integrity.



The current 18x18 attachment matrix (MVP) serves as a static lookup for valid connections, providing a foundational understanding of polyform combinatorics. This will evolve into a dynamic system capable of processing 2,916+ symbol interactions.



Automated face merging and closure detection are key capabilities of the intended system. This process allows for the systematic discovery of new, stable polyforms by algorithmically testing valid connections and identifying complete, closed structures.

Polylog6: Tier 0 Primitive Vocabulary – Towards the Full Vision (2,916+ Symbols)

The foundational "Tier 0" of Polylog6 establishes a universal geometric vocabulary for building complex structures, driving the capabilities of our full intended system. It's built on three core, visually enforced principles, consistent across all phases:

Strictly Equilateral Polygons

All edges, from a triangle to a hexagon, share an identical unit length across the entire workspace, preserving intrinsic symmetry.

Undeformable Nodes

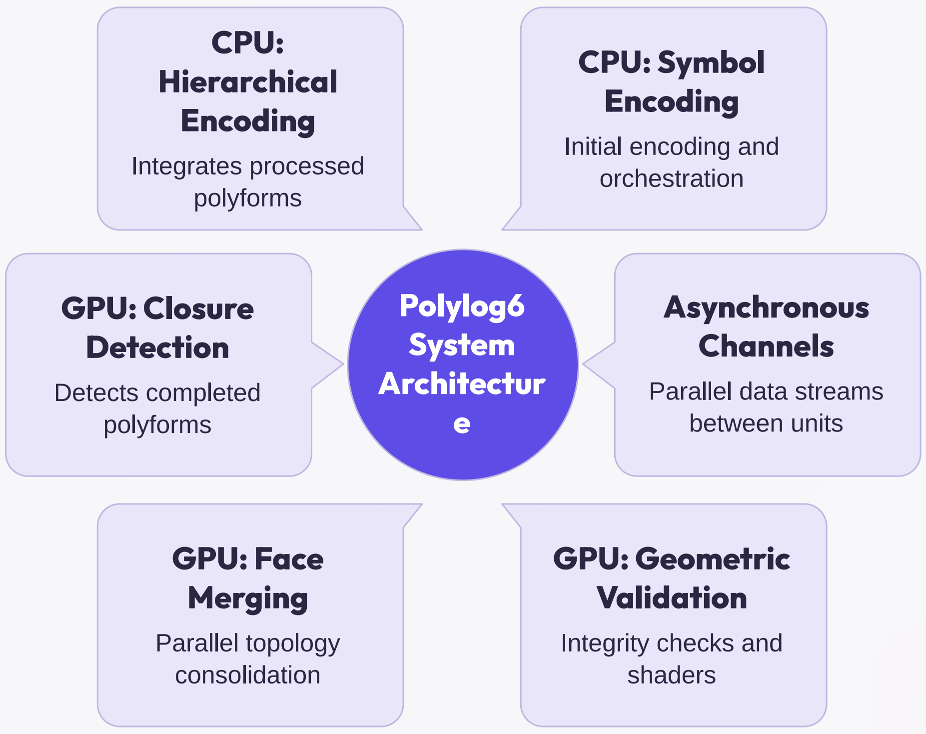
Each polygon maintains its perfect geometric integrity. Larger polygons are simply composed of more identical unit-length edges, not longer ones.

Precise Edge-to-Edge Attachments

Folding occurs only at shared edges between distinct polygons, enabling seamless and non-deforming assembly in 3D space.

This rigorous architecture is fundamental for robust hierarchical encoding, dynamic geometric validation, and efficient processing by our specialized GPU/CPU pipeline. It guarantees the preservation of inherent symmetry and relationships found in complex polyforms like **Johnson Solids** (e.g., square pyramids) and **Archimedean Solids** (e.g., cuboctahedron), enabling predictable construction and stable identification throughout the system's intended vision.

System Architecture: Enabling Dynamic Validation and Polyform Discovery



This architecture is designed for parallel processing and real-time validation, crucial for exploring the vast space of polyforms. The CPU manages the symbolic representation and data flow, while the GPU is specialized for rapid geometric computations, ensuring integrity at every step.

The Polylog6 Vision: Expanding the Primitive Vocabulary

Full Vision: 2,916+ Symbols

The full vision expands to over 2,916 unique Unicode symbols, encompassing single, paired, and chained equilateral polygons. This extensive vocabulary enables dynamic validation, comprehensive user assembly, and novel polyform discovery.

Advanced Encoding & Validation

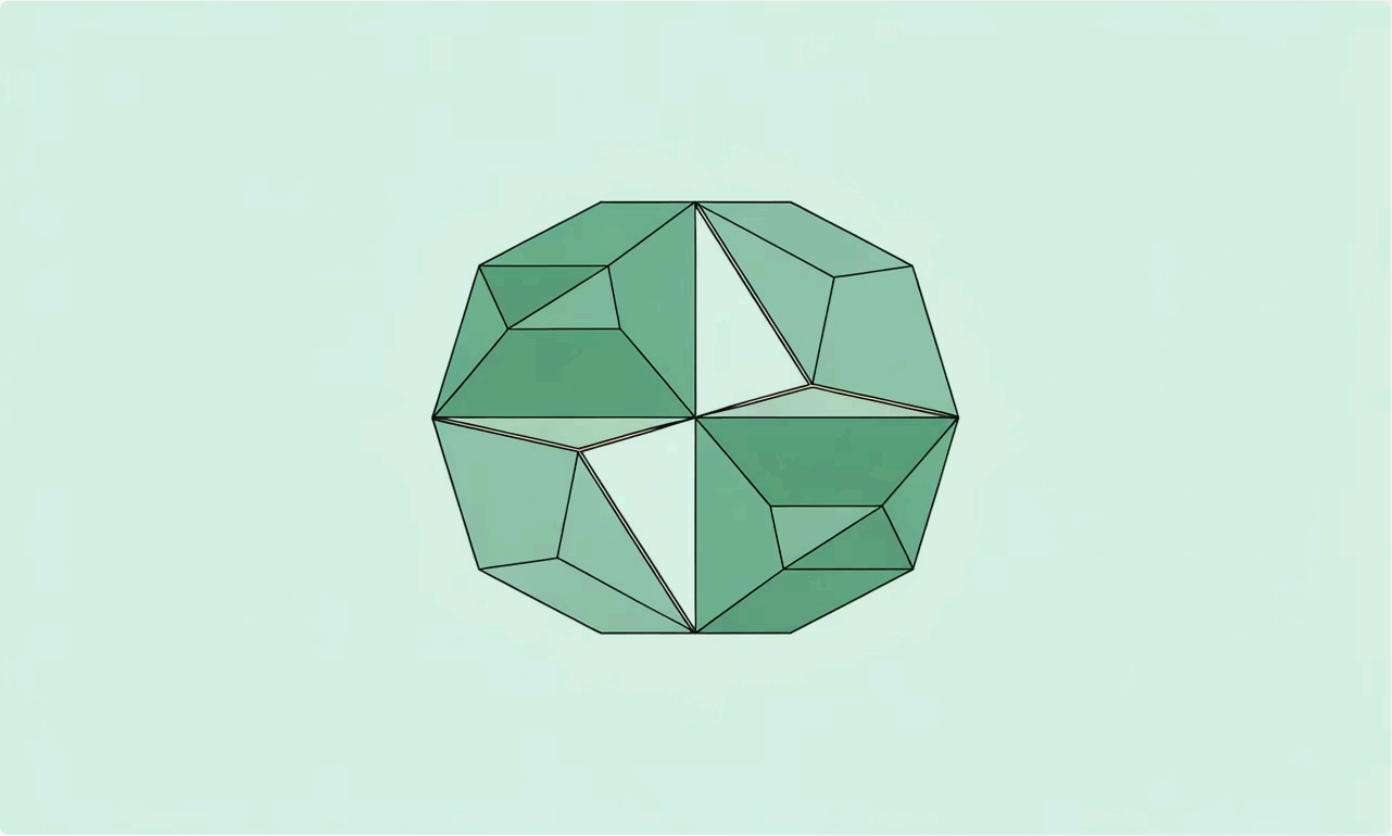
This comprehensive vocabulary supports efficient, deterministic encoding and geometric validation. It forms the foundational layer for higher-tier polyform construction, including face merging, closure detection, and symbolic compression for complex structures.

Current MVP: 18 Primitives

The initial MVP provides 18 fundamental single equilateral polygons, sufficient for core functionalities like static matrix lookups and basic polyhedra construction, serving as a stable foundation for Phase 1 development.

The expanded Tier 0 Primitive Vocabulary (Intended Vision) includes over **2,916** unique Unicode symbols Ω_0, allowing for the efficient and deterministic encoding of perfectly equilateral geometric primitives. This robust foundation ensures dynamic geometric validation and high-performance rendering by a specialized GPU/CPU architecture, laying the bedrock for all higher-tier polyform construction while inherently preserving their symmetry factors. This enables real-time face merging and closure detection, crucial for advanced polyform manipulation and discovery.

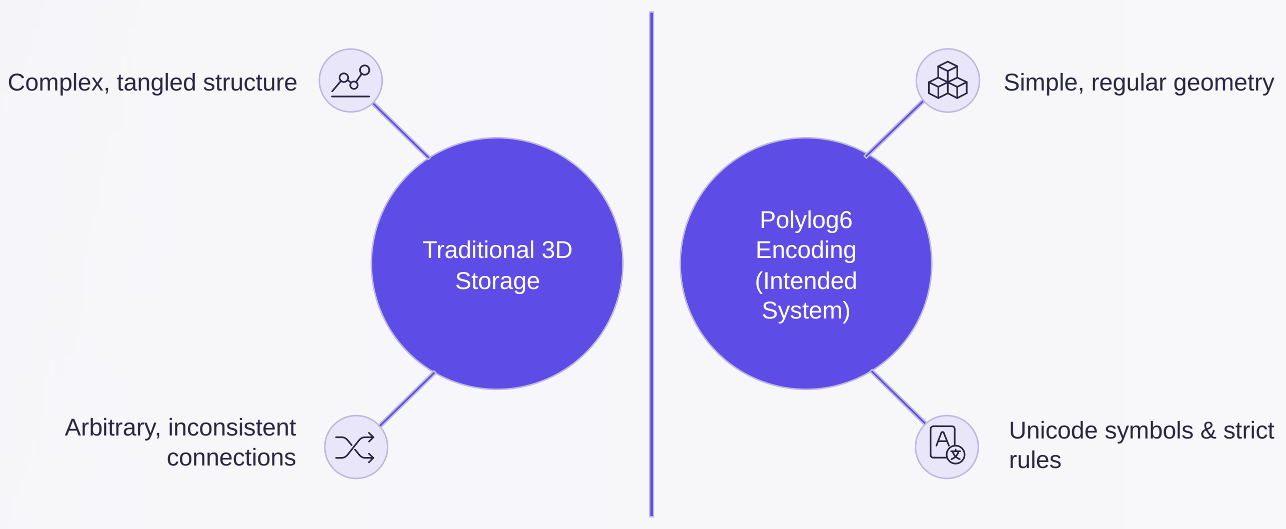
Future Directions: Dynamic Face Merging and Closure Detection



A core capability of the intended system is the dynamic merging of polyform faces and real-time detection of closed volumes. This allows for the construction and validation of complex 3D structures on the fly, a significant leap beyond static representations.

Polylog6: The Geometric Encoding Revolution

Polylog6 introduces a groundbreaking system for encoding **perfectly regular, equilateral polyforms** where **all edges across the entire workspace are of identical unit length**. This enables unprecedented precision, compression, and discovery of novel geometric structures, ranging from fundamental **Johnson solids** to complex **Archimedean solids**.



The Problem: Traditional 3D Storage

Arbitrary Connections

Compromises geometric integrity with internal deformations, leading to unpredictable forms.

Inconsistent Generation

Lacks rule-based methods for ensuring valid and novel geometric structures, hindering discovery.

Inefficient Representation

Struggles with highly symmetrical forms without strict geometric rules, leading to data bloat.

> **Traditional storage:** A simple 3D cube often requires **~3 KB** for vertex data, mesh topology, and materials. This is highly inefficient for complex structures without strict geometric rules.

The Solution: Polylog6 Encoding (Intended System)

Strict Edge-to-Edge

Connections maintain identical unit edge length consistency, enabling precise folding without deformation.

Symmetry Preservation

Inherent constraints maintain symmetries (e.g., cuboctahedron, snub cube), foundational for geometric validation.

Undeformable Nodes

Polygons retain rigid shapes; folding occurs only at shared edges, ensuring geometric integrity.

Dynamic Validation & Discovery

Enables real-time geometric validation and efficient discovery of novel, complex polyforms via our GPU/CPU pipeline.

Face Merging & Closure Detection

Advanced algorithms support face merging and closure detection, crucial for constructing hierarchical and sealed structures.

> **Polylog6 Advantage:** The same 3D cube, encoded with Unicode symbols, can be represented in as little as **~2 bytes**, achieving unprecedented compression and geometric accuracy.

Current MVP: 18 Primitives

The initial MVP focuses on 18 fundamental single equilateral polygons, sufficient for static matrix lookups and basic polyhedra construction. A stable foundation for Phase 1.

Intended Vision: 2,916 Symbols

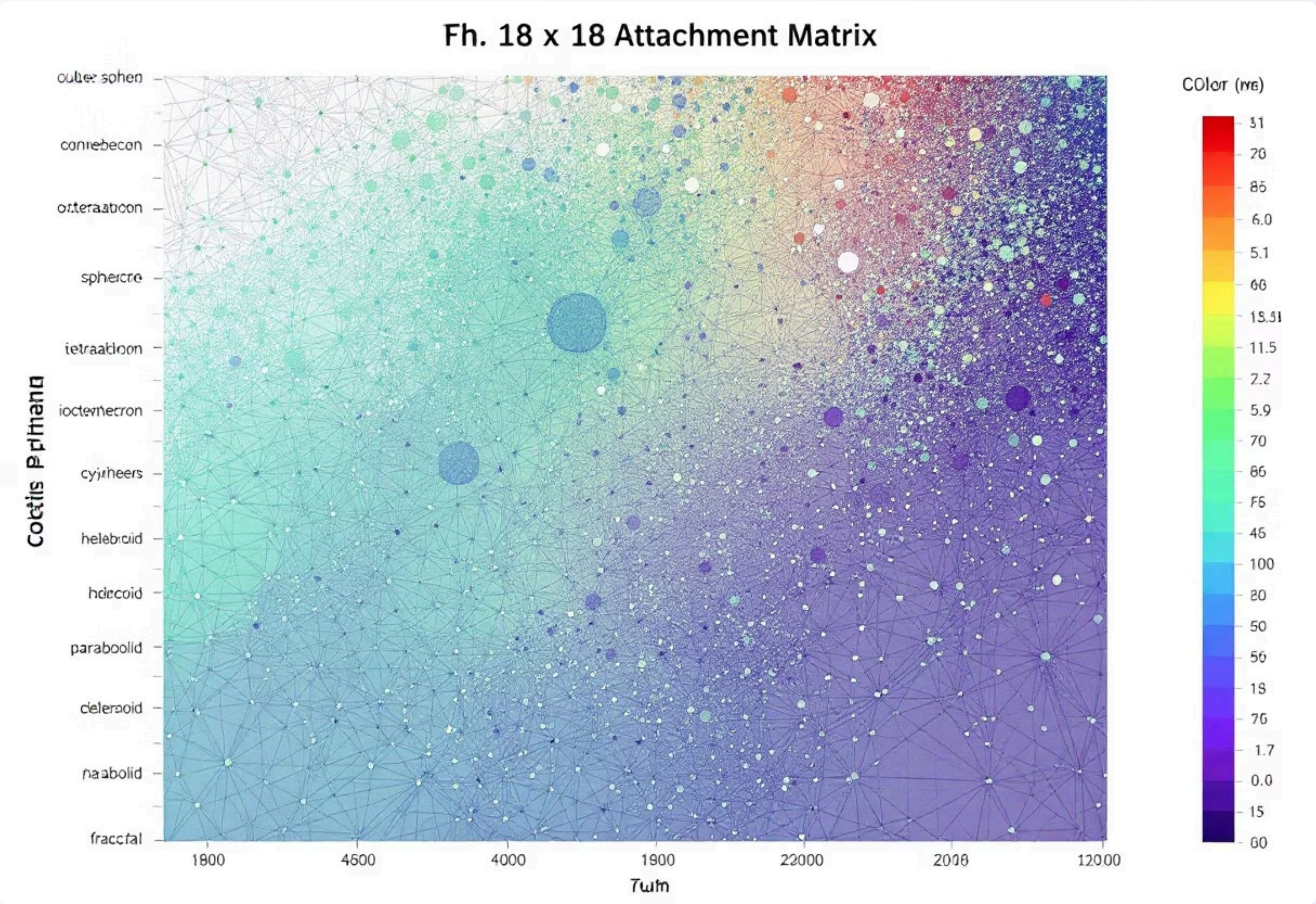
The full vision expands to 2,916 unique Unicode symbols, encompassing single, paired, and chained equilateral polygons for comprehensive user assembly capabilities beyond the MVP.

GPU/CPU Architecture

This comprehensive vocabulary supports efficient, deterministic encoding, dynamic validation, and high-performance rendering by a specialized GPU/CPU pipeline.

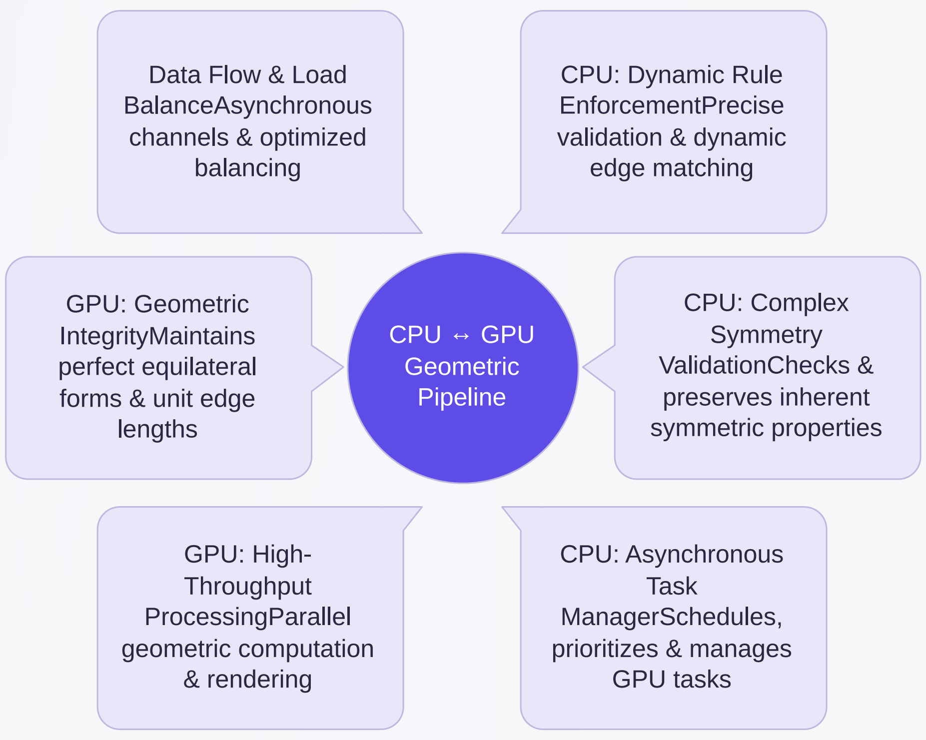
Polylog6 System Architecture

18x18 Attachment Matrix (Phase 1)



Polylog6: Full System Vision & Architecture for Geometric Integrity & Discovery

The Polylog6 system's full vision leverages a sophisticated asynchronous architecture, distributing computational load between CPU and GPU. This ensures optimal performance for geometric integrity and novel structure discovery, minimizing latency and maximizing throughput. Our layered approach guarantees all polyforms adhere to critical geometric rules and enables the advanced capabilities of the Full System (Phases 2-7+).



Strict Edge-to-Edge Connections

Dynamic validation ensures all connections maintain identical unit edge length consistency and prevent deformation, enabling **complex composite forms**.

Symmetry Preservation

Constraints inherently preserve the symmetry and structural integrity of known and **novel polyforms**, from Johnson solids to Archimedean forms.

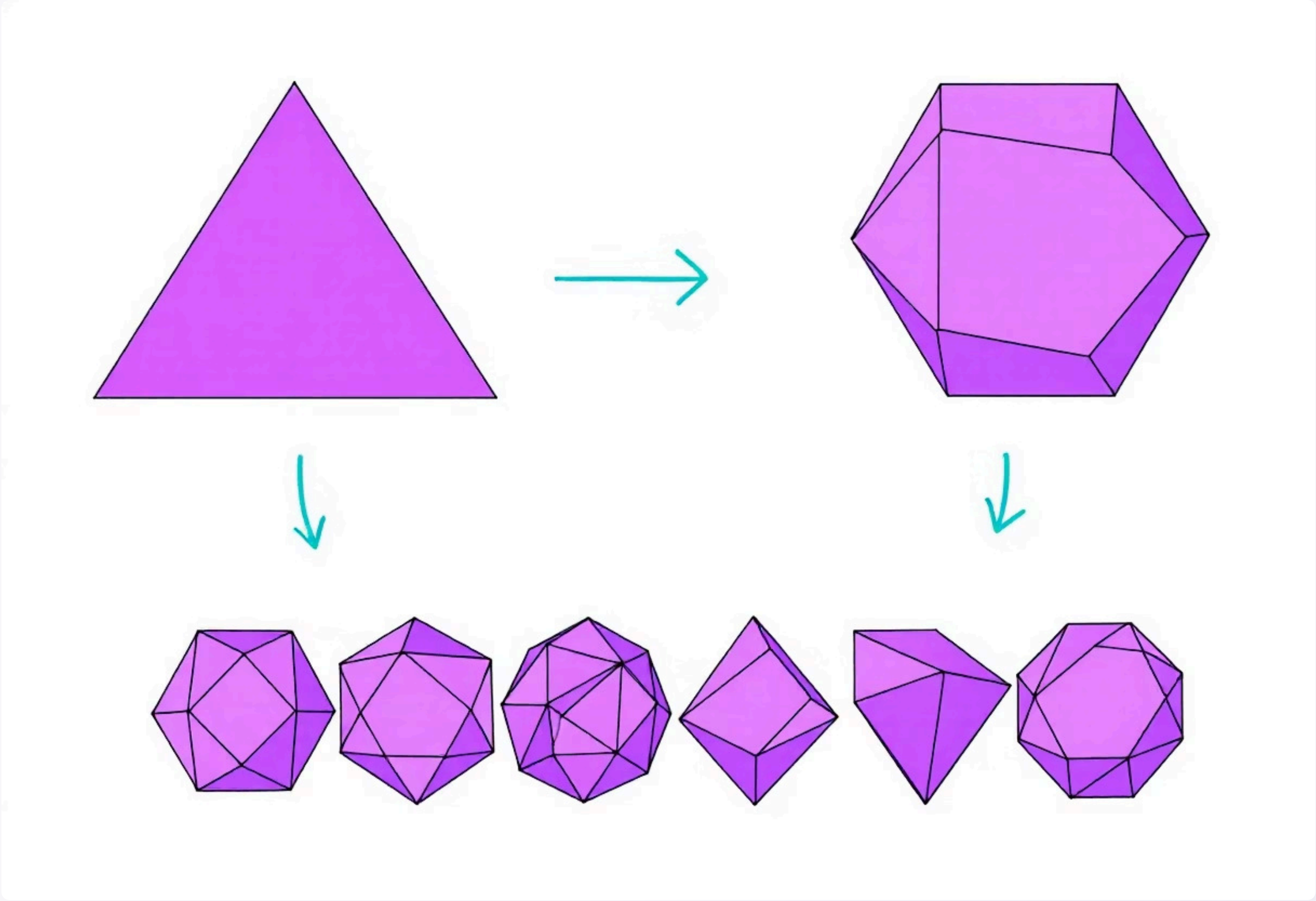
Undeformable Nodes

Folding occurs only at shared edges; polygons retain rigid shapes, allowing for **dynamic face contact detection and merging**.

Scalable Assemblies & Discovery

Enables precise construction of compound and scaled polyforms, and the discovery of **new symmetric arrangements**.

This architecture and these core geometric principles underpin the advanced capabilities of the Full System (Phases 2-7+), enabling the discovery and precise encoding of novel, highly symmetric geometric structures.



The system is designed for unparalleled efficiency in maintaining geometric accuracy for **perfectly equilateral polygons with all edges identical unit length**, particularly for complex polyform assemblies and their inherent symmetry. This applies to both the foundational MVP (Phase 1) and our future phases of custom polyform assembly and discovery:

2,916	~2ms	<1.5GB	~15%
Symbols Supported	**Avg. Latency (Target)**	**VRAM Usage (Target)**	**Avg. CPU Util. (Target)**
Target for the Full System (Phases 2-7+), enabling **custom polyform assembly and novel discovery**.	Minimal average latency for critical polyform validation and rendering tasks, ensuring no deformation and **perfect edge-to-edge fits**, even for intricate structures like the cuboctahedron.	Optimized memory footprint for large-scale, rule-abiding equilateral geometric data on GPU, efficiently handling the complexity of **compound and scaled polyforms**.	Efficient GPU offloading keeps CPU utilization low, allowing the CPU to focus on precise **equilateral polygon rule enforcement and dynamic validation of complex symmetric properties**.

Roadmap: From Foundation to Full System Capabilities

Current Foundation (MVP - Phase 1)

- Static edge matching via 18x18 matrix for individual Johnson and Archimedean solids.
- Fixed face topology per polyhedron (no merging).
- O(1) validation using pre-computed stability scores.
- View-only capability (no user assembly creation).
- 97 polyhedra accessible via API with LOD rendering, each maintaining precise equilateral and symmetric properties.
- Supports 18 primitives.

Full System Vision (Phases 2-7+)

- Real-time edge matching validation during user assembly, enabling **complex composite forms** (e.g., a rectangular hexagon from squares on a hexagon).
- Dynamic face contact detection and merging (e.g., 2 triangles → 1 quad), **critical for scalable compound polyforms**.
- Closure detection (0 boundary edges = closed assembly), **validating integrity of complete symmetric structures**.
- Runtime symbol generation and tier promotion, scaling to **2,916 symbols**.
- Custom fold angles and **novel polyform discovery**, exploring new symmetric arrangements.
- Aims for **110+ polyhedra and beyond**.

Polylog6: Tier 0 - Equilateral Primitives & Unicode Index for the Full System

The foundation of the Polylog6 Full System (Phases 2-7+) rests on its Tier 0 primitive vocabulary, precisely indexed via a FastAPI-powered Unicode system. This tier defines the elementary **equilateral geometric building blocks**, crucial for enabling the dynamic construction and discovery of complex, symmetrical polyforms like Johnson and Archimedean solids. Key principles driving the full system's capabilities include:

Equilateral Polygons

Strict edge-to-edge attachment with equal internal angles, foundational for dynamic validation and face merging.

Consistent Unit Edge Length

All edges are identical unit edge length across the entire workspace, ensuring seamless compatibility for composite forms.

Perfect Shapes

Polygons maintain perfect equilateral shapes; no deformation or stretching is permitted, critical for geometric integrity.

Folding Rules

Precise folding applies **only at shared edges between distinct polygons**, not within individual ones, supporting novel polyform discovery.

This immutable base, characterized by perfect geometric regularity, is essential for the hierarchical construction and symmetry preservation of all higher-order polyforms in the intended system.

Tier 0 Primitive Vocabulary: Building Blocks for Dynamic Assembly

Single Polygons: 36

The core **18 elementary equilateral polygons** (e.g., triangle, square, hexagon) and their mirrored forms, each with **identical unit edge length**.

Polygon Pairs: 324

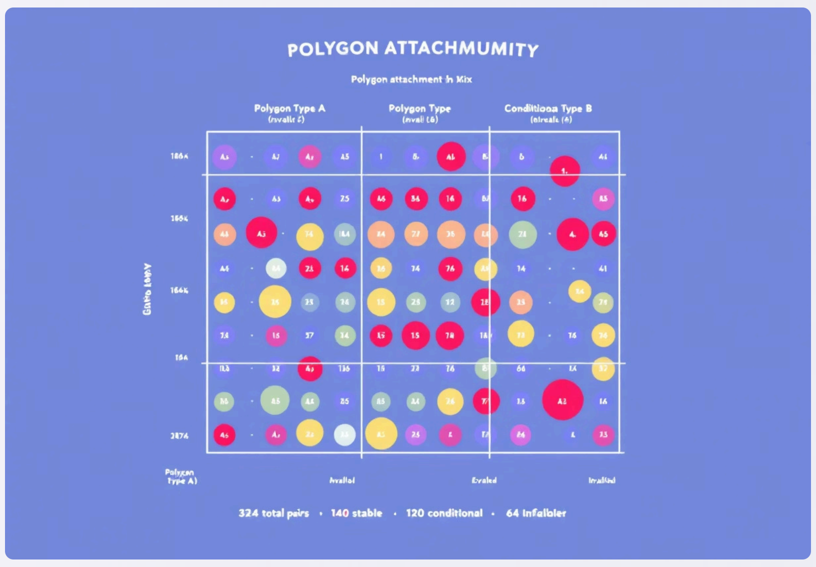
Combinations of two **equilateral polygons strictly connected edge-to-edge**, maintaining **perfect equilaterality** and **zero deformation**, crucial for real-time edge matching validation.

Polygon Chains: 2,556

Sequences of three **equilateral polygons connected at shared edges**, encoding rules for 3D projection and compound polyform discovery.

Total Tier 0 Equilateral Primitives: 2,916 (For Full System, Phases 2-7+)

These primitives are encoded into unique Unicode symbols for compact representation and efficient property validation within the Full System architecture. This hierarchical encoding enables rapid discovery and validation of new polyform structures while ensuring strict geometric integrity and **unwavering equilaterality and consistent unit edge lengths**, crucial for capabilities like dynamic face contact detection and merging.



The 18x18 attachment matrix visualizes the compatibility between primitive polygons, a key component for validating complex symmetric properties and enabling dynamic assembly.

Tier 0 forms the immutable base layer, ensuring geometric integrity and consistency across all higher tiers of polyform discovery within the Polylog6 Full System through its strict adherence to:

- **Equilateral polygons:** With equal internal angles, ready for dynamic validation.
- **Edge-to-edge connections:** Always preserving unit edge length, essential for real-time assembly.
- **Non-deforming shapes:** Maintaining perfect equilaterality, enabling scalable compound polyforms.
- **Symmetry preservation:** Allowing for the construction of known polyforms like the Cuboctahedron, and facilitating the discovery of novel symmetric arrangements, where polygon size is determined solely by the number of unit edges.

Polylog6: Regular Polyforms & Immutable Geometric Architecture

Polylog6's full vision exclusively uses **regular polygons** as its foundational, immutable geometric building blocks. These polygons adhere to strict criteria ensuring perfect regularity and non-deforming shapes, enabling the dynamic validation and construction of complex polyforms:

Consistent Unit Edge Length

All internal edges within each polygon maintain an identical unit length across the entire workspace (e.g., triangle, square, hexagon edges are precisely the same length).

Perfect Regularity & Angles

Polygons maintain their precise, regular shape (no stretching, bending, or distortion) with equal internal angles (e.g., 60° for a triangle, 90° for a square).

Edge-to-Edge Attachment

Polygons attach edge-to-edge at their boundaries. Folding occurs solely along these shared edges between separate polygons, never within a polygon itself.

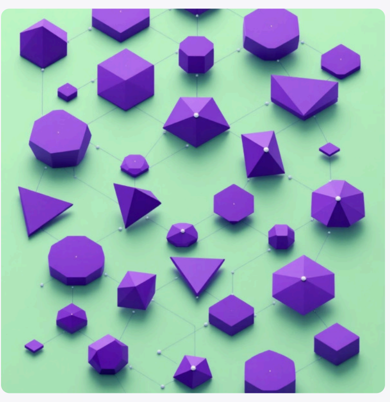
Fundamental Polyform Series & Hierarchical Structure (Full Vision)

Building Blocks: Series A-D

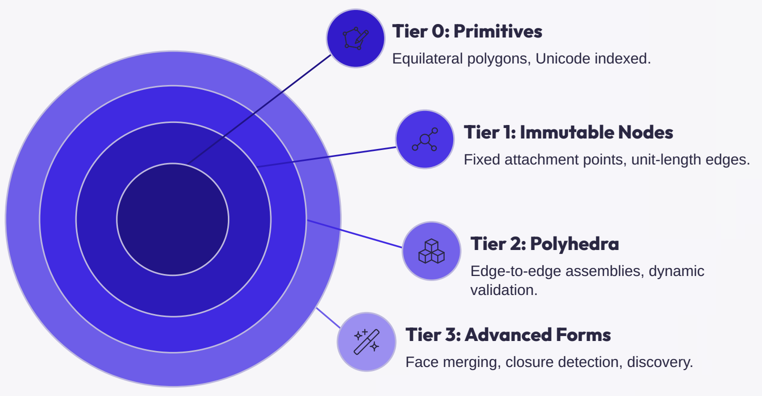
- **Series A & B:** Define 18 regular polygons (3 to 20 unit-length edges) as core Tier 0 primitives for the MVP. The full system will expand to cover all geometrically valid regular polygons.
- **Series C & D:** Provide redundant sets of regular polygons, enabling diverse assembly pathways and robust validation.
- **Unit-Edge Counts:** Dictate immutable attachment points and geometrically regular bonding between non-deforming polygons, crucial for face merging and closure detection.

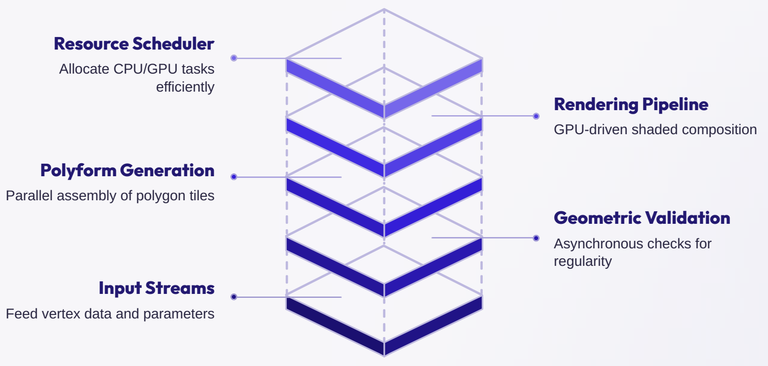
Unicode Encoding & Immutable Matrix

Strategic design of Series A, B, C, and D is crucial for the Unicode-based regular polygon encoding system. This dual coverage approach ensures robust validation and construction of complex regular polyforms with zero deformation and consistent unit edge lengths.

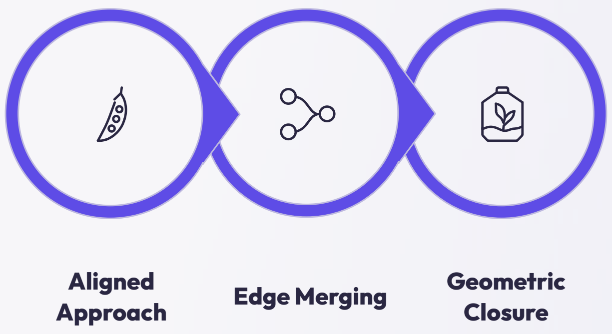


The full vision encompasses 2,916 distinct primitive Unicode symbols, enabling dynamic validation of all polyform structures.





This advanced tiered system progresses from perfectly regular primitives (Tier 0) to known polyhedra (Tier 1), candidate structures (Tier 2), and promoted forms (Tier 3). It ensures systematic discovery and validation of regular polyforms under strict geometric rules and consistent unit edge lengths. Each regular polygon's Unicode representation defines its inherent immutable properties and potential edge-to-edge attachment points, forming an immutable attachment matrix for all Polylog6 assembly, allowing for capabilities like dynamic validation, face merging, and closure detection.



98%

Validation Accuracy Target

Achieving near-perfect accuracy for dynamic geometric validation.

1.5ms

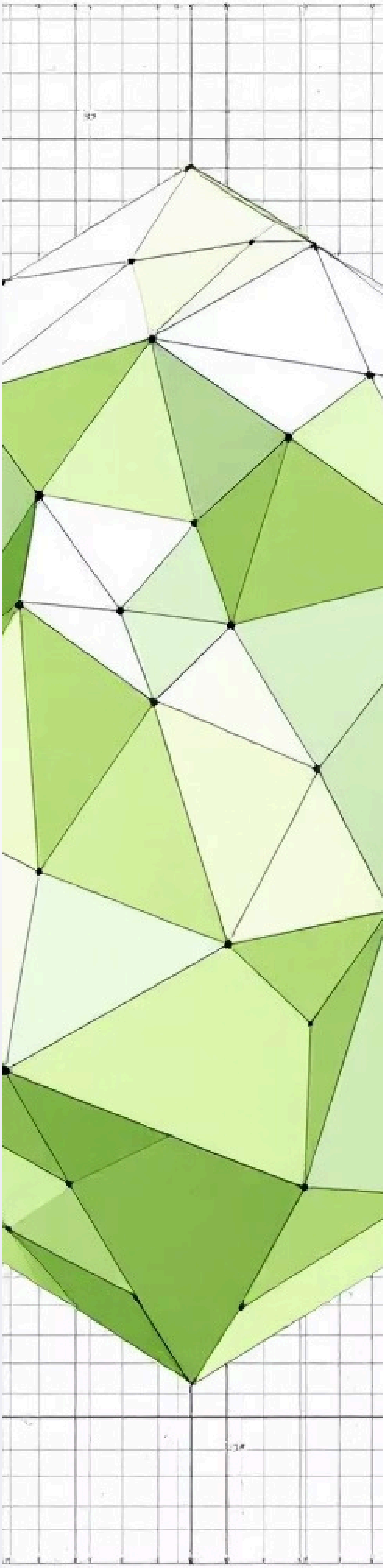
Polyform Generation Latency

Target latency for generating complex polyforms from primitives.

200K/s

Throughput for Closure Checks

Anticipated throughput for real-time closure detection on complex structures.



Polylog6: Envisioning a Dynamic Polyform Encoding Architecture

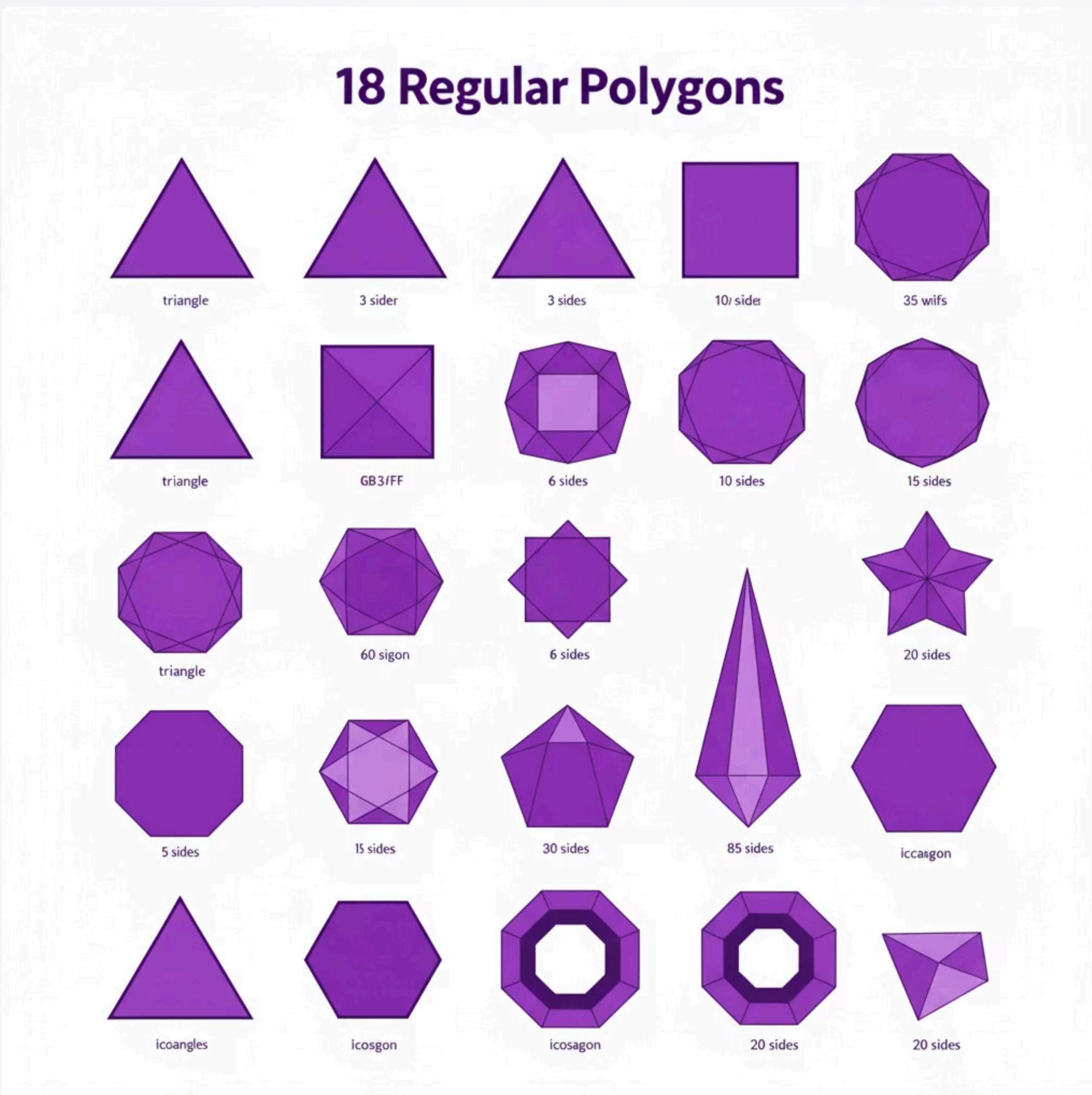
Polylog6 leverages a **Unicode-based encoding system** to precisely define and dynamically reconstruct complex polyform assemblies. Our vision focuses on an advanced architecture that ensures immutable geometric integrity, with **consistent unit-length edges** and **perfectly equal internal angles** at every hierarchical level, enabling zero-deformation and novel structural discovery.

1

Tier 0: Foundational Primitive Polygons

This foundational tier utilizes a comprehensive Unicode character set to represent all possible planar regular polygons. These form the immutable base, each defined by **unit-length edges** and **perfectly equal angles**.

- **Intended Vision:** 2,916 distinct symbols (Ω_1, Ω_2, ... Ω_{2916}) encoding all convex and star regular polygons.
- **Current System:** Initial MVP includes 18 primary primitives (triangle to icosagon).



2

Tier 1: Canonical Polyhedra & Edge-to-Edge Assemblies

Here, Tier 0 primitives combine through strict **edge-to-edge attachment rules** to form known 3D regular polyhedra. This dynamic assembly process is validated against a comprehensive library of canonical forms.

- **Intended Vision:** Automated assembly and validation of 110+ canonical polyhedra (Platonic, Archimedean, Johnson solids, etc.).
- **Current System:** 97 polyhedra accessible via API for foundational testing.

3

Tier 2: Dynamic Polyform Generation & Validation

This advanced tier focuses on the recursive assembly of Tier 1 polyhedra or other candidates to generate novel **geometrically regular structures**. This involves dynamic validation, face merging, and closure detection to ensure absolute geometric integrity and stability.

- **Intended Vision:** Automated pipeline for generating, validating, and optimizing new polyforms, leveraging GPU-accelerated computations.
- **Current System:** Limited, experimental generation capabilities.

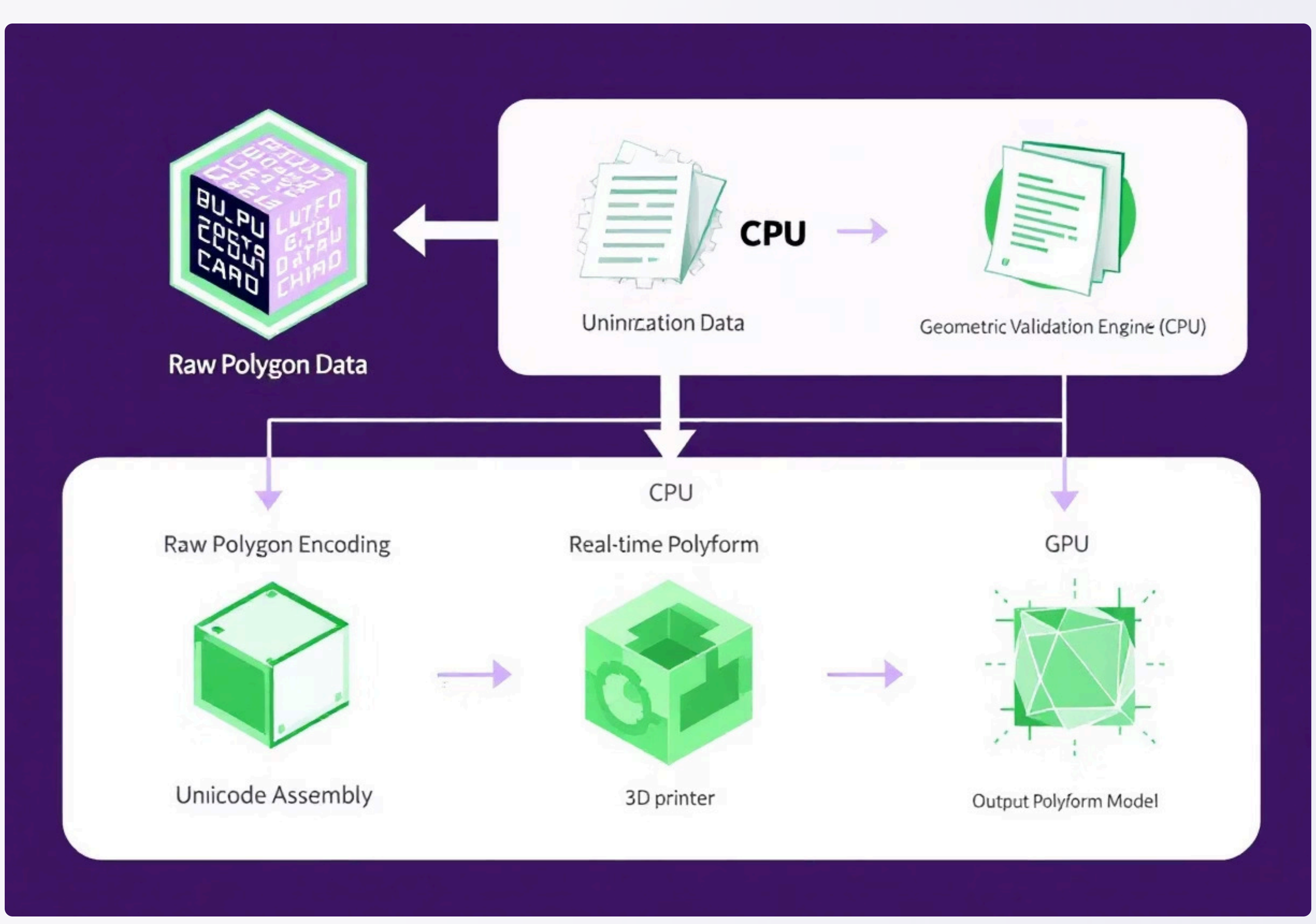
4

Tier 3: Promoted & Integrated Polyform Discoveries

Validated geometric discoveries from Tier 2 are promoted for further exploration and integration into the Polylog6 design space. These advanced polyforms adhere to all strict **regular polyform constraints**, expanding our understanding and application of complex geometries.

- **Intended Vision:** Dynamic promotion of new polyforms, each assigned a unique Unicode symbol and integrated into the global attachment matrix.
- **Current System:** Manual promotion of verified forms.

This hierarchical encoding system, combined with dynamic validation and rendering capabilities, forms the core of Polylog6's ability to discover and construct **immutable geometric architecture** with unparalleled precision.



Polylog6: The Vision for Universal Polyform Encoding

Polylog6 is architected as a revolutionary Unicode-based encoding system designed for the digital representation and discovery of complex polyforms. Our full vision ensures faithful, immutable geometric integrity by strictly adhering to critical, physically accurate geometric principles across all construction phases, leading to dynamic validation and novel discovery:

Equilateral Polygons as Nodes

Fundamental building blocks: equilateral triangles, squares, and regular hexagons. Each acts as a perfect, non-deformable node in the system.

Identical Unit Edge Length

All edges across the entire encoding and reconstruction workspace will maintain an identical unit length, ensuring consistent scaling and precision.

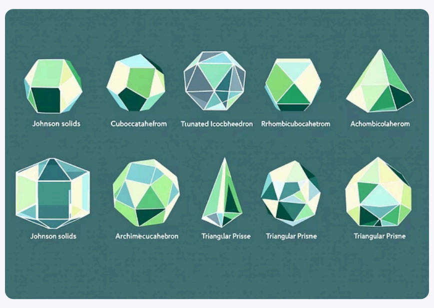
Precise Edge-to-Edge Attachment

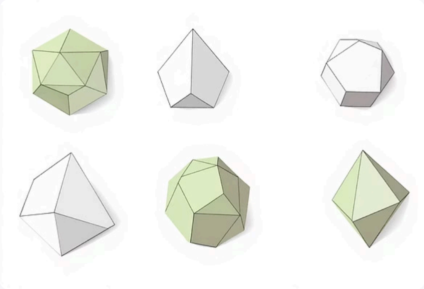
Polygons will connect seamlessly along shared vertices and unit-length edges, eliminating gaps or overlaps.

Immutable Geometric Regularity

Polygons will always maintain their perfect geometric regularity throughout all operations; **no irregular shapes or deformation are permitted**.

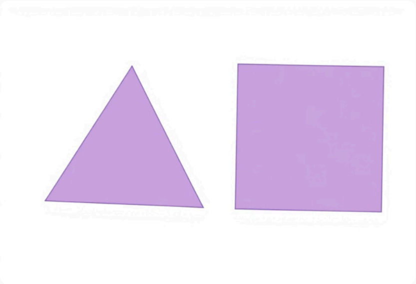
This rigorous adherence enables the precise representation of known forms like **Johnson Solids** and **Archimedean Solids**, and facilitates the discovery of novel **compound polyforms**, all while preserving inherent symmetry and geometric integrity.





1

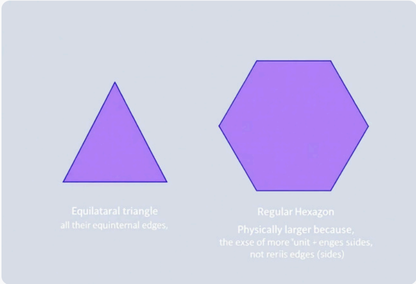
Edge Connections



Attachments occur strictly edge-to-edge between **equilateral polygons** with **identical unit-length edges**. This forms structures like the **cuboctahedron** without deformation.

2

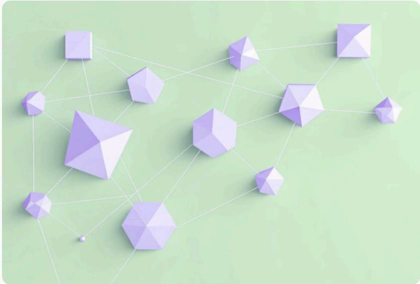
Unit Edge Length



ALL edges maintain identical unit length. Larger polygons are proportionally larger due to more unit-length edges, not longer individual edges.

3

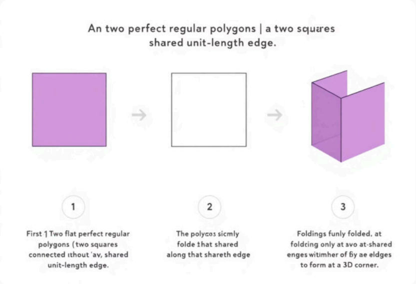
Node Geometry



Each **equilateral polygon** is an independent node with perfect internal geometry, maintaining integrity through **identical unit-length edge** connections.

4

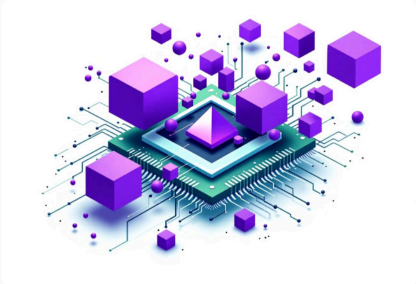
Strict Folding Rules



Equilateral polygons fold only along **shared unit-length edges** to form 3D structures. **No stretching or bending** is permitted, ensuring structural fidelity.

5

GPU/CPU Validation



Robust architecture ensures real-time validation and rendering of all polyform structures, adhering to every geometric rule for **equilateral polygons** and **identical unit-length edges**.

The Polylog6 Attachment Matrix & System Architecture

The system relies on a foundational attachment matrix to dynamically define how primitive polygons connect, ensuring geometric integrity and predictability in polyform construction, validated through a distributed CPU/GPU architecture.

High Compatibility

Allowed Connections - Dark Purple

Conditional Connections - Light Purple

Left: Polygon Type

Right: Polygon Type

Impermissible Connections - Grey

Legend & Labels - Polygon Types

Low Compatibility

CPU: Data preparation
Preprocess meshes and attributes

Geometric data focus
Precision in vertex and topology

CPU-GPU Polyform Pipeline

Asynchronous channel
Efficient, nonblocking data flow

Real-time validation
On-the-fly polyform checks

GPU: Parallel geometry
High-throughput geometric computation

Polylog6: Vision for a Unified Geometric Language

Polylog6 is designed to be a comprehensive system for encoding and manipulating complex polyforms, extending far beyond current capabilities. Our full vision incorporates a vast symbol set and dynamic validation to unlock novel geometric discoveries.

1

Full Symbol Set

Supports **2,916 distinct Unicode symbols** for comprehensive polygon types and configurations, enabling a truly universal geometric language.

2

Dynamic Validation

Real-time checks for geometric integrity, including **angular alignment, unit edge length, and edge-to-edge attachment** during construction.

3

Face Merging & Closure Detection

Advanced algorithms to identify and merge adjacent faces, and to detect when a polyform forms a **closed, watertight volume**.

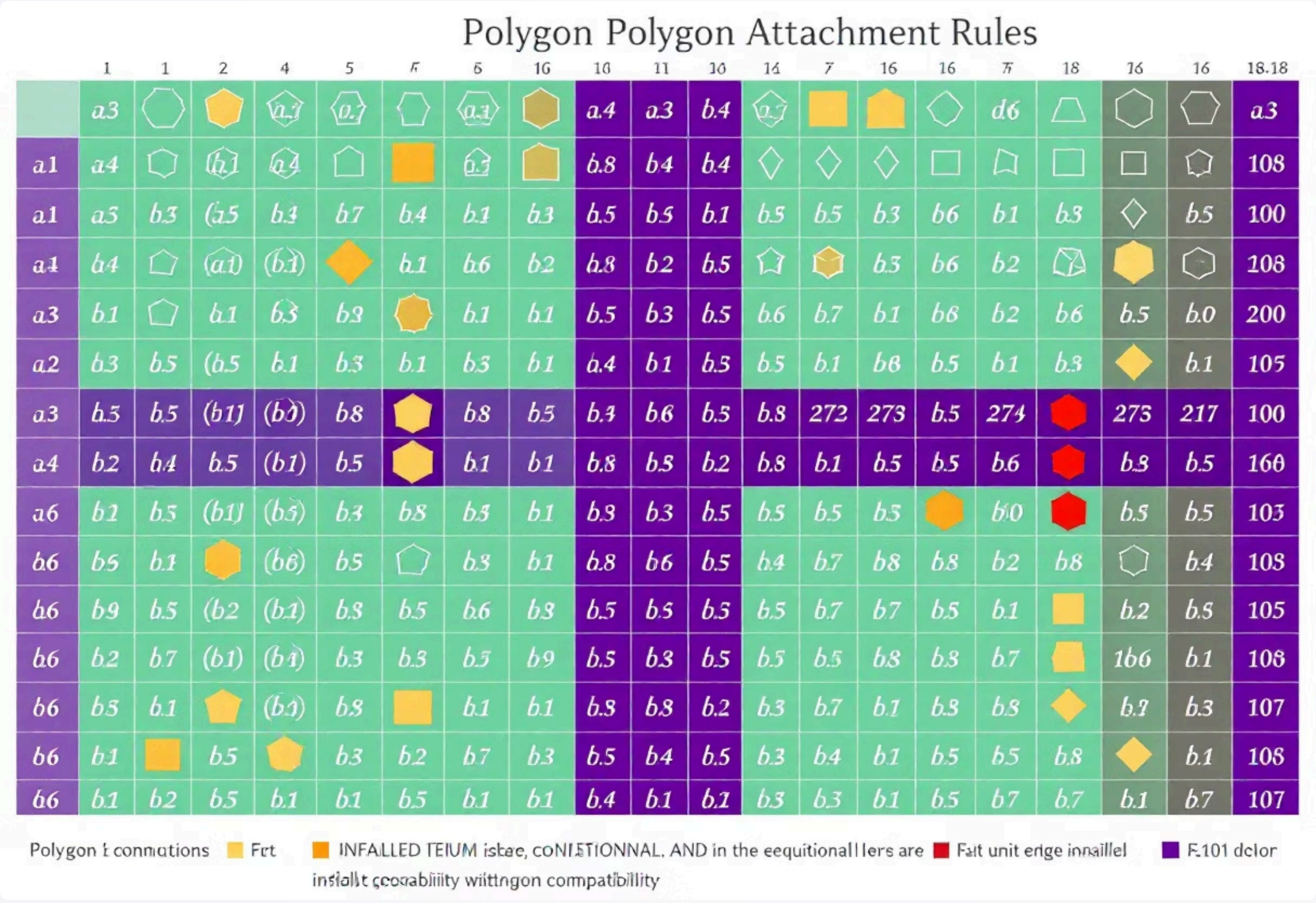
4

High-Performance Architecture

Leverages **CPU and GPU acceleration** for rapid validation, rendering, and manipulation of complex polyforms.

Foundation: The 18×18 Attachment Matrix

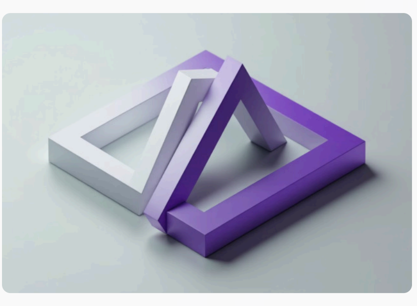
The current MVP utilizes a foundational 18x18 attachment matrix to define permissible connections between **18 primitive polygon types**. This matrix is critical for ensuring rigorous geometric integrity and predictability in polyform construction, serving as the static core of future dynamic validation.



Matrix Legend: Stable connections (>=0.85) | Conditional connections (0.70–0.85) | Invalid connections (<0.50)

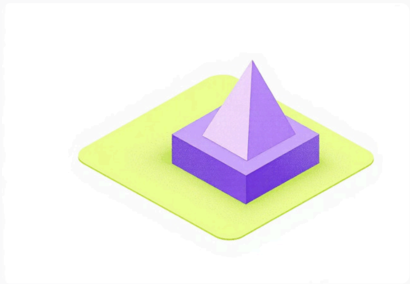
Detailed Connection Examples from the Matrix

a3 ↔️ a3: 70.53°, stability 0.95



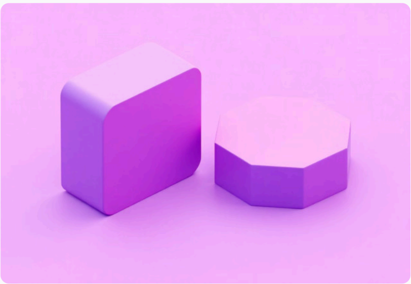
Tetrahedral edge, perfect closure.

a3 ↔️ b2: 60°, stability 0.78



Mixed attachment, context-dependent.

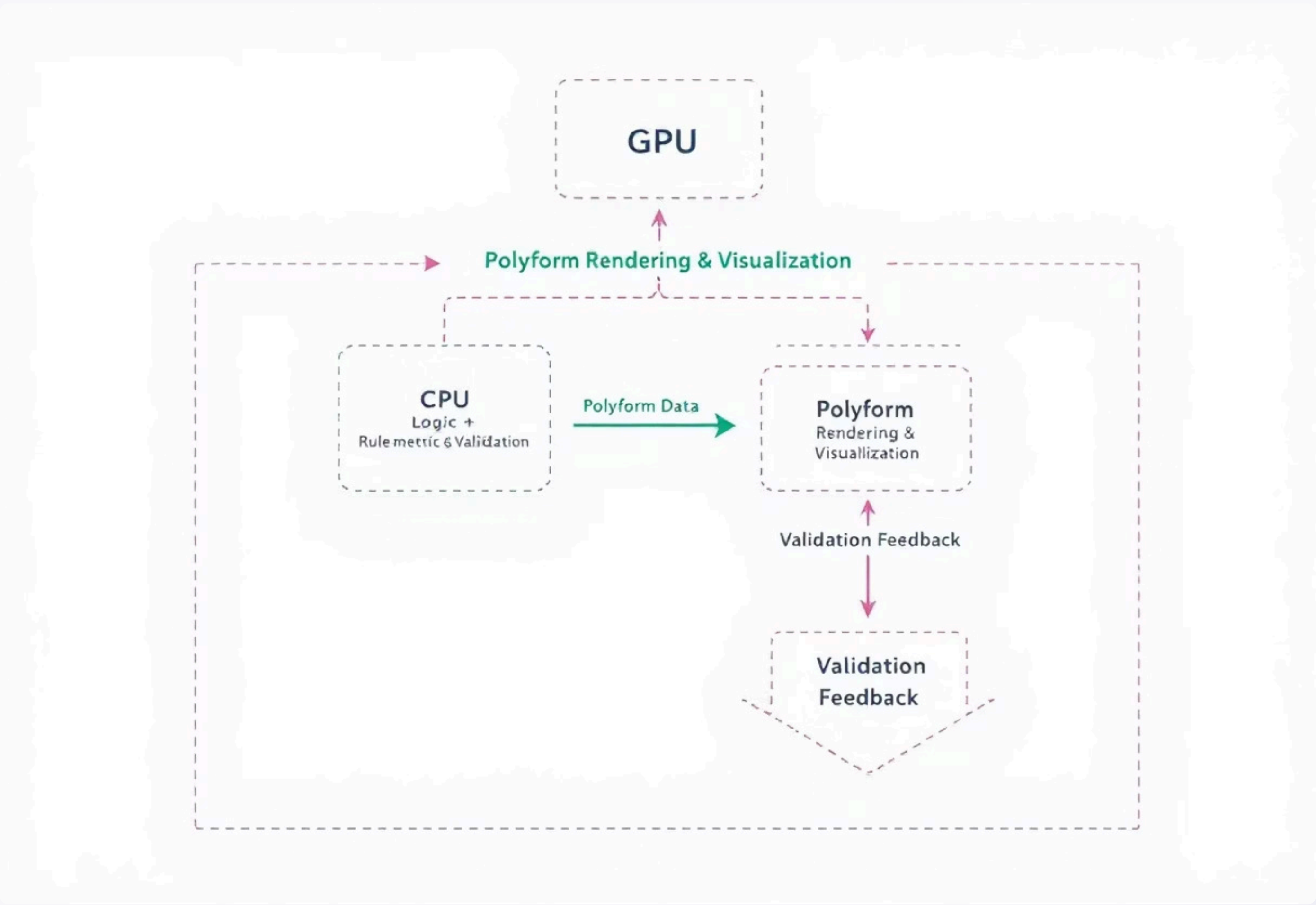
b2 ↔️ d6: stability <0.50



Incompatible connection.

System Architecture: Enabling Dynamic Geometry

The robust architecture of Polylog6 is designed for high-performance geometric computation, crucial for dynamic validation and complex polyform generation.



Performance Metrics

Our system targets and achieves exceptional performance for real-time validation and rendering, with sub-microsecond lookup times for attachment rules.

100ns

Rule Lookup

Average time for attachment rule validation.

60FPS

Rendering

Target frame rate for complex polyform visualization.

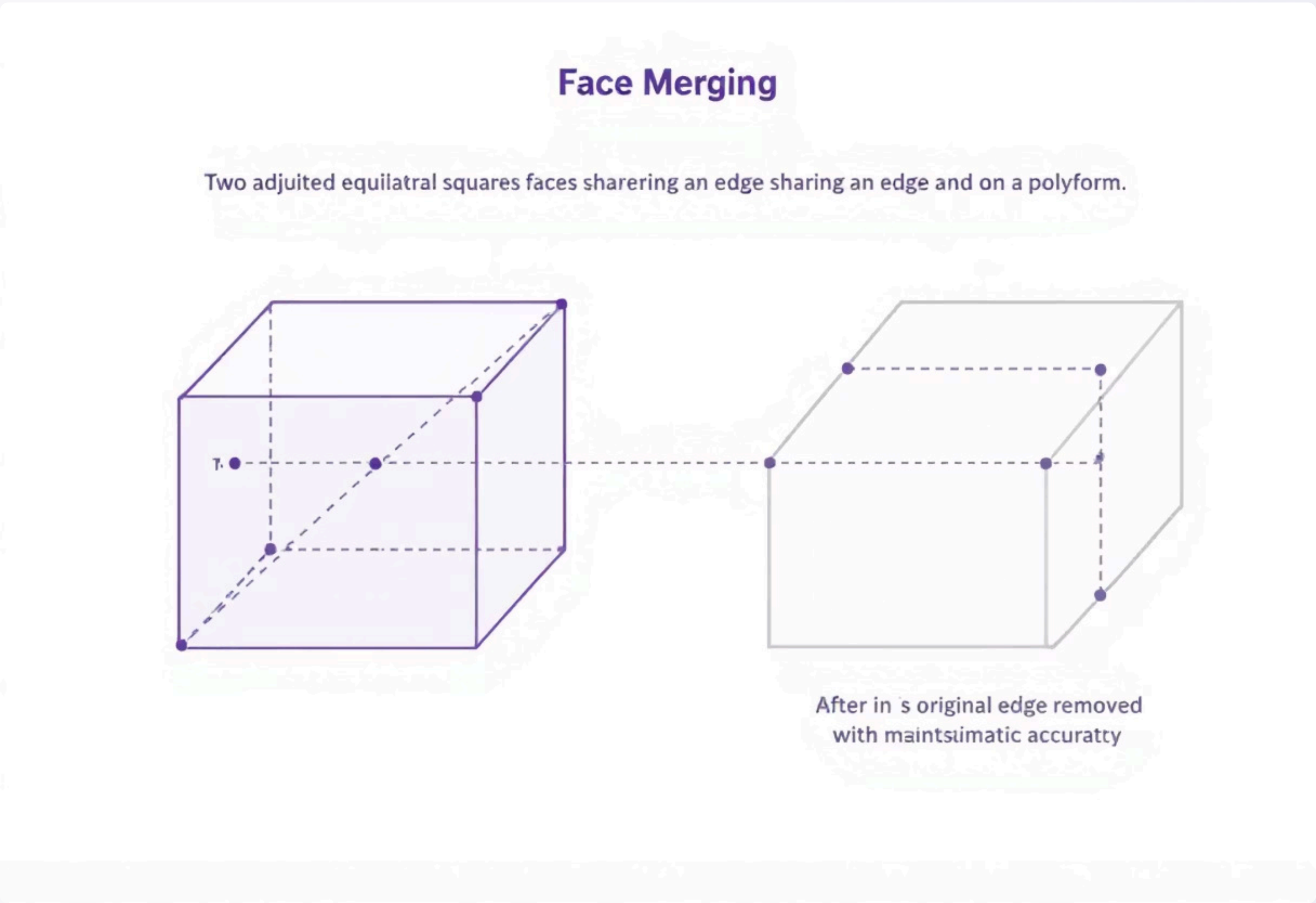
1M+

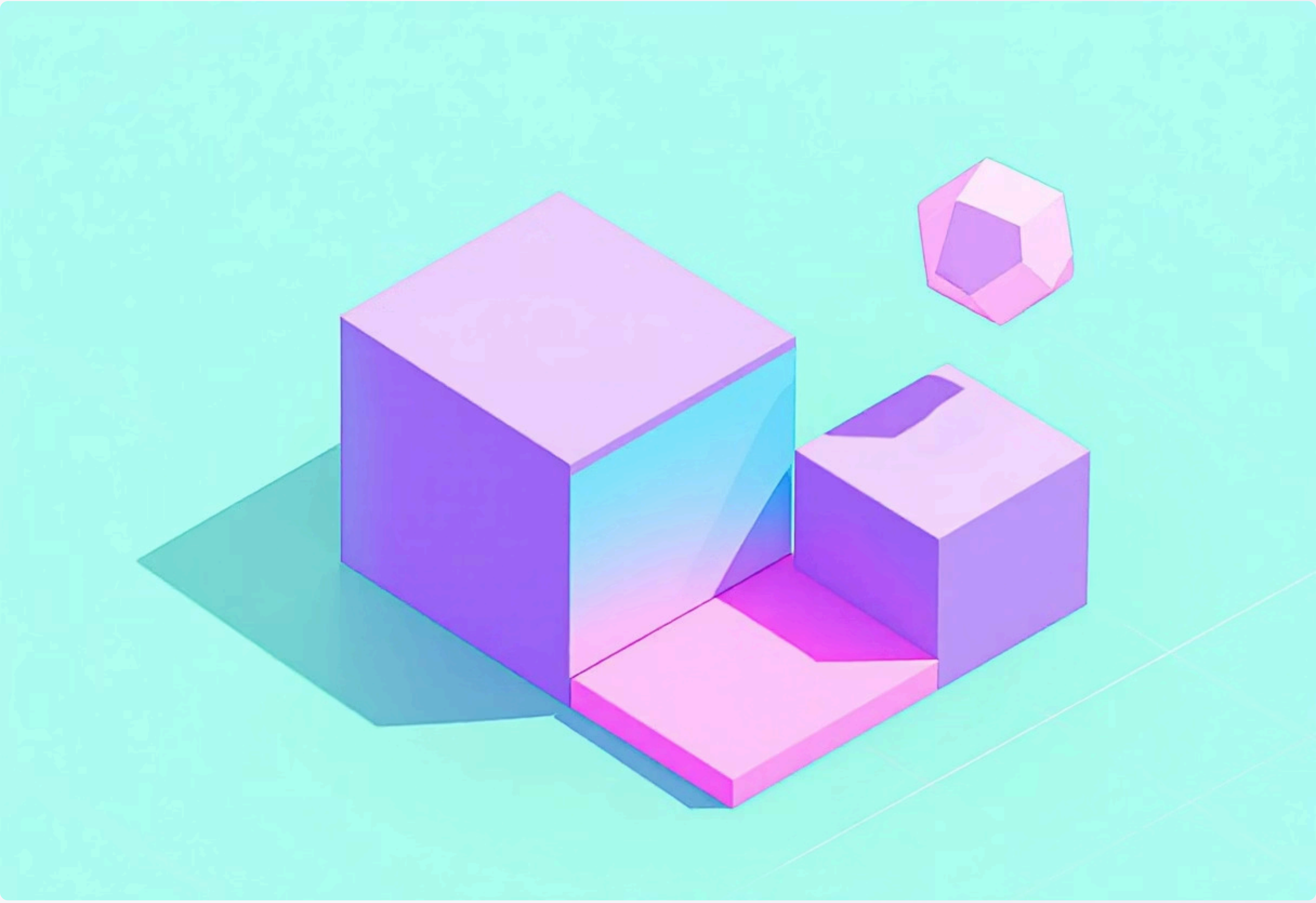
Polyform Elements

Simultaneously validated and rendered.

Advanced Capabilities: Face Merging & Closure

A key aspect of the intended system is the ability to recognize and simplify polyforms through face merging, and to detect when a structure forms a complete, enclosed volume.





Polylog6: Advancing to Dynamic Geometric Validation (Phases 2-7+)

The Polylog6 system is evolving from a static lookup model to a dynamic, geometrically-aware validation architecture. This progression will enable full user control over polyform construction, introducing capabilities like custom fold angles, face merging, and comprehensive closure detection for novel polyform discovery.

Intended System - Phases 2-7+: Dynamic Geometric Validation

Our vision encompasses a system capable of managing **2,916 distinct polyform symbols** and dynamically validating complex geometric assemblies, moving beyond static rules to true geometric computation.

→ Methodology

- **O(1) lookup** for pre-computed attachments.
- **O(n) geometric computation** for custom angles.
- User specifies exact fold angles (e.g., Netlib, custom).
- System dynamically validates assembly closure.

→ Advanced Validation

- **Query:** Will this fold angle create a closed volume?
- **Compute:** Dihedral angles from 3D geometry.
- **Validate:** Comprehensive non-self-intersection checks.
- **Cache:** Store successful configurations for reuse.
- **Real-time:** Target <5ms per validation.

→ Core Capabilities

- User-specified custom fold angles.
- Dynamic edge length scaling (polynomial growth).
- Multi-edge attachments (face merging).
- Accurate closure detection for complex assemblies.
- Facilitates novel polyform discovery and exploration.

Use Case: User-driven assembly with intelligent, real-time geometric validation and exploration.

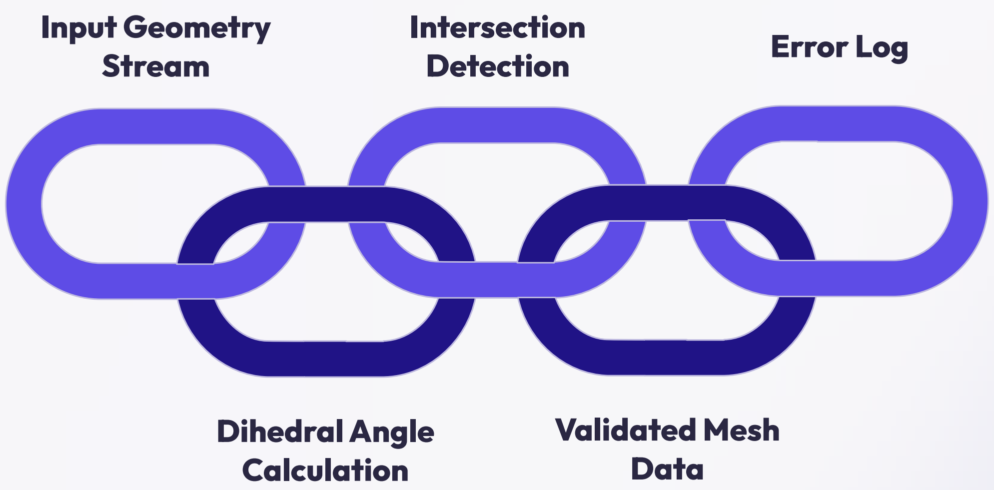
Current MVP - Phase 1: Static Matrix Lookup (Foundation)

The current MVP serves as a critical foundation, demonstrating basic attachment logic through a pre-computed matrix for **18 fundamental polygon primitives**.

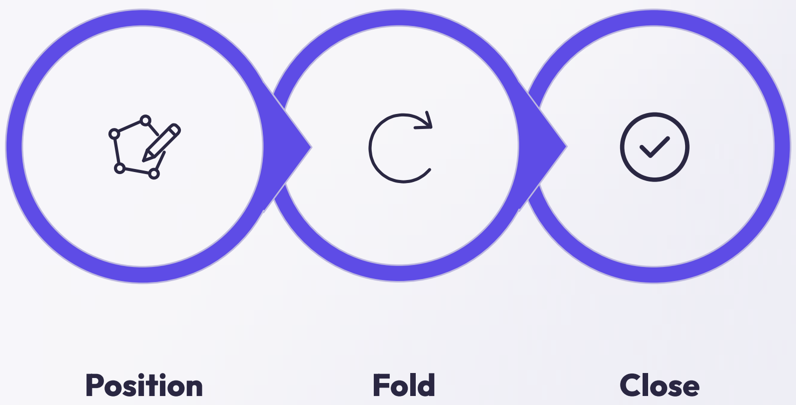
- **Methodology**
  - Pre-computed 18x18 attachment matrix (324 options).
  - **O(1) lookup** in a static JSON file.
- **Validation**
  - Stability threshold checks (≥0.70 or ≥0.85).
  - Simple numeric comparison; no geometric computation.
  - **Instant validation** (<100ns).
- **Limitations**
  - No custom fold angles or arbitrary assembly validation.
  - Lacks dynamic edge-to-edge contact detection.
  - Relies solely on static, predefined rules.

Use Case: View-only mode with a limited set of predefined polyhedra.

Key Visualizations: Enabling Dynamic Validation



Conceptual System Architecture: CPU ↔ GPU Data Flow



Face Merging & Closure Detection Sequence

Performance & Geometric Accuracy

2,916

Polyform Symbols

Target for dynamic system, allowing vast combinatorial possibilities.

<5ms

Validation Time

Real-time geometric validation per complex assembly.

100%

Geometric Integrity

Ensured through precise edge-to-edge connections and non-self-intersection checks.

#7B3FF2

Material Consistency

All polyforms rendered in Royal Purple for visual uniformity and technical focus.

1

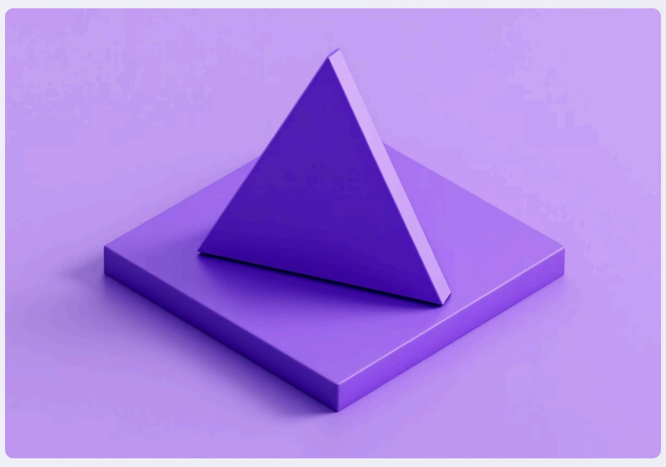
Current MVP: Fixed Connection

A static connection between a triangle and a square, validated via matrix lookup at a predefined 60° angle.

2

Intended System: Dynamic Validation

User specifies a 72° fold angle; the system computes dihedral angles and validates closure geometrically.



Polylog6: Face Matching - Topology Evolution & Closure Detection in the Intended System

While our MVP provides a foundational static lookup for 18 geometric primitives, the full vision of Polylog6 focuses on a dynamic, geometrically-aware system. This involves evolving polyform topology through face merging and robust closure detection, enabling novel assembly and discovery.

Current MVP: Static Face Topology (Context)

- Each polyhedron has fixed face list
- Faces defined by vertex sequences
- Face normals (all point outward)
- LOD simplification (faces removed, not merged)
- No face-to-face contact tracking

Limitation: Assemblies are treated as collections of separate objects, with no merging or topological evolution.

The 18x18 attachment matrix provides pre-calculated attachment options, serving as a rapid O(1) lookup foundation for the intended system.

Intended System: Dynamic Geometric Validation Overview

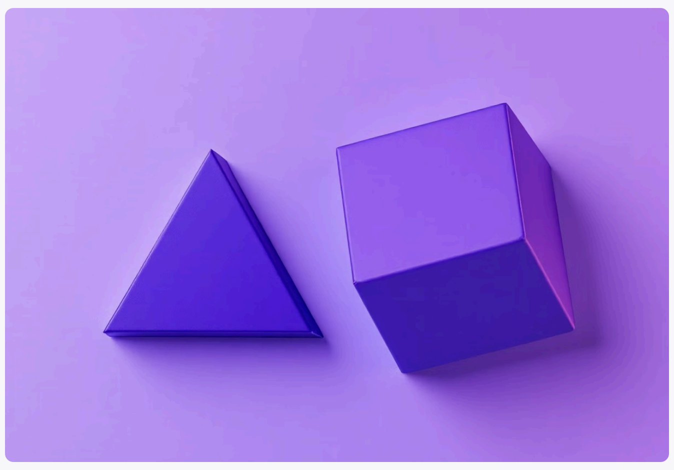
The intended system leverages a hybrid CPU/GPU architecture for dynamic geometric computation. Asynchronous channels facilitate real-time validation and rendering, essential for interactive assembly and discovery.

Dynamic Face Contact Detection

The system intelligently detects when two polyhedra have adjacent faces, performing a series of geometric checks:

- Coplanarity assessment (are faces in the same plane?)
- Identification of shared edges and vertices
- Calculation of face normal alignment
- Determination of potential for geometric merging

Workflow: User interactively places polyhedra. The system detects face proximity, offers merging options, and the user confirms the topological change.



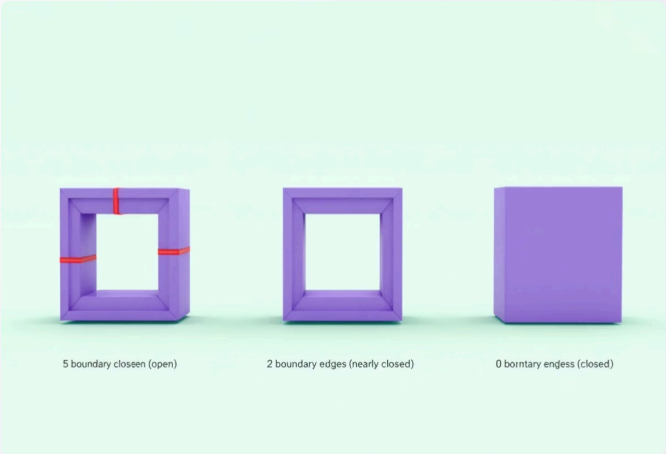
The system determines if the faces can topologically merge based on geometric congruence.

Closed Assembly Detection

Crucial for validating new polyforms, this feature analyzes the overall topology of an assembly:

- Counts boundary edges (edges not shared by two faces)
- If count = 0: Assembly is **CLOSED** ✔ (valid polyform)
- If count > 0: Assembly is OPEN (further building possible)
- Validates for holes and consistent outward face normals

Result: A CLOSED assembly signifies a complete, novel polyform. This triggers potential automatic promotion to Tier 2, face merging optimization, and compression ratio calculation.



Edges highlighted RED (boundary) dynamically transition to ROYAL PURPLE (interior) as the assembly closes.

Performance Metrics Dashboard (Targets)

Target performance metrics are critical for real-time interactive assembly, ensuring a seamless user experience for geometric validation and polyform discovery.

Polylog6: Implementation Roadmap - 6 Phases to Full System

This roadmap details the progression towards realizing the full vision of the Polylog6 system, emphasizing dynamic validation, face merging, and closure detection capabilities. We aim to move beyond the current MVP state (18 primitives, static matrix) to a comprehensive system supporting 2,916 symbols, guided by rigorous geometric principles.

Phase 1: Data & API ✅ COMPLETE

Duration: Weeks 1-4 (completed)

Deliverables:

- 97 polyhedra extracted
- 18×18 attachment matrix generated
- 6 API endpoints live
- LOD metadata generated
- Compression ratios verified

Status: ✅ Complete, deployed

Blockers Eliminated: 0 (foundation)

Phase 2: Frontend Integration ⏳ IN PROGRESS

Duration: 2-3 weeks

Deliverables:

- React workspace component
- Real-time attachment validation
- LOD switching in viewport
- Visual feedback (green/red)
- Polyhedra drag-and-drop

Blockers Eliminated: 4 (Runtime edge validation, Attachment validation UI, LOD rendering, Performance under load)

Status: ⏳ In progress, on schedule

Phase 3: Runtime Symbol Generation ⏳ PENDING

Duration: 1-2 weeks

Deliverables:

- Background assembly analysis
- Composition detection
- Emit `tier_candidates.jsonl`
- Frequency tracking
- Candidate display in UI

Blockers Eliminated: 1 (Runtime symbol generation)

Status: ⏳ Waiting for Phase 2

Phase 4: Tier 2 Ingestion ⏳ PENDING

Duration: 1-2 weeks

Deliverables:

- Candidate persistence
- Frequency aggregation
- Go/no-go criteria defined
- Promotion readiness

Blockers Eliminated: 1 (Tier 2 data pipeline)

Status: ⏳ Waiting for Phase 3

Phase 5: Tier 3 Promotion ⏳ PENDING

Duration: 2-3 weeks

Deliverables:

- Promotion logic (frequency + stability)
- Tier 3 archival
- User library persistence
- Face merging capability
- Closure detection implementation

Blockers Eliminated: 3 (Tier 3 promotion pipeline, Face merging, Closure detection)

Status: ⏳ Waiting for Phase 4

Phase 6: Testing & Validation ⏳ PENDING

Duration: 4-6 weeks

Deliverables:

- Integration tests (edge + face)
- Performance benchmarks
- Data validation suite
- End-to-end workflow test
- Deployment readiness

Blockers Eliminated: 3 (Compression ratio validation, Performance verification, Data consistency)

Status: ⏳ Waiting for Phase 5

The roadmap outlines a horizontal progression through 6 phases, each building upon the last. Phase 1, establishing the foundational data and API, is complete (Deep Purple). We are currently at the transition point to Phase 2, with subsequent phases pending (Gold). Each phase transition is marked by specific "Go/No-Go" criteria, serving as success metrics for moving forward and ensuring geometric accuracy and system integrity.

Polylog6: Real-World Applications - Five Key Use Cases

Education & Discovery

- Students explore 97 known polyhedra and novel compounds
- Interactive 3D visualization for complex structures
- Learn advanced symmetry principles
- Export structures as concise Unicode symbols

Example: "Build a cuboctahedron, observe its 1,500:1 compression ratio"

Geometric Design & Construction

- Designers create complex tessellated facades
- Combine polyforms for intricate architectural structures
- Instant compression facilitates collaborative design
- Share designs globally via Unicode strings

Example: "Facade = octahedron + 4×tetrahedra, represented by 1 Unicode symbol"

Advanced Pattern Discovery & Research

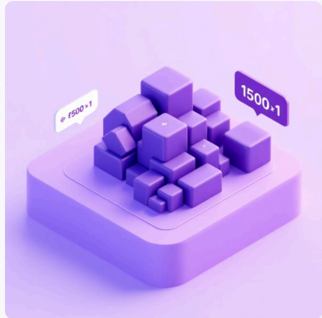
- Researchers identify novel polyforms through automated analysis
- Automatic tier promotion for newly discovered structures
- Publish findings efficiently using unique Unicode symbols (e.g., Ω_{125})
- Contribute directly to a global geometric research library

Example: "Novel compound discovered and published as Ω_{125}"

Efficient Compression & Storage

- Archive vast geometric libraries with minimal footprint
- Enable highly efficient 3D model databases
- Support real-time visualization streaming of complex data
- Achieve significant compression ratios, up to 1,500:1

Example: "A 1GB geometric library compresses to just 700KB"



Collaborative Geometric Design & Versioning

- Teams can co-design complex polyforms seamlessly
- Integrated version history tracks changes via git-like functionality
- Instant reconstruction of designs at any checkpoint
- Share discoveries and designs globally with a single URL

Example: "Branch: feature/snub-cube-variant, diff: 2 bytes for a complex modification"