ITEM #178 — ACLM Horizontal Mutations via Unaligned AND: *From Cantilever Evolution to Simply-Supported Structural Bridging*

Conversation: ACLM Horizontal Mutations UnalignedAND Algorithm

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From Cantilever Evolution to Simply-Supported Structural Bridging

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Abstract

ACLM's most difficult engineering challenge lies in *Gap Bridging* between partially mismatched program states.
Traditional **Vertical Mutations**, modeled as `Operation[i](y) → y`, form an evolutionary self-mapping system with unbounded search space, high branching factor, and unstable intermediate states—analogous to a *cantilever beam* in structural mechanics.

This item introduces **Horizontal Mutations via the DBM Unaligned AND algorithm**, reframing Gap Bridging as a constrained, bidirectional assembly problem between two finite endpoint sets. By treating program fragments as decomposable "cables" composed of structured sub-wires and leveraging explicit connectivity evidence extracted from Calling Graphs, ACLM can pre-compute feasibility, prune invalid pairings, and rank viable candidates before invoking local Vertical repair.

Structurally, this transforms ACLM Gap Bridging from a cantilever evolution into a *simply supported beam* with fixed boundary conditions at both ends—reducing computational

complexity by more than one order of magnitude and establishing a stable, explainable, and engineerable mutation pipeline.

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1. Problem Background

1.1 Vertical Mutations as an Evolutionary System

In ACLM, Vertical Mutations are defined as:

```
Operation[i](y) → y
```

forming a self-mapping evolutionary system over program state space.

While expressive, this structure exhibits several intrinsic difficulties:

- Exponential state-space expansion
- Non-monotonic intermediate quality
- Cyclic and repair-then-break behaviors
- Weak early feasibility signals
- High cost of maintaining explainable evolution traces

From a structural mechanics perspective, this resembles a **cantilever beam**:
one end fixed, the other extending freely into a large, poorly constrained space.

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2. Horizontal Reframing of Gap Bridging

2.1 Gap as a Set-to-Set Structural Misalignment

Instead of viewing Gap Bridging as a unidirectional evolution problem, we reinterpret it as:

- A gap between two finite sets:
  `X = {x[i]}` and `Y = {y[j]}`

Each `x[i]` or `y[j]` is treated as a **cable**, internally composed of multiple structured **sub-wires** (tokens, slots, CCC elements, call edges, constraints).

2.2 Unaligned AND as the Core Horizontal Operator

Using the DBM **Unaligned AND** algorithm, ACLM computes pairwise structural compatibility between `x[i]` and `y[j]` by:

- Evaluating cosine similarity and metric distance
- Aggregating evidence from all sub-wire pairs
- Exploiting *explicit point-to-point connectivity knowledge* extracted from Calling Graphs
- Penalizing conflicts and rewarding verified structural reachability

This yields, for each `(x[i], y[j])` pair:

- Feasibility status
- Structural similarity score
- Distance / cost estimate
- Explainable evidence ledger

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3. Horizontal Mutation Workflow

3.1 Candidate Pruning and Ranking

Once Unaligned AND scores are computed:

- Infeasible `(x[i], y[j])` pairs are eliminated early
- Viable pairs are ranked efficiently
- Search space collapses from exponential evolution to sparse candidate matrices

3.2 Branch-and-Merge Assembly

Based on ranked candidates, ACLM performs:

- Controlled branching from `x[i]`
- Constrained merging toward `y[j]`
- Progressive simplification of remaining gaps

Only residual inconsistencies are delegated to **local Vertical Mutations**, now operating within tight, well-defined bounds.

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4. Structural Interpretation

From a structural mechanics viewpoint:

- **Vertical Mutations** → *Cantilever beam*

- **Horizontal Unaligned AND Mutations** → *Simply supported beam*

With both endpoints fixed, the system gains:

- Stability
- Predictability
- Lower computational complexity
- Improved explainability

This avoids unnecessary exploration of unbounded evolutionary space.

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5. Stage Conclusions

5.1 Core Contradictions Identified

- **(A)** The primary contradiction in ACLM is **Gap Bridging**
- **(B)** The primary contradiction of Gap Bridging is the **Vertical Mutation evolutionary system**

5.2 Strategic Resolution

- Prioritize **Horizontal Mutations via Unaligned AND** to simplify gaps
- Use **Vertical Mutations only as localized repair mechanisms**
- Treat evolution as a *secondary*, not primary, tool

This establishes a stable and scalable foundation for future ACLM expansion.

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6. Significance

This item marks a decisive step in ACLM's maturation:

- From unbounded evolution to bounded structural assembly
- From heuristic search to evidence-driven pruning
- From fragile global mutation to robust local repair

It represents the first fully DBM-native resolution of ACLM Gap Bridging.

ITEM #178 — ACLM 横向变异（Horizontal Mutations）与 Unaligned AND 算法

从悬臂梁式演化到简支梁式结构桥接

摘要

ACLM 工程上最困难的问题在于 **Gap Bridging（结构断层桥接）**。
传统的 **Vertical Mutations** 以 `Operation[i](y) → y` 形式构成自映射演化系统，其搜索空间无界、分支极多、状态不稳定，在结构力学上相当于一根 **悬臂梁**。

本文提出基于 **DBM Unaligned AND 算法** 的 **Horizontal Mutations**，将 Gap Bridging 重构为一个**双端受约束的集合装配问题**。
通过把程序片段视为可分解的“电缆/子线”，并显式利用从 Calling Graph 萃取的连通性证据，ACLM 能在演化前完成可行性判断、候选剪枝与排序，仅在局部残差上使用 Vertical 修复。

结构上，这相当于把 ACLM 从“悬臂梁式无限演化”，转化为“简支梁式双端固定结构”，计算复杂度降低一个数量级以上，并显著增强可解释性与工程可控性。

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1. 问题背景

1.1 Vertical Mutations 的本质

ACLM 的 Vertical Mutations 定义为：

```
Operation[i](y) → y
```

这是一个典型的自映射演化系统，其固有问题包括：

- 状态空间爆炸
- 中间状态非单调
- 环路与“先破后立”现象
- 早期缺乏可行性信号
- 解释链维护成本极高

在结构力学意义上，这等价于 **单端固定、另一端自由延伸的悬臂梁结构**。

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2. Gap Bridging 的横向重构

2.1 从演化问题到集合错位问题

本文将 Gap Bridging 重构为：

- 两个有限集合 `X = {x[i]}` 与 `Y = {y[j]}` 之间的结构错位

每个 `x[i]` 或 `y[j]` 被视为一根“电缆”，内部由多条 **子线（sub-wires）** 组成。

2.2 Unaligned AND 的核心作用

DBM 的 **Unaligned AND 算法** 通过：

- 计算子线级相似度与距离
- 汇总 Calling Graph 中的显式连通证据
- 惩罚结构冲突、奖励可达性

为每一对 `(x[i], y[j])` 生成：

- 可行性判断
- 相似度与距离

- 结构证据包（可解释）

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3. 横向变异流程

3.1 剪枝与排序

- 不可行的 `(x[i], y[j])` 对被快速淘汰
- 可行候选被排序
- 搜索空间从演化级降维为稀疏矩阵

3.2 分叉—合叉装配

ACLM 依据候选对执行：

- 从 `x[i]` 分叉
- 向 `y[j]` 合叉
- 逐步压缩 Gap

仅在局部残差上调用 Vertical Mutations 进行修复。

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4. 结构力学解释

- **Vertical Mutations** → 悬臂梁
- **Horizontal Unaligned AND Mutations** → 简支梁

双端固定带来：

- 稳定性
- 可预测性

- 更低计算复杂度
- 更强工程解释性

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5. 阶段性结论

- **(A)** ACLM 的主要矛盾是 Gap Bridging
- **(B)** Gap Bridging 的主要矛盾是 Vertical 演化系统

战略解法：

先用 Horizontal Unaligned AND 简化结构断层，
再用 Vertical Mutations 做局部修复。

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6. 意义

ITEM #178 标志着 ACLM 从：

- 无界演化
- 启发式试探

迈入：

- 受约束结构装配
- 证据驱动剪枝
- 工程级稳定系统

这是 ACLM 首次在 DBM 框架内，对 Gap Bridging 给出的成熟、可落地解法。
