Brain-CA
Technologies
Casting off the Old Guard
Achieving Superior A.I. Performance through Simplification
ISCA 2024

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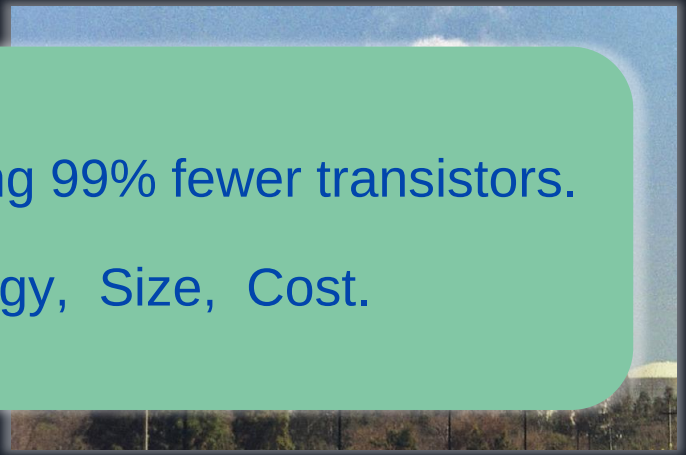
What if we could cut A.I. Energy costs by 99%?

Basic learning task using 99% fewer transistors.

Savings: Energy, Size, Cost.



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Agenda

- **Current LLM and GNN challenges**
  and the inherent limitations of Von Neumann architecture.
- **BRAIN-CA Physical Architecture**
  using Cellular Automata for simplicity, scalability and lower power requirements.
- **BRAIN-CA Logical Architecture**
  using simple bit manipulations and no CPU.

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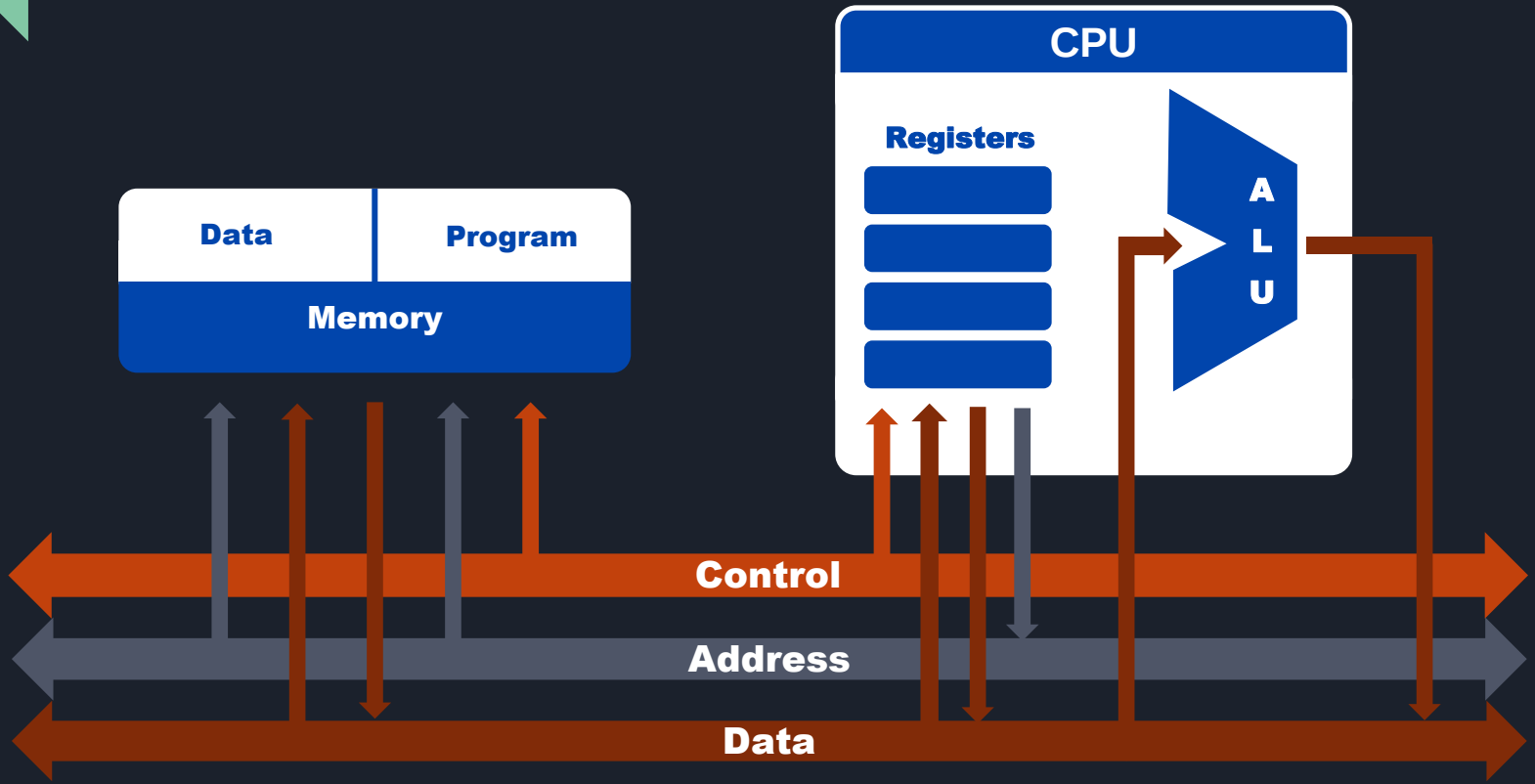
The Legacy of Von Neumann Architecture



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Cellular Automata (CA)

Grid of cells, with

- State (memory)
- Rules (logic)

Rules for State Management

Classic example
Conway’s Game of Life

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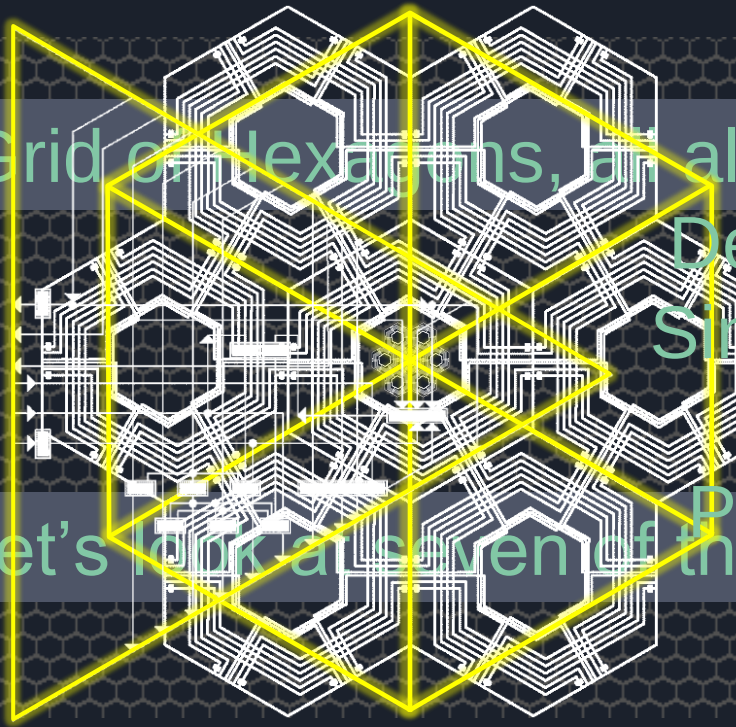
The BRAIN-CA™ Physical Architecture



Grid of hexagons, all alike.

Logic Cells' inputs facilitates align with passing values, neighbors at oblique outputs. angles.

Cells Primary consist paths of six and route identical through equilateral cell. triangles.

Design Simplicity Massive Parallelism.

Let's look at seven of them.

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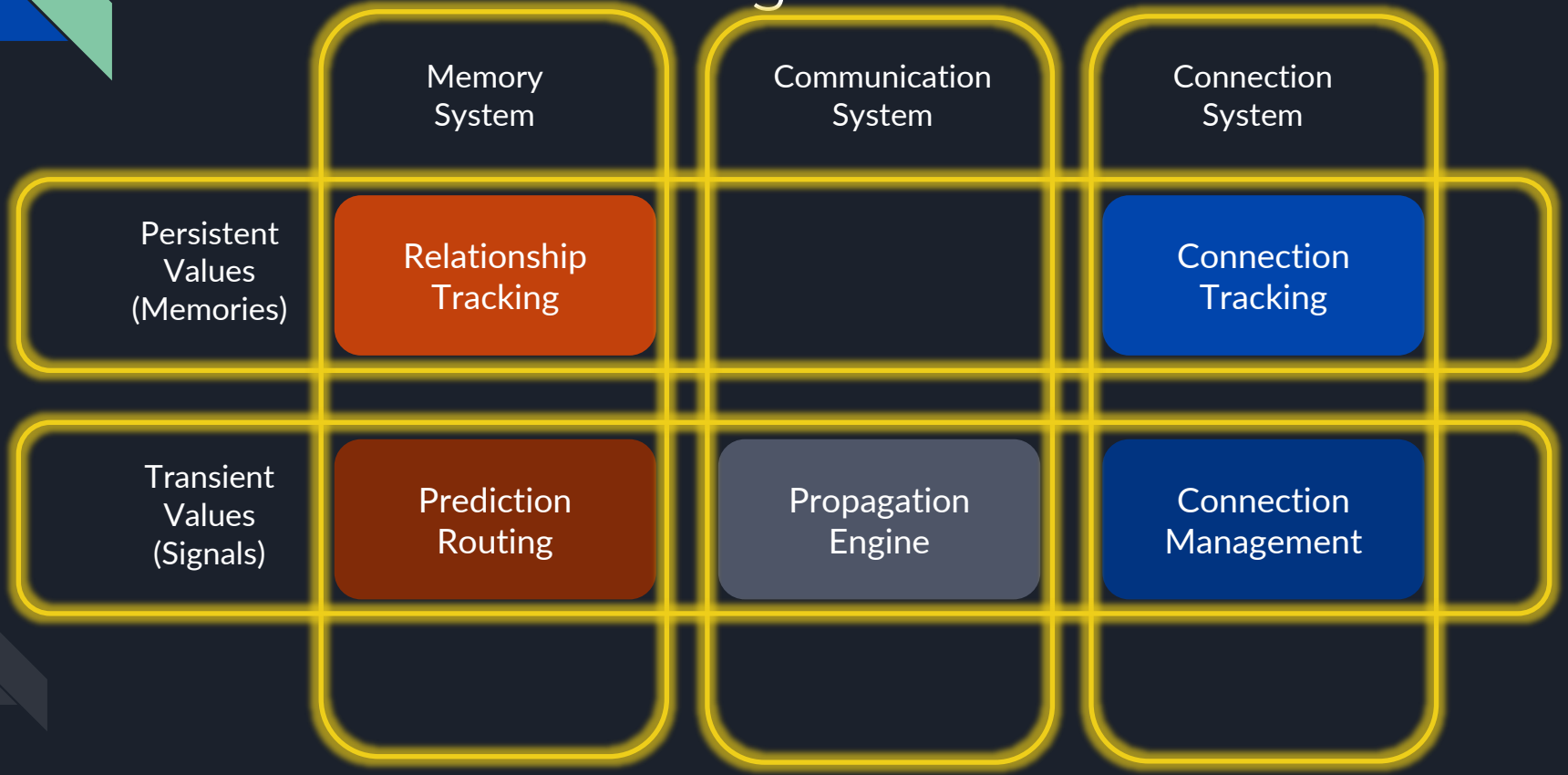
The BRAIN-CA™ Logical Architecture



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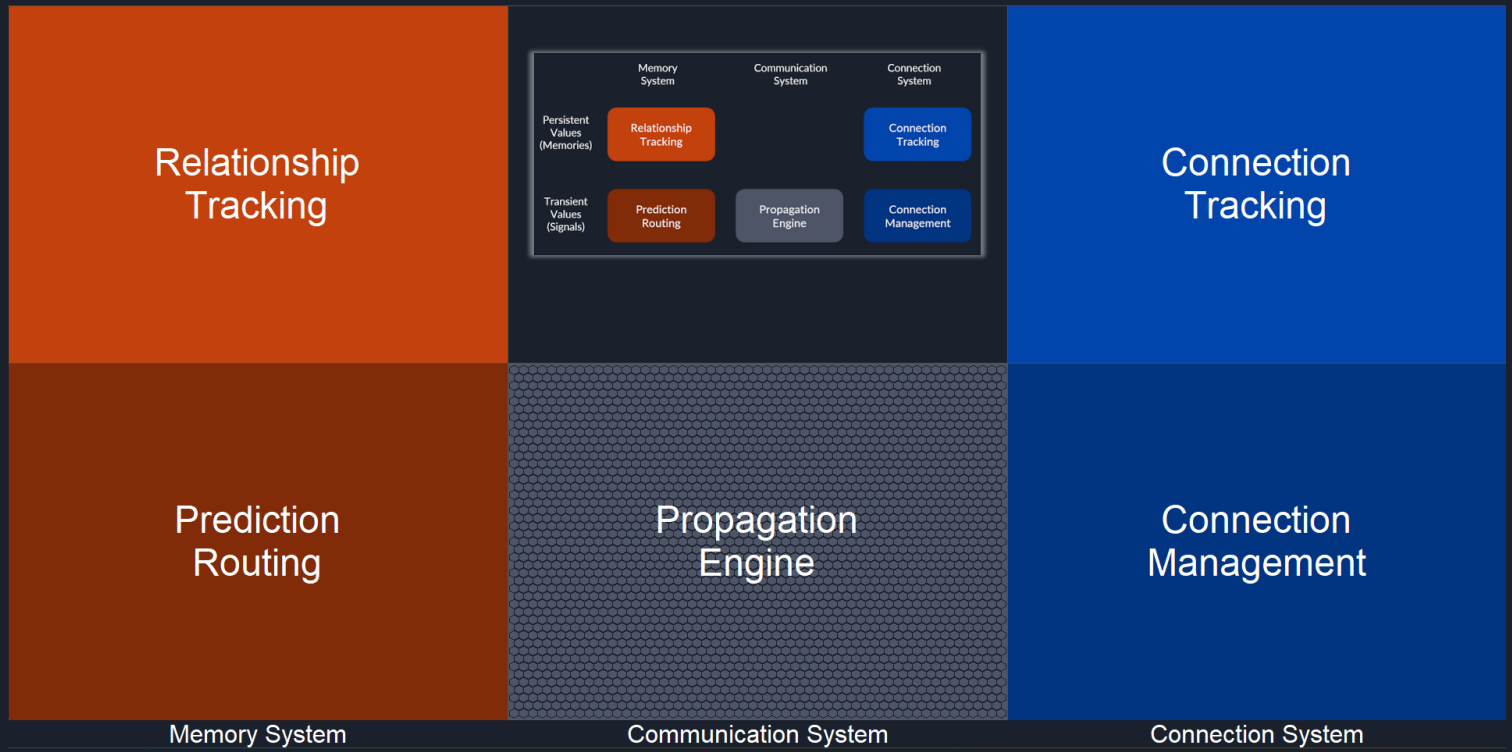
Dashboard



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BRAIN-CA in action

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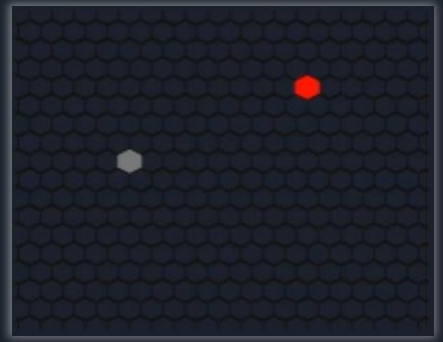
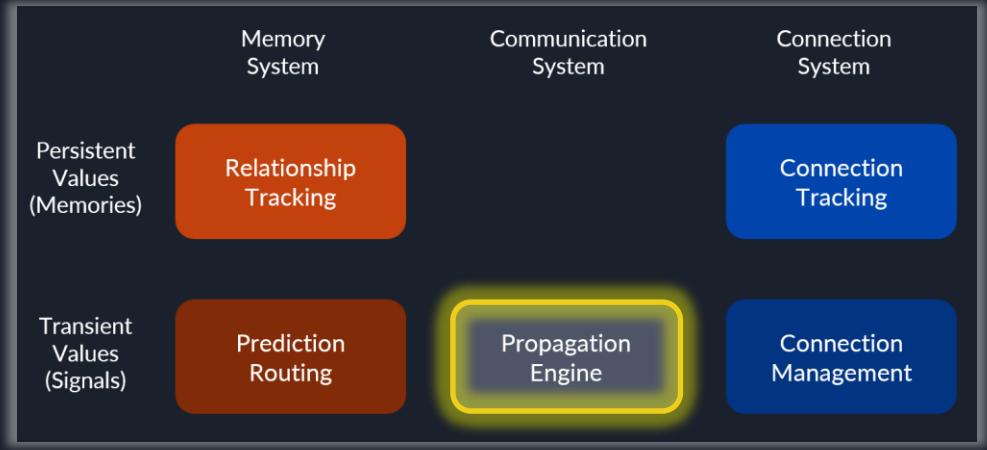
Inputs initiate communication waves





Communication System

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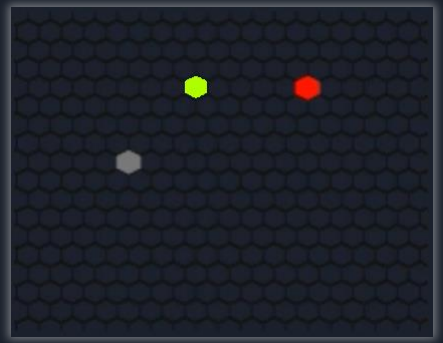
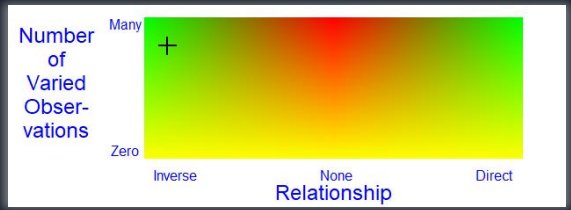
Recurring observations solidify relationship



	Memory System	Communication System	Connection System
Persistent Values (Memories)	Relationship Tracking		Connection Tracking
Transient Values (Signals)	Prediction Routing	Propagation Engine	Connection Management

Communication System
&
Memory System



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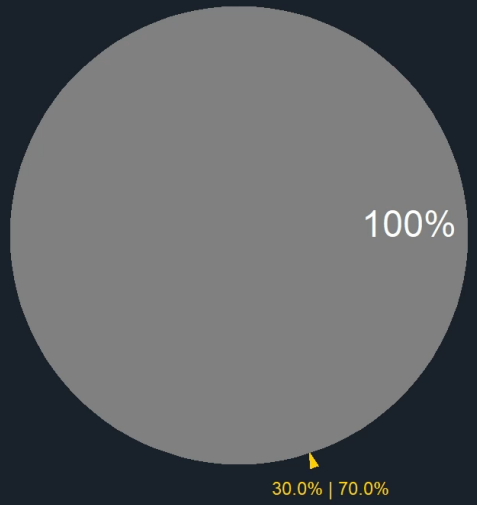
Pie Chart Using Counters

Input



Observations: 1

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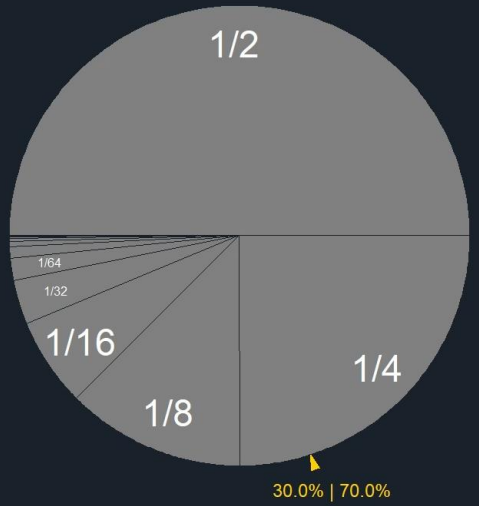
Using Counters Showing Powers of Two

Gray

Input



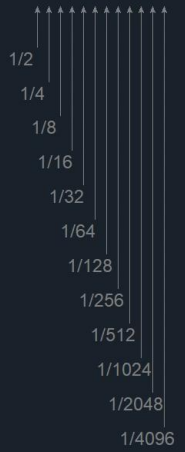
Observations: 1

For Math Nerds

0.0% =0.000000000000...

+100.0%=0.111111111111...

100.0%=1.000000000000...



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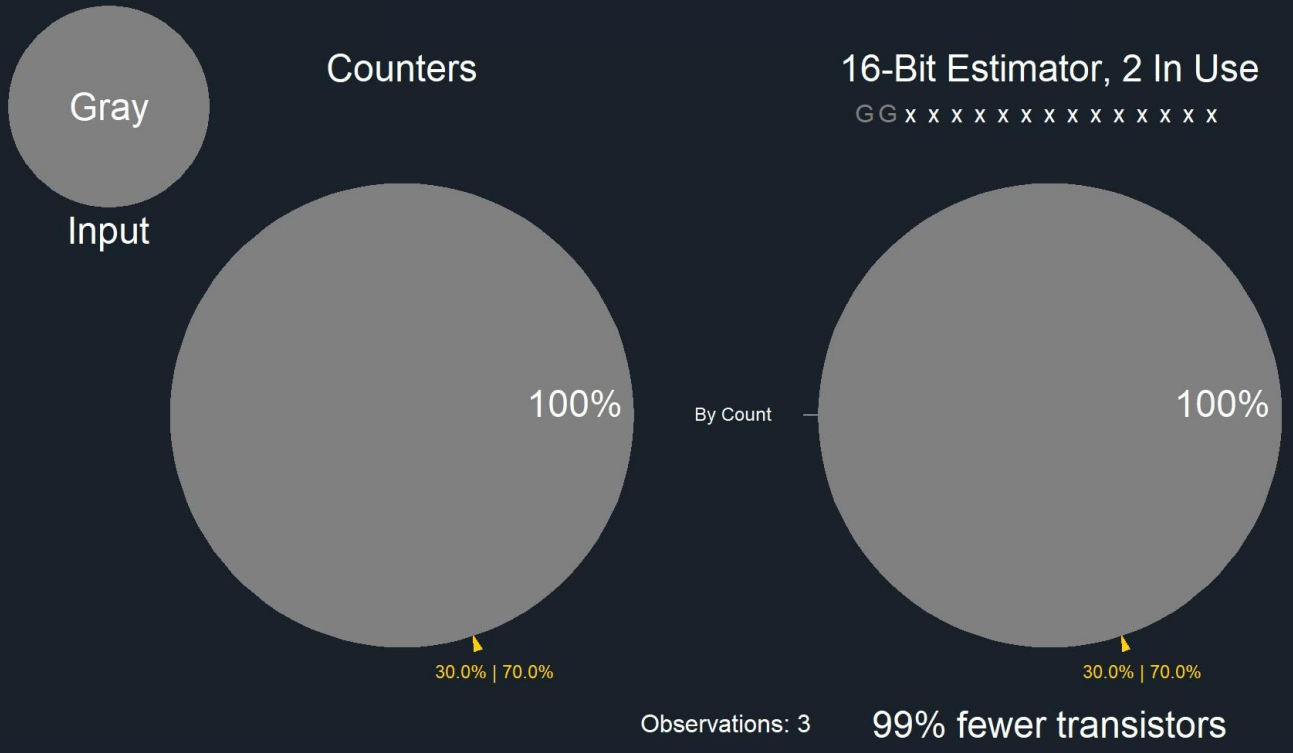
Cincinnati Algorithm & BRAIN-CA™ Estimator



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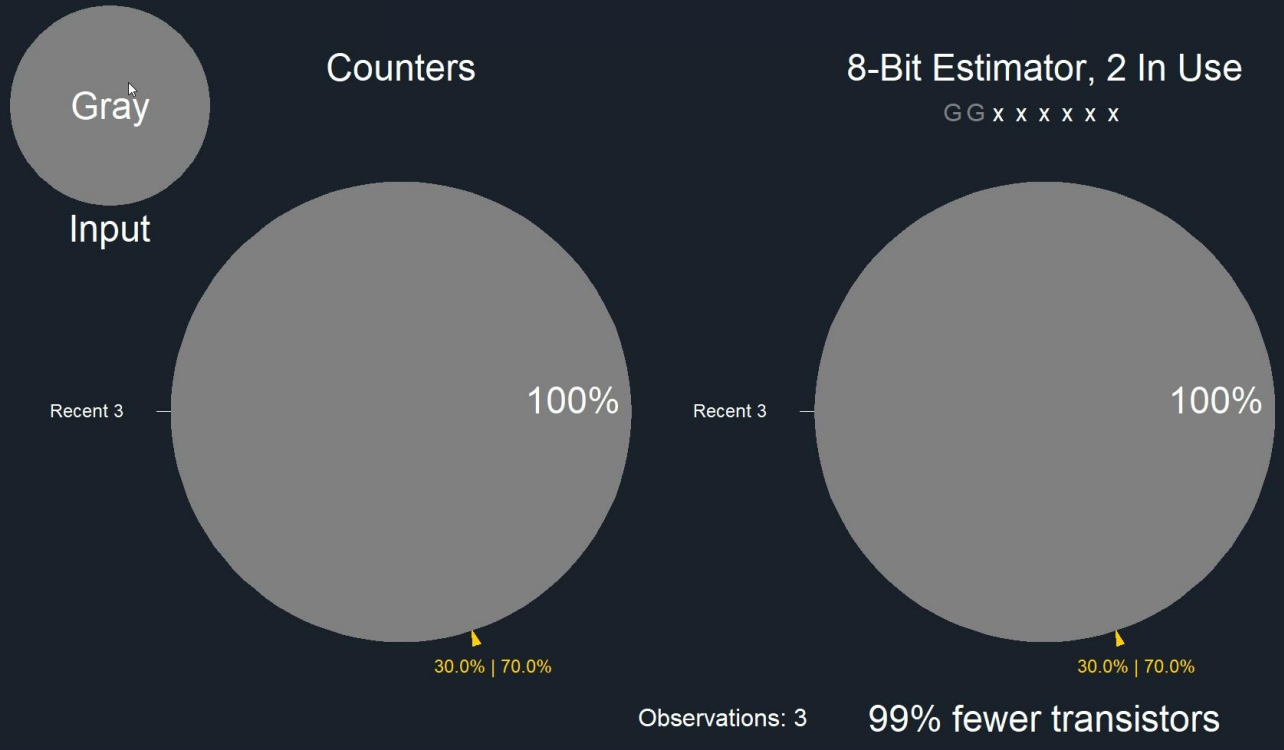
Cincinnati Algorithm & BRAIN-CA™ Estimator



Observations: 3

99% fewer transistors

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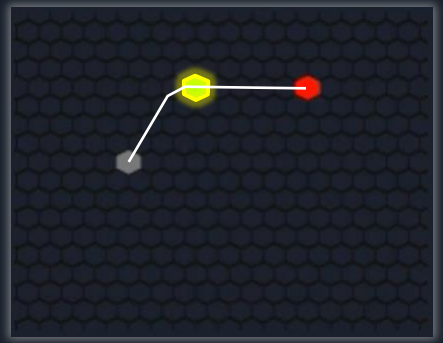
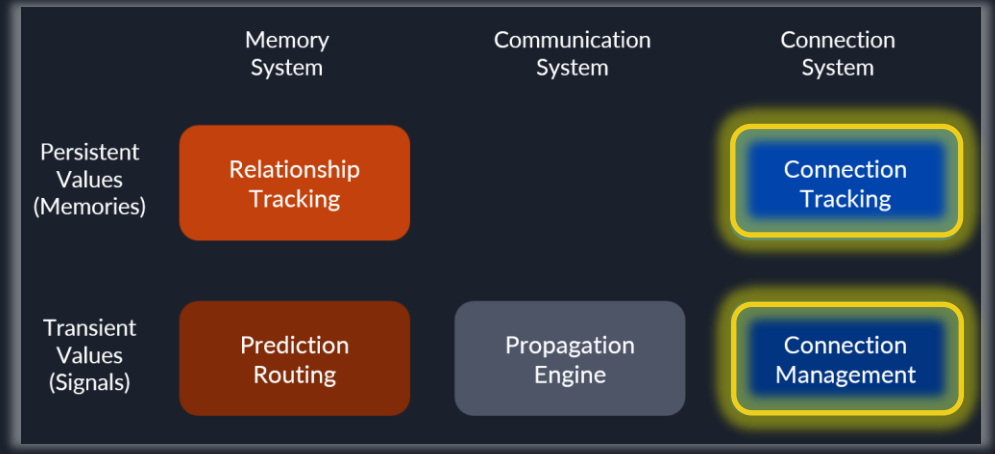
Fast connections for strong relationships





Connection System

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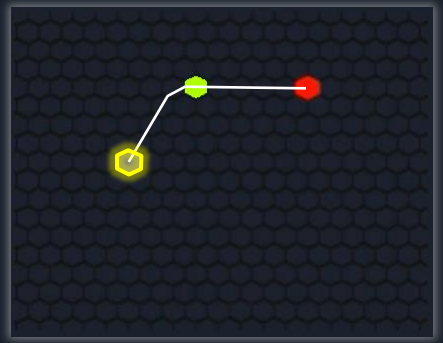
Prediction from relationships & connections



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Persistent Values (Memories)	Relationship Tracking		Connection Tracking
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Memory System

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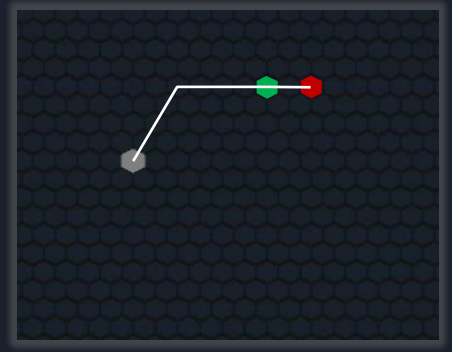
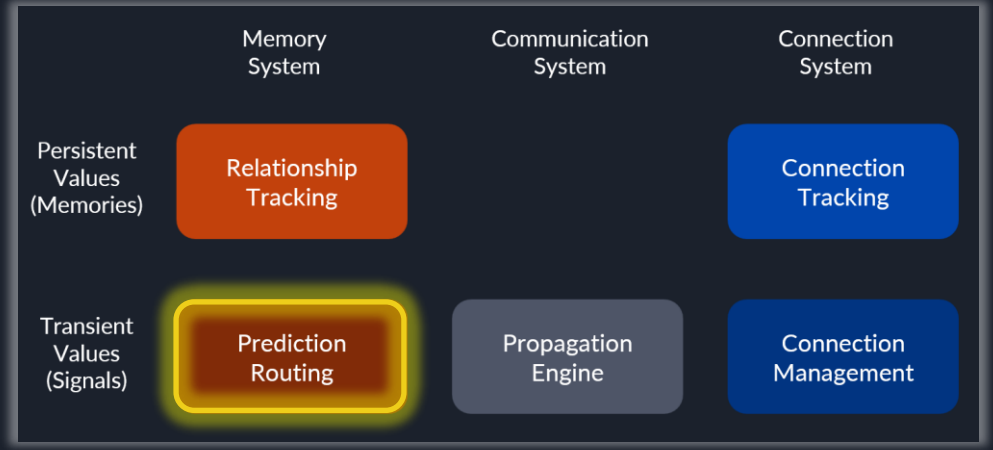
Offset pulses are accommodated – Training





Memory System

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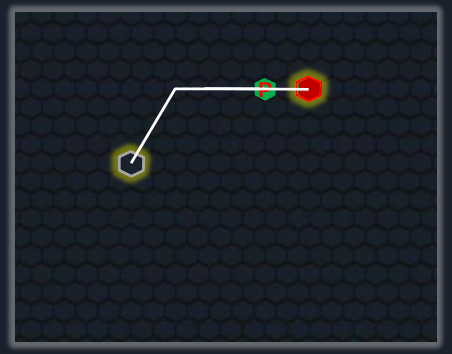
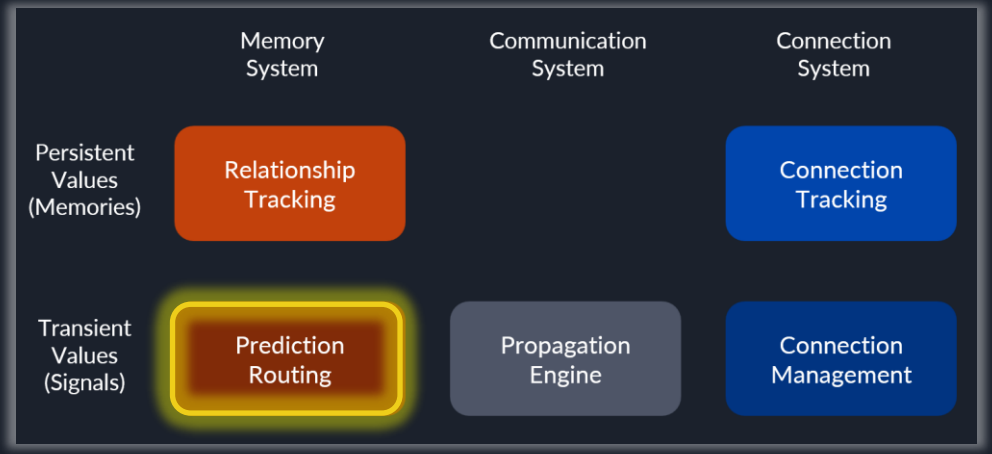
Offset pulses are accommodated – Inference





Memory System

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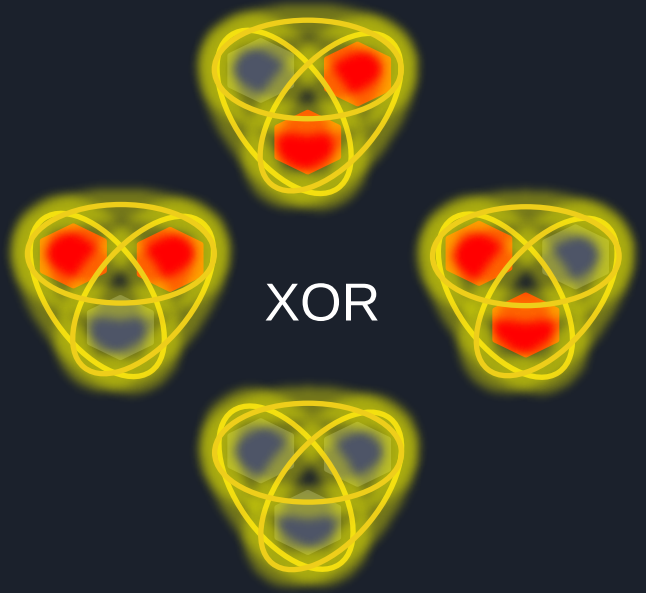
Multi-Bit finds complex relationships



Multi-Bit Technology

addresses complex relationships without the need for hidden layers.

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Key Innovations

Tried and Tested	Bold and Innovative
Von Neumann architecture: separate memory and compute	BRAIN-CA™ Cellular Automata architecture: embedded memory with very simple compute (logic)
Neural networks: weight and bias calculations, back propagation	Binary decomposition: simple correlation table lookups, The Cincinnati Algorithm
Highly complex, hot systems: focus on maximizing FLOPS	Simple systems with lower energy costs: focus on minimizing CA System complexity
Learning through complex calculus	Learning by associating observations
Absolute memory addressing	Relative cell addressing
Rigid node connections	Wave propagation and dynamic connections
Floating point representation	Bit, integer, and BRAIN-CA™ Estimator representation
Floating point math operations (add, subtract, multiply, divide, exponentiate, log, square root, trigonometric, etc.)	Logic only (compare, invert, And, Or, Not, increment, decrement)

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Arrange a meeting with us during ISCA!

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