Explorations in the High Performance Computing Lab

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- Studying **unconventional techniques** for the application of

  sequential, parallel, and/or distributed computing

  to achieve high performance computing throughput with applications to:

  - **Topological Data Analysis (TDA)**
  - **Parallel Discrete Event Simulation (PDES)**

Graduate faculty status in ECE and CS; can serve as advisor to students in EE, CE, or CS

Topological Data Analysis (TDA)

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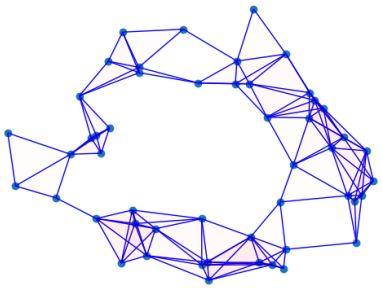
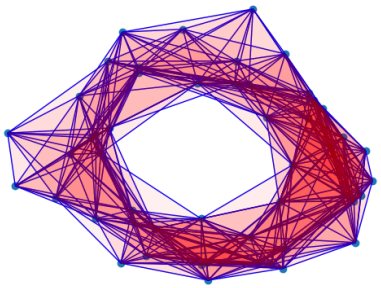
- Techniques for *data mining* using concepts from Topology
- Topology studies the properties of a geometric object that are preserved under *continuous deformation*
- Topology properties are known as **T**opological Invariants, examples include:

  Connectedness, Persistent Homology, or Euler Characteristic

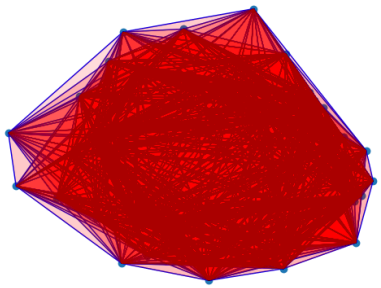
$\epsilon = 0.0$



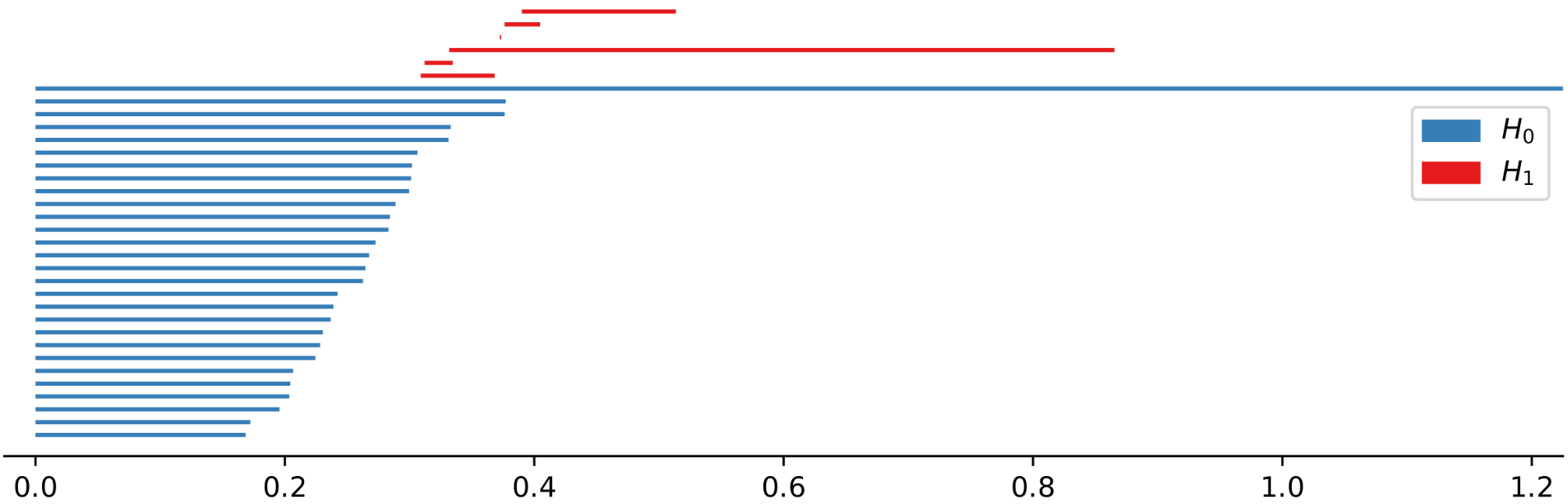
$\epsilon = 0.4$



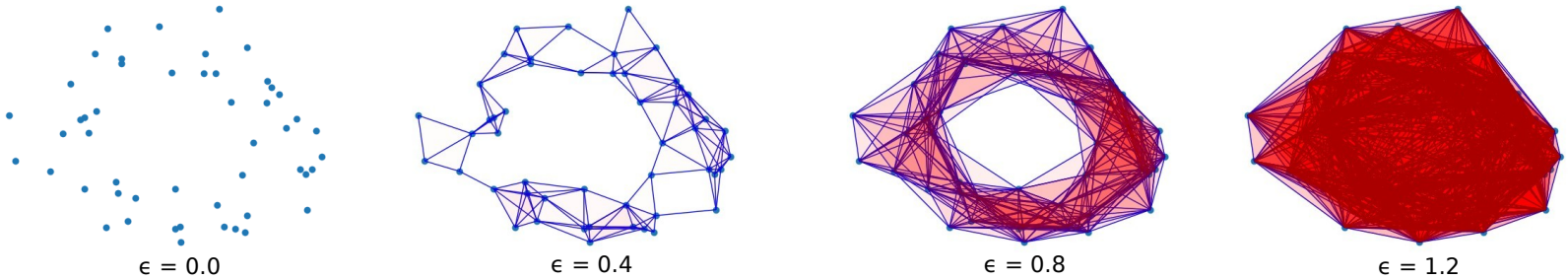
$\epsilon = 0.8$



$\epsilon = 1.2$



Attacks on TDA



- Optimizations to the connectivity graph:
  - planar graphs (Alpha complex) instead of non-planar graphs (Vietoris-Rips complex
  - polytopal complex (convex polytopes) instead of simplicial complex (triangular)
  - topology preserving graph transforms: sampling or sparsification
- Data manipulations:
  - partitioning & sampling (Partitioned Persistent Homology)
  - locating and isolating significant topological features
- Alternate back-end analysis:
  - Euler Characteristic Curves (ECC) $\chi(K) = V - E + F - C_3 + C_4 \ldots = \sum_{k=0}^{\inf}(-1)^k C_k$
  - Piecewise Persistent Homology

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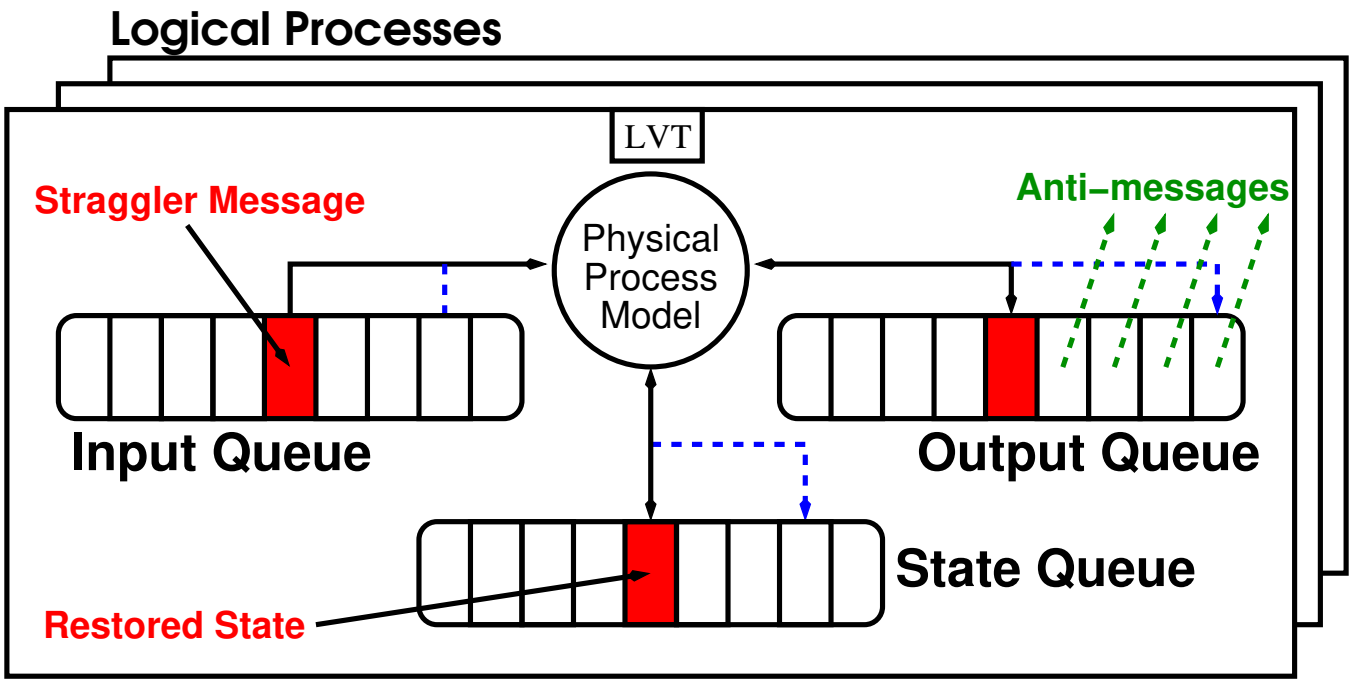
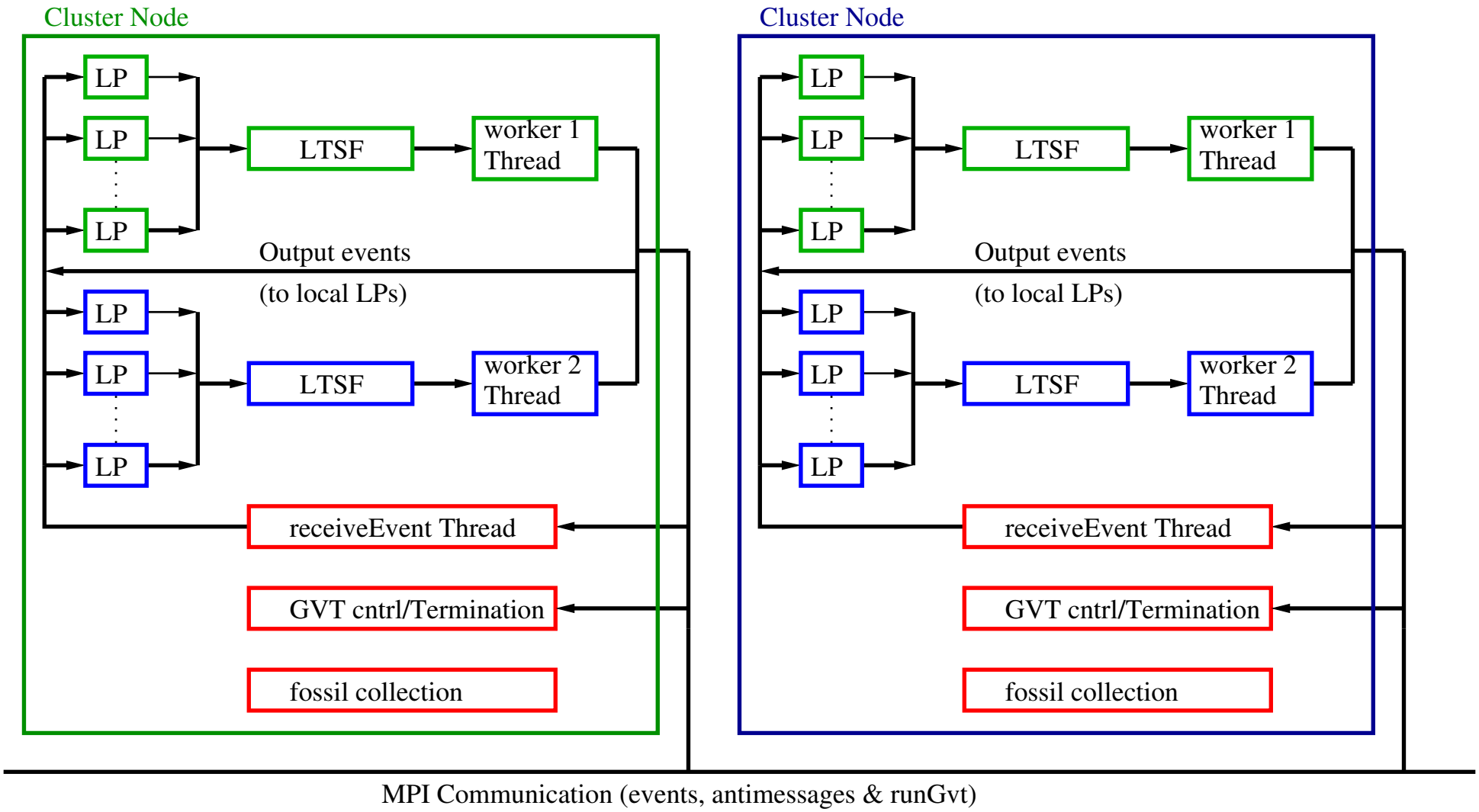
Time Warp: optimistically execute parallel discrete event simulators
recover from causal errors by rollback




Cluster Node
LP
LP
LP
LTSF
worker 1 Thread
Output events
(to local LPs)
LP
LP
LP
LTSF
worker 2 Thread
receiveEvent Thread
GVT cntrl/Termination
fossil collection
Cluster Node
LP
LP
LP
LTSF
worker 1 Thread
Output events
(to local LPs)
LP
LP
LP
LTSF
worker 2 Thread
receiveEvent Thread
GVT cntrl/Termination
fossil collection
MPI Communication (events, antimessages & runGvt)