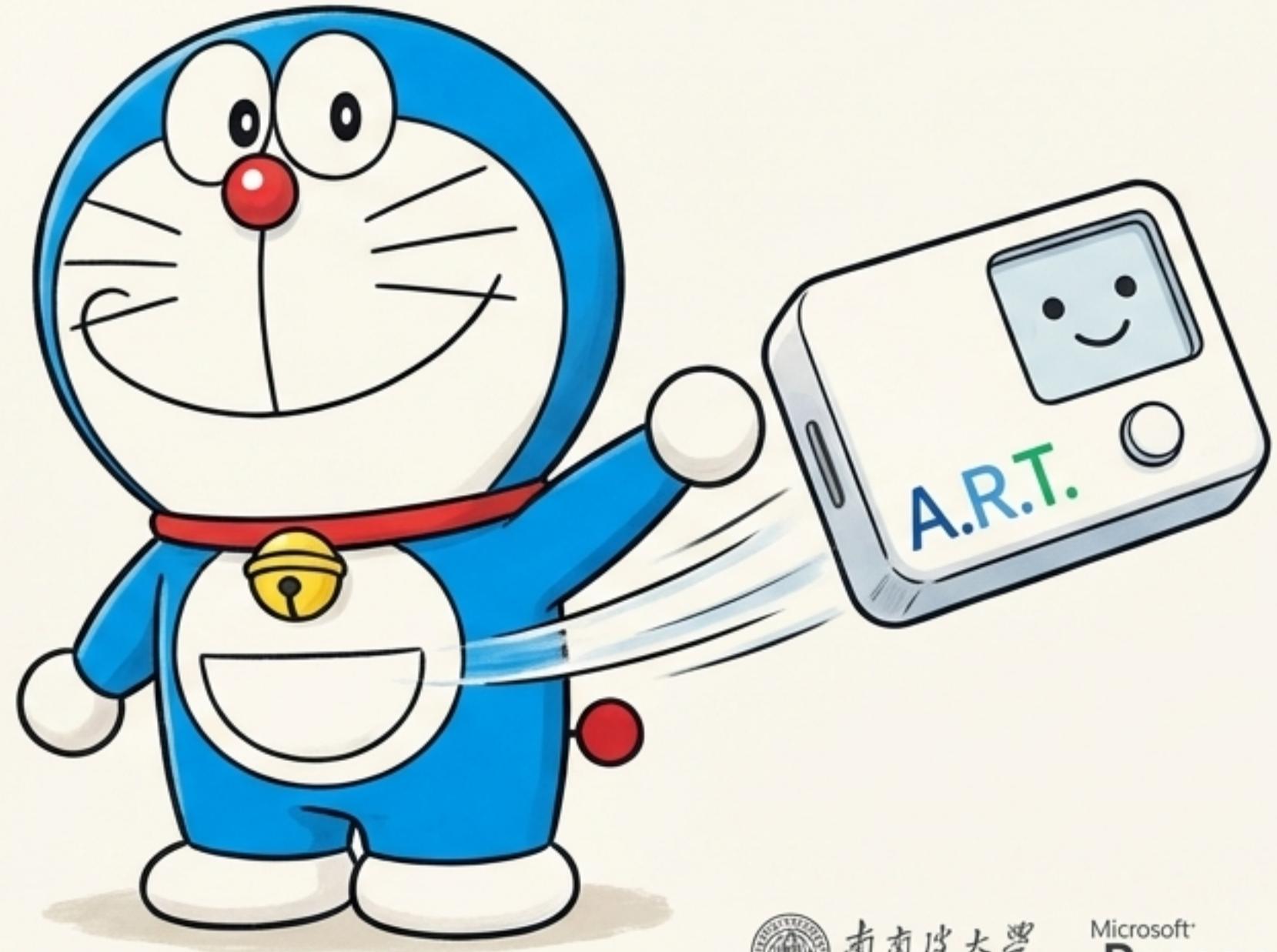
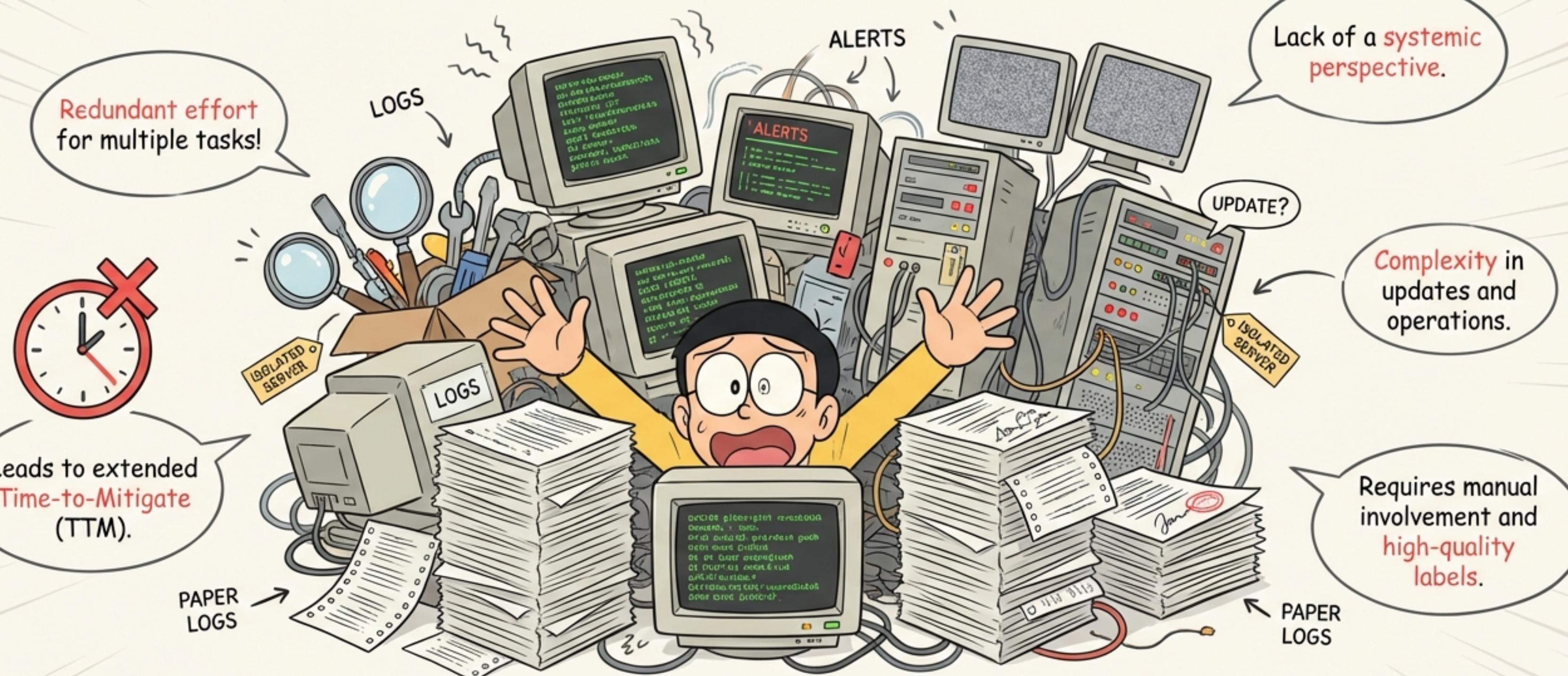


ART: A Unified Unsupervised Framework for Incident Management in Microservice Systems

How a futuristic gadget from Doraemon's pocket rescues
On-call Engineers from the chaos of modern incidents.

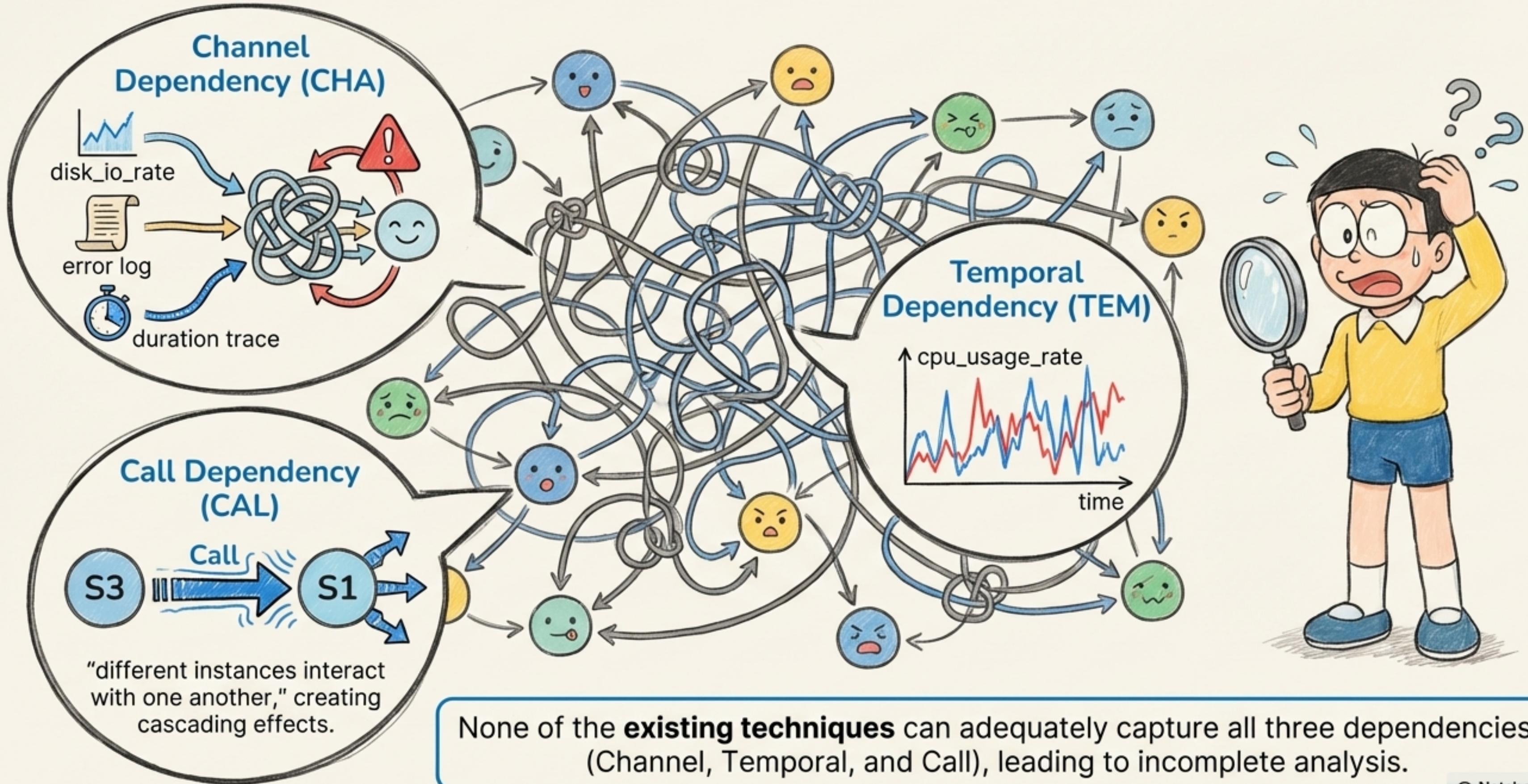


The Life of an On-call Engineer: Drowning in Complexity



Current incident management relies on isolated models for Anomaly Detection (AD), Failure Triage (FT), and Root Cause Localization (RCL). This approach is redundant and inefficient.

A System of Invisible, Tangled Dependencies



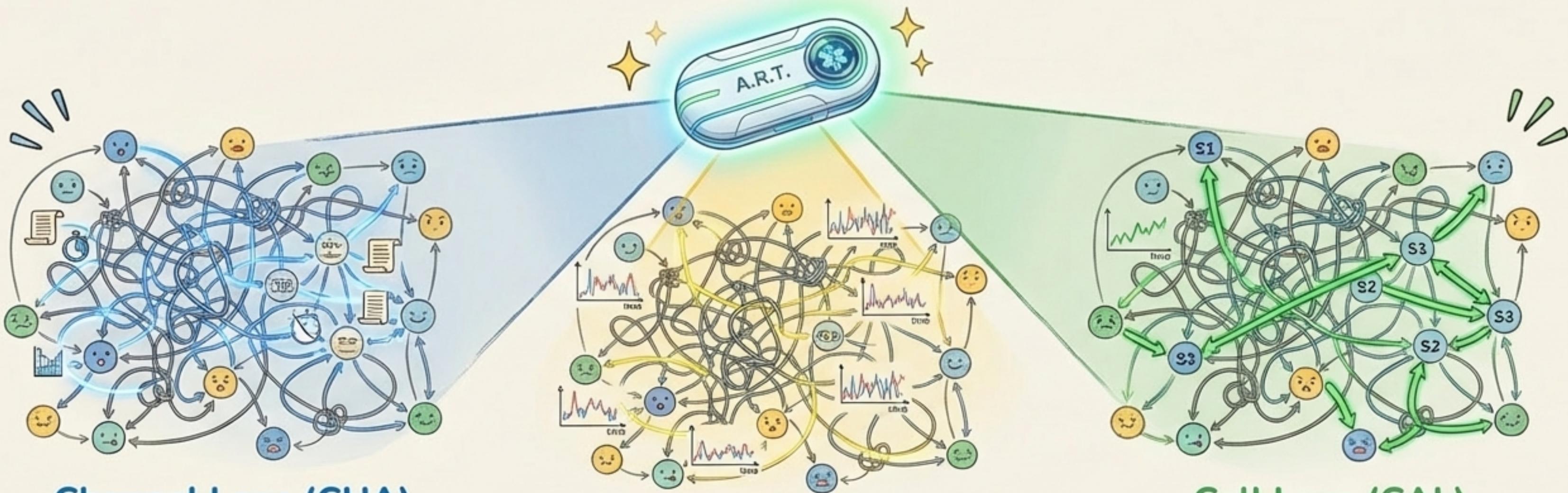
From the Future: Doraemon's Automatic Rescue Tool (A.R.T.)

ART is an **end-to-end unsupervised** incident management framework that integrates Anomaly Detection, Failure Triage, and Root Cause Localization. It achieves this unification by extracting shared knowledge from the system's data.



- ✓ Unified Modeling
- ✓ Fully Unsupervised
- ✓ Elegant & Efficient
- ✓ End-to-End Automation

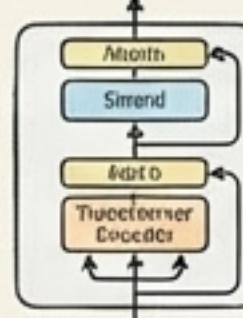
Feature 1: Dependency-Aware "X-Ray Vision"



Channel Lens (CHA)

Sees correlations across all data channels (metrics, logs, traces) within and between instances.

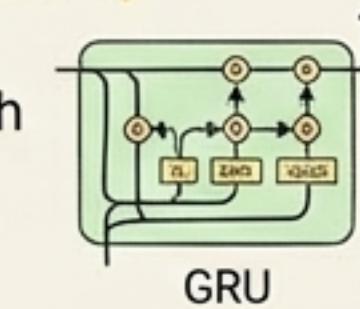
Powered by: Transformer Encoder.



Time Lens (TEM)

Understands the complex fluctuation patterns of each channel over time.

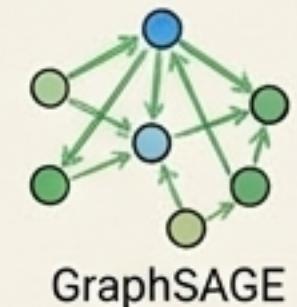
Powered by: Gated Recurrent Unit (GRU).



Call Lens (CAL)

Maps the interactions and dependencies between all instances in the system.

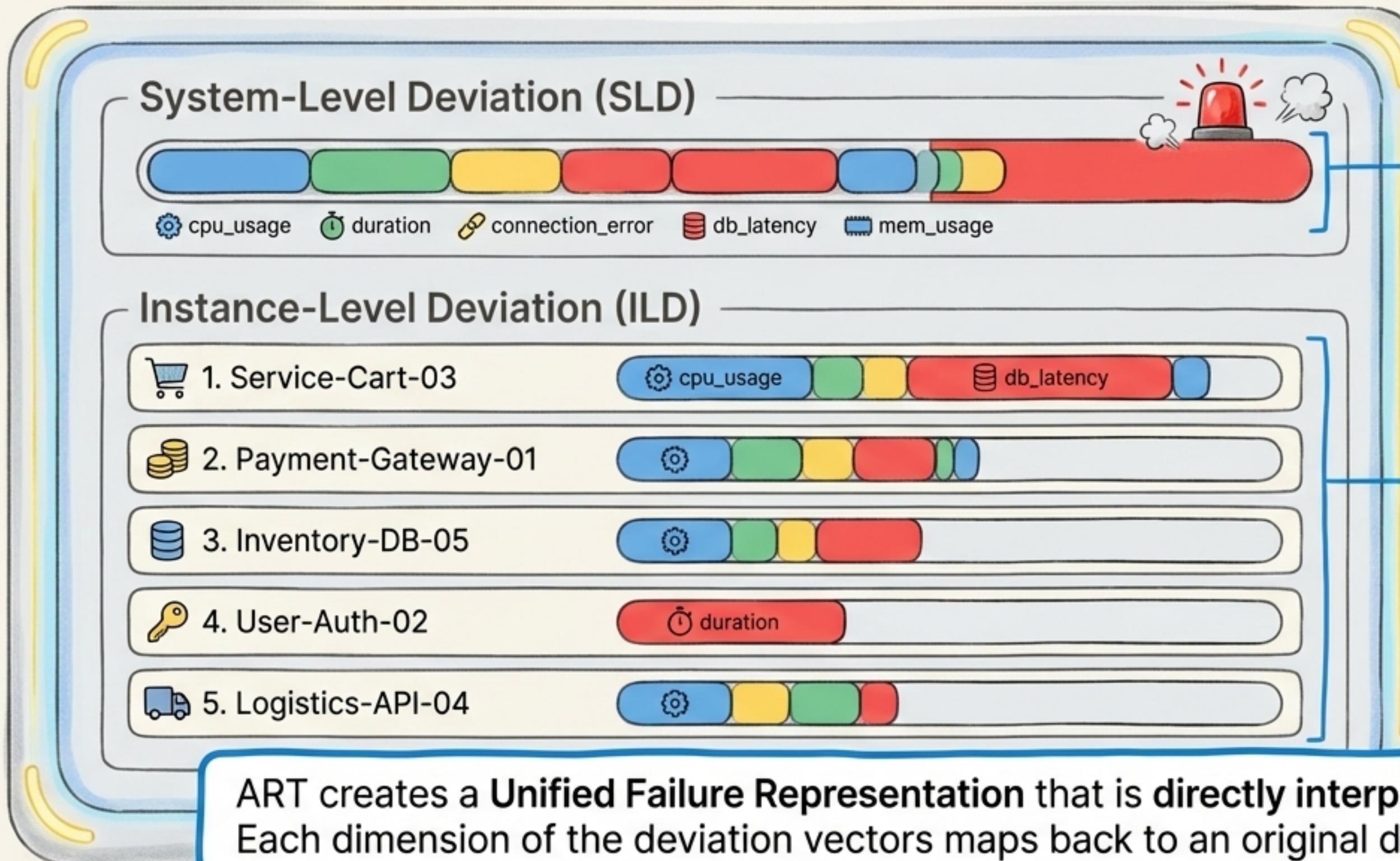
Powered by: GraphSAGE.



CHA → TEM → CAL

→ This sequence, from fine-grained to abstract, is critical for effective knowledge extraction.

Feature 2: The “Health-o-Meter” Display



A K-dimensional vector representing the entire system's deviation on each data channel.

Individual deviation vectors for each instance, showing its contribution to the system's state.

ART creates a **Unified Failure Representation** that is **directly interpretable**. Each dimension of the deviation vectors maps back to an original data channel, exposing the **shared knowledge** needed for all diagnostic tasks.



Feature 3: The Unsupervised “Troubleshooter Trio”

The “Anomaly Alarm”



Triggers when the system's overall deviation ($\|SLD\|_1$) crosses a dynamic threshold automatically set by **Extreme Value Theory (EVT)**. No manual tuning needed.



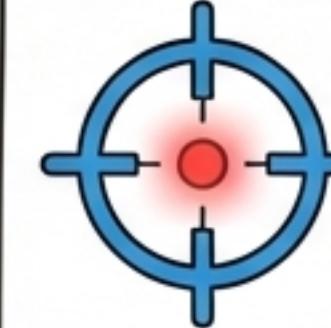
The “Problem Sorter”



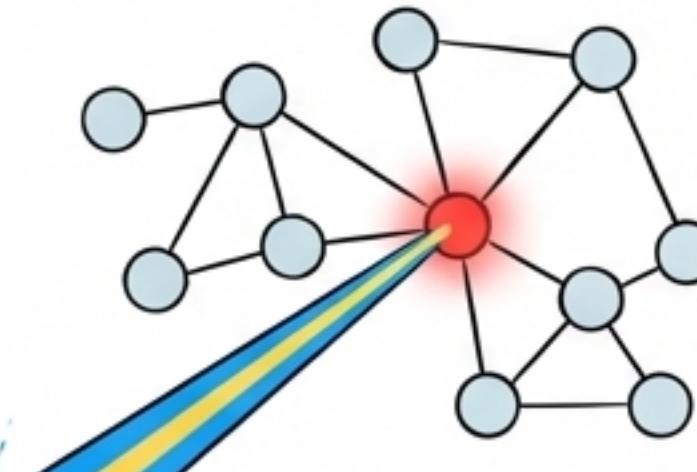
Uses a custom **cut-tree-based clustering** approach to group failures based on their unique system-level deviation (SLD) patterns.



The “Pinpoint Laser”

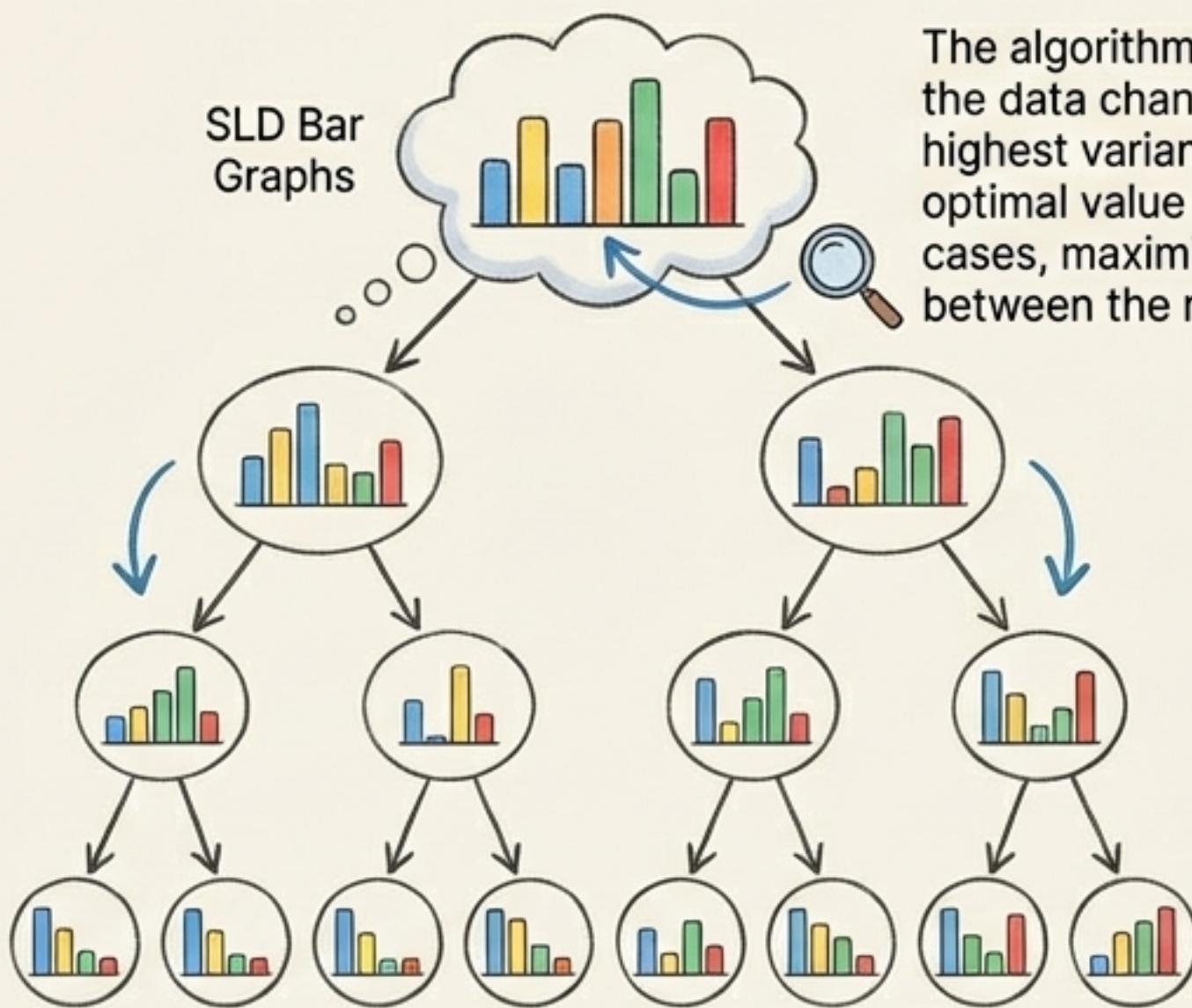


Calculates the **cosine similarity** between each instance's deviation (ILD) and the system's deviation (SLD). The root cause is the one with the most similar pattern.



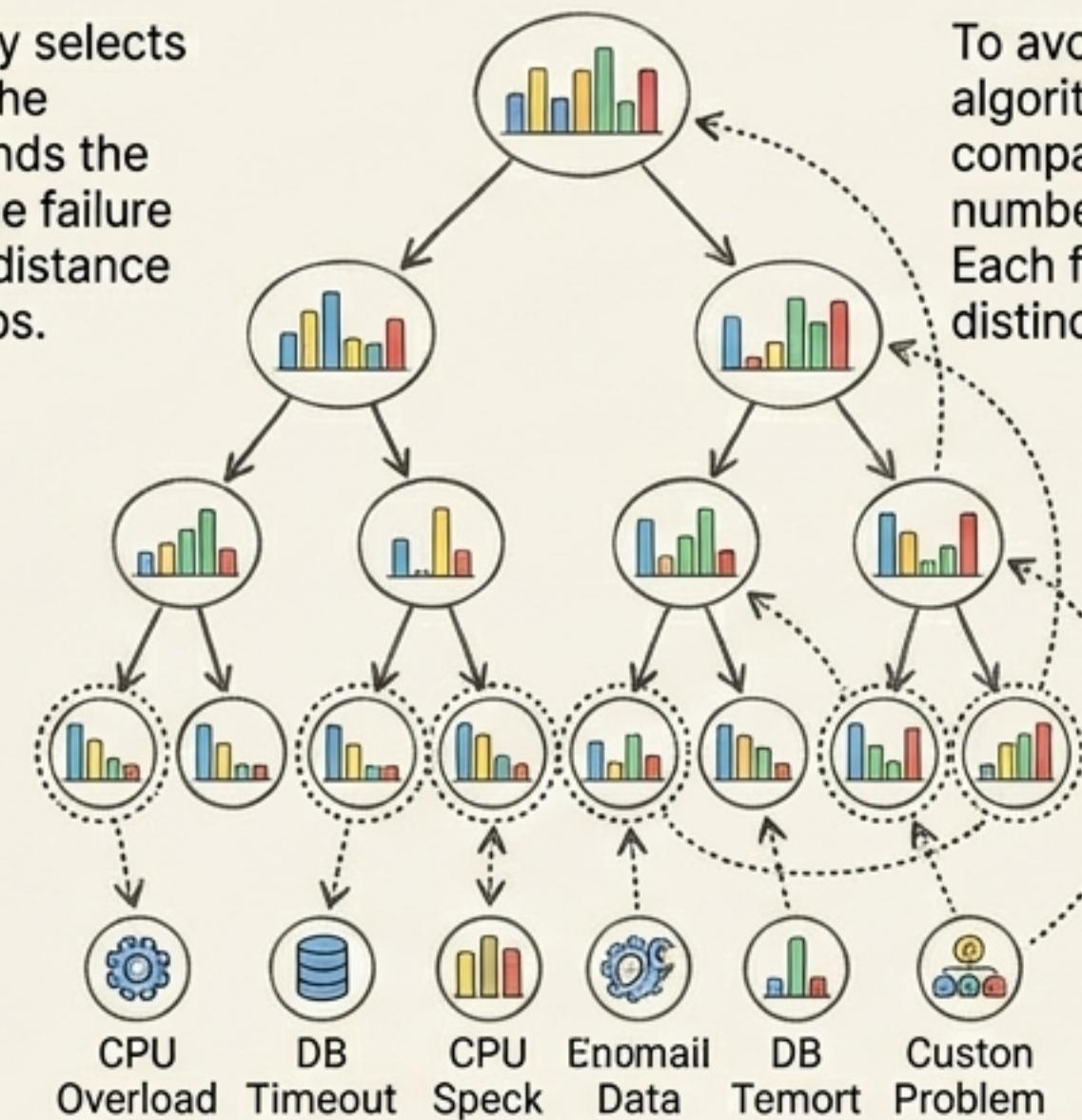
Under the Hood: How the “Problem Sorter” Works

Step 1: Cutting Divisions



The algorithm iteratively selects the data channel with the highest variance and finds the optimal value to split the failure cases, maximizing the distance between the new groups.

Step 2: Backtracking Merge



To avoid over-splitting, the algorithm merges the least compact nodes until a target number of clusters is reached. Each final cluster represents a distinct failure type.



Key Insight: This unsupervised process automatically discovers failure categories based on which data channels deviate most, providing **interpretable** results.

The Ultimate Showdown: ART vs. Prior Work

Prior Work

Eadro

Hades

PDiagnose

ERROR!

Performance Summary (Table 5)

Method	Dataset	AD (F1)	FT (F1)	RCL (AVG@5)
ART	D1	0.942	0.812	0.776
Eadro	D1	0.586	-	0.302
Dejavu	D1	-	0.415	0.625
Hades	D1	0.865	-	-
PDiagnose	D1	-	-	0.685
ART	D2	0.917	0.802	0.870
Eadro	D2	0.842	-	0.310
Dejavu	D2	-	0.417	0.619
Hades	D2	0.868	-	-
PDiagnose	D2	-	-	0.285

ART

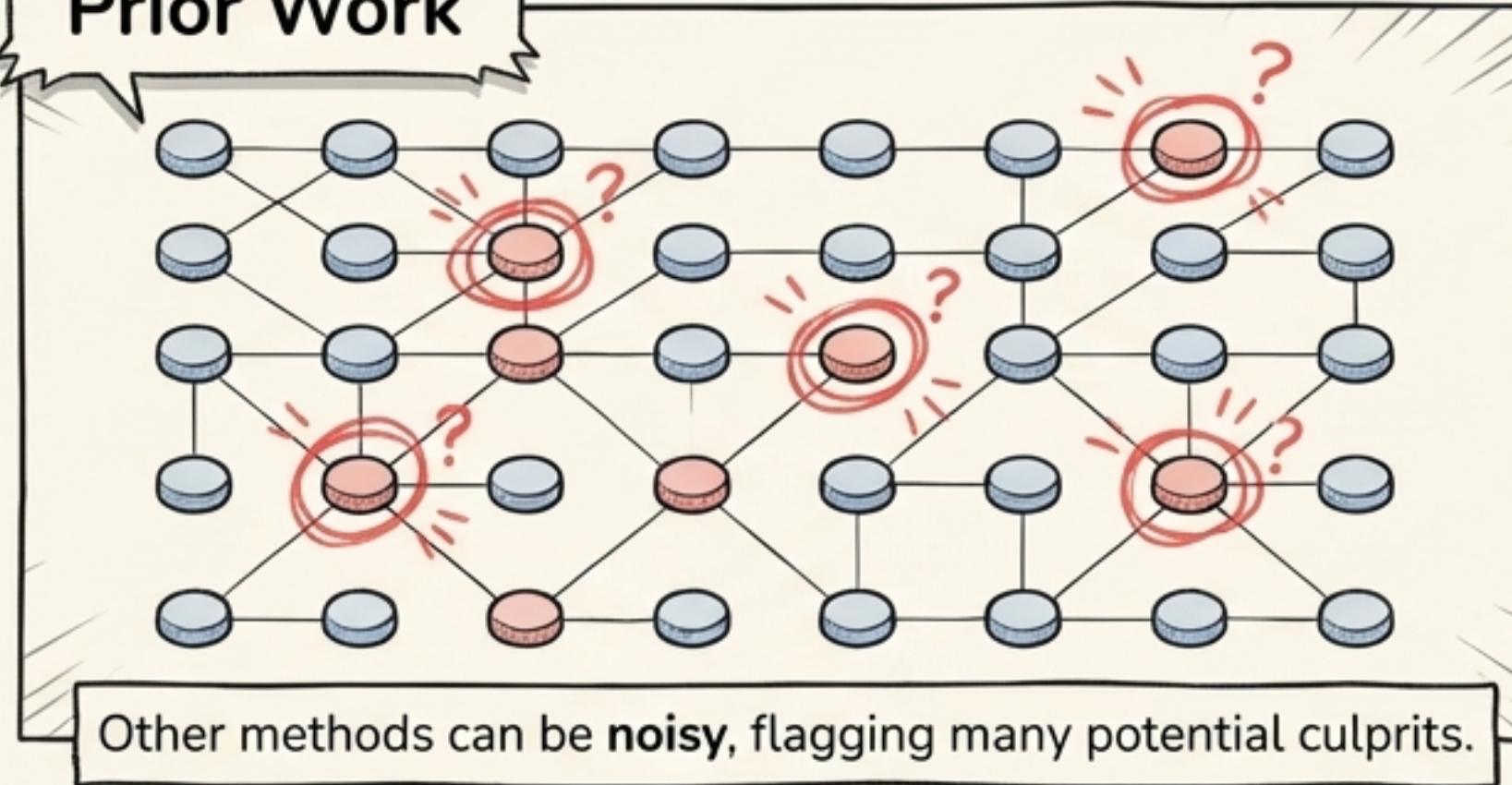
A.R.T.

ART outperforms existing methods in terms of AD (improving by 5.65% to 60.8%), FT (improving by 13.2% to 95.7%), and RCL (improving by 13.3% to 205%).

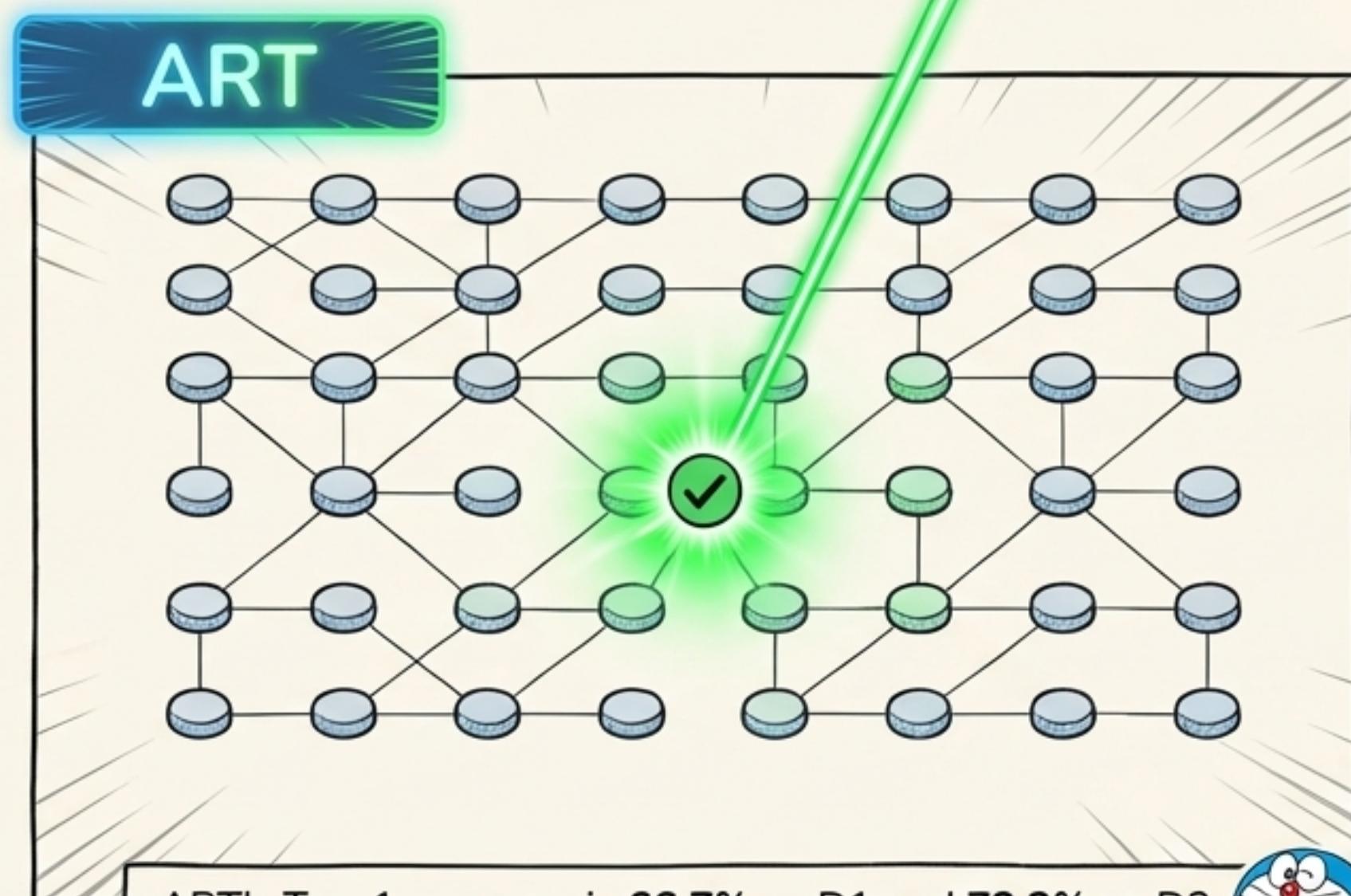
NotebookLM

Finding the Needle in the Haystack: Pinpoint Root Cause Localization

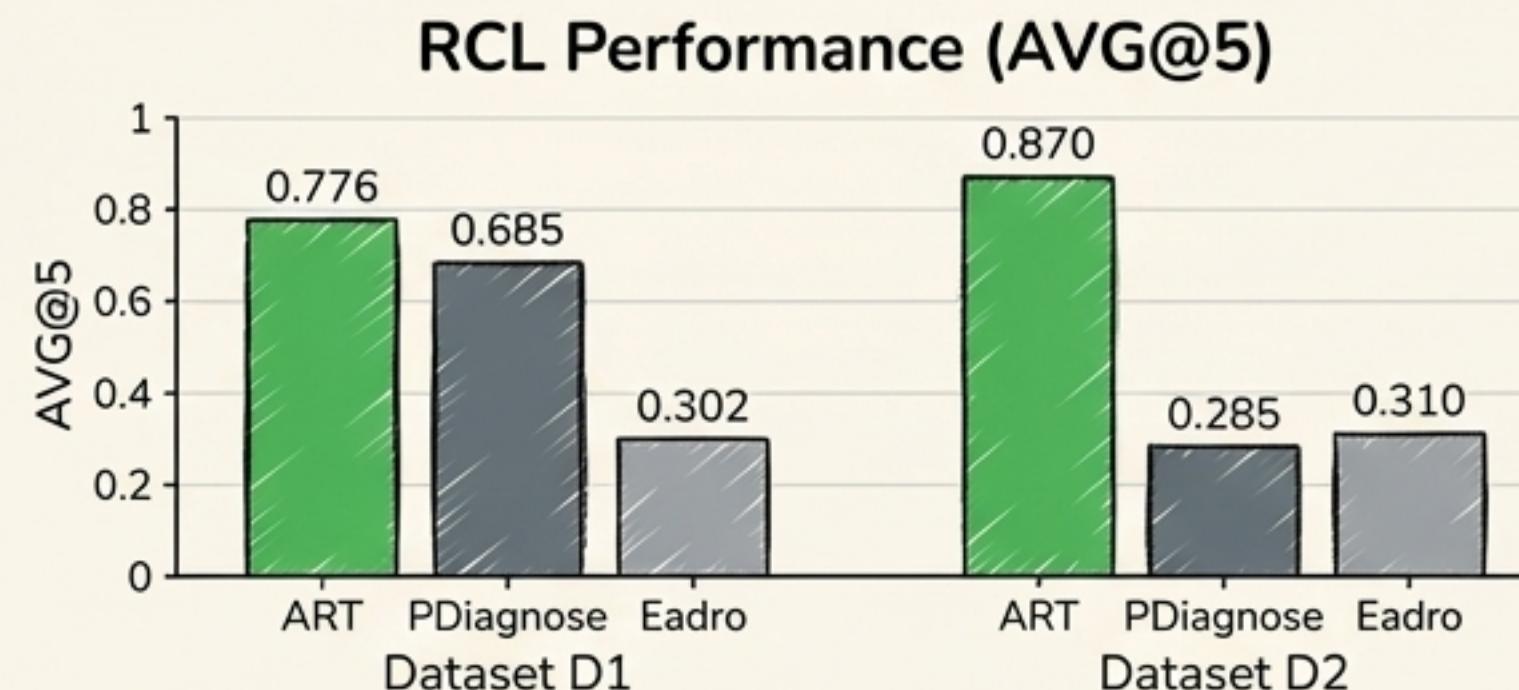
Prior Work



ART



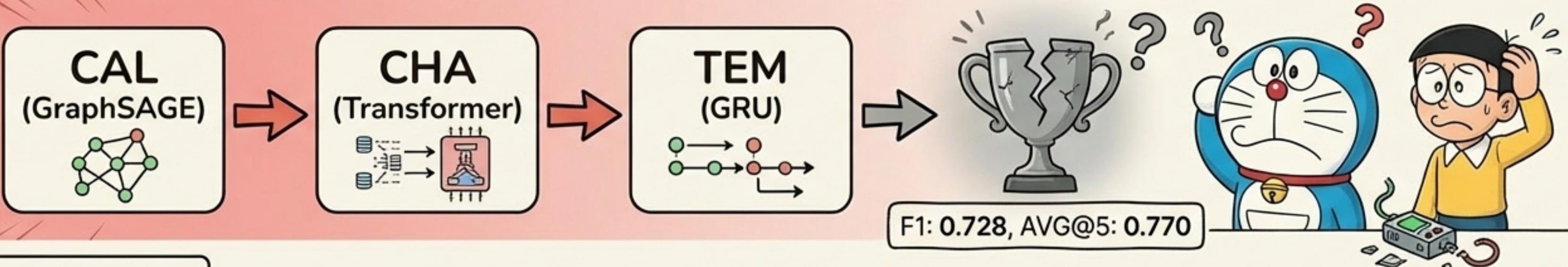
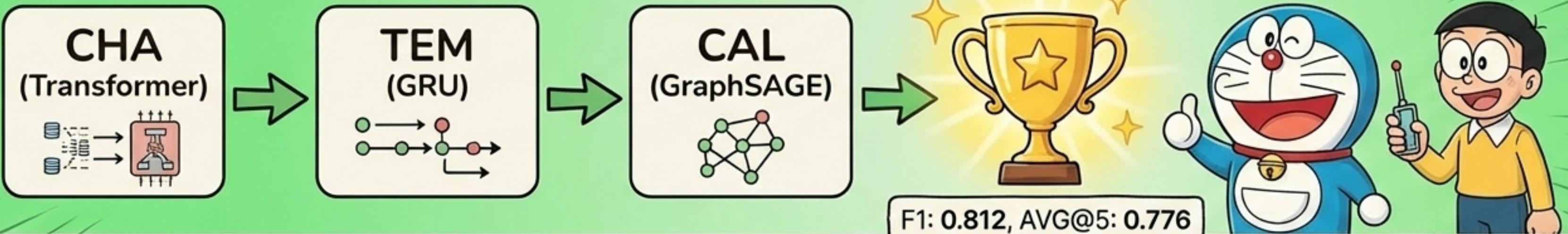
ART's Top-1 accuracy is **66.7%** on D1 and **72.2%** on D2.



★ **ART's** RCL is superior because it identifies the instance whose deviation pattern (ILD) is most similar to the overall system's deviation (SLD), a direct benefit of the unified representation.



The Secret to ART's Power: Order Matters



Explanation

The ablation study proves that the feature extraction order is crucial. ART succeeds by modeling dependencies sequentially: from fine-grained data correlations (Channel), to their patterns over time (Temporal), and finally to coarse-grained instance interactions (Call).

"Combined consideration of channel, temporal, and call dependencies is beneficial... And the order of feature extraction matters."

Finding 2 from Paper

“Peace of Mind, Restored.”

