117-60-D IT Has to Go Back to School … Learning CAS

Why the next generation of engineers must think like ecologists, economists, pilots, and city planners

For more than half a century, the information technology industry has been extraordinarily successful.

- The reason is simple.
- Most of the systems it built belonged to the world of CES (Complex Engineered Systems).
- Engineers designed the components.
- Engineers defined the interfaces.
- Engineers controlled the flow of information.
- Engineers predicted the outcomes.
- The rules were clear. Input → Computation → Output

Then the world changed.

The age of the machine is ending

- Traditional software systems resembled factories.
- Inputs entered one side.
- Outputs emerged from the other.
- If something failed, engineers found the defective component and repaired it.
- The machine returned to normal operation.

Agentic systems are fundamentally different.

- They communicate.
- They learn.
- They adapt.
- They form alliances.
- They create feedback loops.
- They change their behavior in response to their environment.
- They evolve.
- Suddenly, the factory has become a city.

The old curriculum

For decades, information technology professionals studied subjects such as:

- databases;
- operating systems;
- algorithms;
- compilers;
- computer networks;
- cybersecurity;
- transaction processing;
- software engineering;
- CI-CD etc.

These subjects remain essential. But they are no longer sufficient.

The new curriculum

The world of complex adaptive systems demands an entirely different body of knowledge. Tomorrow's engineers may need to understand:

- systems dynamics;
- ecology;
- epidemiology;
- sociology;
- behavioral economics;
- swarm intelligence;
- game theory;
- network science;
- nonlinear mathematics;
- control theory;
- stability engineering;
- emergence theory.

Strangely enough, the engineer of the future may need to think less like a machinist and more like a gardener.

The Beer Game warning

The famous Beer Distribution Game (I learned it at MIT Sloan) provided an early warning.

- Perfectly intelligent rational people repeatedly produced irrational collective outcomes.
- Nobody intended the failure.
- Nobody wanted the failure.
- The failure emerged naturally from the interactions between participants.

The Innovator's Dilemma Warning

Professor Clayton Christensen's *The Innovator's Dilemma* revealed a phenomenon strikingly similar to the Beer Distribution Game. Perfectly intelligent executives, armed with abundant data, extensive experience, and the best intentions, repeatedly drove successful companies toward decline. They listened carefully to their customers. They allocated capital rationally. They improved products methodically. They optimized margins relentlessly. Yet, collectively, these sensible decisions often proved catastrophic. The problem was not incompetence; it was adaptation to the wrong signals. Local optimization gradually undermined global resilience. Established companies became increasingly efficient at serving yesterday's market while newcomers quietly captured tomorrow's opportunities. The resulting failure was not the consequence of a single mistake. Rather, it emerged from the interaction of incentives, feedback loops, organizational structures, market expectations, and human behavior. Once again, the system behaved logically while human intuition failed.

The Beer Game demonstrated that intelligent people can unintentionally destabilize supply chains. Christensen demonstrated that intelligent organizations can unintentionally destabilize themselves. In both cases, the culprit was not intelligence. It was the hidden logic of a complex adaptive system.

The airline boarding paradox

Another example is the famous airplane-boarding simulation.

- The most orderly boarding strategy turns out not to be the most efficient.
- A seemingly chaotic strategy produces superior results.
- Human intuition fails.
- The system's internal logic prevails.
  See video https://x.com/stats_feed/status/2066948967204605959?s=20

The cybersecurity lesson

Traditional cybersecurity assumes that individual components can be observed, analyzed, and controlled.

- That assumption works well when systems behave like machines.
- It becomes far less effective when systems behave like ecosystems.
- In ecosystems, relationships are often more important than components.
- Interactions become more important than intentions.
- Emergence becomes more important than design.

The arrival of HCAS

The challenge becomes even more profound when these complex adaptive systems begin operating at machine speed.
This is the world of HCAS (Complex Adaptive Systems operating at machine speed).

- The timescale changes.
- The density changes.
- The coupling changes.
- The consequences change.
- A phenomenon that once unfolded over weeks may now unfold in seconds.

A humbling realization

The information technology industry taught the world how to build machines.
Now it must learn how to cultivate ecosystems.

- That will require humility.
- The assumptions that carried us successfully through the age of deterministic computing may not survive the age of cognitive computing.
- IT has been one of humanity's greatest teachers.
- Now IT itself must become a student again.

The next great challenge of computing will not be making intelligence more powerful.
It will be learning how to live with intelligence that adapts, interacts, cooperates, competes, and evolves.


IT HAS TO GO
BACK TO SCHOOL..
LEARNING CAS
COMPLEX ADAPTIVE SYSTEMS (CAS)
★ EMERGENCE
★ ADAPTATION
★ FEEDBACK LOOPS
★ NONLINEARITY
★ SELF-ORGANIZATION
★ DELAY
★ COUPLING
THE BEER GAME
RETAILER
WHOLESALER
DISTRIBUTOR
- LOCAL OPTIMIZATION
- INFORMATION DELAYS
- OVERREACTION
- OSCILLATION
AIRPLANE BOARDING PARADOX
ORDER ≠ EFFICIENCY
THINK LIKE
ECOLOGISTS
ECONOMISTS
PILOTS
CITY PLANNERS
SYSTEMS
THINKERS
INNOVATOR'S DILEMMA
CLAYTON M. CHRISTENSEN
SYSTEMS DYNAMICS
NETWORK SCIENCE
COMPLEXITY
GAME THEORY
SWARM INTELLIGENCE
BEHAVIORAL ECONOMICS
CONTROL THEORY
STABILITY ENGINEERING
IT PROFESSIONAL
STUDENT AGAIN
while (true) {
observe();
adapt();
learn();
collaborate();
stabilize();
}
// Welcome to CAS world
ECOLOGY
EPIDEMIOLOGY
SOCIOLOGY
NONLINEAR MATHEMATICS
UNLEARN
RELEARN
ADAPT
FROM
MACHINES
TO
ECOSYSTEMS
HUMILITY
CURIOSITY
SYSTEMS
THINKING
USA
GUDIYA
THE NEXT GREAT CHALLENGE OF COMPUTING
WILL NOT BE MAKING INTELLIGENCE MORE POWERFUL.
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