

## Supercomputers could generate early-warning system for stock market crashes

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Powerful computers can wreak havoc on American stock markets, creating hair-raising volatility and eroding investor confidence in the lightning-fast search for profit.

But far more powerful computers, such as a supercomputer run by Berkeley scientists, could help save it.

High-speed trading now dominates the U.S. stock markets, executing trades in a fraction of the time that it takes to blink. It generates a sea of chaotic data and can lead to nightmares like the May 2010 "flash crash," when stock values swung wildly for no apparent reason.

Yet faster still is "Edison," a supercomputer tended by Lawrence Berkeley National Lab scientists in a former Wells Fargo Bank Building in downtown Oakland. Edison-like computers could track ultrafast trading across the nation's many markets, detecting precursors to a crash -- and sound an early warning for regulators seeking to avert a gruesome economic wreck.

It would be like a NASCAR race yellow flag warning racers to slow down when it recognizes market instability, the scientists say.

"If improved monitoring and regulation can build some greater trust in the market, everyone benefits," said David H. Bailey, director of the Berkeley lab's new Center for Innovative Financial Technology, which is building a bridge linking computational science and financial market communities.

Edison loves big data. Its idea of an average day is simulating a supernova explosion, measuring the expanding universe's rate of acceleration. Or modeling 150 years of Earth's future climate change -- in three dimensions.

When fully deployed later this year, Edison will perform up to two quadrillion operations a second. How big is that number? Two quadrillion cups of water would fill Lake Tahoe twice.

Tracking every trade, in real time, on every U.S. stock exchange? No big deal.

"That data size -- we do routinely do 10 times that much. Easily. It's a trivial matter," said Bailey, a leading figure in both the high-performance scientific computing and computational mathematics.

Not so long ago, life was simpler. U.S. stock markets moved at a human pace, simply matching buyers with sellers. But now there are many exchanges. And more than half of all trading is done by high-speed computer "traders" who live their electronic lives in server parks.

Most agree that computer trading is good for the average investor because it's cheap. But it also triggers unpredictably large price swings -- causing widespread Maalox moments. It's breeding distrust in the market.

The "flash crash" of 2010 was triggered by a single firm using algorithms to rapidly sell 75,000 futures contracts. In moments, the Dow Jones industrial average fell more than 700 points, or almost 10 percent, and quickly recovered. Individual stocks experienced wild price swings. How crazy was it? Apple briefly traded

for \$10,000 a share. Within seconds, Accenture traded at \$40 and then one cent.

Since then, numerous mini-flash crashes and other anomalies have slapped around stock values and investor confidence.

"Electronic markets ... seem capable of impressively flaky behavior," says Lawrence Berkeley lab's David Leinweber, a computer scientist and former investment manager who is an expert in algorithmic trading.

"We are lost in the jungle when it comes to our ability to understand ever-faster markets well enough to keep them safe, stable and secure," he said.

Regulators with weak and incompatible computer systems have since set safeguards. One uses shutdown switches -- "circuit breakers" -- to halt all trading. A second, called "Limit Up, Limit Down," cancels trades outside a normal price range.

But these, asserts Leinweber, are like applying the rules of the road to aircraft. Slowing, rather than suddenly halting markets, is less traumatic.

Months later, using the lab's Cray XE6 "Hopper" supercomputer, the Leinweber team found one precursor to a flash crash that a supercomputer could identify.

Called Volume-synchronized Probability of INformed trading, or VPIN, it detected an imbalance between buy and sell orders, and growing volatility, about 45 minutes before a crash.

A second measure of market volatility, the Herfindahl-Hirshman Index, or HHI, also rose sharply for some stocks, although not for others.

These two measures "can tell when it is 'safe to go in the water' of continuous fast markets," wrote Leinweber, in an email. They could be used by regulators to issue a "yellow flag" warning or "green flag" go-ahead, creating trust in the market.

Market experts said they saw promise in the idea. Leinweber "is well situated to speak to the role that machine learning and artificial intelligence can play for detecting patterns in markets," said David Andre of San Francisco's Cerebellum Capital.

A venture firm leader sees Leinweber's work in the forefront of understanding market complexities.

"Leveraging 'smart' machines to parse and extract signals from massive quantities of textual data is hard, and David's work has put him at the vanguard of the next wave of the alpha generation," said Roger Ehrenberg of the New York City-based venture firm IA Ventures.

Bryan Harkins, chief operating officer at Direct Edge, the fourth-largest stock exchange, was more cautious. "It is great that the academic community has chimed in -- not that we choose any specific winning idea, but these different ideas and themes are woven into what we are seeing as we look to improve the market," he said.

The scientists don't want Edison to do the Securities and Exchange Commission's work -- the computer belongs to the U.S. Department of Energy.

But they hope to study the possibilities more, marking the path to the next generation of market surveillance.

"We have got to find a way to make the system work, and monitor it," he said. "If this science is better understood, perhaps another flash crash can be averted."

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## ONLINE

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