**The Disappeared: Beyond Winning and Losing**

*Opening* comments . . . At 82 years of age, I’m an old-timer . . . Born in 1938, before television, jet planes and computers . . . and I vividly remember the frightening radio’s news of Dec. 7th, 1941.

So **I’ve lived through LOTs of technological and social change** and am now a kind of **“a messenger from the past”!**

Today I’d like to take us “Back to the Future” of decades past. . . and **travel together FORWARD in time down memory lane**. As we go, let’s look for **clues about the following “DEI” question:**

***When “others” (such as women, people of color and all types of excluded minorities) make innovations in science and engineering . . . why do their contributions “disappear” from later history . . . and are ascribed elsewhere? Why does this happen?***

By now, many of you’ve seen the 2016 film *Hidden Figures* . . . **about the key roles 3 black women played during the 60s** . . . in the “space race” between the US and the Soviet Union . . . **a story that had completely disappeared from history.**

Historian Margaret Rossiter has documented in detail how ever-so-many accomplished women have disappeared from the history of science. She calls this “the Matilda Effect”— i.e., the **systemic repression of contributions of women** and attribution of their accomplishments to male colleagues.

And it’s still happening, to women in computing . . . as **when the four women deeply involved** in Apple’s Macintosh development . . . **later erased in news and films** about the historic project.

**Can you imagine how it feels . . . to be disappeared? SLIDE 1**

**So, what causes these disappearances?**

It’s natural to look for stories involving bad versus good . . . with bad people “disappearing” the stories of good people. Or bad men disappearing good women. But looking for deliberate “repression” is far too narrowing a view.

Sociologist **Robert Merton coined the term the “Matthew Effect”** to describe how **prominent scientists’ get more credit than lesser-knowns**. For example, honorific awards often go to a project’s most senior researcher . . . even if a grad student or post-doc did the innovating.

Now, that kind of “repression” isn’t usually thought of as deliberate — it’s “just part of the game” where **advantage accumulates to already-known innovators** (mostly prominent men) . . . who’re **expected to innovate** as the “natural order of things.” Most such men are good men — they aren’t deliberately being bad. Most just don’t notice what’s going on.

Today no major university or tech company would tolerate explicit policies to reward prominent men over much-less-prominent women. **But the problem is still with us** . . . asseenin the Apple McIntosh story . . . deeply buried within our culture, it’s difficult to change. **What to do?**

**BACK TO THE FUTURE:**

**Let’s go “Back to the Future” and follow the story of an actual disappearance . . .** during the **Very Large Scale Integrated (VLSI) microelectronics revolution** in the 1980s and 90s . . **. and look for clues.**

The revolution built on the early integrated circuits of transistors and wiring “printed” onto silicon chips. **Advances in lithography enabled printing of ever smaller features**, and the number of transistors per chip rapidly increased during the 60s. **In 1971, Intel lauched the 4004 micro-processor** (a very basic computer-processor on a chip). **It contained 2,300 transistors.** **SLIDE 2**

Intel’s Gordon Moore observed that the number of transistors per chip doubled about every two years. Caltech prof Carver Mead, who was Moore’s consultant at Intel, dubbed the insight “Moore’s law”.

Such dramatic scaling **made it conceivable that supercomputers of the ‘70s could be printable on single chips by 1990.** However, there were no means to design such complex chips. **It was as if the printing press had been invented, but no written language existed in which to write printable stories.**

**Attacking a big “complexity problem”:**

In 1976, my lab manager **Bert Sutherland at Xerox Palo Alto Research Center (PARC)** and his brother **Ivan Sutherland (Caltech’s Chair of Computer Science)** launched a collaboration to attack this problem. I led the team at PARC **using my expertise in computer architecture**, while Mead at Caltech **brought his expertise in semiconductor physics** and a team of grad students.

It was the perfect place and time: PARC researchers had **just innovated the Alto** interactive-display mouse-controlled personal computer, the Ethernet, and the Xerographic laser-printer. PARC was also connected to ARPANET, the internet precursor pioneered by the **Defense Advanced Research Projects Agency** **(DARPA)**. Few outside advanced research circles knew that such technologies even existed. We entered a vast new frontier for exploration, **armed with these secret Xerox PARC weapons**. **SLIDE 3**

**In a crash effort during 1976-77**, we coalesced a set of new, highly streamlined methods for designing digital systems in silicon . . **. The methods could be quickly learned** and enabled digital designers to craft chip-designs using interactive graphical software running on Xerox Altos, **much like a writer used the Altos’ word-processing tools to create documents for printing.**

**But how could these new methods be propagated?** No way by just “writing scholarly papers and waiting for things to happen . . . Recalling how Charles Steinmetz had launched the AC electricity revolution in 1912 by writing a seminal textbook and teaching innovative courses at Union College in Schenectady. . I suddenly envisioned a huge opportunity.

**What if we rapidly created and evolved a textbook** (using the Altos and laser-printers) that contained working design examples using the new VLSI methods . . **. including just the bare-minimum knowledge** of transistor behavior, digital design, computer architecture, electronic design automation (EDA) and chip fabrication . . . that students needed to confidently begin designing prototype project chips.

**By teaching the methods in a “how to do it” manner**, they’d be seized-upon as already proven . . . as in texts **written well after their methods are proven**. I suggested this idea and Mead excitedly agreed.

Thus we launched an evolving book that could be printed on PARC’s laser-printers and sent to early users. It went on to become the **seminal 1980 textbook *Introduction to VLSI Systems***. **SLIDE 4**

In the fall of 1978, **Bert Sutherland arranged for me to take a sabbatical MIT** . . . using the draft textbook **to launch an experimental VLSI chip design course there**. So began my **“Steinmetz revolution-launching reenactment”,** complete with his photo on my office wall . . .

**Students learned the methods in the 1st half-semester, and created chip design projects in the 2nd half**. The designs were fabricated at HP Research’s Integrated Circuit Processing Lab **(led by my colleague Pat Castro, another woman engineer)**. Packaged chips were returned to students shortly after the course ended. One student (Guy Steele) **designed a complete LISP microprocessor! SLIDES 5, 6**

**The MIT course stunned hig-tech leaders in Silicon Valley.** Large-scale chip design had been the mysterious province of the few computer architects who worked for semiconductor companies. **So, if you wanted to “be an author” in the new silicon medium, you had to work for a “printing plant”**!

**But now apparently anyone could do it**, and many major research universities wanted to offer such courses. **It held the promise of “freedom of the silicon press!**”

**But how could we do it at Scale?**

But how could my little research team at PARC coordinate fabrication of project chips for many courses? **Just in time, I got a wild idea** . . . on how to create **what’s now called an e-commerce system**:

What if students **remotely submitted chip layout-design files via the ARPANET to a server at PARC** . . . where software packed designs into mask-making files for multi-project chips (MPCs). . . and they could all be fabricated as one small lot in among many boatloads of wafers during mass-production runs.

**This ‘conjectured-innovation’ promised widely shared, economical access** to expensive chip-printing equipment at remote “silicon foundries” (as they’re now called).

**But could we make one that worked RIGHT NOW and at scale?** It was like suddenly seeing a majestic mountain . . . right in front of you . . . that no one’d ever climbed. **We were compelled to attempt the first ascent!**

While my PARC team scrambled to prepare the prototype software, we used the ARPANET to announce the **“MPC79 VLSI project implementation service”** to EECS departments at major research universities.

Although given the go-ahead by Bert Sutherland, **this was an exploratory project**, unofficial and off the books . . . operated under the principle **“it’s easier to beg forgiveness than to get permission.”**

On the surface, MPC79 appeared to be an official institutionally-based project. But it was done in the spirit of a classic “MIT hack”, a very-visible technical stunt that stuns observers, who can’t figure out how it was done or who did it. **The bait: promise of chip fabrication for student VLSI design projects.**

**An Incredible Success!**

**Faculty at 12 research universities took that bait** and signed on to offer MIT-style VLSI design courses. **I sent them all my MIT lecture notes**, to help them **run their courses in synchrony**. “**MPC79”** rapidly escalated into **a huge ARPANET “happening.”** **SLIDE 7**

**12 instructors and 129 students and researchers all acted together**, creating scores of innovative designs. Fabricated chips were returned from Pat Castro’s “foundry” at HP one month after the design cutoff—**an astonishingly short turnaround time**. One prototype**, the Geometry Engine by Jim Clark at Stanford**, led to his start-up of Silicon Graphics.

A huge success, **MPC79 demoed and validated the design methods, the book, the design courses, the EDA tools, and the e-commerce infrastructure**. In just three short years, we had **bootstrapped a** “**techno-social ecosystem” for VLSI chip design and manufacturing into existence**. **SLIDE 8**

By 1983, Mead-Conway VLSI design courses were offered at **113 universities around the world**. Moore’s law held for decades. Modern chips contain complex systems of billions of transistors.

**Early Accolades, Then Disappearance:**

By the early 1980s, the stunning potential of VLSI microsystems had electrified the high-tech community. **Mead and I were spotlighted by prominent trade magazine *Electronics*** with its 1981 Annual Achievement Award. We got the Pender Award from the University. of Pennsylvania in 1984 and the Wetherill Medal from the Franklin Institute in 1985. Mead was elected to the National Academy of Engineering in 1984. I was elected in 1989. **But suddenly, everything changed**.

In 1989, George Gilder — an influential speechwriter for Ronald Reagan, a staunch evangelical and author of the anti-feminist books *Sexual Suicide* and *Men and Marriage* — **published the book *Microcosm: The Quantum Revolution In Economics And Technology***

Gilder portrayed Mead as a primal force behind the rise of Silicon Valley . . . **an exemplar of elite science-based Christian-capitalism**. High-tech leaders and conservative politicos loved the book. **It became a national best seller**. I was portrayed as Mead’s assistant.

During the 90s, Mead was elected to the NAS and the AAAS. He received the IEEE John von Neumann Award, the $500,000 Lemelson-MIT Prize, the Computer History Museum Fellow Award . . . and in 2002, received the National Medal of Technology . . . the highest honor of all.

Whether Mead deserved these awards isn’t the point. **The point is that I no longer received any such recognition** . . . even though **most of Mead’s later awards** **cited innovations that were solely mine**.

In 2009 the Computer History Museum held a gala celebration of the 50th anniversary of the integrated circuit, where 16 men, described by media as **“the Valley’s founding fathers,**” were inducted into the National Inventors Hall of Fame. **Top billing went to Gordon Moore and Carver Mead**. **SLIDE 9**

Turns out I wasn’t invited to the event. I didn’t even know it was happening. **As a woman, I’d disappeared from history, and so had my innovations.** No one set out to do this. It just happened.**BACK TO THE FUTURE (2): Investigation, Reappearance, and Reflection**

My reaction to my personal disappearance was one of accumulating shock, stress, and even despair. Then one day, I had an epiphany: I should investigate how and why I’d disappeared! My motto: **“When Weirdness breaks out, don’t get upset . . . go meta and do Science on It!”**

I began by compiling an online “VLSI archive” with help from vets of the VLSI revolution. By 2010, the archive contained scans of many original documents, technical reports, course notes, design reports, and chip photos. A treasure trove of artifacts, it helped me build a timeline and sort out flows of events.

For the 1st time, I began sharing my perspective . . writing a reminiscence of the revolution in a Special Issue of *IEEE Solid State Circuits Magazine* in 2012. **I clawed my way towards reappearance. SLIDE 10**

I also began to visualize **how my transgender journey affected my role in the revolution**. I’d been fired from a research position at IBM during my transition back in 1968, and had to restart my career in a covert new identity.

While rising from contract programmer at CAI, to computer architect at Memorex, to working at Xerox PARC, **I lived like a foreign spy in my own country** . . . Always looking over my shoulder, terrified I’d be outed and lose my career again. Not wanting to call attention to myself**, I used “tradecraft” I’d learned during my transition to covertly make things happen** . . . while staying hidden behind the scenes.

**But my reminiscences** have finally **triggered my reappearance** . . . **Since 2014 I’ve become** a Fellow of the Computer History Museum, received three honorary doctorates and received the James Clerk Maxwell Medal from the IEEE and the Royal Society of Edinburgh. **And just one month ago, IBM openly apologized** for firing me 52 years ago. **I’ve finally emerged from the shadows . . . SLIDE 11**

**The Conway Effect:**

**One really cool result of my investigation is an insight I call the “Conway Effect.”** It builds on the Matthew and Matilda Effects by adding a social twist — “**People tend to be blind to innovations made by “others,” whom they don’t expect to make innovations**.”

After all . . . people usually don’t notice when something that’s never been done before happens right in front of their eyes. Even if they did sense “something was up” and it might be an innovation, they’d think some “known innovator” had originally created it . . . rather the person right in front of them . . .

**Examples of blindness to innovations**

Turns out that students in the MIT 1978 course thought they were learning **how chips were designed in Silicon Valley—the known institutional innovator**. They didn’t realize they were learning radical new methods not yet-used in the Valley.

Silicon Valley thought leaders were in turn **astonished at “what MIT had done”**, for MIT was a known innovator. Top research universities rushed to follow that leader by offering “MIT VLSI design courses.”

The participants in the “MPC79 happening” took for granted the innovative infrastructure they were using, **not realizing it was a covertly-generated, paradigm-shifting hackathon that would launch fabless chip design, silicon foundries, and e-commerce**.

**Flying under the radar** . . . I deployed a radical new techno-social functionality **that appeared to users as existing institutional infrastructure**.

MPC79’s success led **DARPA to launch a major program in 1981** to fund research in Mead-Conway-style chip architecture and design tools. **DARPA also funded tech-transfer** of the MPC79 system and operation of the “MOSIS” service, as national research infrastructure for advanced chip prototyping.

In tradecraft terminology, I’d triggered and spread the VLSI revolution by covertly sailing under the “false flags” of MIT and DARPA. **MIT’s mystique triggered the rush to offer VLSI design courses** at other research universities. **DARPA’s historical reputation as an innovator was so great** that government-sponsored MOSIS-like services sprung up in other countries . . . with **no one having a clue** that it’d all **been covertly orchestrated** via an escalating **series of techno-social “happenings**.”

**Visualizing the “separate social process” of credit assignment:**

Social awareness of an innovation (in this case the VLSI revolution) **triggers a social process of credit assignment** . . . **where credit is socially assigned, gained, bartered and seized** as a function of visibility, status, prestige, class, power, location, credentials, prejudice, influence, wealth, and accident.

**The resulting social recognition** via awards, medals, media coverage and biographies . . . **tends to** **mask the underlying story of how the innovation was made** and **SUSTAINS the social-crediting rituals**—rituals that then reinforce (often inaccurate) beliefs about how and by whom innovations are made.

For example, Gilder’s storytelling projected Mead as a vital force behind the rise of Silicon Valley**. The story fit the times, and rapidly spread in the consciousness** of high-tech and national political leaders. **Mead never explained how the revolution happened**. He didn’t have to. **Gilder had already framed it.**

**Corollary:** Large paradigm shifts can be orchestrated right out in the open, **if people have no clue what you’re doing** . . .

**Closing Reflections:**

**If innovations are not expected from women**, the stories of women’s innovations, even major ones, disappear. Credit for their innovations then go to men associated with the innovation, who do not have to aggrandize credit. Credit accrues to those men as they are remembered, while the women disappear.

**To be able to “win at innovation,” women must be expected to be able to win**. This expectation **must live inside women themselves.** And **to live inside them, it must fully-live in society**.

As a **previously-marginalized “unexpected-innovator”** this struggle was existentially-difficult at times . . especially during the decades of my disappearance . . .

Fortunately, **it’s led to insights into how people can be wronged, even when no one is deliberately doing wrong**. Hopefully these insights can **help empower us** . . . to better-visualize what’s going on . . . to better seize our moments . . . and better-trigger positive social change. **MORAL OF THE STORY:**

**“When Weirdness breaks out, don’t get upset . . . Do Science On It!”** **SLIDE 12**