University of Victoria

November 10, 2016

An Invisible Woman: The Inside Story Behind the Microelectronic Computing Revolution in Silicon Valley*,**

Lynn Conway, Professor of EECS Emerita

University of Michigan, Ann Arbor

In 2015, US CTO Megan Smith raised profound questions about women’s contributions in science, engineering and math being erased from history. In this talk we explore a case study of such erasure, and surface a very counter-intuitive conjecture about the underlying causes and effects.

UVIC Transgender Archives

*In remembrance of pioneering novelist Ralph Ellison, author of *Invisible Man*, 1952.

**Based on a Pride Keynote at the National Science Foundation, Arlington, VA, June 10, 2015.

UVIC Engineering & Computer Science

Unfolding The Story:

Setting the Stage: Reflectios on LGBT Pride & Human Life Trajectories

Visualizing the Historical Erasure of Women's Contributions in STEM

A Case Study: The Inside Story Behind the VLSI Revolution

A Counter-Intuitive Explanatory Conjecture: The *Conway Effect*

Thought-Experiments: Insights from the Evolution of Culture in Animals

Conclude with: Glimpses of the Emerging Techno-Social Age

Lynn Conway Become a fan
Professor of Electrical Engineering and Computer Science,
Emerita, University of Michigan

The Many Shades of 'Out'

Posted: 07/14/2013 7:48 pm EDT | Updated: 09/13/2013 5:12 am EDT

Reflections on LGBT Pride Month and Human Life Trajectories

Reading of Lynn's essay on the White House Reception in Celebration of LGBT Pride Month, June 13, 2013

For full text, see next slide and this link:
http://www.huffingtonpost.com/lynn-conway/the-many-shades-of-out_b_3591764.html

The Many Shades of 'Out', by Lynn Conway (read aloud):

On a sultry June afternoon, as my husband and I walked towards the White House, I reflected back on my gender transition, in 1968.

Shamed as a social outcast, I'd lost my family, friends and all social support. Fired by IBM, I'd lost a promising research career. In many cities I could've been arrested, or worse yet, put in a mental hospital.

Evading those fates, I completed my transition, took on a secret new identity, and started all over as a contract programmer. Any 'outing' and I'd have become unemployable and on the streets for good. Fear channeled me into 'stealth-mode'. For over 30 years I covered my past, always looking over my shoulder, as if a spy in my own country.

But it was now June 13, 2013. What a contrast. My husband Charlie and I with many other advocates were joining the President's White House Reception for LGBT Pride Month. The air was full of joy. As we awaited the President, I reflected further.

I'd been 'out' for 15 years by now, or so I'd thought: out on the Internet to reveal my past to colleagues, out as an advocate for trans people and an activist against psychiatry's pathologization of gender variance.

It was one thing to hide in the back-rooms of Xerox Palo Alto Research Center decades before, launching innovations as the hidden-hand behind the VLSI microelectronics revolution. I didn't mind being invisible in my field back then, or that no one had a clue what I was doing . . . Or who was doing it. I was thrilled to even have a job.

But 'out' has many shades of grey -- and even in recent years I kept on partly covering, shyly holding back, lingering in the darker shadows. Although times had changed, I'd clung to old habits.

Down through the decades no one could explain how the VLSI revolution actually happened. The results were simply taken for granted. Although I'd gained vital knowledge about generating such engineering paradigm shifts, I feared my personal history would loom large in folk's minds, and obscure attempts at explanation. It wasn't till 2012 that I got up the nerve to publish a career memoir, and begin telling the story of how the VLSI revolution came about.

As the president entered the room, I glanced around and took in the joyful vibes. As he began to speak, I grasped how far we'd come. Times had more than changed: a fresh wind was sweeping through our society, especially amongst younger generations.

Then I thought of the millions of LGBT people out there. I tried to envision the lifelong struggles against stigmatization and ostracism, of losses of families and employment, of their oppression by having to 'cover', often not fully engaging life nor being known for who they were, what they'd done, who they loved or who loved them.

In a flash, I saw the vastness of the suffering down through time. Then it hit me: we've come so far, so fast, that now many others could begin uncovering too! After all, freedom isn't just an external concept framed by our laws. It's a gift of the spirit that we must give ourselves, by going towards brighter shades of 'out'.

http://www.huffingtonpost.com/lynn-conway/the-many-shades-of-out_b_3591764.html

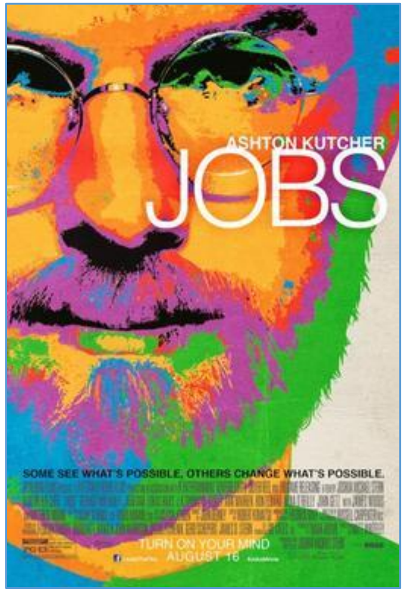
With that as a backdrop, let's now examine history's treatment of women's contributions in STEM

Link

First, listen to U. S. Chief Technology Officer Megan Smith revealing how women in STEM are erased from history . . .

http://www.youtube.com/watch?v=fHyRdAyqV5c&t=0m1s
http://boingboing.net/2015/05/08/cto-megan-smith-explains-how-w.html
http://www.charlierose.com/watch/60554078 (4-28-15)

Although four women were on the Macintosh team in the 1980s, not a single one was cast in the 2013 biopic *Jobs*. Even worse, all seven men on the project had speaking roles in the film.



It’s not just *harder* for women to break into STEM fields, but the many contributions they *do make* aren’t celebrated.
“It's debilitating to our young women to have their history almost erased,” Smith explains.

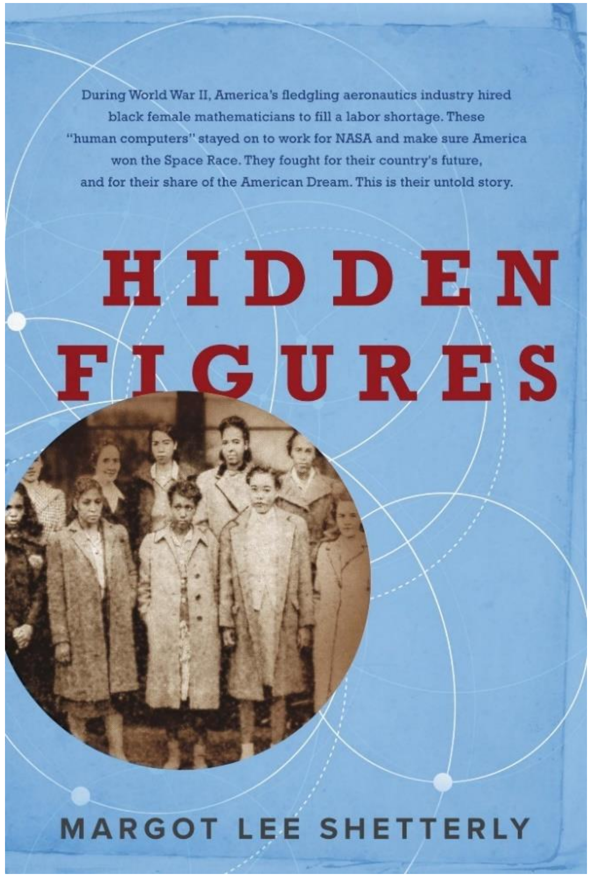
For more about Katherine Johnson, the NASA mathematician whose story was discussed by Megan Smith, see the 2016 book:

Hidden Figures: The Story of the African-American Women Who Helped Win the Space Race, Margot Lee Shetterly (2016)

Katherine Johnson at her NASA Langley desk, 1960

Katherine Johnson, age 98
Photo by Annie Leibovitz for Vanity Fair, 2016

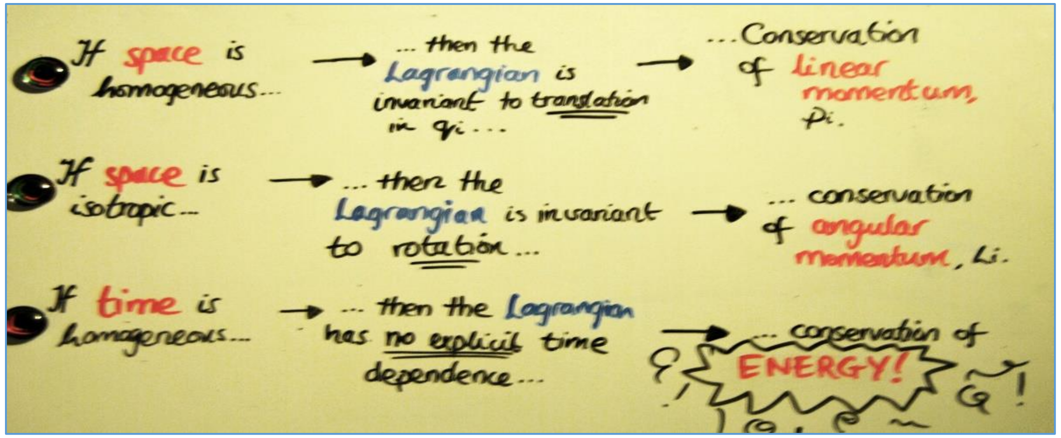
Fortunately, she's lived long-enough to see the story told!



Emmy Noether (1882-1935)**:**

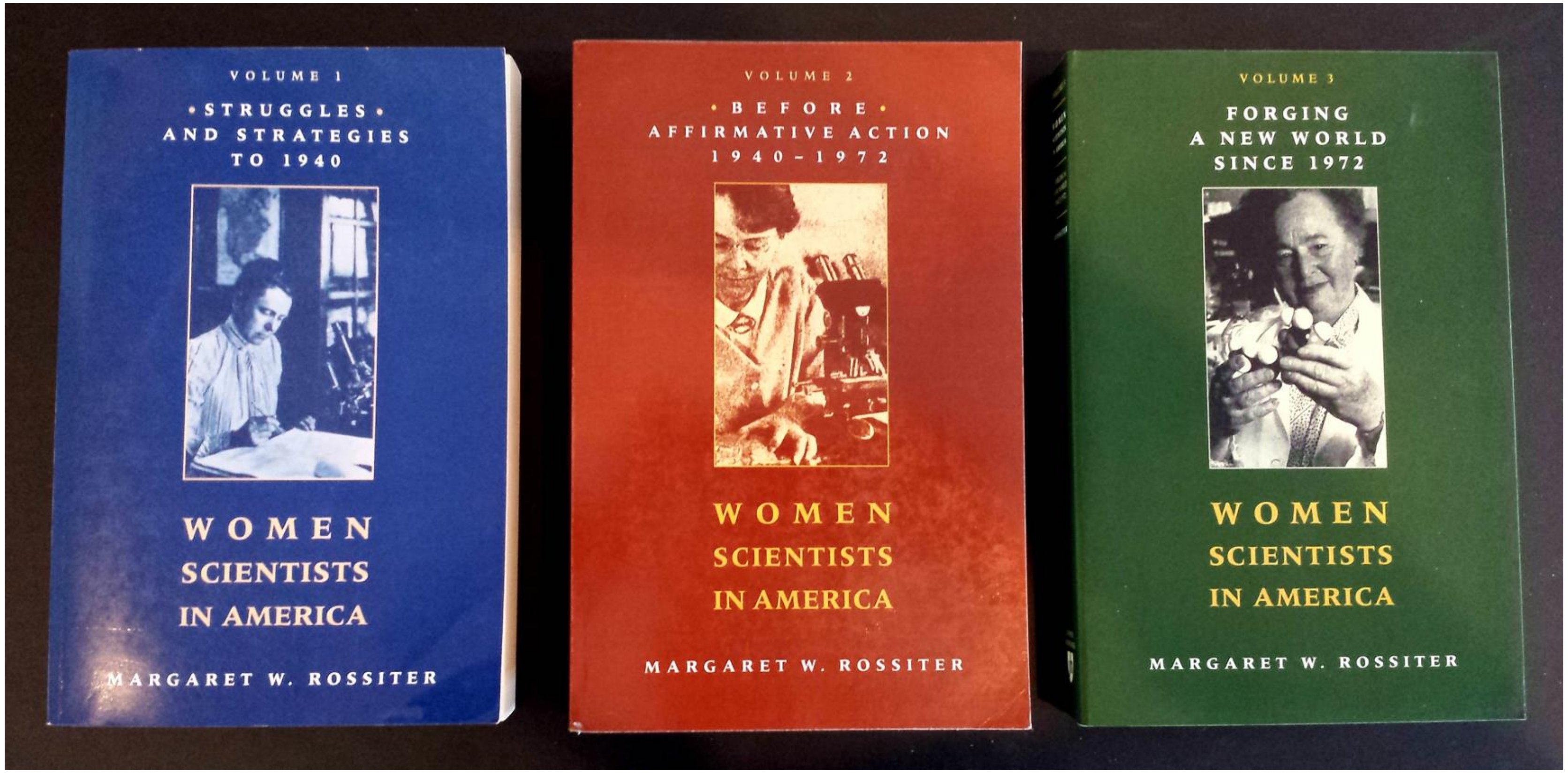
[The Mighty Mathematician You've Never Heard Of]

Some consider Noether's theorem, as it is now called, as important as Einstein's theory of relativity; it undergirds much of today's vanguard research in physics . . . Yet Noether herself remains utterly unknown, not only to the general public, but to many members of the scientific community as well.



"My [algebraic] methods are really methods of working and thinking; this is why they have crept in everywhere anonymously" – Emmy Noether

This effect is seen throughout the history of women in science, as reported by science historian Margaret Rossiter in *Women Scientists in America* *(V 1-3):*



Where she documents many, many case-studies of such historical erasures.

In 1993 Margaret Rossiter coined the term “Matilda effect” for the systematic repression and denial of the contributions of women scientists, whose work is often attributed to their male colleagues.

This is similar to the "Matthew effect“, coined in 1968 by Columbia University sociologist Robert K. Merton, describing how eminent scientists often get more credit than a lesser-known researcher, even if their work is similar.

For example, a prize will most always be awarded to the most senior researcher involved in a project, even if the work was all done by a grad student.

CASE STUDY: The revolution in Very Large Scale Integrated (VLSI) Silicon Microchip Design and Manufacturing, Beginning in 1976.

Link

Now, why are we looking at this particular case study?
[in addition to being one I was involved in . . .]

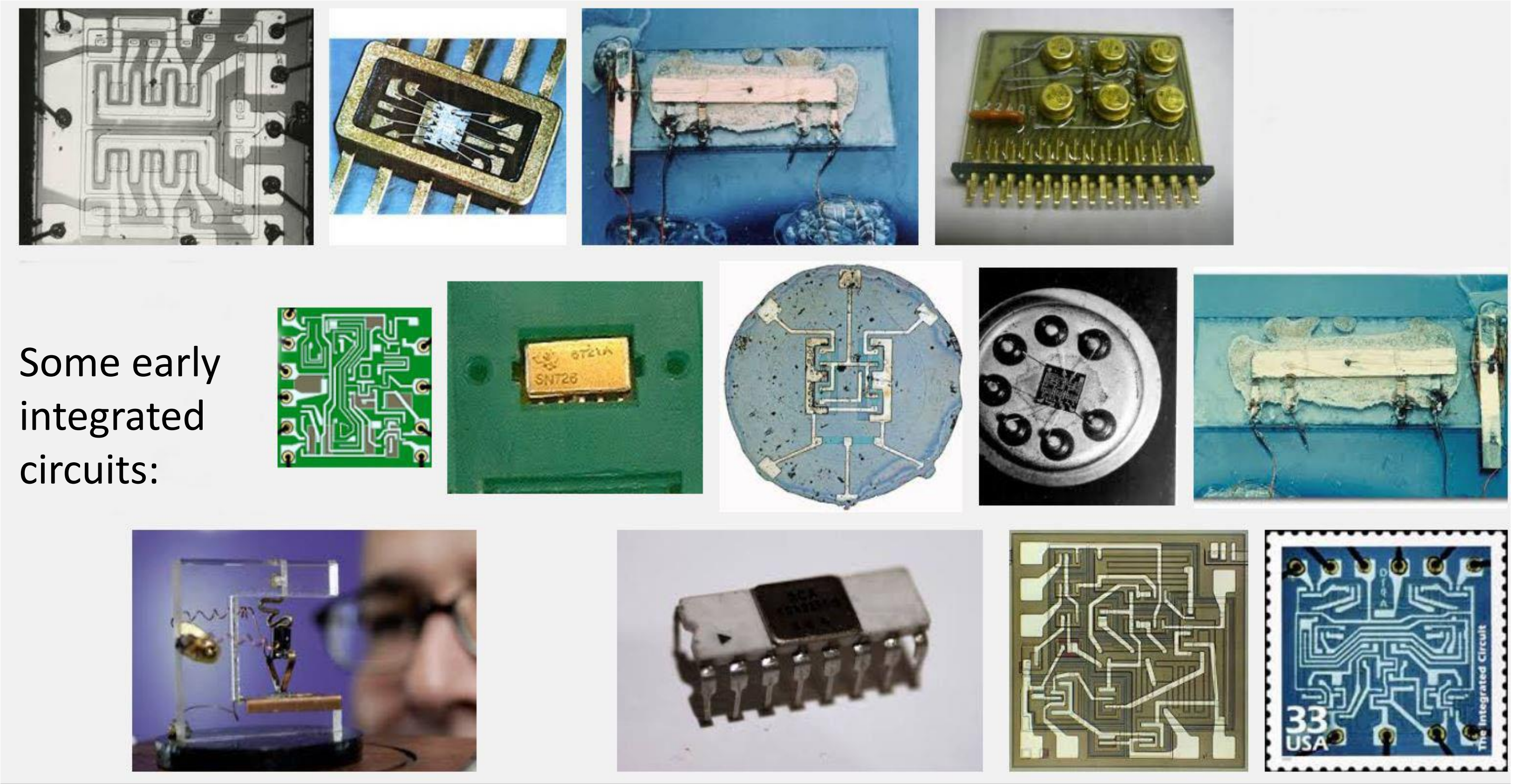
We're becoming surrounded by Smartphones, Social Media, Drones, Self-Driving Cars, Internet of Things, Artificial Intelligences (AIs), etc., in a sudden escalation of novel human-empowerment technology . . .

Guess what's embedded-in and making all this stuff work?

The *mechanizations* of ever-increasing amounts of *mathematics, logic* and *programmed scripts* . . . in ever more powerful **VLSI Silicon Chips**!

The stage was set by the emergence of integrated circuit technology in the 1960's, enabling modest numbers of transistors and wiring to be 'printed' onto chips of silicon . . .

Some early integrated circuits:

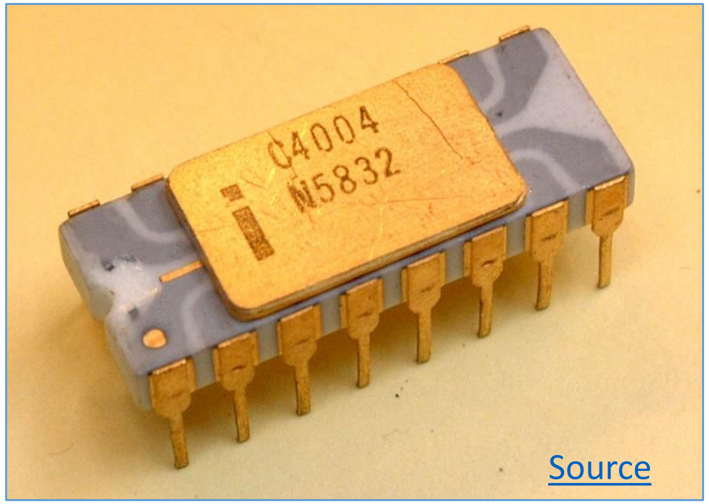


Snip from Goggle images

Rapid advances in lithography enabled ever-finer features to be printed, ever-increasing the numbers of transistors printable on single chips.

By 1971, a watershed was crossed with the introduction of the Intel 4004, the first single-chip "microprocessor": a "computer processor on a chip" . . .

It contained 2300 transistors . . .



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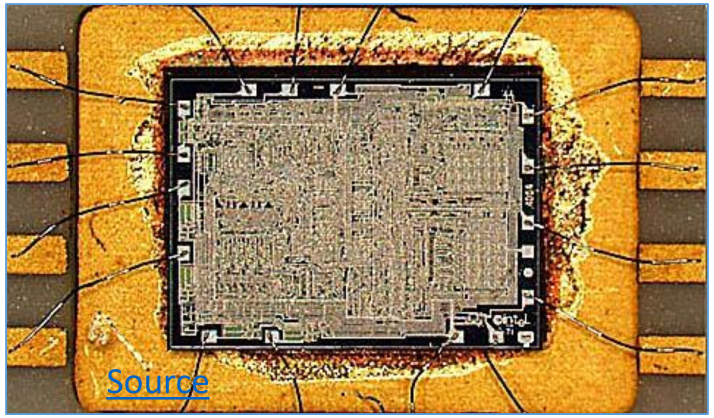

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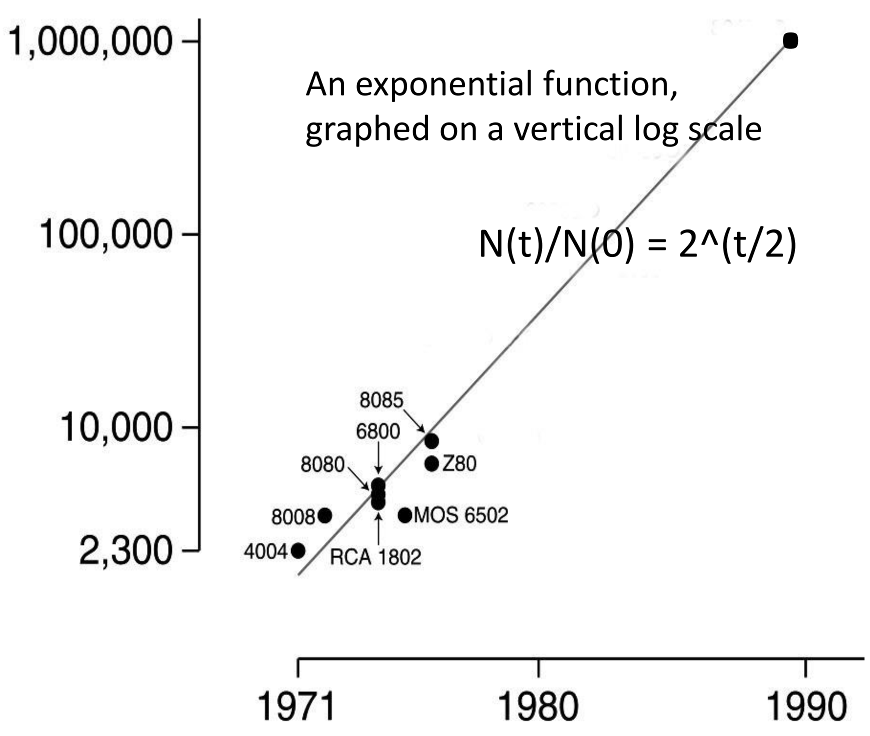
Gordon Moore at Intel observed
that the number of transistors reliably printable on commercial chips was roughly doubling every two years . . .

Carver Mead named this “Moore’s Law” (clever career move, eh?) and his student Bruce Hoeneisen showed there were no physical limits to densities up to several million transistors/cm^2.

Looking ahead it was conceivable that by ~1990 an entire “supercomputer” could be printed on a single chip . . .

In 1976 this set-off a push at Xerox PARC and Caltech to explore how to enable such complex chips to be designed.

Moore’s Law (as of 1976)



The stage was further set by seminal innovations in personal computing & networking:

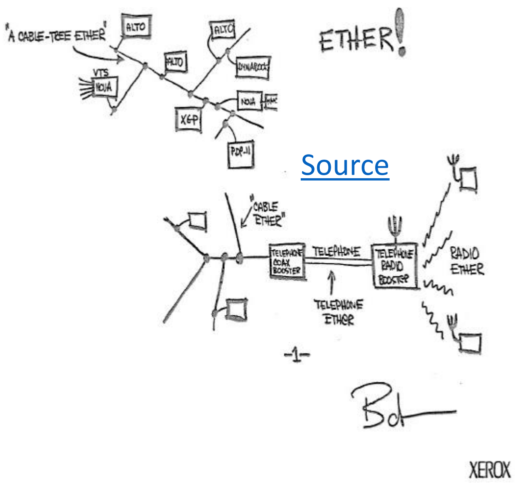
Innovation of the interactive-display, mouse-controlled "personal computer", the "Ethernet" local-area network, and the "laser printer" (at Xerox PARC) . . .

And the Dept. of Defense's "Arpanet" (the early internet, at DARPA) . . .

Xerox Alto, 1973

Wiki commons

Metcalfe's original Ethernet sketch, 1973



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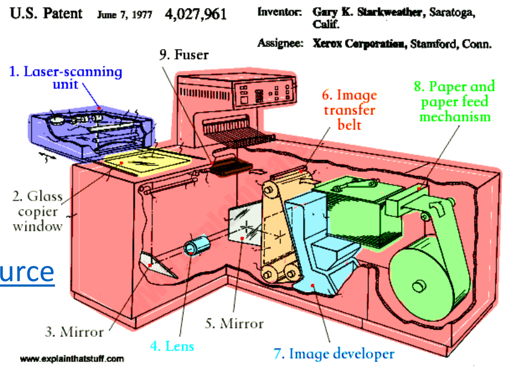
Laser printer, 1971



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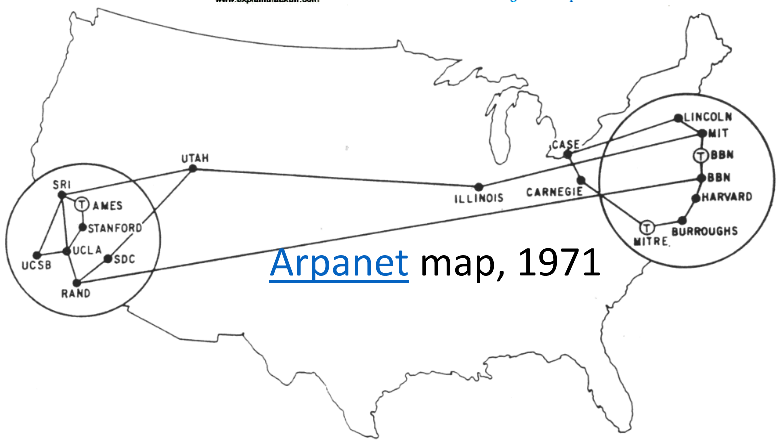


Arpanet map, 1971

[A sudden disruptive breakout was triggered by a cluster of abstract innovations, primarily at PARC . . .]

[Included was a set of scalable VLSI chip-layout digital design rules], as ratioed (dimensionless) inequality equations (Conway, Xerox PARC) . . .

These enabled digital chip designs to be numerically encoded, scaled, and reused as Moore's law rapidly advanced . . .

They also enabled subsystem designs to be scaled and open-source shared . . .

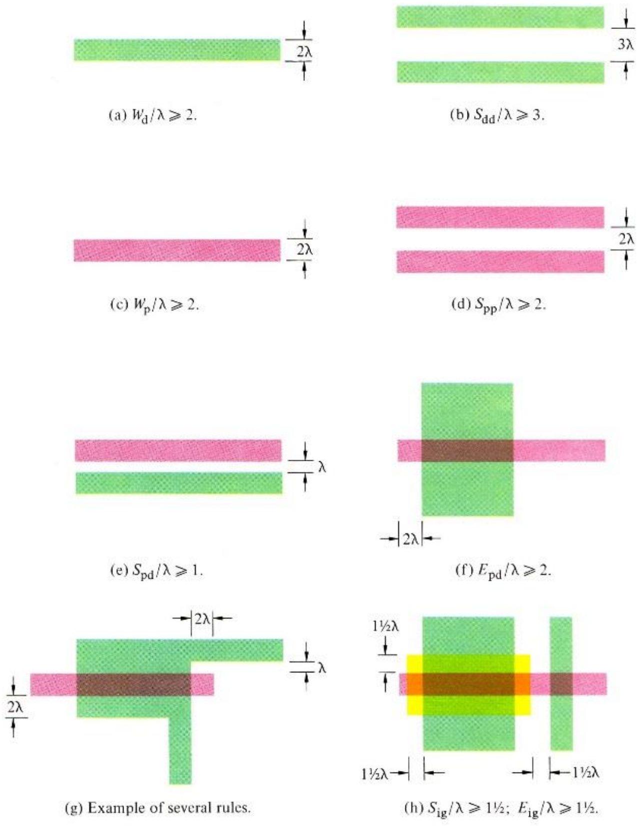


PLATE 2 *n*MOS design rules

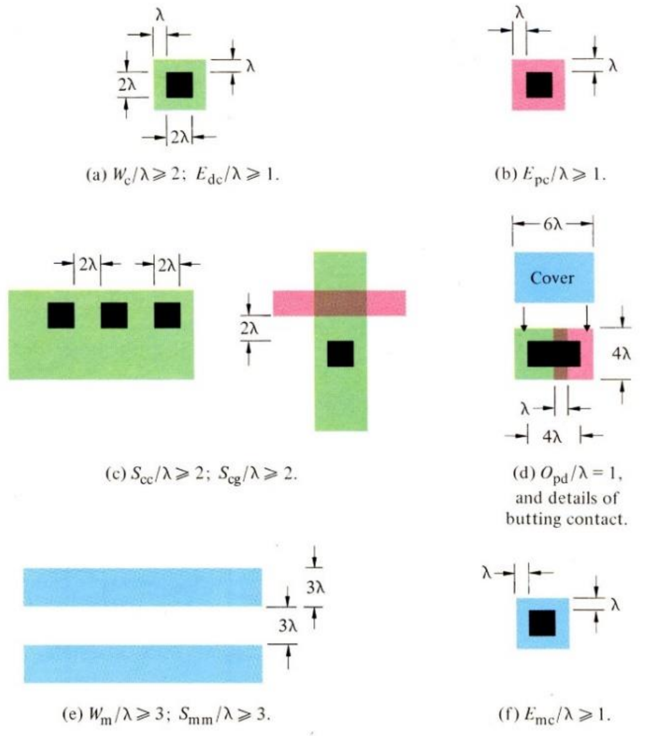


PLATE 3 *n*MOS design rules (continued)

[Link]

The driving meta-architectural idea:

As chip lithography scales-down according to Moore's Law, and ever-more ever-faster transistors can be printed on individual chips as time passes, we can imagine launching the following "techno-social scripted-process":

STEP (i):

Use design tools on current computers to Design chip-sets for more powerful computers.

Print the more powerful chip-sets using foundries' next-denser fabrication processes.

Use some of those chip-sets to Update current computer-design computers & design tools.

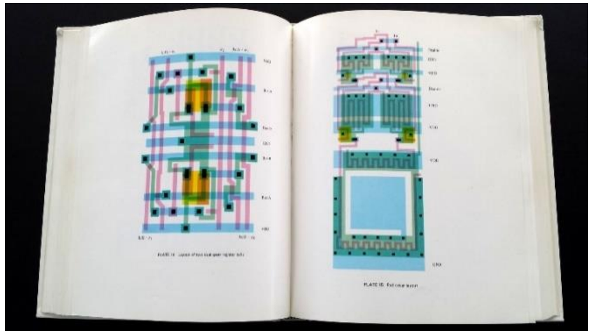
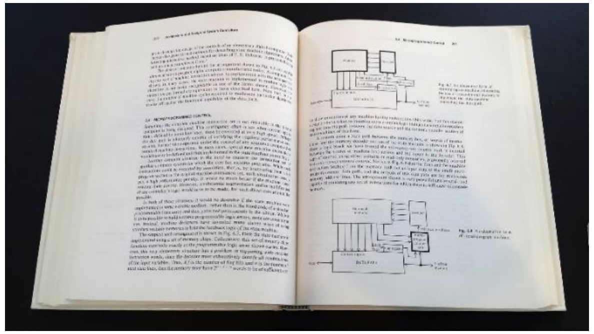
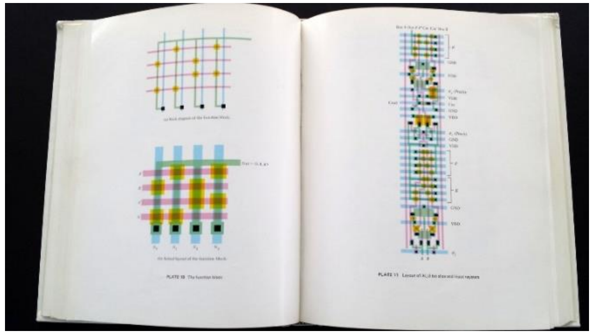
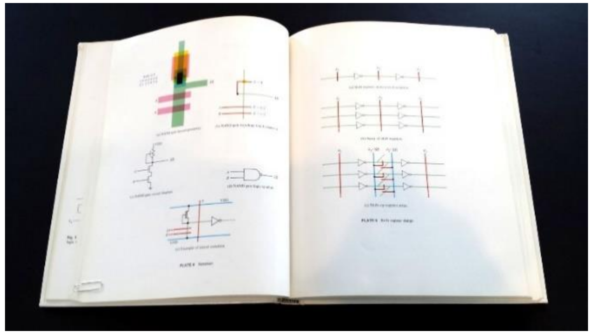
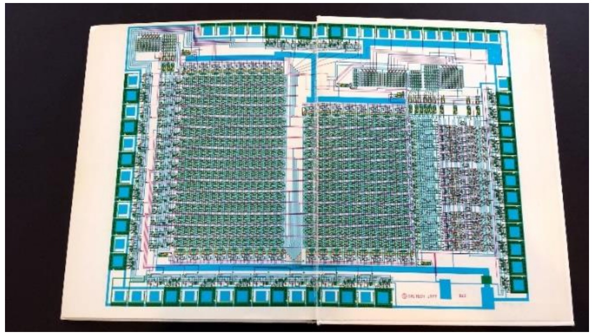
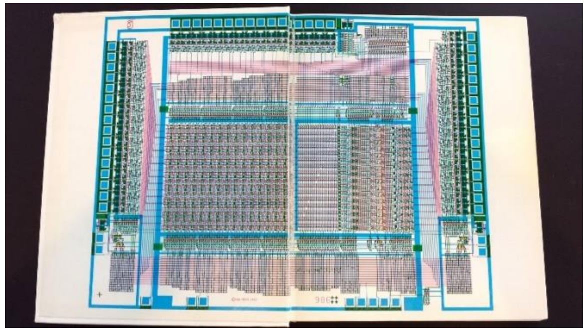
REPEAT (as STEP (i+1))

If ever-more engineers and design-tool builders did this (on an expanding number of increasingly powerful computers), the iterating techno-social expansion-process could exploratorily and innovatively-generate ever-more, ever-more-powerful, digital systems . . .

I.e., that techno-social process could **exponentiate!** (until Moore's Law saturates . . .)

But there's a big problem: Where will all these engineers/programmers come from, and how will they learn to do all this?

To cope with this, I began documenting the new system of simplified, restructured chip design methods in [an evolving computer-edited book] . . .

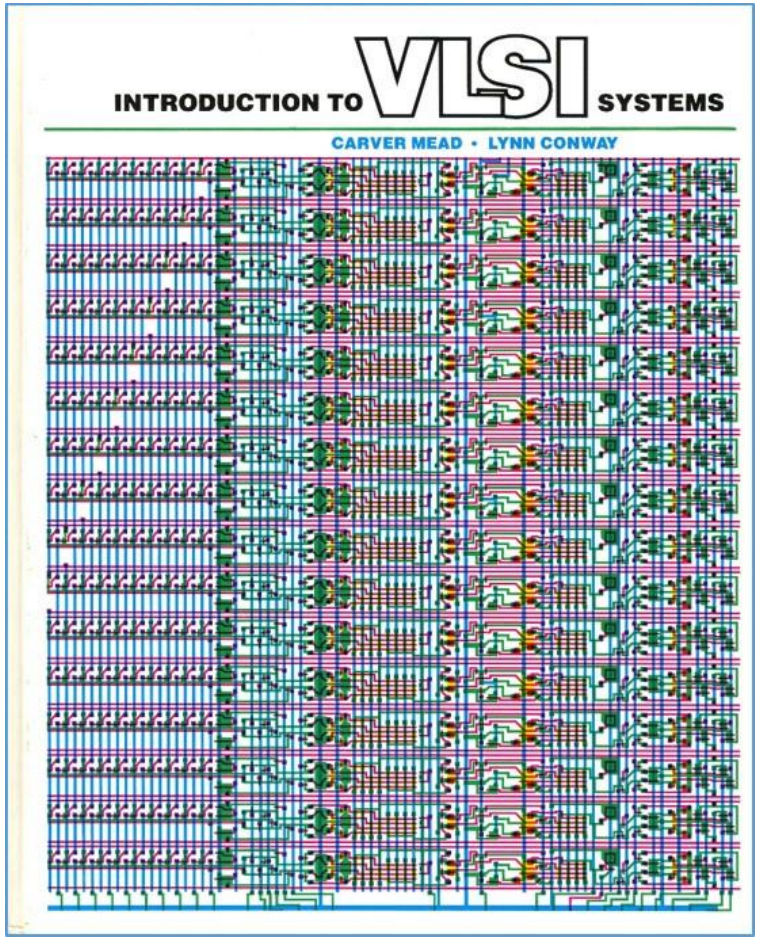
[Link]

Thus using our Alto computers not only to mechanize the generation of chip-designs, but also to mechanize the evolution of the design-knowledge-book itself . . .

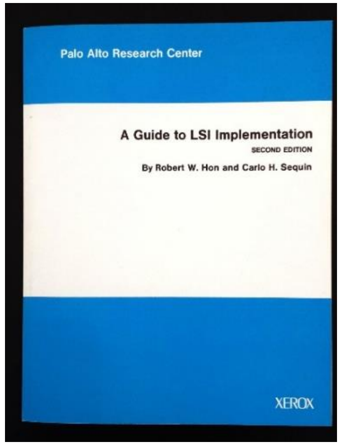
That computer-edited evolving book, printed on laser printers at PARC, became the draft of the seminal textbook . . .

Introduction to VLSI Systems
by Mead and Conway, 1980.

(later called "the book that changed everything" . . .)



We also used our Altos (at PARC) to generate and encode many open-source cell-layout-designs for key digital-subsystems, and disseminated them to students and colleagues via the Arpanet …



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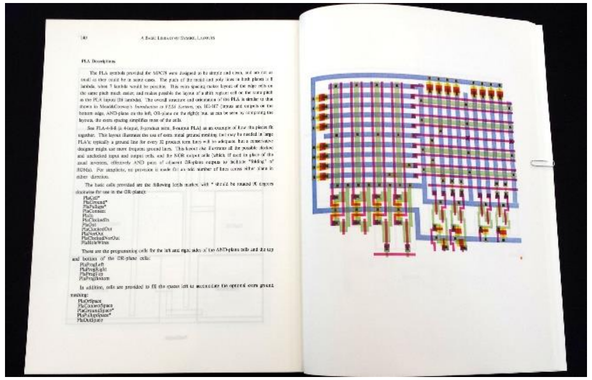
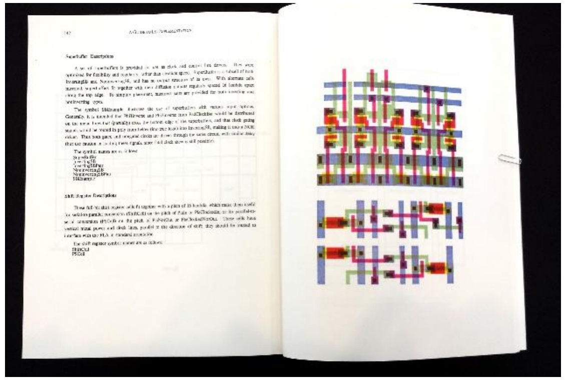
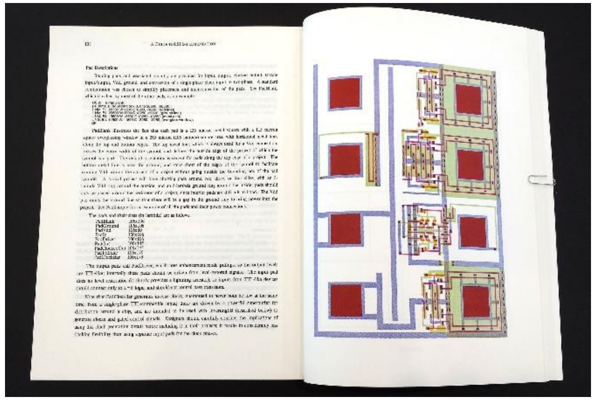


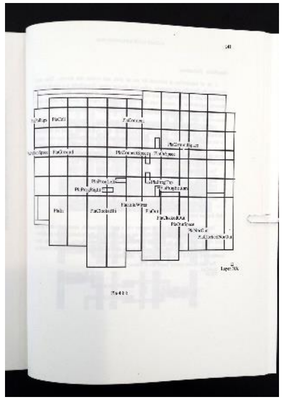
PLA cells



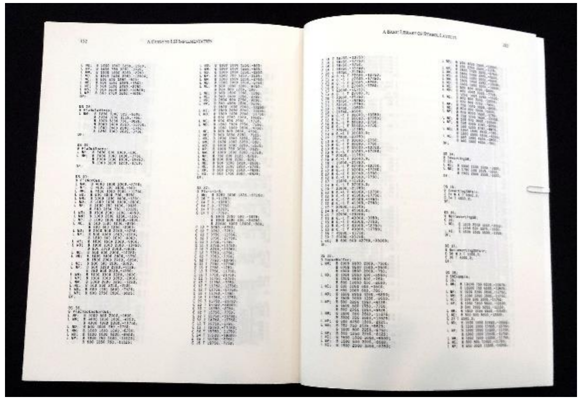
Clock drivers



I/O Pads



Cell locations



CIF 2.0 Cell-Library code

Following the "script" Charles Steinmetz used to propagate his revolutionary AC electricity methods at Union College in 1912, I introduced the new methods in a special VLSI design course at MIT in 1978.

THE M.I.T. 1978 VLSI SYSTEM DESIGN COURSE

by Lynn Conway

[Update: 11-14-07]

This course was an important milestone in the development, demonstration and evaluation of the Mead-Conway structured VLSI design methods. Lynn Conway conceptualized and planned the course during the late spring and summer of '78, and taught the course while serving as Visiting Associate Professor of EECS at MIT in the fall of '78 and early '79.

Link
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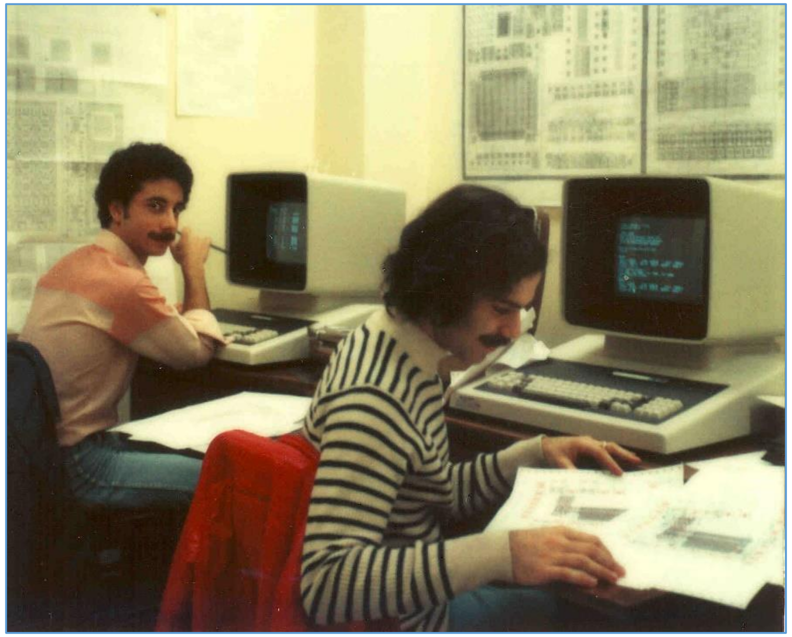
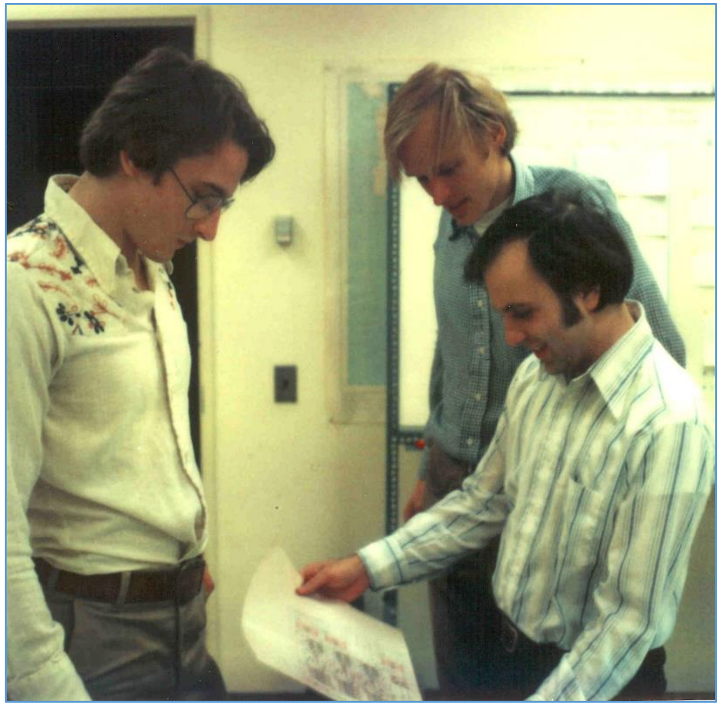
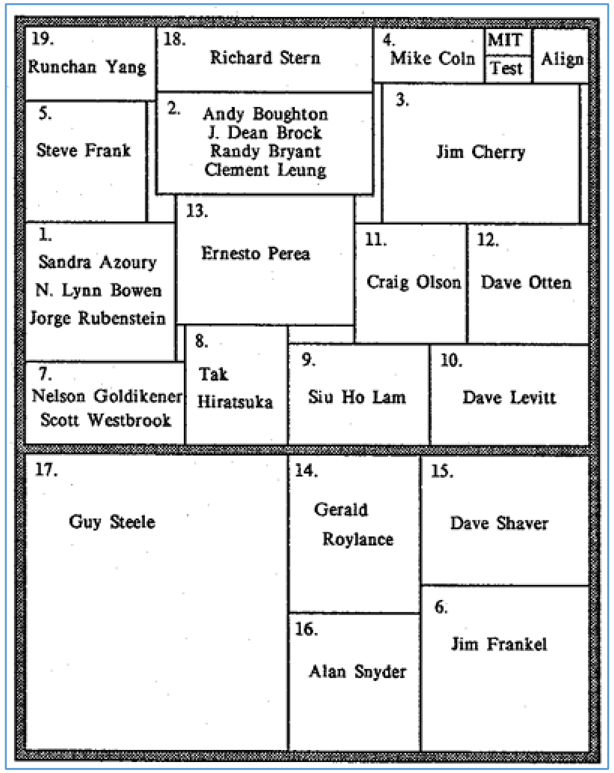
The students learned to design chips in the 1st half of the course, then did project-chip designs in the 2nd half. These were fabricated in Pat Castro's lab at HP shortly after the course.

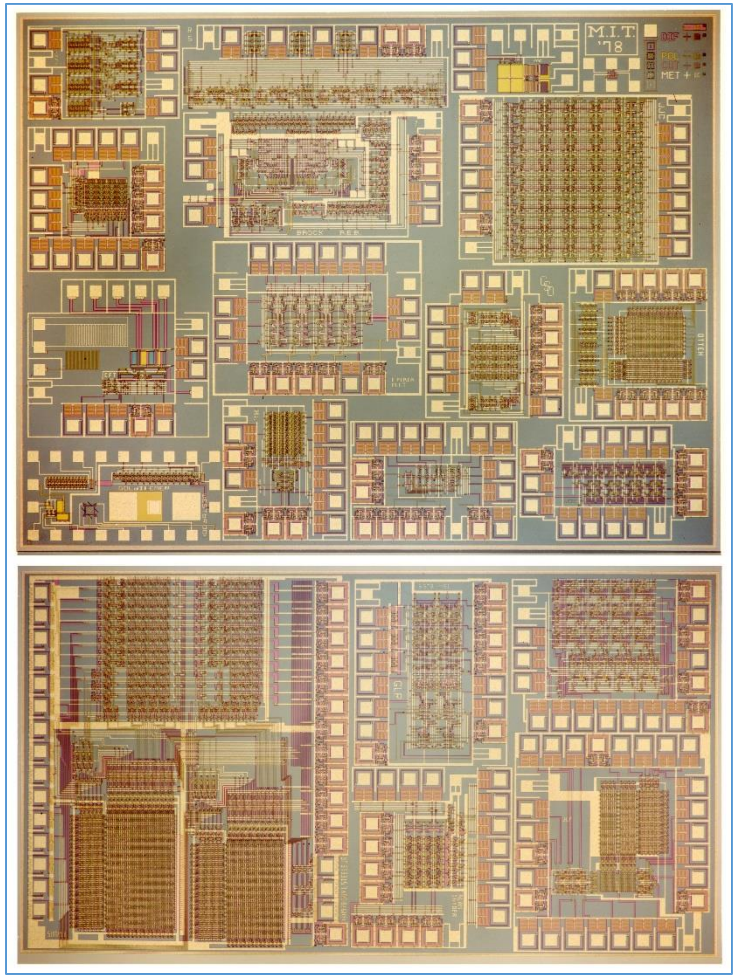




There were many amazing results including a complete Lisp microprocessor design by Guy Steele . . .

Map and photomicrograph of the 19 student projects on the MIT’78 ‘MultiProject’ Chip





For more about the MIT’78 course, see Lynn’s “MIT Reminiscences”

The MIT'78 course stunned various top folks across Silicon Valley . . .
Chip design till then had been a mystery, only grasped by a few computer engineers working for chip manufacturers . . and who thus had access to the "printing plants" . . .

Many other top research universities wanted to offer an "MIT-like" course. But how?

After intensive pondering, I grasped the answer: Rerun the MIT'78 course at a dozen research universities . . . using my MIT lecture notes to keep everything in sync.

But how to "print" all the student project chips?

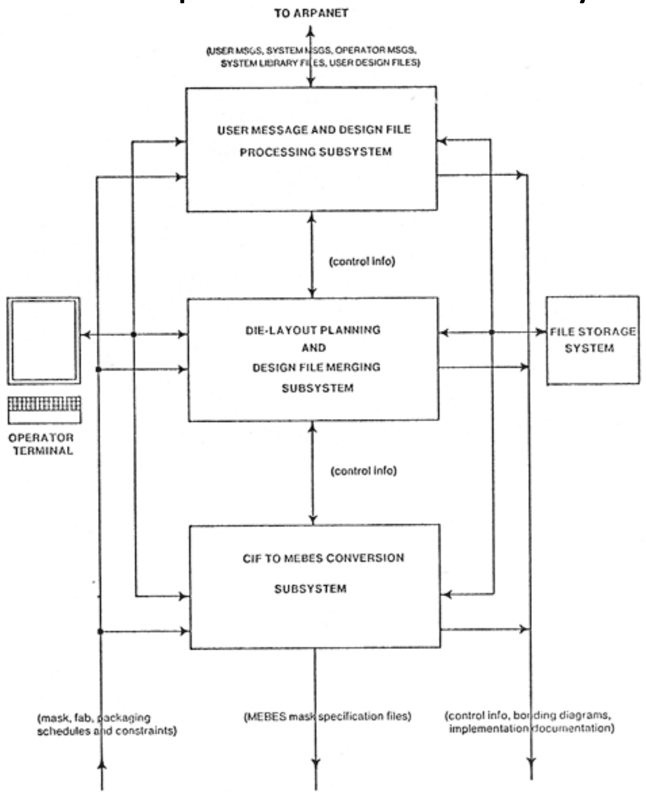
I suddenly envisioned the idea of (what's now called) an "e-commerce" system enabling student design files to be remotely submitted via the Arpanet to a "server" at PARC .

That server would run software to pack designs into multi-project chips (like composing the print-files for a magazine, using remotely-submitted articles) . . .

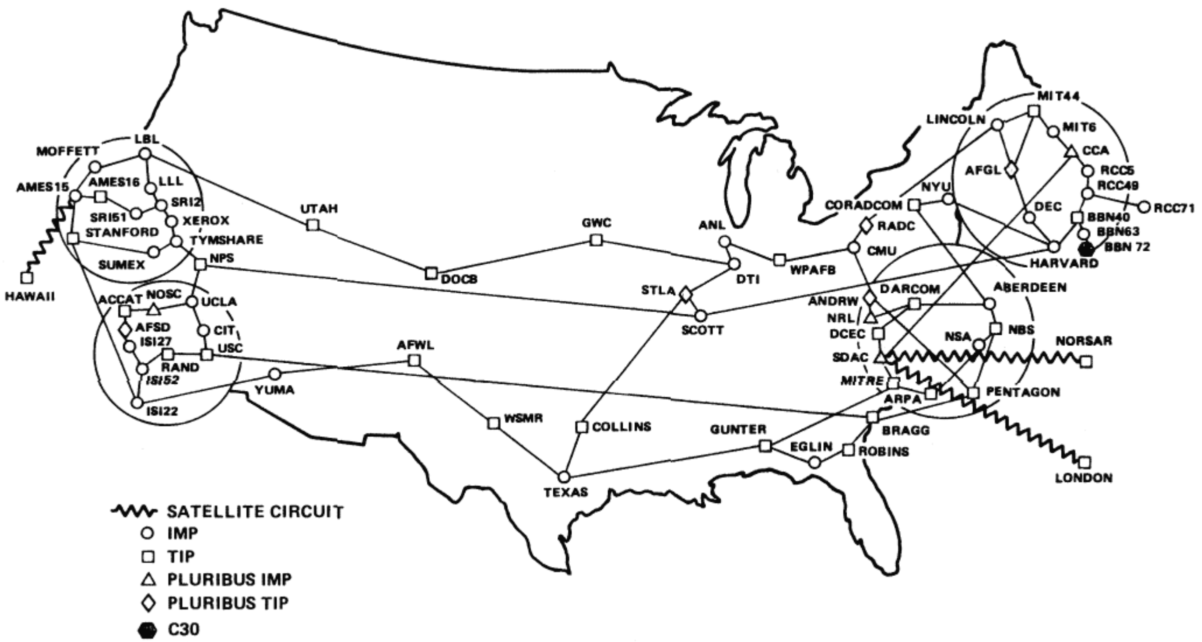
We'd then "print" the MPC's again at HP (where Pat Castro had prototyped the first "silicon foundry"), and quickly return the chips to students.

In the fall of 1979, I orchestrated a huge "happening" (MPC79)* . . . It involved 129 budding VLSI designers taking Mead-Conway courses at 12 research universities…

MPC79 Arpanet E-commerce system:

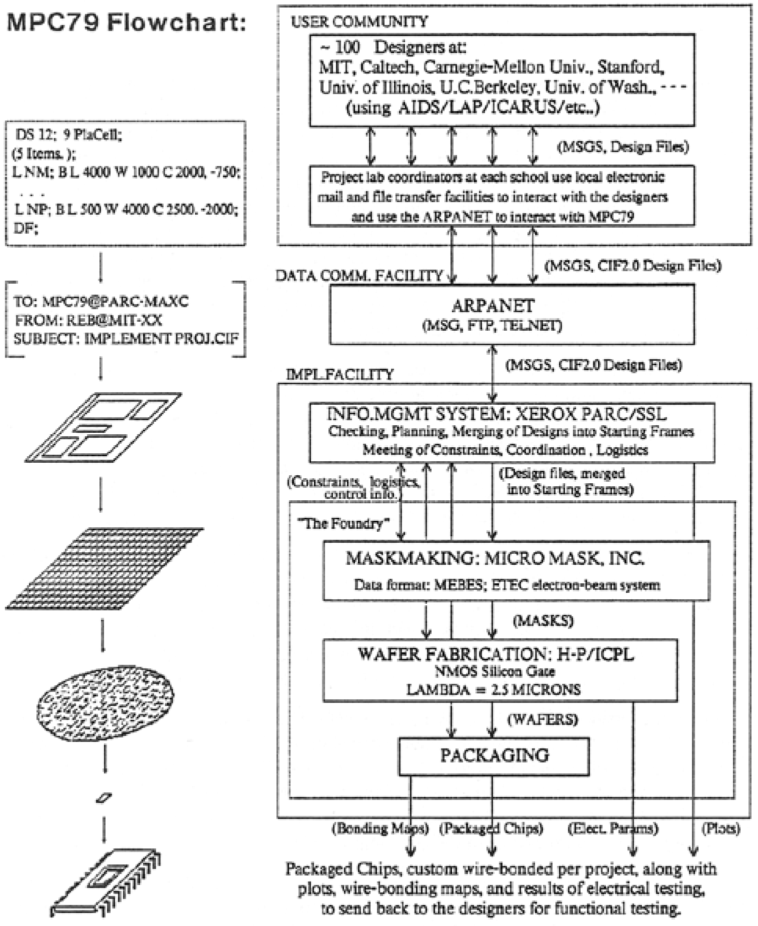


ARPANET GEOGRAPHIC MAP, OCTOBER 1980



*The MPC Adventures: Experiences with the Generation of VLSI Design and Implementation Methodologies, L. Conway, Xerox PARC, 1981 (PDF)

MPC79 not only provided a large-scale "demonstration-operation-validation" of the design methods, design courses, design tools and e-commerce digital-prototyping technology …
it also triggered 'cyclic gain' in, and exponentiation of, the budding VLSI-design-ecosystem…



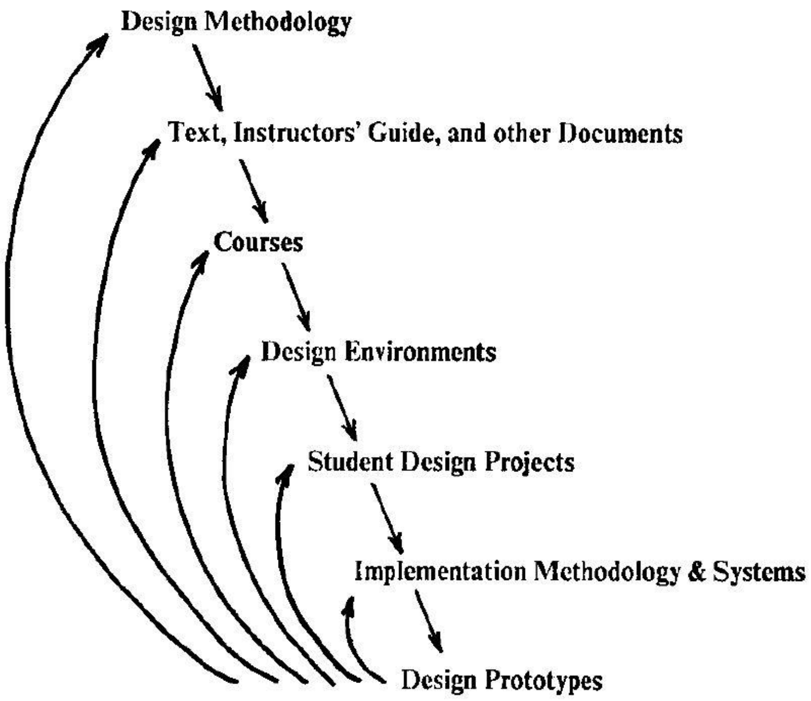


Figure 8. The Joint Evolution of the Multi-Level Cluster of Systems

The MPC Adventures, L.ynn Conway, Xerox PARC, 1981.

Visualizing how techno-social-system dynamics triggered an exponentiation of the new VLSI chip design-and-making ecosystem via the emergent internet-communication technology . . .

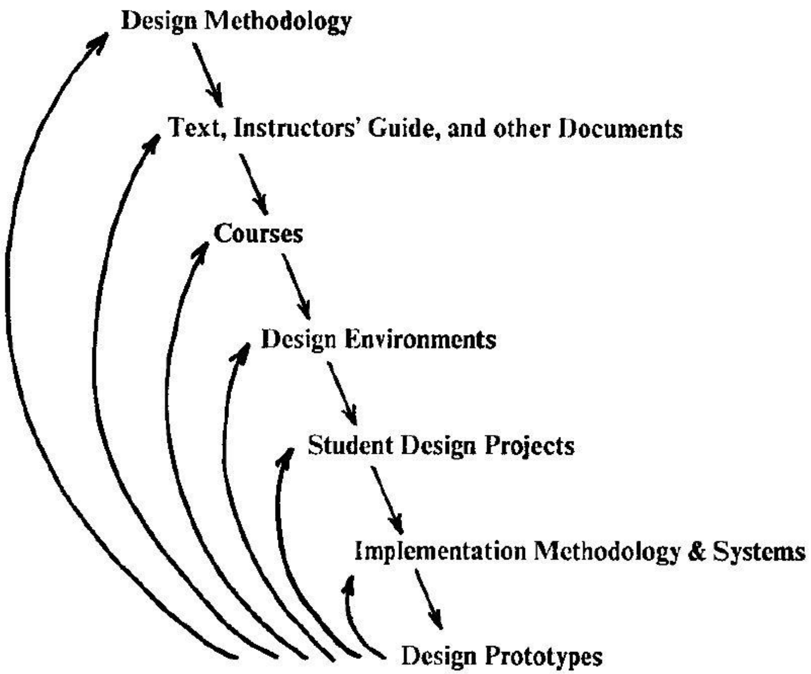
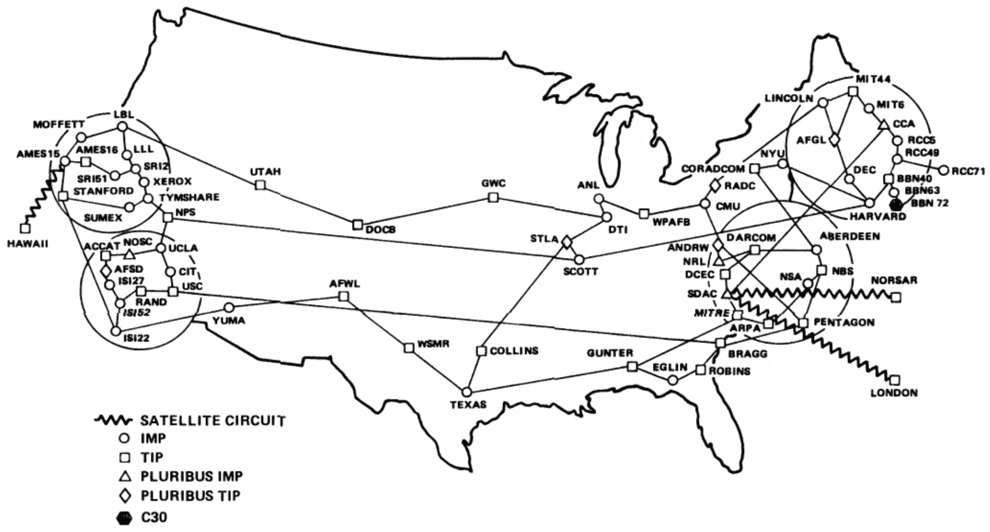


Figure 8. The Joint Evolution of the Multi-Level Cluster of Systems
The MPC Adventures* (LC, 1981, p. 16)

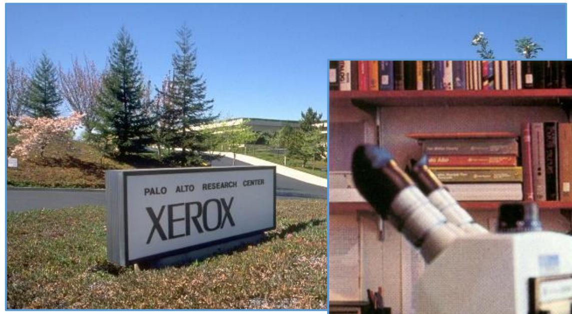
ARPANET GEOGRAPHIC MAP, OCTOBER 1980



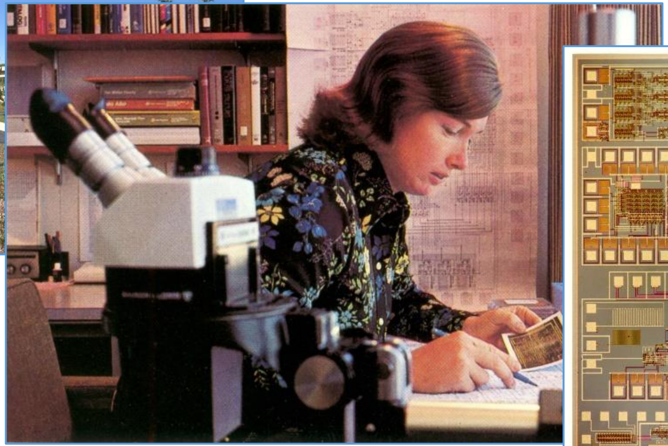
By 1982-83, Mead-Conway VLSI design courses were being offered at 113 universities all around the world

***An early exploration of emergent techno-social-system dynamics by doing what decades later is becoming known as "social physics"**

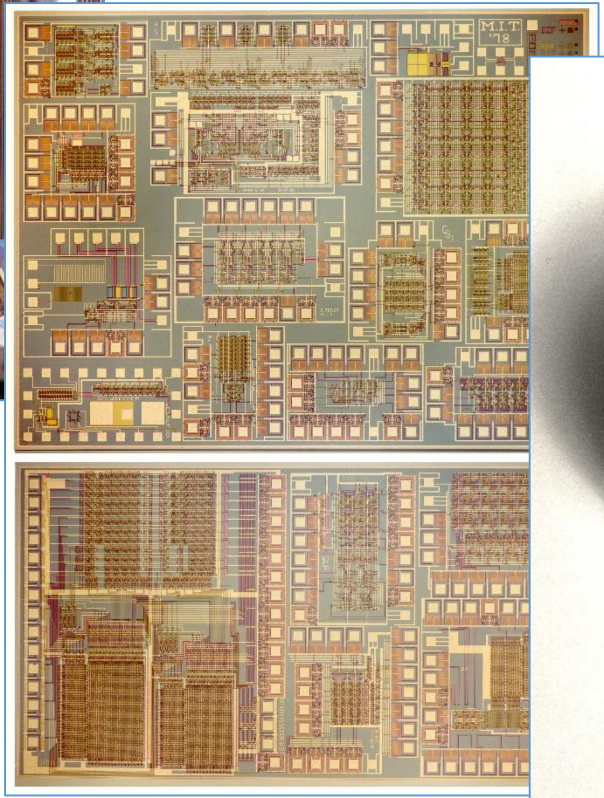
1976



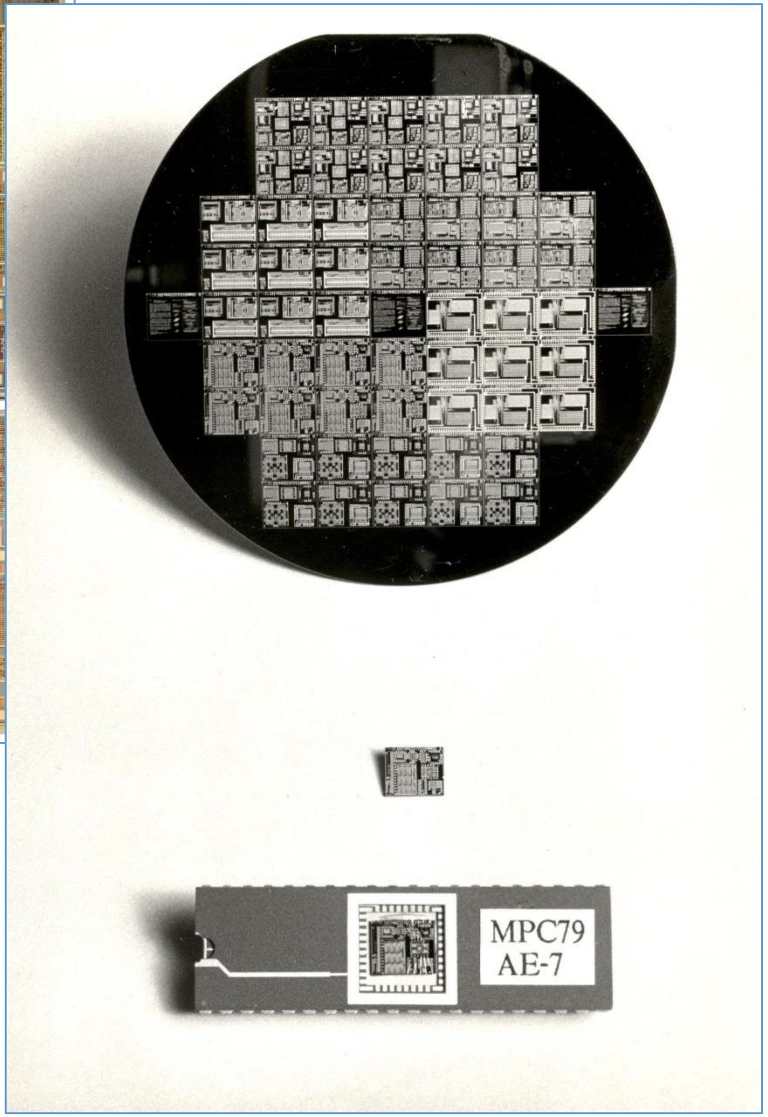
1977



1978



1979



Visualizing the exponentiating wave of VLSI innovation . . .

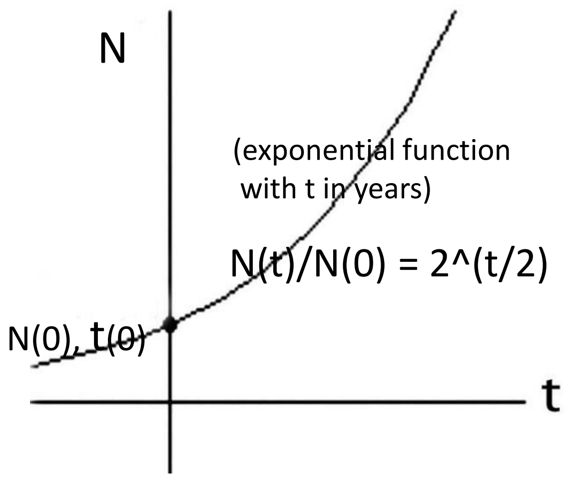
’76: How to cope with VLSI complexity?

’77: Inventing scalable VLSI design rules.

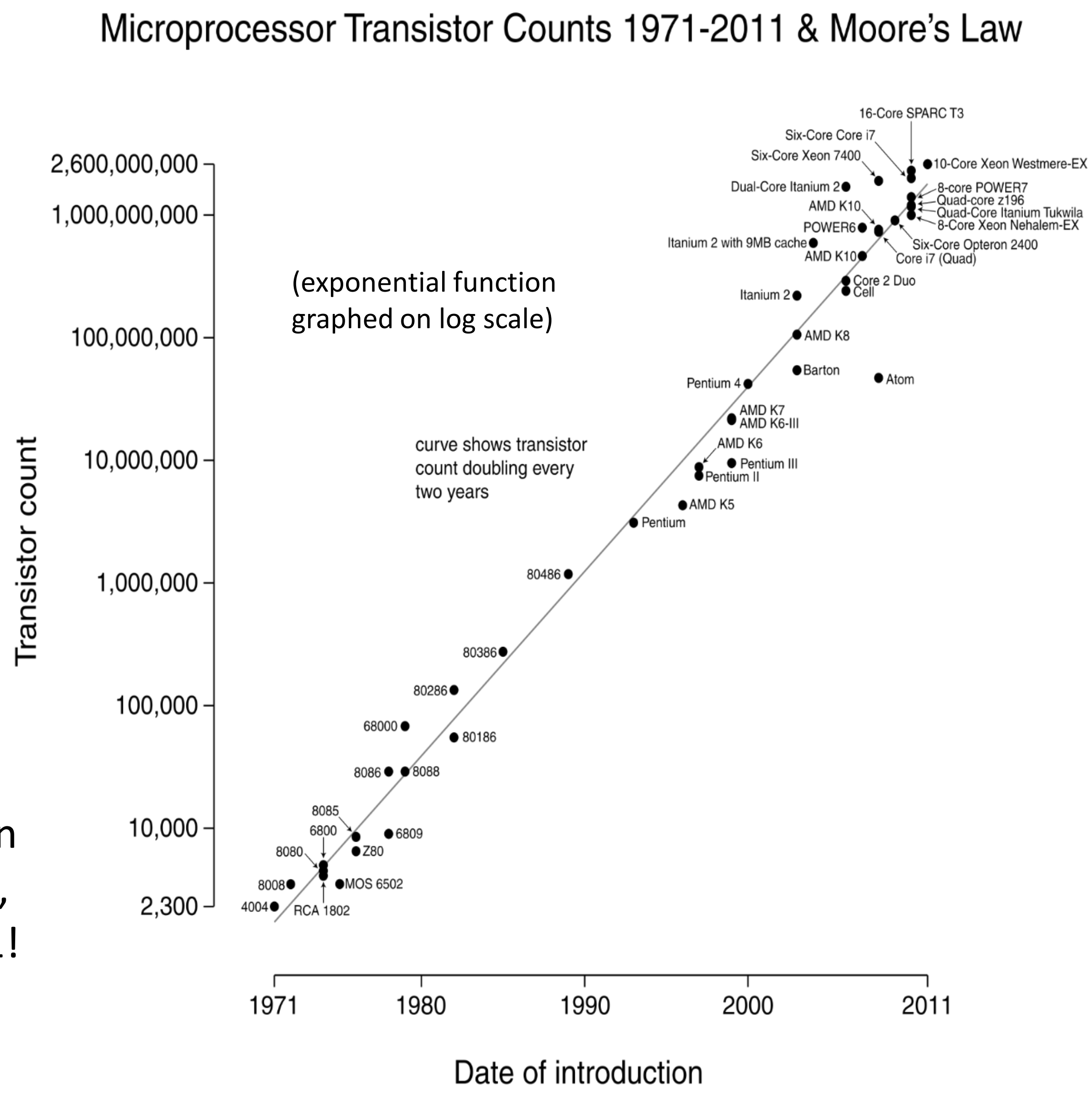
’78: Launching the VLSI methods at MIT!

’79: Launching the VLSI courses via MPC79!!

Over the past 40 years or so, Moore's Law stayed on track all the way:



Starting with several thousand in 1971, the number of transistors on a chip passed one million by 1991, and passed several billion by 2011!



For example, this [iPhone 5 'A6' chip](#) contains several billion transistors!

[Source](#)

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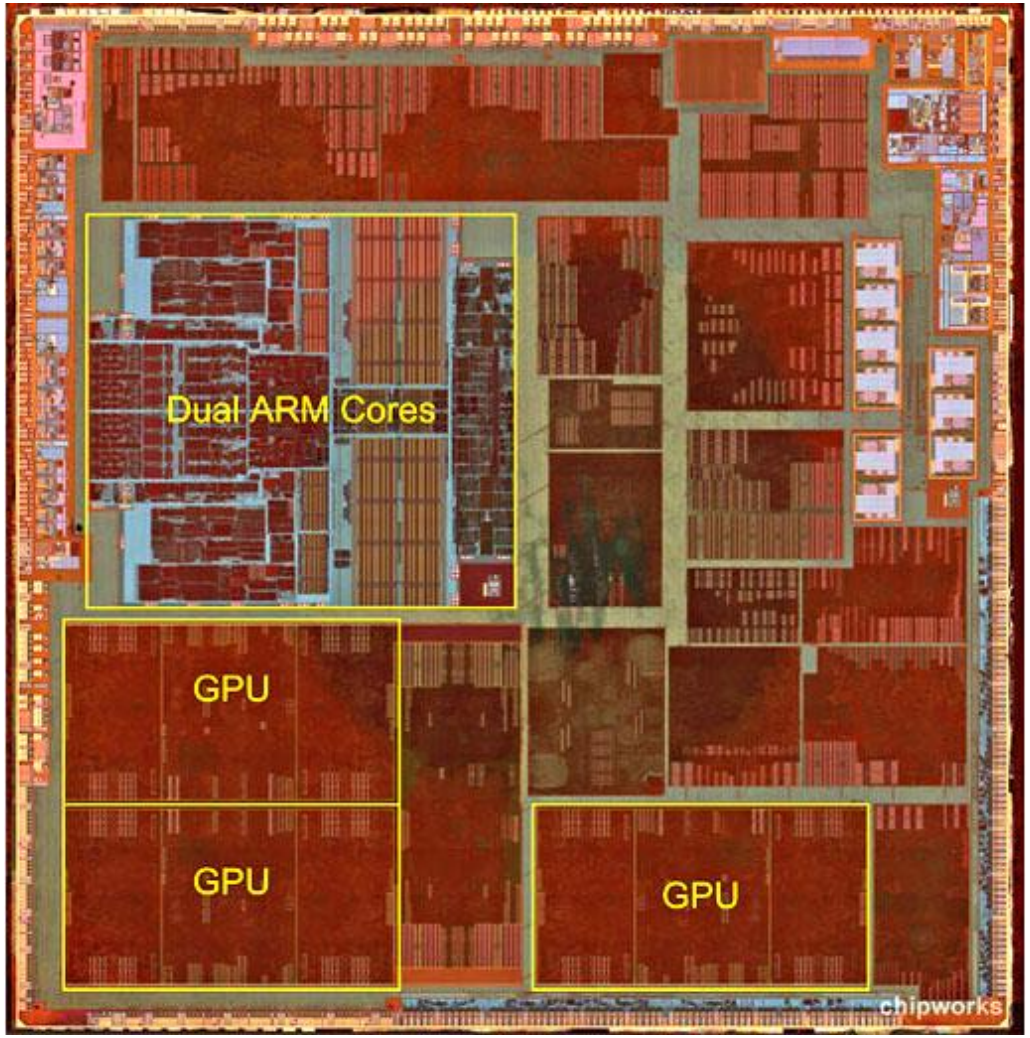
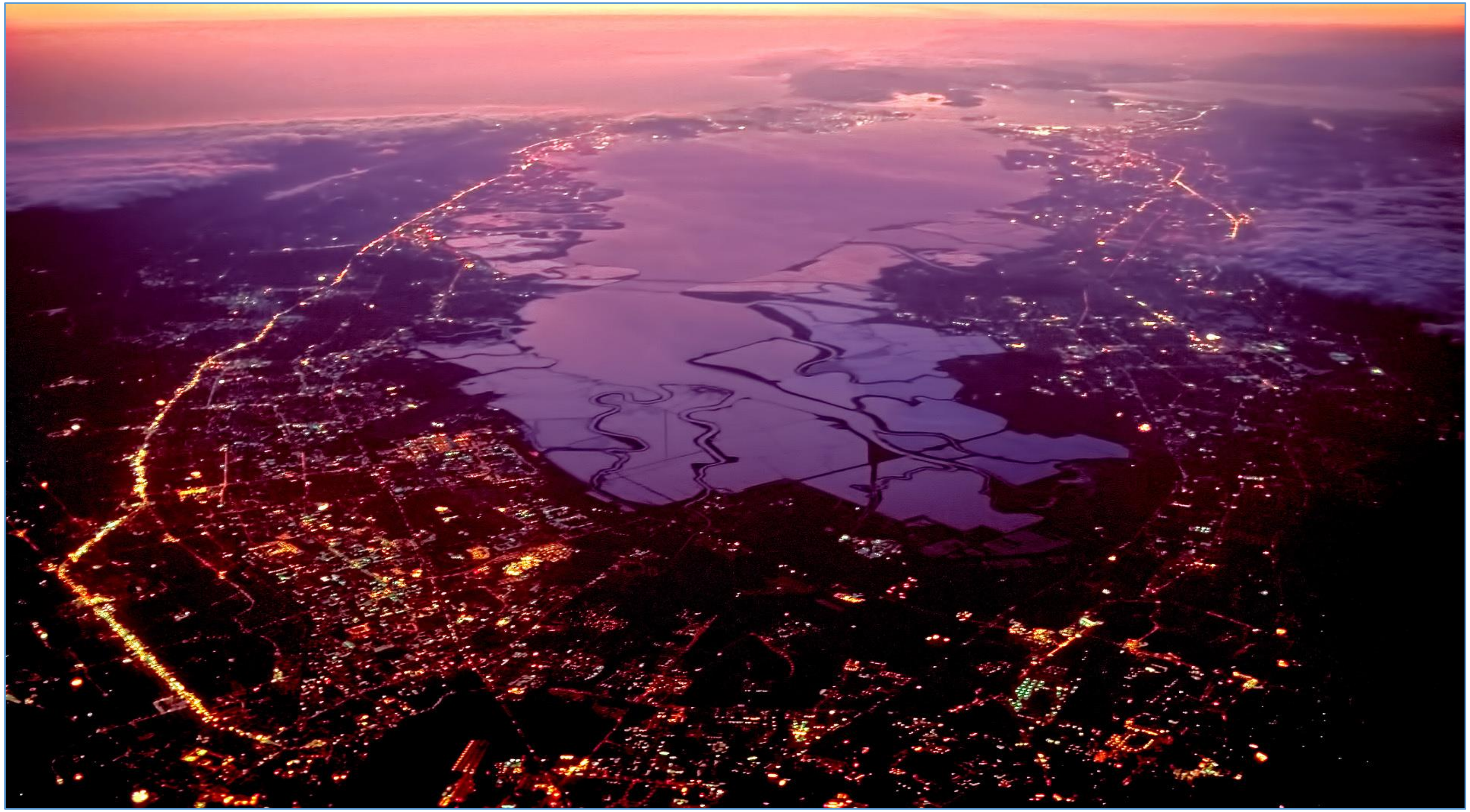


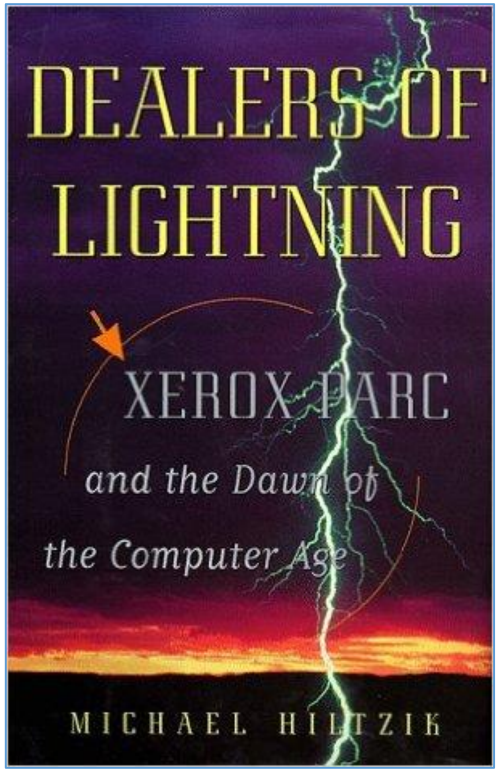
[Source](#)

Exponentiation! Visualizing the *compounding of techno-social-system "interest"* . . .

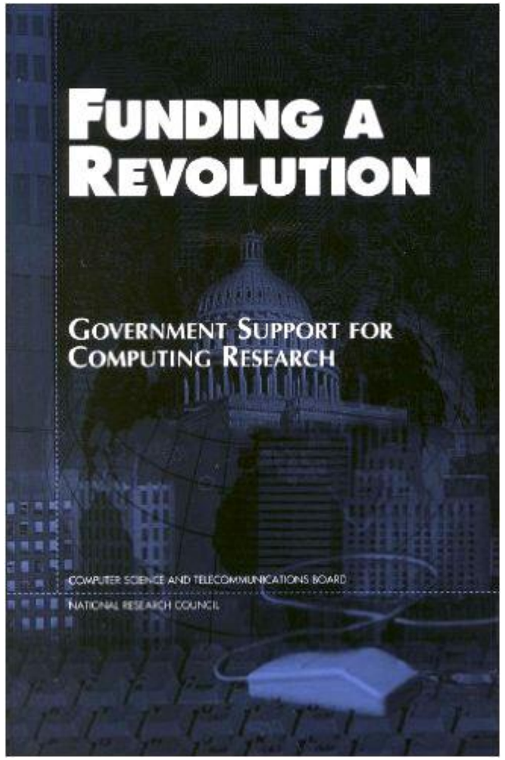


Source

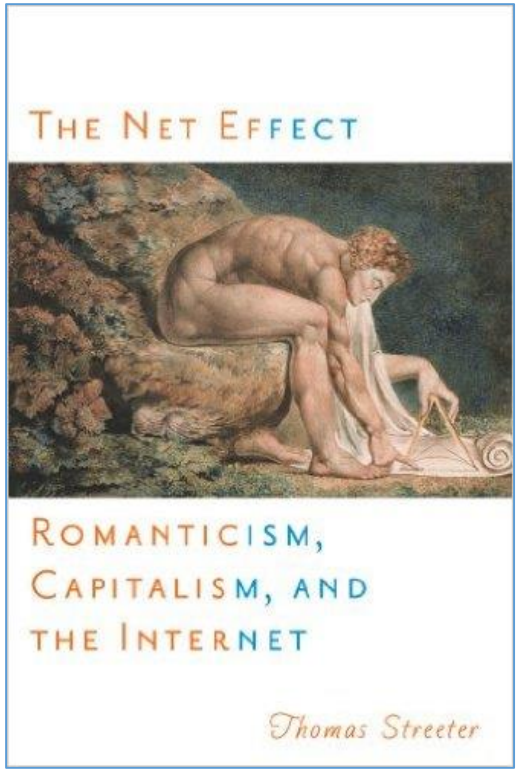
For more about PARC and the amazing things done there, see Michael Hiltzik's *Dealers of Lightning*:



For insights into the role of gov't in VLSI's emergence, see this book from the NRC:



For a wider sociological perspective on the internet's emergence, see Thomas Streeter's *The Net Effect*



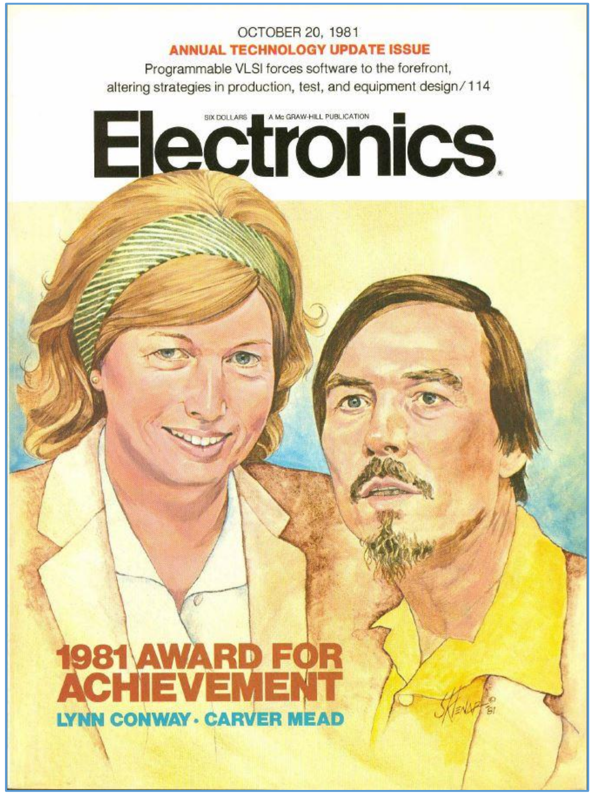
Let's now go back and follow the high-tech community's reactions to the "Mead-Conway" innovations during the ensuing decades:

Link

Key people sensed 'something significant' had happened, and Mead & Conway began receiving major recognition in the 1980s:

Electronics Award for Achievement '81

Pender Award, Moore School '84
Wetherill Medal, Franklin Institute '85
NAE, Mead '84
NAE, Conway '89. . .



However, from ‘89 on through the 00s, Mead received increasingly major recognitions, while Conway’s role was erased*:

NAS ‘89
American Academy of Arts and Sciences ‘91
EDAC Phil Kaufman Award ‘96
IEEE John Von Neuman Medal ‘96
ACM Allen Newell Award ‘97
MIT Lemelson Award ‘99 ($500,000)
Fellow Award, Computer History Museum ‘02
National Medal of Technology ‘02
NAE Founders Award ‘03
Inventors Hall of Fame, at Computer History Museum Gala ‘09

Most of these awards were for innovations that were solely Conway’s

As a result, by 2009 the erasure was complete:

Chip inventors getting their due at Hall of Fame induction

By Mike Cassidy, San Jose Mercury News

Apr. 30, 2009 --The 50th birthday celebration of the integrated circuit kicks off in Silicon Valley this weekend, and frankly, I'm a little overwhelmed . . .

On Saturday night, the National Inventors Hall of Fame is inducting this year's class. The sold-out ceremony (at the Computer History Museum) is in Silicon Valley for the first time, because the Ohio-based hall is honoring 15 who are responsible for breakthroughs in semiconductor technology -- the technology that put the "silicon" in Silicon Valley . . . In a way, it's as if the valley's founding fathers are coming together to be honored in person and posthumously.

Inductees Gordon Moore, co-founder of Intel and namesake of Moore's Law, and Carver Mead, chip design pioneer and all-around brainiac, will be at the ceremony. So will lifetime achievement honoree Andy Grove, Intel's former CEO . . .

With Andy Grove, Gordon Moore and Carver Mead taking center stage:

INTEGRATED CIRCUIT

HONORING THE PEOPLE WHO HELPED PIONEER COMPUTER CHIP TECHNOLOGY

Andrew "Andy" Grove, top left, who cofounded Intel, will be given a lifetime achievement award.

Besides cofounding Fairchild Semiconductor and Intel, **Gordon Moore**, top right, will be honored for devising Moore's Law, which accurately predicted that the number of transistors built into each computer chip would double every two years, though he initially thought the doubling would occur annually.

Carver Mead, left, will be honored for devising the so-called VLSI method for designing chips.

MERCURY NEWS PHOTO ILLUSTRATION WITH IMAGES FROM MERCURY NEWS ARCHIVES AND ISTOCKPHOTO.COM

INNOVATORS TO BE INDUCTED INTO HALL AS PART OF 50TH CELEBRATION

By Steve Johnson
Mercury News

To celebrate the 50th anniversary of the integrated circuit, the National Inventors Hall of Fame will honor 16 people who helped pioneer computer-chip technology during a sold-out ceremony Saturday at the Computer History Museum in Mountain View.

Andy Grove, who cofounded Intel and formerly served as the Santa Clara chip maker's chief executive and chairman, will be given a lifetime achievement award.

Among the others being honored is Gordon Moore. Besides cofounding Fairchild Semiconductor and Intel, he devised Moore's Law, which accurately predicted that the number of transistors built into each computer chip would double every two years, though he initially thought the doubling would occur annually.

Also to be honored are:

■ Carver Mead. By devising the so-called VLSI method for designing chips, he helped to develop the standards and tools that permitted tens of thousands of transistors to be packaged onto semiconductors.

See **INVENTORS**, *Page 2*

Freethinkers shaped the valley

Honoring an era of innovation

MIKE CASSIDY
» Silicon Valley Dispatches

The 50th birthday celebration of the integrated circuit kicks off in Silicon Valley this weekend, and frankly, I'm a little overwhelmed.

It's like being the movie writer in Hollywood during Oscar week. Or being the golf writer in Augusta when the Masters comes to town. Because this weekend, the stars are coming out. Our stars, anyway.

Saturday night, the National Inventors Hall of Fame is inducting this year's class. The sold-out ceremony is in Silicon Valley for the first time, because the Ohio-based hall is honoring 16 who are responsible for breakthroughs in semiconductor technology — the technology that put the "silicon" in Silicon Valley. Add to that excitement the group of A-listers expected to be in the audience and, well, it gives me the vapors.

But seriously, whether or not they are all household names, these men changed our households and our history for the better. In a way, it's as if the valley's founding fathers are coming together to be honored in person and posthumously.

See **CASSIDY**, *Page 2*

SALUTE TO THE SEMICONDUCTOR

In addition to Saturday's National Inventors Hall of Fame induction ceremony, the Computer History Museum in Mountain View is holding several events next week as part of a yearlong program called Salute to the Semiconductor, in honor of the 50th anniversary of the integrated circuit. Museum officials expect the events to be booked to capacity. The events:

Wednesday: "From Tinkertoys to Solid Circuits: Microcircuitry in the Late 1950s," with speakers Michael Riordan, Charles Phipps, Jay Lathrop and L. Arthur D'Asaro. 6 p.m. reception, 7 p.m. event.

Thursday: Tours of the Computer History Museum (2:30, 3:30 and 4:30 p.m.) and the Intel Museum (3:30 p.m.).

Friday: Commemorative plaque unveiling at original Fairchild site (shuttle bus leaves museum at 3:30 p.m.). Also: "The Planar Integrated Circuit: Building the Future at Fairchild Semiconductor," with speakers Christophe Lécuyer, Leslie Berlin, Gordon Moore and Jay T. Last. 6 p.m. reception, 7 p.m. program.

Information/registration: www.computerhistory.org/events

San Jose Mercury News April 30, 2009

Andrew "Andy" Grove, top left, who cofounded Intel, will be given a lifetime achievement award.

Besides cofounding Fairchild Semiconductor and Intel, **Gordon Moore**, top right, will be honored for devising Moore's Law, which accurately predicted that the number of transistors built into each computer chip would double every two years, though he initially thought the doubling would occur annually.

Carver Mead, left, will be honored for devising the so-called VLSI method for designing chips.

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Also to be honored are:

■ Carver Mead. By devising the so-called VLSI method for designing chips, he helped to develop the standards and tools that permitted tens of thousands of transistors to be packaged onto semiconductors.

See **INVENTORS**, *Page 2*

BTW, not only was Lynn Conway not invited, she didn't even know it was happening !

Recent investigations into and reporting on what happened,
Hoping to regain some of my legacy along the way . . .

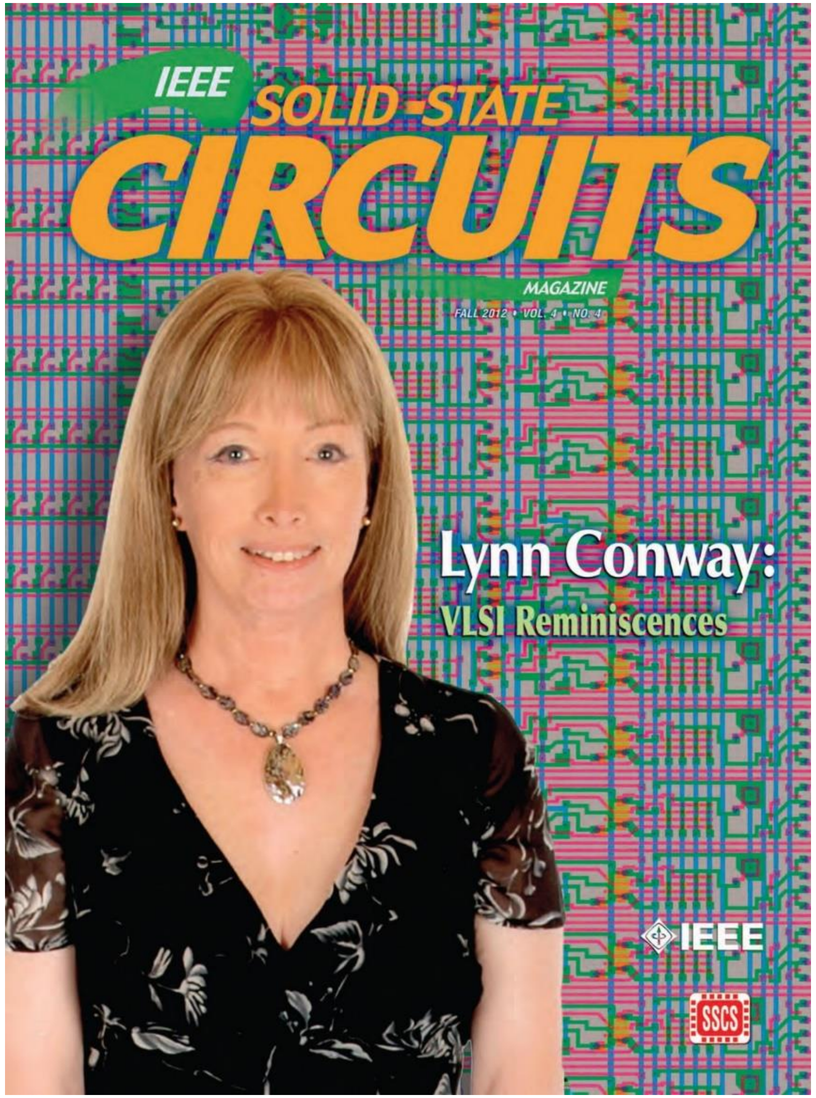
[Link]

The story of my investigations in recent years is quite a saga, yet to be told . . .

To make a long-story short:
I uncovered, documented and archived all sorts of fascinating data and evidence.

All that led me to write and publish my "Reminiscences of the VLSI Revolution" in the Fall 2012 IEEE *Solid State Circuits Magazine*.

It was the first time I'd openly stepped forward to tell the story . . .



Here are links re the investigation (i) to understand what happened, and (ii) to reclaim my life-legacy:

Compilation of the VLSI Archive, 2009-2012

Publication of my IBM-ACS Reminiscences, 2011

Publication of my VLSI Reminiscences, 2012

Publication of The Many Shades of 'Out', 2013

Publication of my MIT Reminiscences, 2014

Here's evidence that "it's begun":

Hall of Fellows, Computer History Museum, 2014

Honorary Doctorate, Illinois Institute of Technology, 2014

IEEE & Royal Society of Edinburgh, James Clerk Maxwell Medal, 2015

Honorary Doctorate, University of Victoria, Nov. 9, 2016

A Counter-Intuitive Explanatory-Conjecture:

Visualizing *Mathew Effects*, *Matilda Effects* and *Conway Effects!*

Link

Throughout this case-study we “appear to observe” the following effects in play:

(i) the “Matilda effect” (repression of women scientists’ contributions)
(ii) the "Matthew effect“ (eminent scientists get more credit)

These effects involve “self-fulfilling prophecies”, which Merton describes as:

“. . . a *false* definition of the situation evoking a new behavior which makes the original false conception come *true*. This specious validity of the self-fulfilling prophecy perpetuates a *reign of error*. For the prophet will cite the actual course of events as proof that he was right from the very beginning.”

But is that all that’s happening? Or are other forces also in play?

On closely investigating these events, I sensed something far more subliminal, more fundamental, happening at a social level . . . something that involves no errors, no conspiracies, no repressions, **and no 'bad guys'**:

CONJECTURE: almost all people are blind to innovations, especially ones made by 'others' whom they do not expect to make innovations.

Since for most people, 'others' = 'almost all people', few people ever witness or visualize innovations, even ones made right in front of their eyes, including even some made by themselves!

They instead look for cues from others when constructing internal-orientations towards 'novelties' they stumble upon . . . and not just whether or not to accept or reject a novelty . . . but even whether to notice it in the first place!

From this perspective, the Mathew Effect and Matilda Effect are derivatives of the conjectured **"Conway Effect"**, which covers 'all outsiders'.

Visualizing the Conway Effect in action:

Most students in MIT'78 thought they were learning "how chips were designed in Silicon Valley" (the course was, in effect, a giant MIT hack!). They "did it" without realizing they were learning radical new methods.

The astonished reaction amongst Silicon Valley cognoscenti then led to intense interest in reverse engineering: "How did MIT do this?" And many research universities immediately wanted to offer an "MIT VLSI course".

Similarly, the many users of MPC79 took it for granted and just "used it". No one realized MPC79 was an even larger paradigm-shifting-hackathon that launched the modern industrial system of "fabless design" + "silicon foundries" + "internet-based e-commerce infrastructure."

By analogy with Engelbart's classic 1968 demo that led to PARC and PC's:
MPC79 was "The Godmother of All Demos"

What might MPC79 participants been thinking?

Since MPC79 used the ARPANET, many thought DARPA had "innovated it."

When DARPA later funded the transfer of the MPC79 technology to USC's Info. Sci. Inst., many high-tech'ers and future users thought "MOSIS" had been "innovated by DARPA"! Government-sponsored MOSIS-like services even sprang up in other countries too!

Thus the VLSI revolution swept through the high-tech community without anyone realizing it had been deliberately generated, much less how that was done, or who did it.

Although the VLSI Book by 'Mead' became iconically-connected with these large-scale techno-social events, Mead himself was never able to explain what happened . . .

Meanwhile, Conway remained in the shadows until 2012, when she finally felt able to emerge and explain how it happened . . .

The Conway Effect: Almost all people are blind to innovations, especially those made by people they don't expect to make innovations.

- Innovations diffuse via social-processes involving subliminal subgroup noticings, mimickings, rejections, adoptions, adaptations, tradings and displacements

Credits for innovations as social tokens are *separately* subliminally assigned, gathered, seized, gained, granted, bartered, etc . . .

- Crediting-processes are modulated by visibility, status, prestige, class, power, location, credentials, prejudice, popularity, influence, money and accident . .

The *visibility of crediting* (vs little visualization of innovations) *thus sustains* both the crediting-processes <u>and</u> the ongoing-blindness to innovations.

Corollary: It's possible to trigger large paradigm-shifts, right out in the open, without people having a clue what you're doing (as long as you don't tell)!

Moral : "When Weirdness breaks out, don't get upset . . . **Do Science On It!**"

Questions to Ponder!

Have you noticed an innovation this week?

Have you made an innovation this week?

What is an innovation???

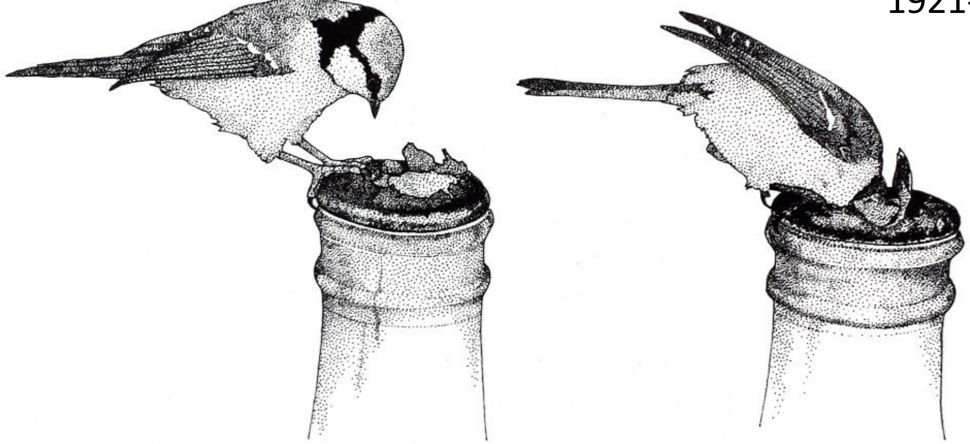
How to think abstractly about such things?

Some insights from the evolution of culture in animals . . .

Glimpses into Emerging Techno-Social Dynamical-Systems . . .

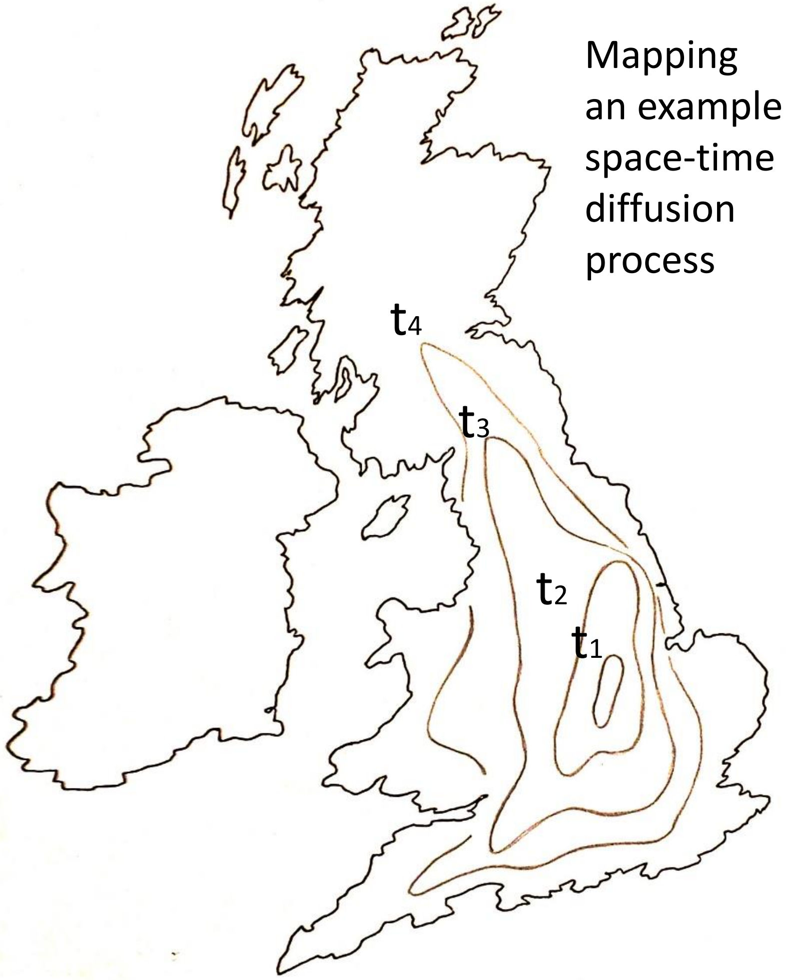
Thought Experiment!*

Visualizing the diffusion of an 'innovation', 1921-1949



John Tyler Bonner, *The Evolution of Culture in Animals*, Princeton University Press, 1980, p.183-4.

*As unfolded by Lynn to mystified audiences decades ago
in her spirited keynotes at Spring Compcon '83 and DAC '84.



Mapping an example space-time diffusion process

Thought experiment!**

"The most remarkable of such examples comes from the work of the Japanese Monkey Center where macaques were isolated in groups on small islands, and differences in the behavior patterns of different island populations arose by cultural evolution . . .

The greatest achievement is that of Imo, the female genius among the macaques.

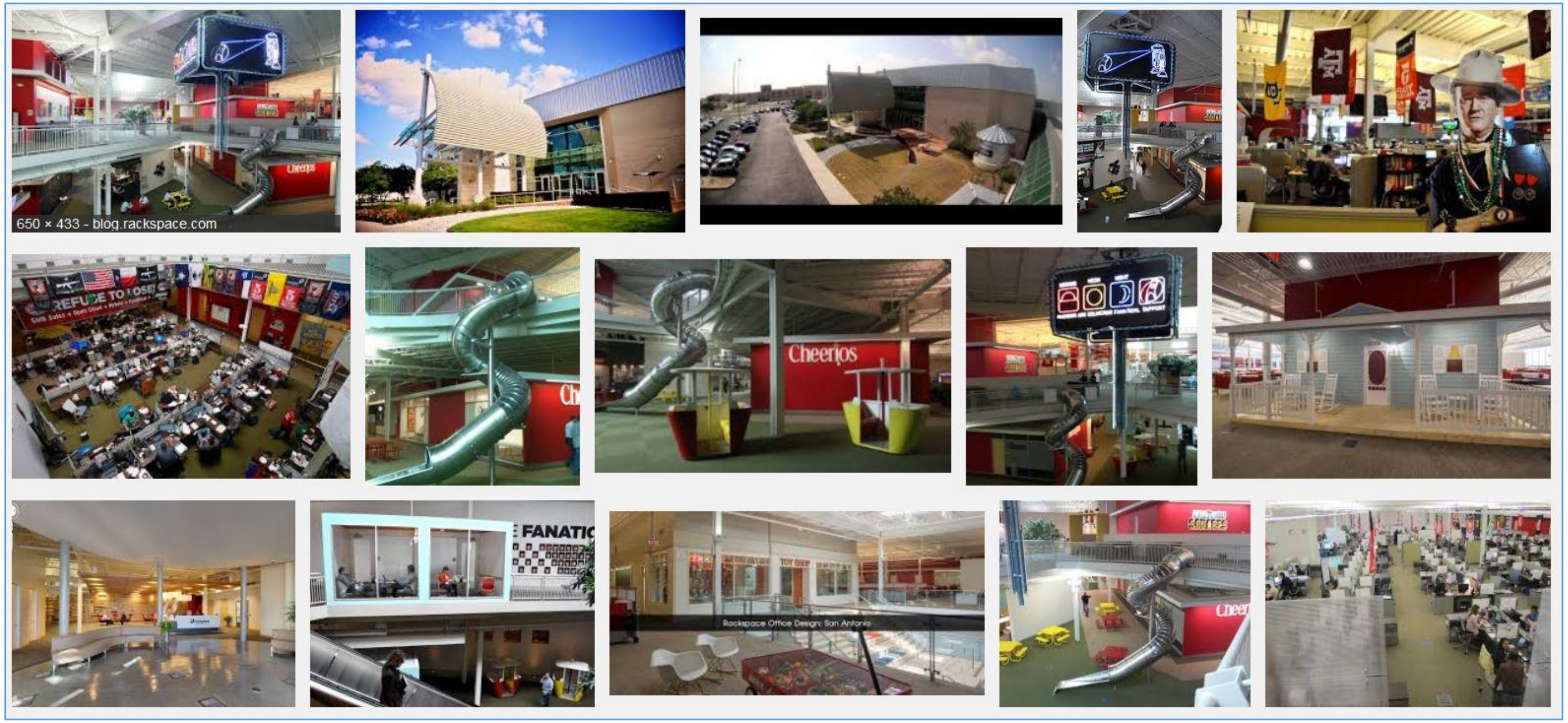
At the age of two she invented washing the sand off sweet potatoes before eating them, and at a later date she found a way of separating wheat from sand by throwing the mixture in the water and skimming off the wheat from the surface.

These discoveries spread slowly through the colony, although in general the older individuals were the last to acquire the new tricks."***

**As unfolded by Lynn to mystified audiences decades ago in her spirited keynotes at Spring Compcon '83 and DAC '84.

***John Tyler Bonner, *The Evolution of Culture in Animals*, Princeton University Press, 1980, p.184.

Thought Experiment: Inside Rackspace's Headquarters (video of “The Castle”)



Just imagine what’s going on inside “1 Fanatical Place, Windcrest, TX”, and similar high-technology exploration-grounds all around the world!

For glimpses into Techno-Social Systems in the emerging Social Age see:

http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno_Social_Talk.pptx
http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno_Social_Talk.pdf

END

Moral Of The Story:

"When Weirdness breaks out, don't get upset . . . Do Science On It!"

http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Inside_Story_Talk.pptx
http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Inside_Story_Talk.pdf
www.lynnconway.com ; conway@umich.edu

Readings:

Ken Shepard, “Covering”: How We Missed the Inside-Story of the VLSI Revolution”, *IEEE Solid State Circuits Magazine*, FALL 2012, pp. 40-42. (more)

Chuck House, “A Paradigm Shift Was Happening All Around Us”, IEEE Solid State Circuits Magazine, FALL 2012, pp. 32-35. (more)

Lynn Conway, “Reminiscences of the VLSI Revolution: How a series of failures triggered a paradigm shift in digital design”, *IEEE Solid State Circuits Magazine*, FALL 2012, p. 8-31. (more)

Lynn Conway, “The Many Shades of Out”, *Huffington Post*, July 24, 2013.

Paul Penfield, "The VLSI Revolution at MIT", *2014 MIT EECS Connector*, Spring 2014, pp. 11-13.

Lynn Conway, "MIT Reminiscences: Student years to VLSI revolution", *lynnconway.com*, March 11, 2014.

Computer History Museum: “Lynn Conway, 2014 Fellow, For her work in developing and disseminating new methods of integrated circuit design”, April 2014.

Nicole Casal Moore, “Life, Engineered: How Lynn Conway reinvented her world and ours”, The *Michigan Engineer*, FALL 2014, pp. 42-49.

Catharine June, “Lynn Conway to receive 2015 IEEE/RSE James Clerk Maxwell Medal”, *Michigan Engineering News*, December, 15, 2014.

IEEE and the Royal Society of Edinburgh, “James Clerk Maxwell Medal ceremony at the Royal Society of Edinburgh”, YouTube, Nov. 12, 2015.

Magnus Linklater, “‘Life in stealth’ of microchip genius who migrated to a new identity: Lynn Conway beat transgender bias and began a revolution”, *The Times* (UK), Nov. 14, 2015.