**Back to the Future: The Incoming Wave of Innovation**

**Lynn Conway, Univ. of Michigan**

**Abstract:**

Lynn first reflects on the personal computer and VLSI revolutions, on what it felt like back then, and on the bootstrapping processes that led to the breakout. She believes history is about to repeat itself on a yet vaster scale, as we suddenly begin embedding macroscale-product-enhancing modular interconnected microsystems into almost everything. The trigger for this looming breakout: the commingling and hybridization of (i) EDA tools, (ii) digital macro/micro/nano “making” and (iii) social-media, yielding multi-technology "exploration infrastructure" for widespread user-engaged market development and rapid open-source technology evolution. By exploiting collaborative learning, crowdsourcing, crowdfunding, IP brokering, agile methods, rapid-digital-prototyping and more, all participants, from users to makers, can dramatically scale up their connectivity and rate-of-impact. Thus, even as Moore’s Law “ends”, a whole new dimension of digital architectural exploration is opening up, as individual processing/MEMS components exploit TSVs and interposers in 3-D stacks, and as novel arrays, lattices and networks of such components are interconnected via printed, woven, flexible and wireless means, for embedding in an ever-expanding array of end-uses. As the pace of innovation escalates, the time to innovate, prototype, validate and distribute will become key to surfing this wave, and thus of central concern to system architects.

**I. Introduction:**

**(2 min)**

**II. Back to the Future:**

**(4 min)**

How bootstrapping via positive feedback among a cluster of existing technologies can generate an expanding techno-social ecosystem in a disruptive wave of innovation . . . reflecting on the “innovation-diffusion-selection-displacement rates” and the “feedback cycle-times” in such waves.

1. The age of discovery: 1450-1800

Shipbuilding, navigation, timekeeping, map-making and printing.

"Printer in 1568-ce" by Jost Amman - Meggs, Philip B. A, *History of Graphic Design*, Wiley & Sons, 1998. [http://commons.wikimedia.org/wiki/File:Printer\_in\_1568-ce.png#mediaviewer/File:Printer\_in\_1568-ce.png](http://commons.wikimedia.org/wiki/File%3APrinter_in_1568-ce.png#mediaviewer/File:Printer_in_1568-ce.png)

2. The industrial/technological revolution:

Mines, coal, iron, steam-engines, mass-production, railroads, telegraphy: ~ 1800 to 1900

Slides: mines, railroads and telegraphs

3. The networked interactive personal computing revolution:

Personal computers, networks, EDA tools, fabless design methods, silicon foundries:

Computing, communications, electronics ~ 1970 – 2010.

Slides: Fairchild, Intel, Licklider, Englebart, Arpanet, PARC, VLSI, universities, computer architecture, EDA, MOSIS, the Silicon Valley ecosystem

**III. Challenges vs Opportunities:**

**(2 min)**

1. “Chip Design Game at the End of Moore’s Law”, by Bob Colwell, Keynote 1, Hot Chips 25, 8/26/13.

<http://www.youtube.com/watch?v=JpgV6rCn5-g>

2. “Dark Silicon and the End of Multicore Scaling”, by Hadi Esmaeilzadeh, et al, Proc. of ISCA ’11, 6/4-8/11.

<http://www.cc.gatech.edu/~hadi/doc/paper/2011-isca-dark_silicon.pdf>

“Power Challenges May End the Multicore Era”, by Hadi Esmaeilzadeh, et al, CACM, Feb 2013.

<http://cacm.acm.org/magazines/2013/2/160168-power-challenges-may-end-the-multicore-era/fulltext>

3. “Rest in Peace CPUs, Hello FPGAs”, by Luke Miller, SemiWiki, 7/20/14.

<http://www.semiwiki.com/forum/content/3689-rest-peace-cpus-hello-fpgas.html>

<http://www.thefpgaexpert.com/>

<http://contest.techbriefs.com/2013/entries/sustainable-technologies/3726>

4. "Accelerator-Rich Architectures — From Single-chip to Datacenters", by Jason Cong, 14th IEEE International Symposium on Low Power Electronics and Design (ISLPED), August, 2014 (Keynote Speech)

<http://cadlab.cs.ucla.edu/~cong/slides/islped14_keynote.pdf>

“FPGA Implementation of EM Algorithm for 3D CT Reconstruction”, Young-kyu Choi, Jason Cong, and Di Wu, IEEE International Symposium on Field-Programmable Custom Computing Machines, May 2014.

<http://vast.cs.ucla.edu/sites/default/files/publications/FPGA%20Implementation%20of%20EM%20Alg%20for%203D%20CT%20Reconstruc.pdf>

“Accelerator-rich architecture with composable and reconfigurable accelerators”, Center for Domain-Specific Computing.

<http://www.nsf.gov/news/mmg/media/images/graphics2-expanded.jpg> ‘

5. “The Innovation Valley of Death”,

6. “Taking great ideas from the lab to the fab”, NSF Innovation Transition (lnTrans) Press Release 14-086, 7/17/14.

<http://www.nsf.gov/mobile/news/news_summ.jsp?cntn_id=132053&org=NSF&from=news>

**IV. The Incoming Wave of Innovation: Embedding Interconnected Microsystems in Almost Everything**

**(20 min)**

<http://ai.eecs.umich.edu/people/conway/Memoirs/Microworld/The_Incoming_Wave_of_Innovation.pdf>

<http://wims2.org/publications/newsletter/WIMS2_Horizons_Newsletter_Summer_2013.pdf>

Envisioning the Adventures Ahead: How a coalescing cluster of technologies will launch this tsunami when it hits critical-mass.

Immersive social-media, enhanced design-exploration infrastructure, user-community-engagement tools, social learning and coordination tools, MOOCs and flipped-courses, agile design methods, open-source standards, rapid digital-prototyping, modularized 3-D digital making, makerspaces, FABLABs, crowdsourcing, crowdfunding, IP brokering, supply-and-distribution-chain interweaving, and ‘Alibaba-type’ infrastructure connecting innovators-designers-investors-makers-sellers-users.

Social-age wave of increasingly sustainable human-empowerment technology, by embedding ever-more ever-smaller processing, memory, interconnections, sensors, transducers, communications and controls to ‘animate’, ‘functionalize’ and increasingly ‘humanly-customize’ almost everything – from wearables, to the IoT, to personal health, recreation and mobility systems, smart homes, smart cities, smart environments ~ 2010 to 2040.

Things to show:

[www.technologyreview.com/photoessay/529761/micro-chiplets/](http://www.technologyreview.com/photoessay/529761/micro-chiplets/)

<http://www.hooktraffic.com/history-of-social-media/>

<http://www.vox.com/a/internet-maps>

The Rise of the Internet of Things – Infographic

<http://blogs.jabil.com/2014/08/13/internet-of-things-infographic/>

“Makers Conquer the World -- From Artisan to Arduino at World Maker Faire”, by Kevin Morris, *EE Journal*, September 23, 2014

<http://www.eejournal.com/archives/articles/20140923-makerfaire/>

“What separates Maker Faire and the maker movement from artisanal movements of the past? We talked with Dale Dougherty - president and CEO of Maker Media and co-founder of Maker Faire. He pointed out that one key enabler is today’s ready availability of low-cost high-tech building blocks. If your basic building blocks are squares of fabric, the range of things you can create is limited. When you expand your repertoire to include things like microcontroller boards, 3D printers, and the full gamut of modern technology, tools, and techniques, the universe of things you can create expands exponentially. This re-connection to the building blocks of technology is where the realm of makers begins. “It’s cheaper and easier than it ever was,” Dougherty explains . . . “

**V. Reflections on what’s ahead:**

**(2 min)**

Escalating rates of global participation as users-innovators-designers-makers-distributors, higher visibility into international needs-and-opportunity spaces, faster-paced innovative team-based responses, more rapid standards-based testing and validation, more rapid diffusion via open-source design files and production via remote digital making, rapidly improving investment, logistical and business infrastructure, more rapid noticing-selection-marketing-adoption and building-upon effective innovations.

“If you want to change the future, start living as if you’re already there.”

“Embrace and enjoy the escalating rate of techno-social change”

“Within your lifetime you’ll live farther into the future than you’ve ever imagined!”

**Q/A**

**(5 min)**