

IEEE HISTORY COMMITTEE MEMORANDUM

February 18, 2016

To: IEEE History Committee and IEEE Milestone Proposal Website

From: David Bart, IEEE History Committee Milestone Advocate

Re: **PROPOSED MILESTONE -- MOORE'S LAW**

I fully support the Milestone proposal for Moore's Law which will be well situated for public education, fully documents the historic importance of its event, and which, with some wording revisions, accurately captures the nature of and importance of its event.

Documentation Sources

I verified the sources referenced in the Milestone proposal and confirmed that they do support the basic assertions about the description and importance of Moore's Law. I note that the number of sources cited in the proposal which document the impact of Moore's Law has continued to grow during the proposal process and is quite substantial. I noted the following representative sources attest to the legacy and influence of Moore's Law:

- The Chemical Heritage Foundation (CHF) held a symposium in May 2005 marking the 40th anniversary of Moore's Law and published "Four Decades of Moore's Law" in 2006 outlining the history, progress and influence of Moore's concepts and providing a lengthy reference bibliography.
- Gordon Moore wrote "Moore's Law at 40" with his reflections for the CHF symposium.
- The Computer History Museum issued a 50th anniversary series of articles in *CORE* in 2015 outlining the nature of Moore's Law and its many interpretations and overall impact.¹
- The Computer History Museum dedicates significant website content to Moore's Law and treats it as a 1965 milestone. The CHM offers links to contemporary documents, oral history transcripts, oral histories and other information about Moore's Law.² One article calls it "the most important graph in human history."³
- Gordon Moore was interviewed by Michael Wolff for the IEEE History Center on March 4, 1976 for an Oral History.⁴
- Gordon Moore presented at the International Solid State Circuits Conference 50th anniversary in 2003 where he outlined the concepts of Moore's Law and explained that "No Exponential Is Forever".⁵
- In April 2015, the *IEEE Spectrum* included a series of articles dedicated to the 50th anniversary of Moore's Law.⁶

¹ Computer History Museum, *CORE*, 2015: Walter Isaacson, "Moore's Law @ 50"; David Brock, "How Moore's Law Came to Be"; Stevan Levy, "How Understanding Moore's Law Made Goggle Possible"; Steve Jurvetson, "Transcending Moore's to Forge the Future."

² See <http://www.computerhistory.org/semiconductor/timeline/1965-Moore.html>.

³ See <http://www.computerhistory.org/atcm/moores-law50-the-most-important-graph-in-human-history/>.

⁴ See http://ethw.org/Oral-History:Gordon_Earl_Moore.

⁵ See http://ethw.org/Archives:No_Exponential_is_Forever.

⁶ *IEEE Spectrum*, April 2015: "The Long Good-bye"; Mack, Chris, "The Multiple Lives of Moore's Law"; Hutcheson, Dan, "Transistors by the Numbers"; Koomey, Joathan, and Naffziger, Samuel, "Efficiency's Brief Reprieve";

- *Moore's Law: The Life of Gordon Moore, Silicon Valley's Quiet Revolutionary* by documents Gordon Moore's biography and the impact of his ideas.⁷

Although there is debate whether Moore's Law is a law or prediction or a self-fulfilling prophecy, its impact on the computer industry is widely acknowledged. Moore presented the key insight in an internal paper at Fairchild Semiconductor in 1965; namely, that the number of components per integrated circuit for minimum cost per component developed between 1959 and 1964 (5 data points) would double approximately every 12 months, representing an exponential rate of growth over time. He published this insight in *Electronics* on April 19, 1965, "Cramming more components onto integrated circuits." This is the date generally acknowledged as the anniversary. The prediction itself was revisited a number of times and extrapolated for varying uses during the next 50 years. For example, Rock's Law or Moore's Second Law, named for Arthur Rock or Gordon Moore, states that the cost of a semiconductor chip fabrication plant doubles every four years.

Although Moore's Law was initially an observation and prediction, the more widely it became accepted, the more it served as a goal for an entire industry. Thus, it drove both marketing and engineering departments of semiconductor manufacturers as they competed to achieve the specified increases in processing power that were presumed to be attained by competitors. In this regard, Moore's Law can also be viewed as a self-fulfilling prophecy. Nevertheless, whether it represents an observation, prediction or self-fulfilling prophecy, its tremendous impact continues to be widely acknowledged.

Testimonials

I noted that two testimonials were submitted by prominent people who were directly aware of and who were influenced by Moore's Law in setting their R&D programming goals. The statements of Dr. Marcian Edward "Ted" Hoff, Jr. and Dr. Eli Harari each provide important first-hand statements of their experiences with the dramatic influence of Moore's Law. Each is an esteemed participant in the computer industry. Ted contributed to the development of the 4004 microprocessor at Intel. He is a recipient of: the IEEE Computer Society's Computer Pioneer Award, IEEE Cleo Brunetti Award, the National Medal of Technology and Innovation from President Obama, and the IEEE/RSE Wolfson James Clerk Maxwell Award. He is an IEEE Fellow, Fellow of the Computer History Museum, and an Intel Fellow and was inducted into the National Inventors Hall of Fame. Eli holds approximately 150 issued patents and is a recipient of: Ernst and Young Entrepreneur of the Year Lifetime Award, IEEE Reynold B. Johnson Data Storage Device Technology Award, GSA (Global Semiconductor Alliance) Dr. Morris Chang Exemplary Leadership Award, IEEE Robert N. Noyce Medal for Exceptional Contributions to the Microelectronics Industry. He is a member of the National Academy of Engineering, received the National Medal of Technology and Innovation from President Obama, and was inducted into the Consumer Electronics Hall of Fame.

Location

I support the proposed location of the plaque since it is near the actual site (which is no longer standing) where Gordon Moore worked at the Shockley Semiconductor Laboratory in Mountain View, California. It will be placed adjacent to another planned IEEE Milestone, the "Birthplace of Silicon Valley, 1956". The current site is under development as a mixed retail, residential, parks and public plaza space that will be completed in late 2017. In addition, the site will include a "Technology Plaza" that will incorporate exhibits and a video information booth

Courtland, Rachael, "When Mead Met Moore"; "The Law That's Not A Law, Conversation with Gordon Moore"; Huang, Andrew, "Moore's Law is Dying (and That Could Be Good)."

⁷ Thackray, Arnold; Brock, David; Jones, Rachel (2015). *Moore's Law: The Life of Gordon Moore, Silicon Valley's Quiet Revolutionary*. New York: Basic Books.

related to Shockley and the development of Silicon Valley. The historic location, public plaza and educational exhibits all place the proposed Moore's Law plaque in a relevant setting.

Plaque Text

I carefully considered the proposed text of the plaque and suggest refining the wording.

The proposed text reads as follows --- Title: "Moore's Law Predicts Integrated Circuit Complexity Growth, 1965", Citation: "Gordon E. Moore, co-founder of Fairchild and Intel, began his work in silicon microelectronics at Shockley Semiconductor Laboratory in 1956. His 1965 observation and prediction at Fairchild Semiconductor, now known as Moore's "Law," that the number of components (transistors, etc.) on an integrated circuit, for the minimum manufacturing cost per component, increases at an exponential rate, served as the foundation for advances in electronics and computing for over 50 years.

My recommended text reads as follows with changes underlined --- Title: "Moore's Law Predicts Growing Complexity in Integrated Circuits, 1965", Citation: "Gordon E. Moore, co-founder of Fairchild and Intel, began his work in silicon microelectronics at Shockley Semiconductor Laboratory in 1956. His 1965 observation and prediction at Fairchild Semiconductor, now known as "Moore's Law," that the complexity of an integrated circuit (number of components) increases at an exponential rate over time, guided the industry's long-term research and development goals for over 50 years, leading to significant advances in electronics and computing."

My rewording of the title is simply to tighten the language and make it an active voice statement. I would use "Moore's Law" rather than Moore's "Law" --- the question of whether this is a law or a term of art is better resolved by placing quotes around the whole term which is used as a word pairing anyway. My revisions to the later portion of the text after "Moore's Law" are intended to emphasize the influence on industry R&D planning and to clarify that Moore's Law dealt with the complexity of an integrated circuit as measured by the number of components.

Other Aspects of the Proposal

The other aspects of the proposal indicate that the local IEEE Chapter supports the Milestone, it has funding and the site location is approved.

The actual building on which the Milestone plaque would be mounted has not yet been constructed. That building is part of Phase II construction at the real estate development, the Village at San Antonio Center, which will be completed in late 2017. Phase I of the development is open and operating. A map and photos are available at <http://www.thevillagesanantoniocenter.com/pdf/TheVillageSiteMap.pdf>.