

Convergent Biomedical Science and the Johns Hopkins Information Economy

The history of this discussion evolved as a result of the April 17, 2010 Rising to the Challenge panel¹, the University committees on Personalized Health and the Science of Learning, and the 2011 SoM Dean Search and Provost's Initiative on Innovation.

1. The Post Information Age

I believe that Machine Learning and APPs running on the Clouds will be of the greatest technological and scientific impact on my work over the next several decades. Just as in the early history of communications, pre-Shannon, we focused on devices, medical technologies have focused on devices as well – from microscopes to MR imagers. That will continue. However, the information deluge is remarkable and the focus will continue to grow on the metadata that is derived from the measurements coming out of the devices. Let me argue the case.

The bit was only defined roughly 50 years ago²– now thanks to Google we are in the *post-information age* in which all that is quantized and known can be instantaneously retrieved on our mobile devices. Likely there won't be even that barrier, we will browse directly from our thoughts.

Imagine, when I was growing up we actually purchased an *Encyclopedia Britannica* set from the travelling book salesman who visited us in our Valley Stream house in Long Island; he probably knew the Fuller Brush man. That was how I did book reports at the dining room table; my 13 year old daughter can't imagine it.

So the information age as we knew it, the age of discovery associated with the 2nd half of the 20th century, is over. Just as the quantum age receded, the information age recedes. *Now we are in the commoditization phase*: both remain as stalwart commodities.

¹ http://www.jhsph.edu/alumni/events/event_archives/2010/rising_ny.html

² "http://en.wikipedia.org/wiki/A_Mathematical_Theory_of_Communication

"Mathematical Theory of Communication" is an influential^{[1][2]} 1948 article by mathematician Claude E. Shannon. It was renamed "The Mathematical Theory of Communication" in the book^[3], a small but significant title change after realizing the generality of this work. [p://en.wikipedia.org/wiki/Information_theory](http://en.wikipedia.org/wiki/Information_theory)

2. The great flattening and the APP driven world

Those of us who have grown up in the Academy appreciate that this great post-internet-Google flattening of the globe is changing the University as we know it. The ascent of Wikipedia as a knowledge source is an interesting example. And the speed of the change is frightening. As Friedman pointed out recently on *Meet the Press*, his book *The World is Flat*³ didn't mention *FaceBook*; it was published in 2005. As recently chronicled by Business report of Bloomberg, Stanford recently offered several classes in Artificial Intelligence which have 140,000 students on line.⁴ Something is afoot.

One of the Ministers of Industry for China was recently on *Charlie Rose* and pointed out that China is building its economy based on the commoditization of information. He emphasized that with the upwards of 2 billion people in Asia, the 20th century industrial manufacturing economy wouldn't scale without the risk of exhausting the planet's resources. In this new post manufacturing economy, DATA EQUALS COMMERCE. This is instantiated at the architecture level by the fact that the compute engines are collocated with the data – *MapReduce* and the Yahoo open source *Hadoop* project⁵. The data is where the money is. The commerce is of course the APPs running on the DATA in the CLOUDS. Thanks to Steve Jobs, we are in an APP driven world.

3. The BioCloud

At Johns Hopkins we are in a unique position. As the economic clouds recede, the data clouds are growing at an astronomical rate. As depicted in the figure, by 2020 we can estimate that the Clouds will reach 10^{20} images, what I term the Human Click Limit, which corresponds to one picture taken every second by every person on the planet for 100 years.⁶

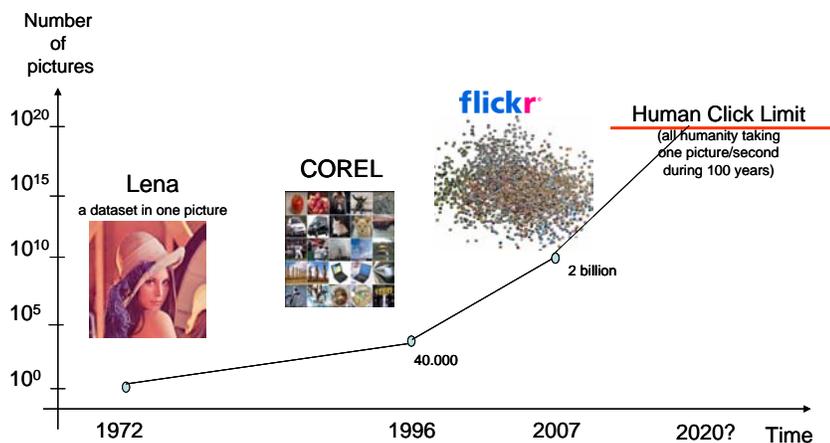


Figure 1: The super-geometric growth trend continues to exceed Moore's law then all of the imagery and data being collected will be stored on the Clouds and visited via Cloud computing. At the same time, the surge of mobile computing will dictate Cloud based applications interacting directly with the mobile users.

³ http://en.wikipedia.org/wiki/The_World_Is_Flat *The World Is Flat: A Brief History of the Twenty-First Century* is an international bestselling book by Thomas Friedman that analyzes globalization, primarily in the early 21st century.

⁴ <http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2011/10/13/BUFR1LH9JR.DTL>

⁵ <http://en.wikipedia.org/wiki/Hadoop>

⁶ Taken from a lectures by Antonio Torralba, Center for Imaging Science, The Johns Hopkins University, April 2009, <http://people.csail.mit.edu/torralba/courses/6.870/slides/lecture7>

The good news for Johns Hopkins is that as IBM estimated medical images and medical data would constitute 30% of all the data in the world by 2010.⁷ Much of this medical data will be stewarded by the great medical universities, as we are the subject-matter-knowledge-experts. High throughput genomics and imaging informatics will certainly be an important part of the Personalized Medicine economy which has always been a tradition at Johns Hopkins Medicine. As William Osler famously quoted, “better to understand the patient who has the disease than the disease that has the patient”.

Just as I was fortunate to learn from the leading thinkers of their time in Neuroscience about the evolutionary organization of structure and function in the brain, our next generations of students, residents, interns will be in a unique position to write the next *Angry Birds* application that will revolutionize Personalized Medicine as we know it. I hope they put it in the Johns Hopkins School of Medicine APPstore.

4. Convergent Biomedical Science Initiative (CBSI): A University-wide Initiative

Having said all this, we need to be mindful – they are knocking on the Gates of Gondor. During our own lifetime we saw the dominance of America in the Edison century of Engineering with Bell Labs, Sarnoff, and Xerox Park. Our RCA and Zenith color TVs were made in the US. We had AT&T. We have been protected in North America by our great oceans.

Similarly Medicine and Biomedicine has been protected during its 100 year creation and evolution within the confines of the Johns Hopkins continent. But that has changed. The disruptive technologies come quickly; what happened to *RIMM* and *Blockbuster*?

Our competitors have new “roads” and have developed wireless. They are investing heavily into engineering and medicine. India and China now produce 20 times the number of engineers as produced in the USA. Biomedicine is likely to feel the pressures. These countries don’t have the historic infrastructures already in place to slow them down.

Having said that, we still have a huge – perhaps singular – advantage here at Johns Hopkins University: we have our own “bio-information economy”. The history of Arts & Sciences is 400 years old; Medicine is 100; Biomedical Engineering is 50. The latter two were both created within the Johns Hopkins continent. Taking seriously the 30% number, we will be stewards of a global biomedical cloud, positioned to scale

⁷ www.forbes.com/2009/06/17/health-care...governance-information.html By 2010 medical images will account for an estimated 30% of the data ... is the chief health care officer of IBM.

Convergent Biomedical Science⁸ by an order of magnitude at Johns Hopkins University.

We should launch a new “school” of Convergent Biomedical Science (CBS), immersed in the 500 million dollar research enterprise of Johns Hopkins Biomedical research. CBS must be built around the incentive of fostering convergent science, coupled to the departmental model. It must scale the already success proven department - center - institute models which have independently developed for “big science”. CBS should draw its faculty via tenure lines in the home departments throughout the University. The convergent themes should be built around clusters of faculty – each being a Manhattan Project for biomedicine – emerging from the Universities’ constituencies. The Provost’s office should lead the recruitment. The departments would advance recruitment of faculty who are members of the convergence clusters. The model has already been instantiated at several of our competitors so we don’t want to squander our lead.^{9,10}

Co-location is a must so that CBS becomes a destination theme park, like Kendall Square, connecting the two campuses of basic science and engineering departments and creating a facility which is filled with the energy of undergraduates. Unleash the entrepreneurial energy of our 100’s of undergraduates to the fantastic energies of our Homewood and SoM basic science departments. With nothing to lose, invention is a property of the young.

⁸ Promoting Convergence in Biomedical Science Phillip A. Sharp*, Robert Langer The next challenge for biomedical research will be to solve problems of highly complex and integrated biological systems within the human body. Predictive models of these systems in either normal or disease states are beyond the capability of current knowledge and technology. Science 29 July 2011: Vol. 333 no. 6042 p. 527 DOI: 10.1126/science.1205008

⁹ <http://provost.uiowa.edu/clusters/> Meeting the Grand Challenges of the 21st Century: The University of Iowa Cluster Hire Initiative As one of the premier research institutions in the nation, The University of Iowa is committed to advancing knowledge and education through discovery, application, and creative work. Many of today’s most exciting and important research frontiers transcend traditional disciplinary boundaries. If we are to maintain and strengthen our research and creative excellence, we must facilitate multidisciplinary scholarship, instruction, and public service. This is the aim of the cluster hire initiative. As a centerpiece of our 2010-2016 strategic plan, *Renewing the Iowa Promise: Great Opportunities—Bold Expectations*, the cluster initiative will bring 100 new tenured and tenure-track faculty to campus to collaborate with existing faculty in multidisciplinary cluster areas focused on many of the “Grand Challenges” of the 21st century.

¹⁰ <http://www.princeton.edu/genomics/> The Lewis-Sigler Institute for Integrative Genomics The Lewis-Sigler Institute for Integrative Genomics, housed in the Carl Icahn Laboratory at Princeton University, was established to innovate in research and teaching at the interface of modern biology and the more quantitative sciences. The Institute is the hub of the Center for Quantitative Biology, funded by the National Institute of General Medical Sciences (NIGMS), one of the National Institutes of Health (NIH).

We had better get on it. Examine the Cornell/Stanford¹¹ competitive efforts to open a new Engineering school during the rebirth of Manhattan in this consumer-generated, social-media Cloud age. The lost opportunity cost is big. Think about Microsoft's leadership with *Windows mobile*. I guess they didn't take that little boutique Apple company seriously and they didn't anticipate the first browser-based Android operating system.

What we risk is the BioCloud. China is going to have 1.3 billion medically insured lives in the BioCloud; India the same. *I just hope it is the JHU BioCloud.*

¹¹ <http://www.dnainfo.com/20111024/upper-east-side/cornell-stanford-compete-for-green-tech-campus-designs>,
<http://stanford.edu/nyc/>