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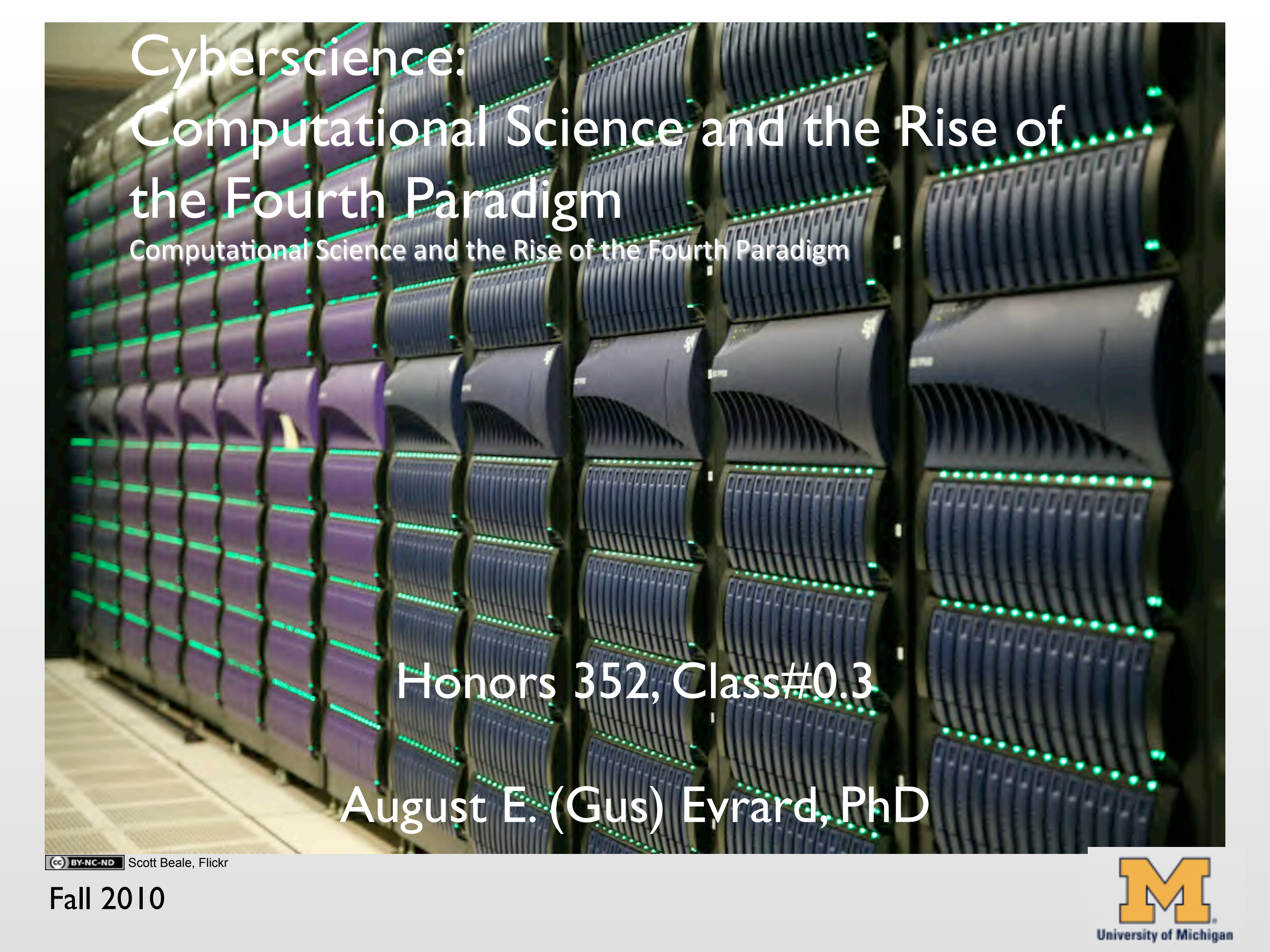
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Cyberscience: Computational Science and the Rise of the Fourth Paradigm

Computational Science and the Rise of the Fourth Paradigm

Honors 352, Class#0.3

August E. (Gus) Eyrard, PhD

today

- * reading quiz
- * lecture: broad themes from 4th P, Sec 1,2 reading
+ Cosma as a specific example
- * discussion: forming groups and choosing group projects
- * reminder: first (wordpress) blog entry due next **Monday 9am**
choose your theme:
What has scientific computing done for society?
What interests me most about scientific computing is ...

science is evolving

- **basic (natural) sciences** drove the first three paradigms

- physics, chemistry, biology, astronomy, etc.
- many important, fundamental questions:
nature of matter, origin of life, evolution, ...
- particle physics = purist (?) form:
standard model of particle physics (theory)
+ collider accelerators (experiment)
+ lattice quantum chromodynamics (simulation)

- **solving societal problems** under 4th P requires broad scope: natural + social sciences + engineering

healthcare
climate
energy
agriculture
social justice
...

With science moving toward being computational and data based, key technology challenges include the need to better capture, analyze, model, and visualize scientific information. The ultimate goal is to aid scientists, researchers, policymakers, and the general public in making informed decisions.



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science is evolving

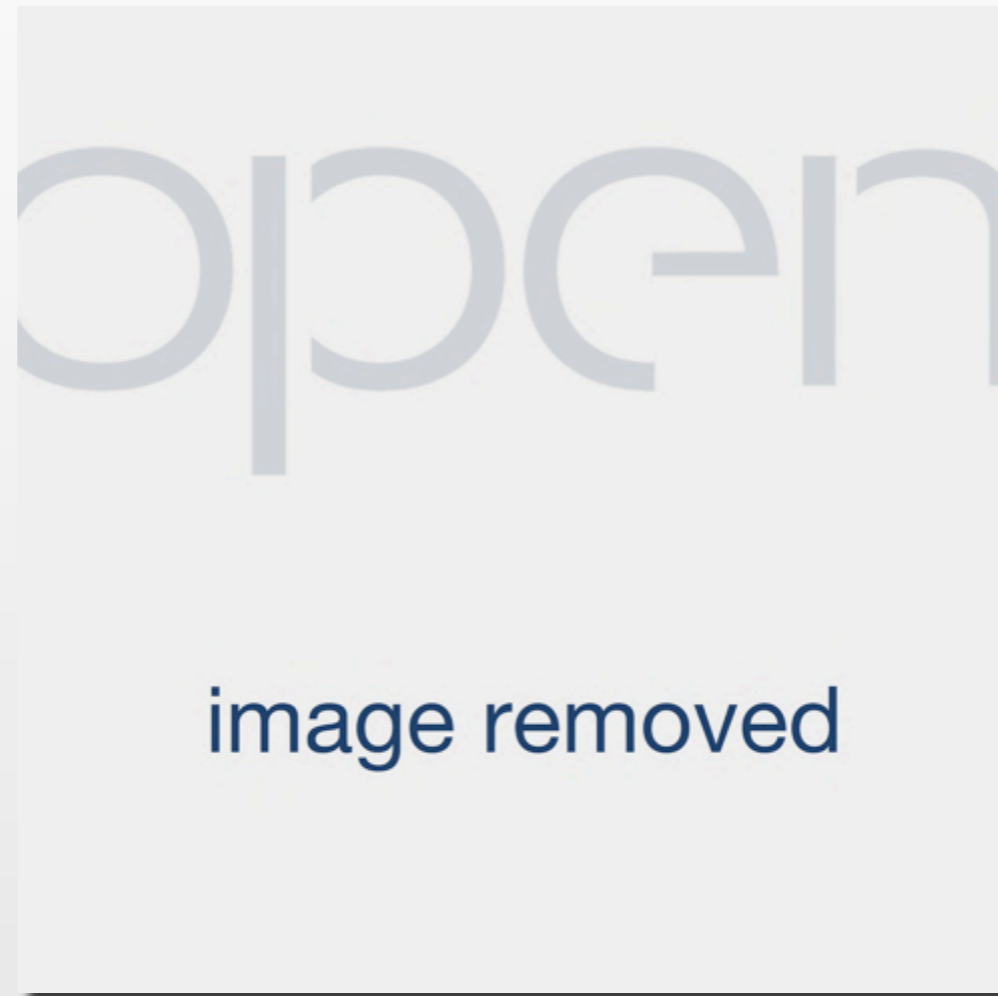


 Lawrence Berkeley National Laboratory, Flickr

“We seek solutions. We don’t seek – dare I say this? – just scientific papers anymore.”

 R. DelVecchio, “UC Berkeley: Panel looks at control of emissions”
San Francisco Chronicle, 27 March 2007

opportunities for data capture abound

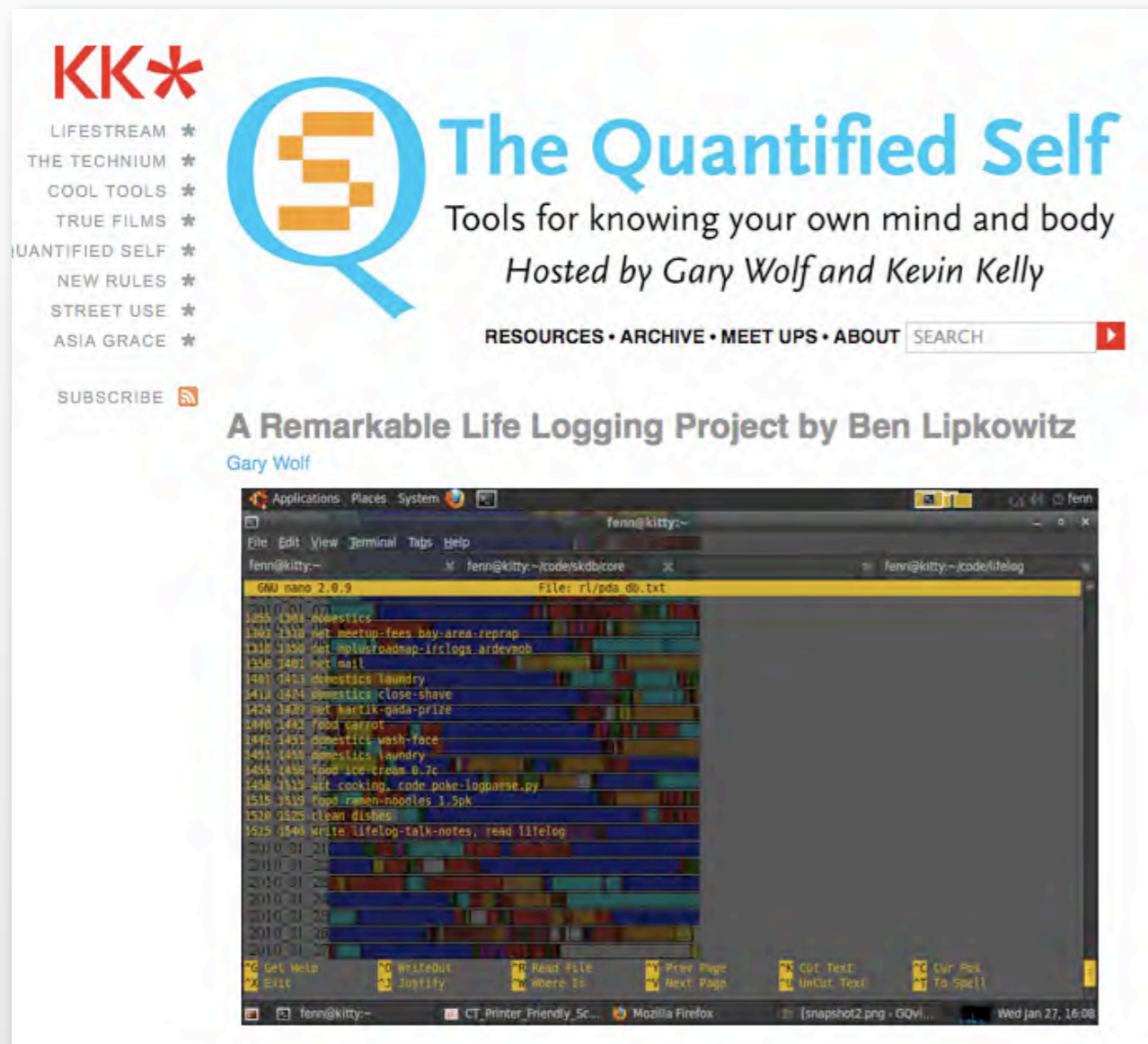


Please see original image of New York Times article at
<http://www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html>

data capture for *self-quantification*

Ben started self-tracking when he wondered how much time he actually spent doing his roommate's dishes. He estimated that he spent an hour a day. (The true amount, he learned, was about 20 minutes.) This led him to track more things. This led him to track everything. **Ben considers this project a scientific investigation**, but is a type of science inspired by Buckminster Fuller, aka "Guinea Pig B," rather than by a more conventional academic tradition.

It is easy to imagine somebody watching this video and saying: "well, that's a full scale geek-out that has nothing to do with me." But I think this would be an error. Ben uses data to find out details about himself, such as how he sleeps. He also uses data to figure out problems in his social life, such as whether the distribution of housework is reasonable. While it's true that Ben's method of data gathering is unusable by most people, **the type of questions he's asking and the conviction that these questions are answerable are a preview of the coming age of self-quantification.**



The image shows a screenshot of the 'The Quantified Self' website. The website header includes the 'KK*' logo, a navigation menu with items like 'LIFESTREAM', 'THE TECHNIUM', 'COOL TOOLS', 'TRUE FILMS', 'QUANTIFIED SELF', 'NEW RULES', 'STREET USE', and 'ASIA GRACE', and a 'SUBSCRIBE' button. The main title is 'The Quantified Self' with the subtitle 'Tools for knowing your own mind and body' and 'Hosted by Gary Wolf and Kevin Kelly'. Below this is a search bar and a link to 'RESOURCES • ARCHIVE • MEET UPS • ABOUT'. The main content area features the article title 'A Remarkable Life Logging Project by Ben Lipkowitz' by Gary Wolf. Below the article title is a terminal window showing a life log in a nano editor. The log contains entries such as '1355 1355 domestics', '1365 1315 get beerup-tees bay-area-reprap', '1316 1320 get mp3s-roadmap-ifclogs-ardevnob', '1356 1401 get mail', '1411 1413 domestics laundry', '1411 1414 domestics close-shave', '1424 1429 get aestik-pada-prize', '1446 1442 food carrot', '1446 1441 domestics wash-face', '1446 1441 domestics laundry', '1446 1449 food ice-cream 8.7c', '1446 1313 get cooking_code_poke-logparse.py', '1516 1319 food ramen-noodles 1.2ph', '1520 1325 clean dishes', and '1529 1546 write lifelog-talk-notes, read lifelog'. The terminal window also shows the date '2010-01-21' and '2010-01-26'.

data capture/broadcast for a better life



Magic Bus

Status Updates

- >>>MAGIC BUS UPDATE: MagicBus is processing changes and updates to system data. These updates will greatly increase the stability and reliability of your experience with MagicBus. DURING THE UPDATE, TRACKING OF MOST ROUTES WILL NOT BE AVAILABLE! PTS regrets the occurrence of any outages and places a high priority on minimizing service downtimes.<<<
- SYSTEM STATUS: All services operating on regular schedule and route.

Select a Route:

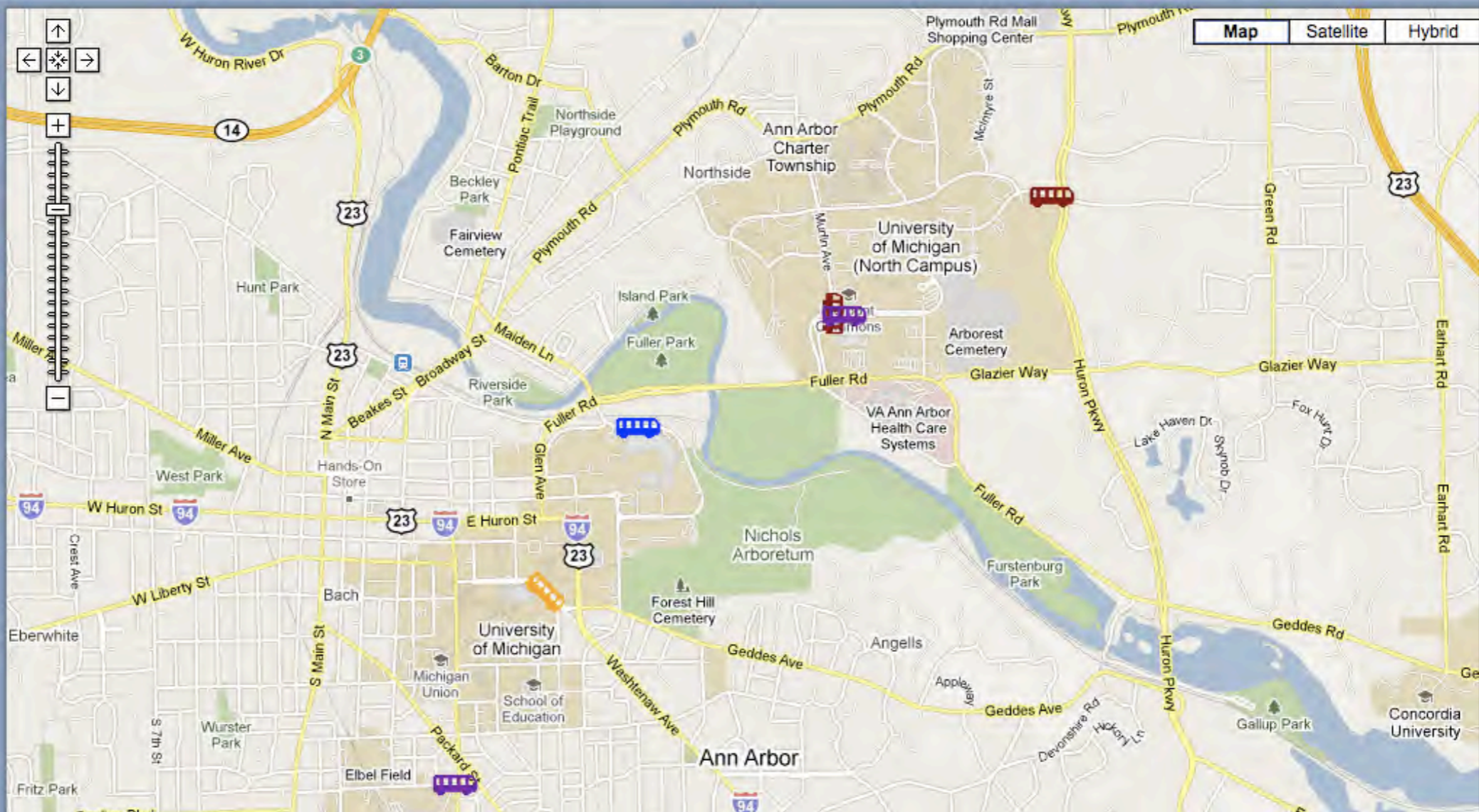
Select a Stop:

Reset Map

Line View

Resources

About Us



some broad themes

- data exist from many sources
 - government agencies, research societies
 - large project collaborations (= “big science”)
 - small research groups (= “individual investigators”)
 - amateur scientists
 - general public
- scientists conducting a study typically
 - identify appropriate data sources
 - collect and validate data sets
 - process and generate new data
- current data suffer from
 - lack of data definition conventions within research communities
 - weak incentives: **“knowledge”** > **“data”**
 - ‘raw’ data is often unpublished (invisible to WWW)
 - what’s worth keeping?

flavors of data-intensive science

- *ab initio* simulations
 - solve governing equations of a dynamical system
- model testing
 - compare theoretical/computational model expectations to observations/experiment
 - perform statistical (likelihood) analysis to confirm/refute model or constrain model parameter values
- empirical studies of natural or social phenomena (*data mining*)
 - correlations among internal properties of a population or system
 - influence of external factors
 - spatial or temporal dependencies
- signal processing
 - separate data into a useful portion – the *signal* – and unwanted noise
 - estimate errors on measured signals

Mature scientific areas involve all of these!

Cosma NSF proposal: a cyberscience *instantiation*

- **Dark Energy Survey = `medium-sized' (~40M\$) astronomical survey of galaxies**
 - follows Sloan Digital Sky Survey (SDSS), ~2000
 - precursor to Large Synoptic Survey Telescope (LSST), ~2020
 - makes happy both Astrophysicists and Cosmologists!
(A: How did galaxies form? C: How is space expanding?)
 - first survey to use four dark energy methodologies on same data set (CL, WL, BAO, SN)
- **collaboration of ~300 observers, theorists, computational scientists**
 - sparse funding model: camera and database fully funded, nothing (yet) for analysis
 - proposal seeks to fund small team focused on ***simulating model expectations***
- **preparing for survey data analysis requires planning and preparation**
 - simulations of cosmic structure formation `dressed' with galaxies => `truth' sky catalog
 - pretend to observe `truth' by adding real-world effects => `observed' sky catalog
 - distortions in galaxy images from intervening matter (gravitational lensing)
 - distortions from telescope optics and camera electronics
 - process `observed' catalog in same manner as real data
 - compare to `truth' to estimate fidelity of survey processing
- **iterative process**
 - science teams employ catalogs with different levels of detail
 - multiple simulations to provide modest coverage of model space

Additional Source Information

for more information see: <http://open.umich.edu/wiki/CitationPolicy>

Slide 3: Scott Beale, "Columbia Supercomputer," <http://www.flickr.com/photos/27403767@N00/465519540/>, CC: BY-NC-ND 2.0, <http://creativecommons.org/licenses/by-nc-nd/2.0/deed.en>

Slide 5, Image (top): tsevis, "Barack Obama: A mosaic of people," Flickr, <http://www.flickr.com/photos/tsevis/2279253649>, CC: BY-NC-SA 2.0, <http://creativecommons.org/licenses/by-nc-sa/2.0/deed.en>

Slide 5, Quote (bottom): Dan Fay, *4th Paradigm*, p. 3

Slide 6, Image (top): Lawrence Berkeley National Laboratory, "Energy Secretary Chu Visits Berkeley Lab," Flickr, <http://www.flickr.com/photos/29648341@N08/4050433770/>, CC: BY-NC-ND 2.0, <http://creativecommons.org/licenses/by-nc-nd/2.0/deed.en>

Slide 6, Quote (bottom): R. DeVecchio, "UC Berkeley: Panel looks at control of emissions" *San Francisco Chronicle*, 27 March 2007

Slide 7: Please see original image of New York Times article at <http://www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html>

Slide 8: Please see original image of screenshot and quote from regarding quantification at <http://www.kk.org/quantifiedself/2010/02/a-remarkable-life-logging-proj.php>

Slide 9: Please see original image of real-time University of Michigan bus tracking program at <http://mbus.pts.umich.edu/>.

Slide 10: woodleywonderworks, "The Night Lights of the United States (as seen from space)," Flickr, <http://www.flickr.com/photos/wwwworks/2712986388/>, CC: BY 2.0, <http://creativecommons.org/licenses/by/2.0/deed.en>