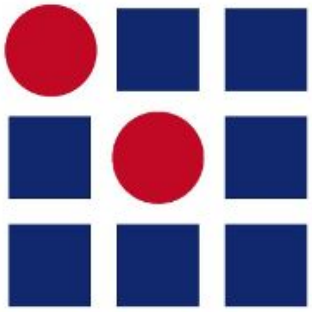

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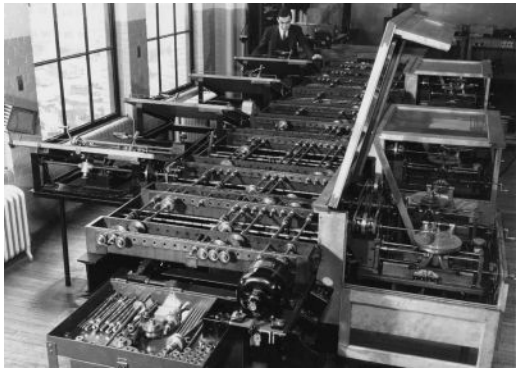
BITS AND ATOMS
Massachusetts Institute of Technology

Prof. Neil Gershenfeld
Director

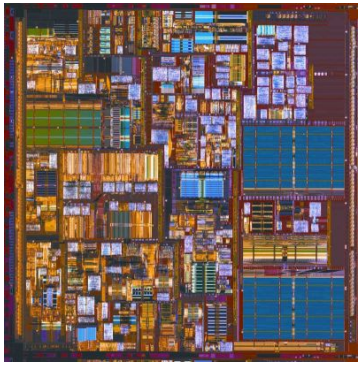
http://cba.mit.edu/~neilg

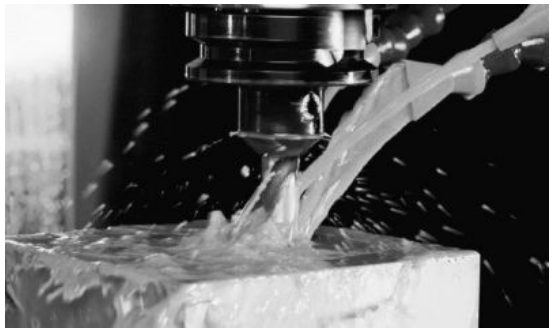
Digital Revolutions

analog → digital communication
~1945

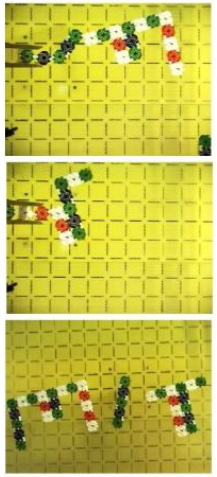


analog → digital computation
~1955

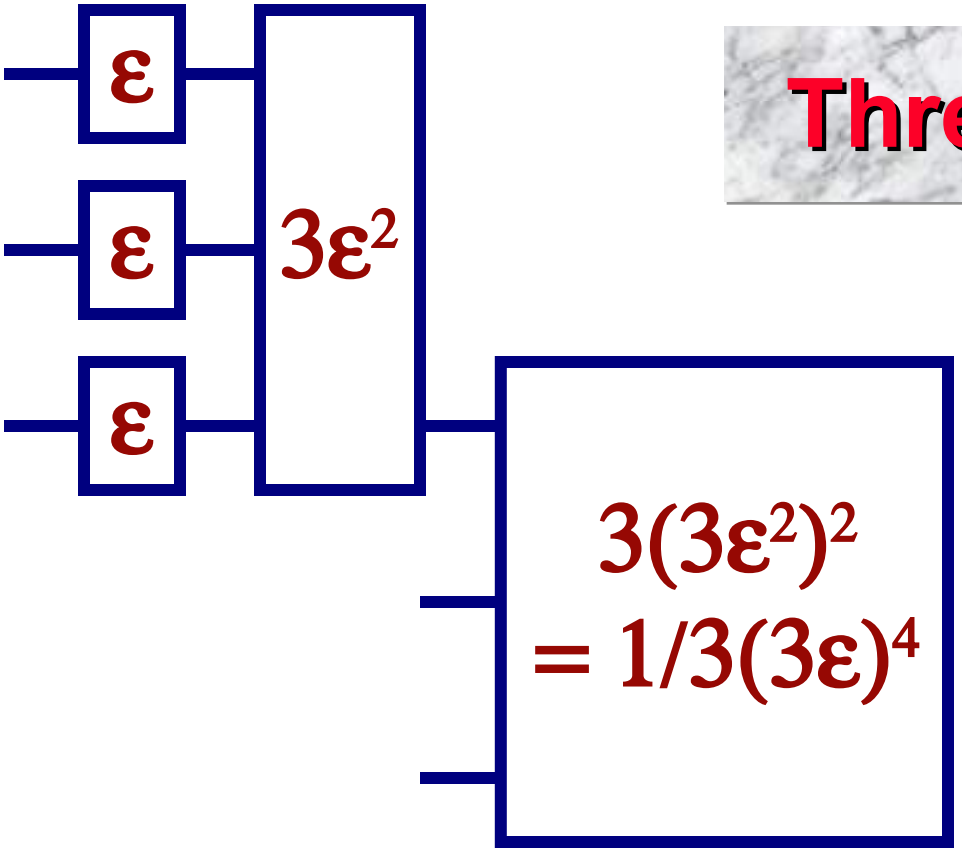




analog → digital fabrication
~2005

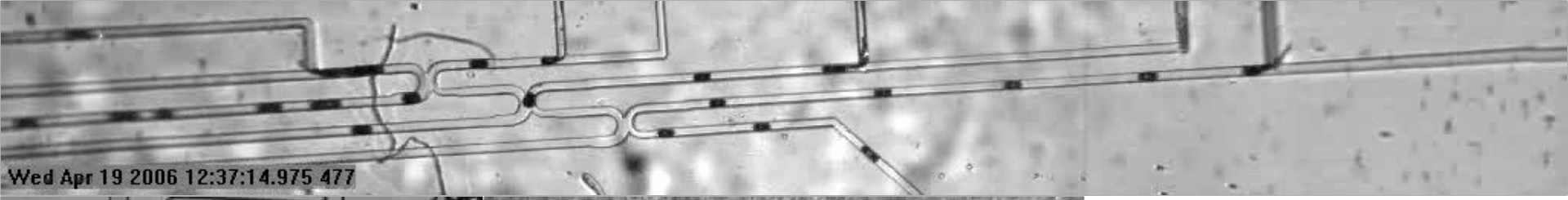


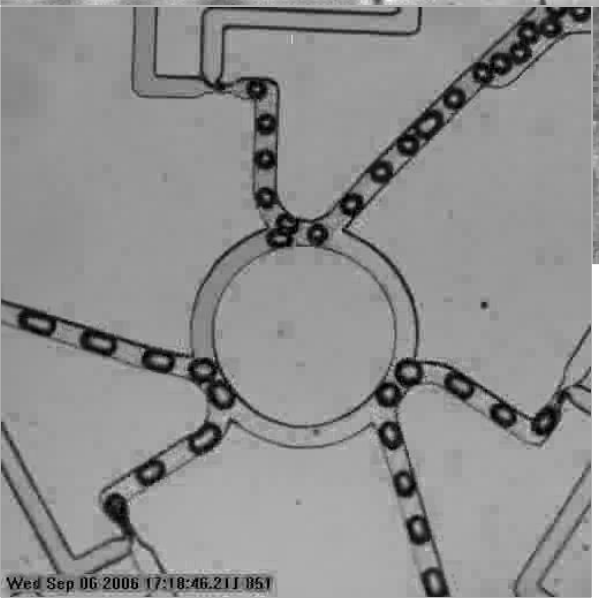
Threshold Theorems

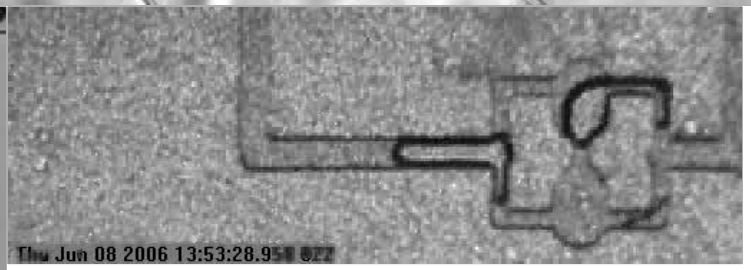


3^n

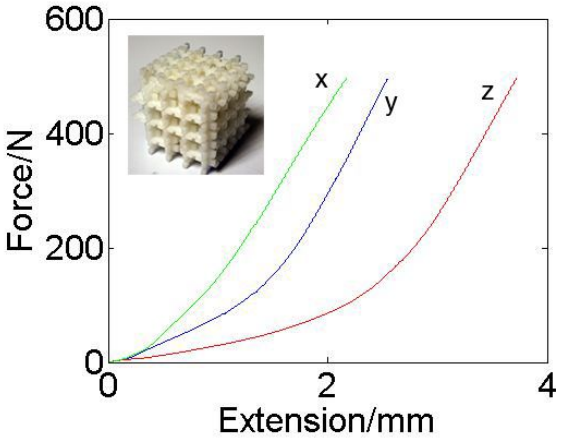
$1/3(3\varepsilon)^{2n}$

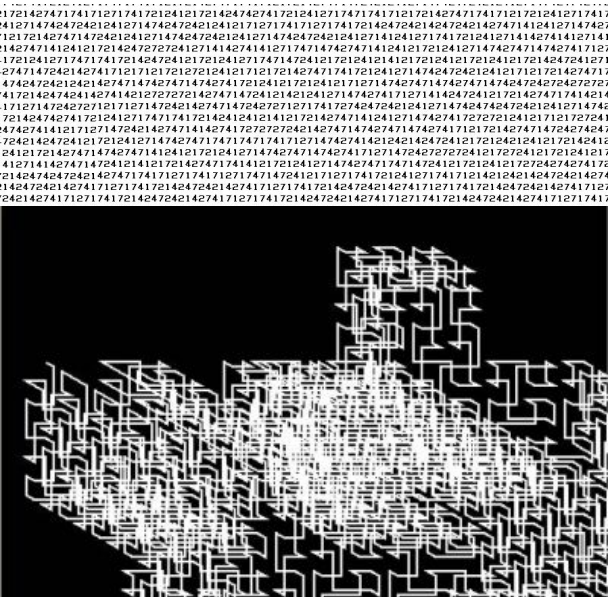


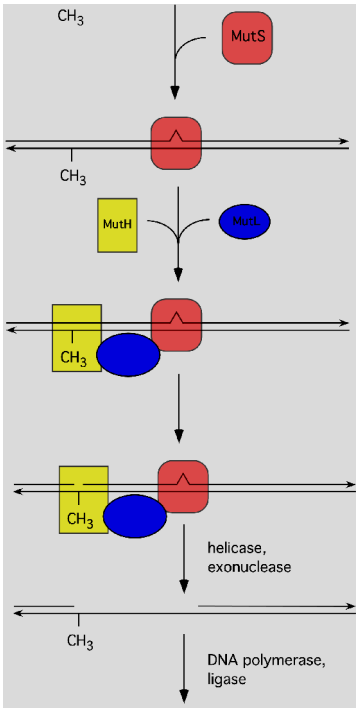




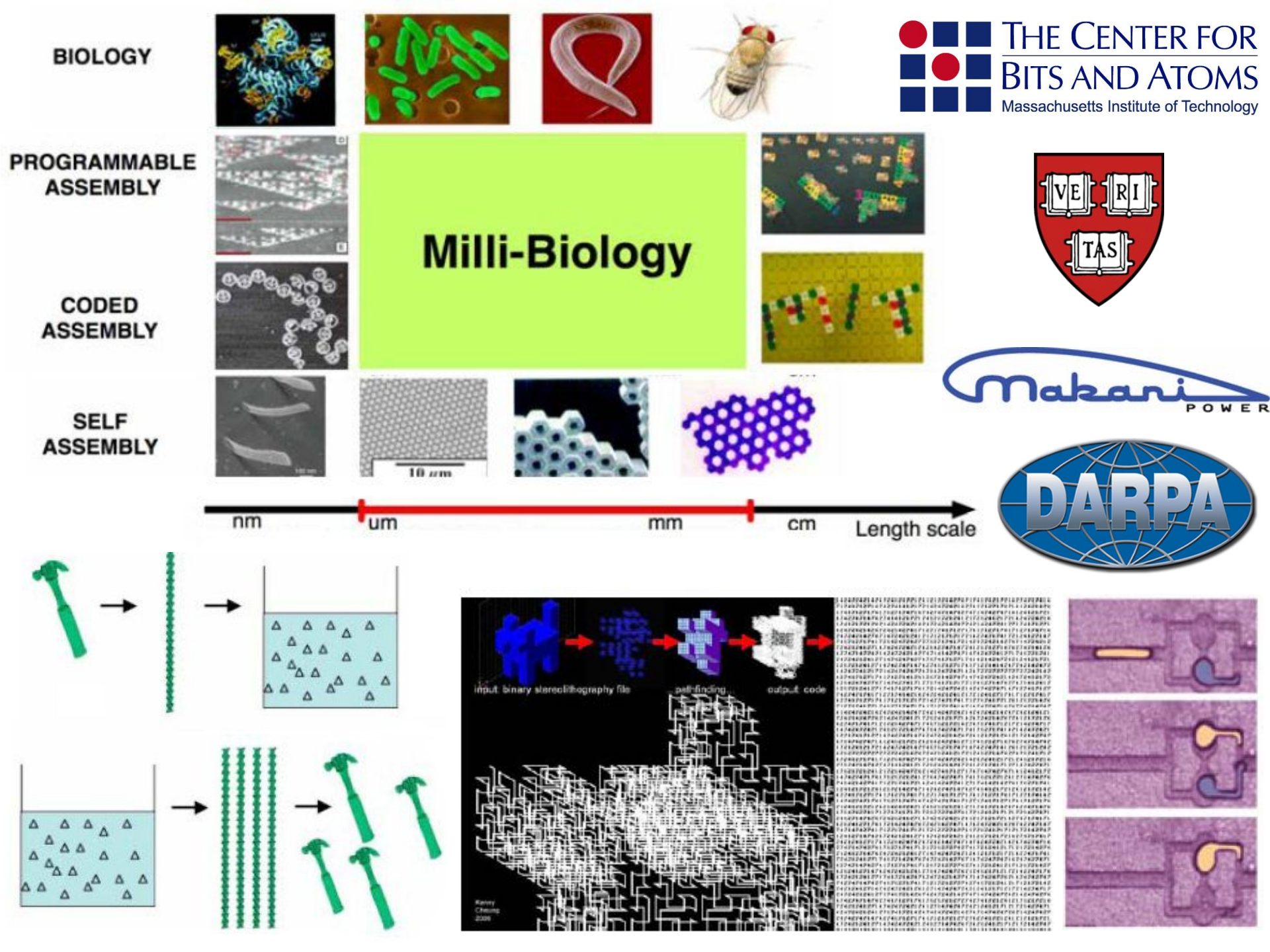
Microfluidic Bubble Logic
Manu Prakash and Neil Gershenfeld
Science 9 February 2007
Vol. 315. no. 5813, pp. 832 - 835







Robotics: Self-Replication from Random Parts
Saul Griffith, Dan Goldwater, Joseph Jacobson
Nature 437, 636 (29 September 2005)


BIOLOGY
PROGRAMMABLE ASSEMBLY
CODED ASSEMBLY
SELF ASSEMBLY
Milli-Biology
10 um
nm
um
mm
cm
Length scale
THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology
VE RI TAS
Makani POWER
DARPA
input: binary stereolithography file
path-finding
output: code

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Massachusetts Institute of Technology

in

out

m

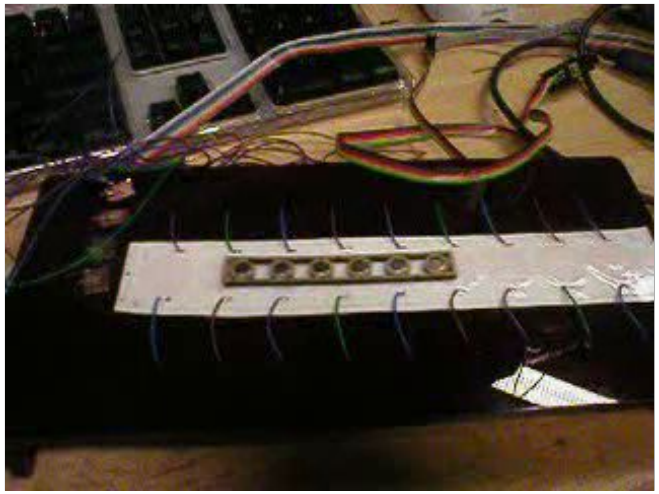
mm

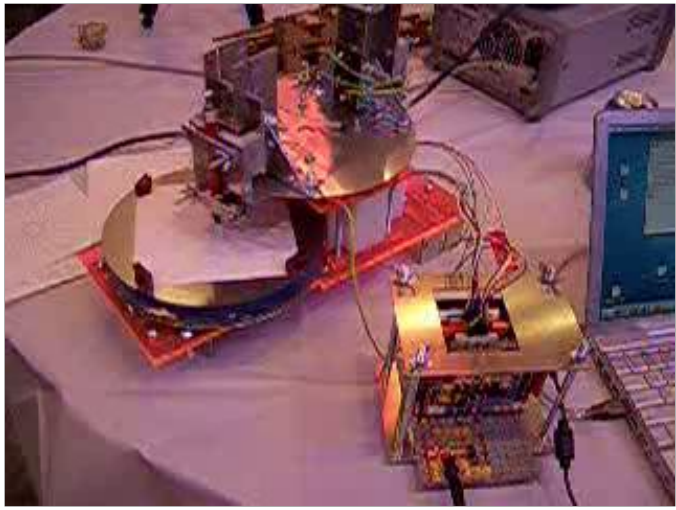
µm

nm

How To Make (almost) Anything

Date	Subject
9/10	Design Tools, Input Devices
9/24	Machining
10/1	3D Printing, NC machining
10/15	Laser, Water Jet, NC Knife Cutting
10/22	Materials and Finishes
10/29	Forming and Molding
11/5	Basic Electronics
11/12	ECAD
11/19	Sensor Technology
11/26	Programmable Logic
12/3	Microcontrollers
12/10	Wired & Wireless Communications





The Liberal Arts

The Trivium

- Grammar
- Rhetoric
- Logic

The Quadrivium

- Arithmetic
- Geometry
- Music
- Astronomy

The Illiberal Arts

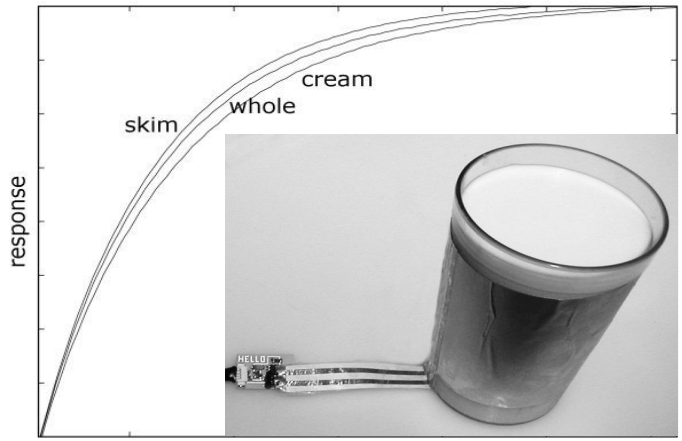

CNN
HIGHLIGHT

THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology

Ghana, South Africa, India, Costa Rica, Boston, Norway, …

Fab Labs

fabrication and instrumentation divide



invention

↑

job creation

↑

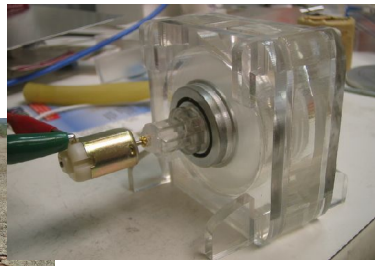
problem solving

↑

education

↑

empowerment



The Third International
Fab Lab Forum
and
Symposium on Digital Fabrication

Pretoria, South Africa
June 29, 2006

THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology

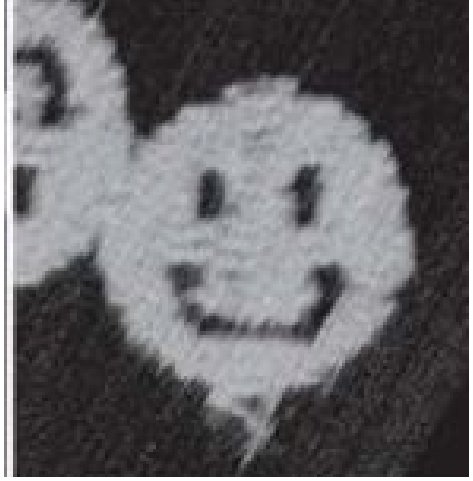
science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

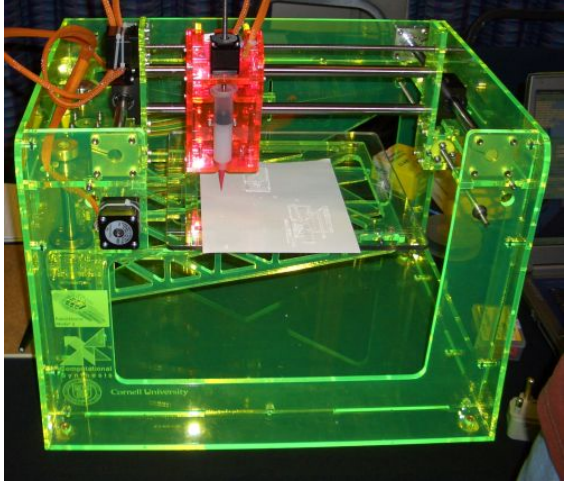
amts
advanced manufacturing technology strategy

CSIR
our future through science

9:00-9:30 **Introduction**
Neil Gershenfeld
CSIR, AMTS, DST

9:30-10:45 **Foundations**
Charles Bennett: *molecular machines*
Joe Jacobson: *fabricational complexity*
Saul Griffith: *programmed assembly*
Paul Rothemund: *DNA origami*
Erik Winfree: *algorithmic self-assembly*
Hod Lipson: *machines that make machines*





9:00-9:15: *Welcome and Introduction*

Don Levy (University of Chicago)
Neil Gershenfeld (MIT)

9:15-10:30: *Form and Function*

George Church (Harvard)
Fabricating with DNA
Pete Carr (MIT)
Error-Corrected DNA Synthesis
Milan Stojanovic (Columbia)
DNA Computing and Robotics
Millie Firestone (Argonne National Laboratory)
Design and Fabrication of Nanomaterials
Manu Prakash (MIT)
Microfluidic Bubble Logic

10:30-11:00: *Break*

11:00-12:30: *Form and Function*

George Popescu (MIT)
Digital Materials and Printers
Evan Malone, Jonathan Hiller (Cornell)
Printing Electromechanical Machines
Larry Sass (MIT)
Large-Scale Rapid Prototyping
Berok Khoshnevis (USC)
Solid Free Form Fabrication
Luis Lafuente Molinero (MIT)
Fabricational Capacity

12:30-2:00: *Lunch*

Gordon Center Atrium

FAB 4:
The Fourth International Fab Lab Forum and Symposium on Digital Fabrication

August 22-23 2007

2:00-3:30: *Applications and Implications*

Smári McCarthy (Vestmannaeyjar, Iceland)
Digital Design Tools
Peter Bosscha (Council for Scientific and Industrial Research, South Africa)
Thinner Clients
George Sergiadis (Aristotle University of Thessaloniki, Greece)
Field Fabrication of Advanced Antennas
Dhananjay Gadre (Netaji Subhas Institute of Technology, India)
Lighting and Instrumentation
Saul Griffith (Makani Power)
Making Trouble

3:30-4:00: *Break*

4:00-5:30: *Applications and Implications*

Anil Gupta (Indian Institute of Management Ahmedabad, India)
Grass-Roots Invention
Ian Foster (Argonne National Laboratory)
Technology for Distributed Collaboration
Joel Cutcher-Gershenfeld (University of Illinois at Urbana-Champaign)
Lateral Alignment of Stakeholders in Innovation Networks
Leo Kadanoff (University of Chicago, American Physical Society)
Formal and Informal Science

5:30-7:00: *Reception*

Gordon Center Atrium

7:00 - *I-House*

Coulter Lounge
Mobile Fab Lab

The Fab Foundation

invention as aid

The Fab Fund

VC + microfinance = micro-VC

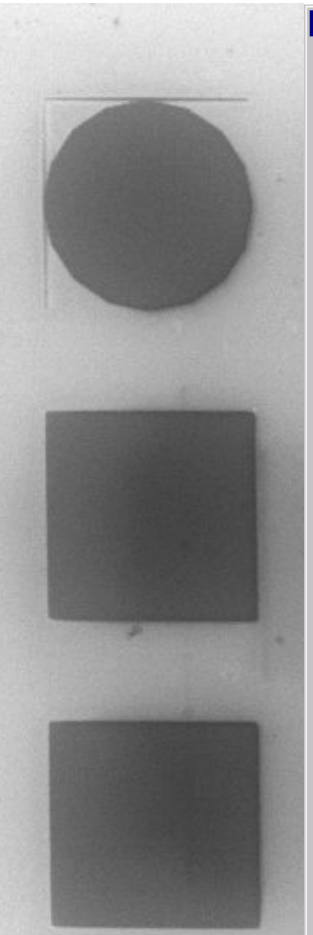
The Fab Academy

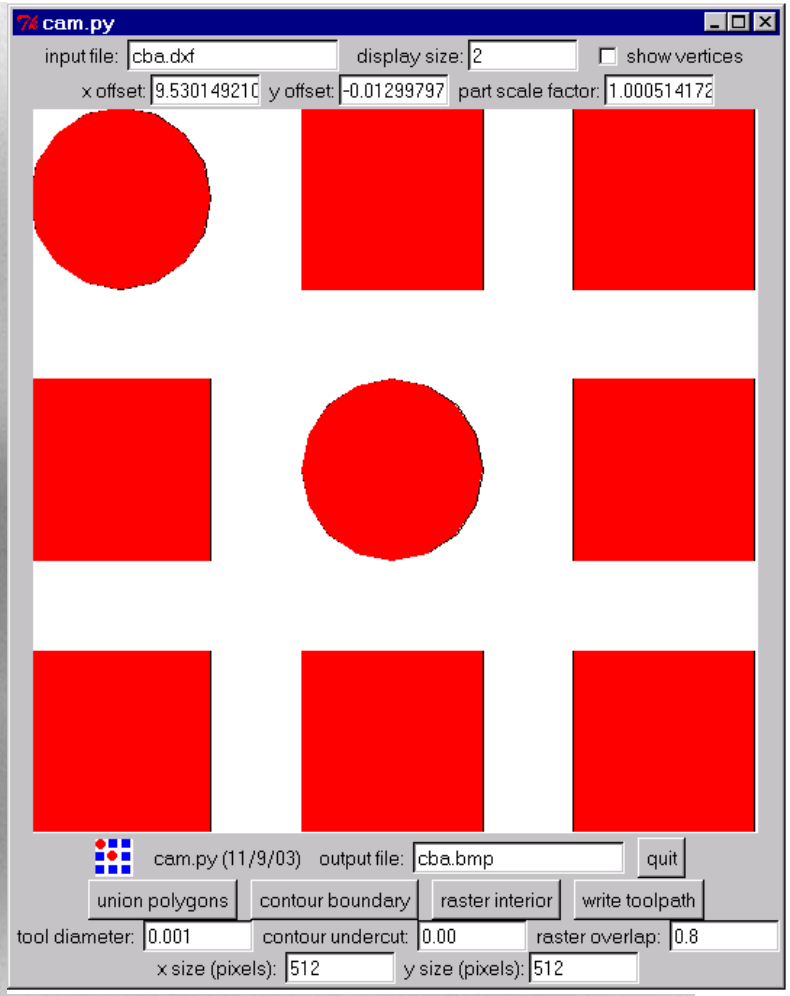
distributed technical education

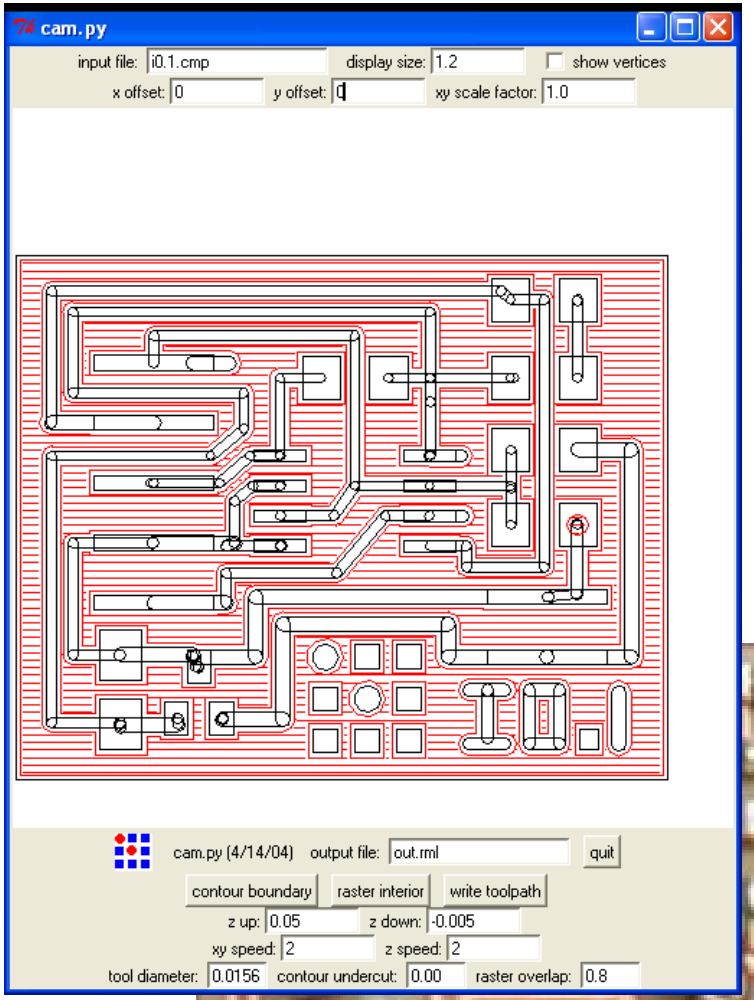
research partnerships

enabling processes and projects

cam.py



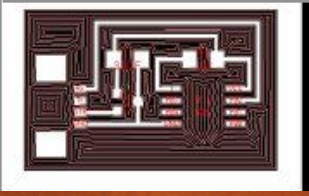


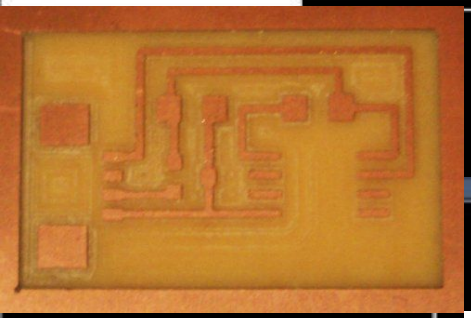


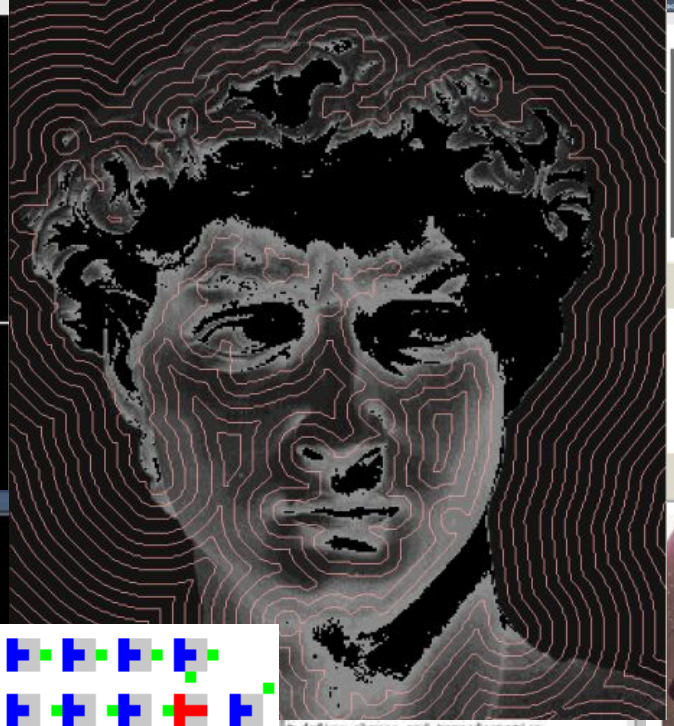
input: **SVG, DXF (2D,3D), Gerber PCB, Excellon drill, JPG, TIFF, STL**

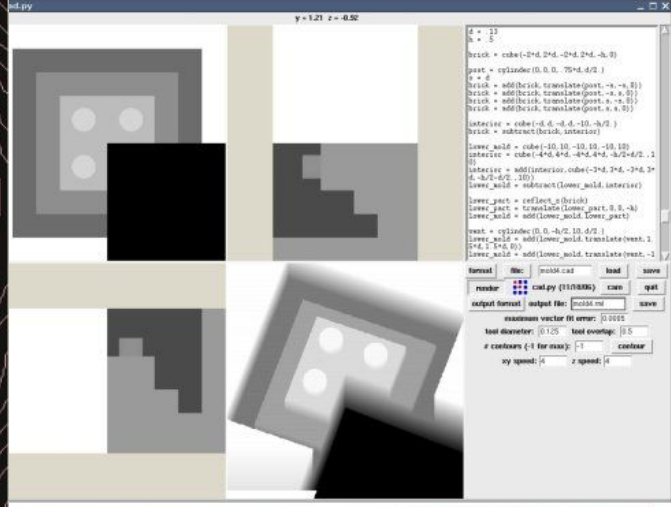
output: **G code, Roland mill & cutter, Omax waterjet, Epilog & Universal lasercutter, FEI focused ion beam, Haas machining center, Resonetics excimer micromachining**

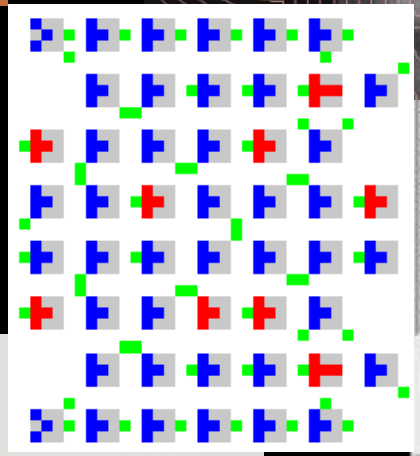
cad.py











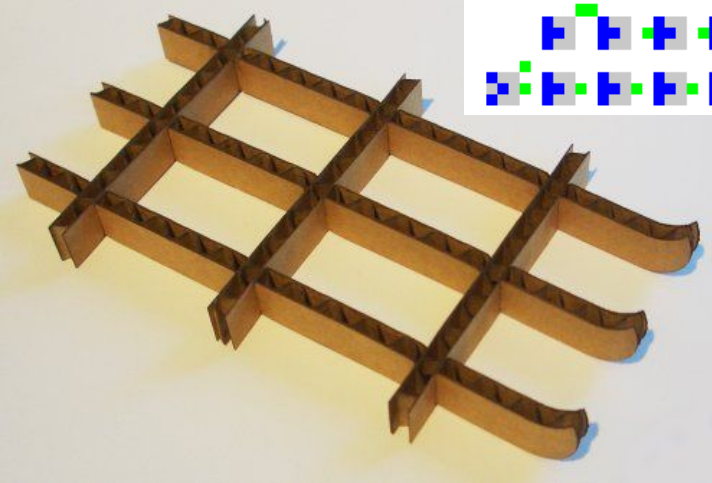
```
# define shapes and transformation
#
# circle(x0, y0, r)
# cylinder(x0, y0, z0, z1, r)
# sphere(x0, y0, z0, r)
# torus(x0, y0, z0, r0, r1)
# rectangle(x0, x1, y0, y1)
# cube(x0, x1, y0, y1, z0, z1)
# add(part1, part2)
# intersect(part1, part2)
# subtract(part1, part2)
# move(part, dx, dy)
# rotate(part, theta)
# rotate_x(part, theta)
# rotate_y(part, theta)
# rotate_z(part, theta)
```

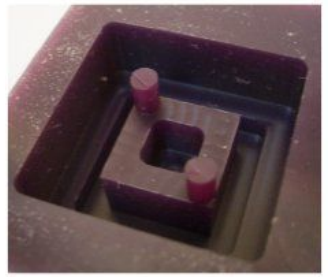
.cad file: sledcad load save

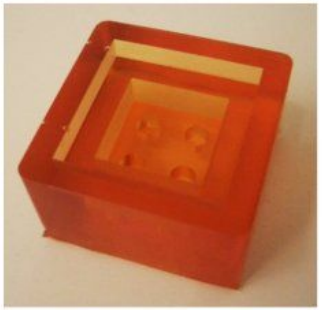
render cad.py (10/18/06) cam quit

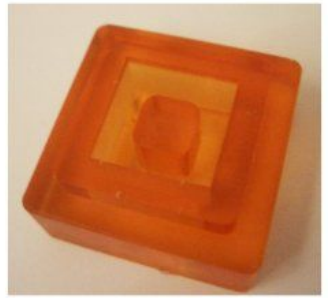
.sat file: sledcad save

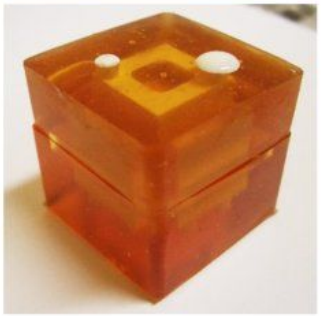
SAT function:

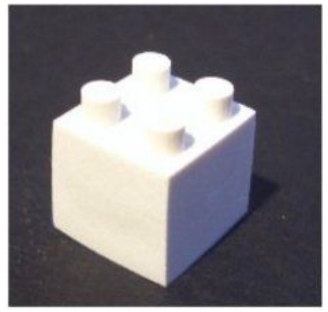












kokompe

content management

SVG+Javascript, Java, ... interfaces

math string

machine control

XMLHttp

server

global merging

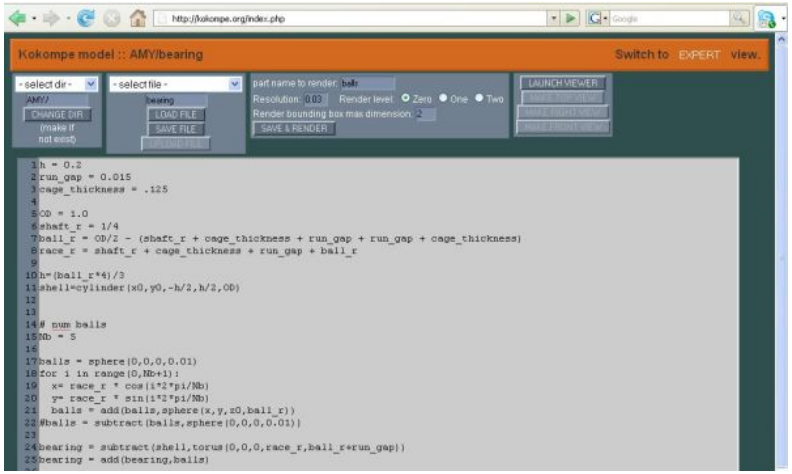
version control

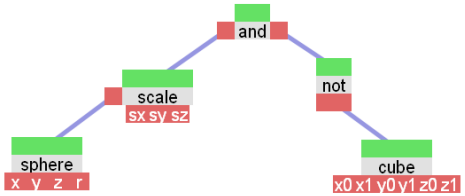
octree evaluation

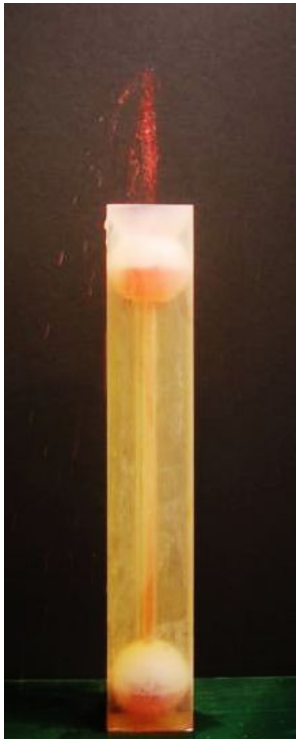
CA toolpath generation

real-time virtual machine execution

Internet 0 machine control network







BLD Controller

input rml file: C:/neilg/www/fab/class/mold.

XY Velocity (steps/s): 4 Z Velocity (vzunits/s): 4

XY units (steps/inch): 32 Z units (zunits/inch): 32

Only one step at once

Prev Reading rml command 20 Next

rml command: PU2333,1666

bld command: PU20,20;

IO command: [34048, 65044, 64532]

+Y PU -X +X -Y PD

Number of steps(zunits):

-X -Y Up

+X +Y Down

Start move

Send to file: Send to builder

bldControl.py (5/21/07) quit

GIK Controller

inches/GIKu: steps/turn:

clicks/inch (X): XZ velocity (x100rpm):

clicks/inch (Z): 1/4 velocity (x100rpm):

Only one unit at once

GIKControl.py (05/21/07)

1/4 turn Motor

+90 degrees -90 degrees

Info:

XZ Motors

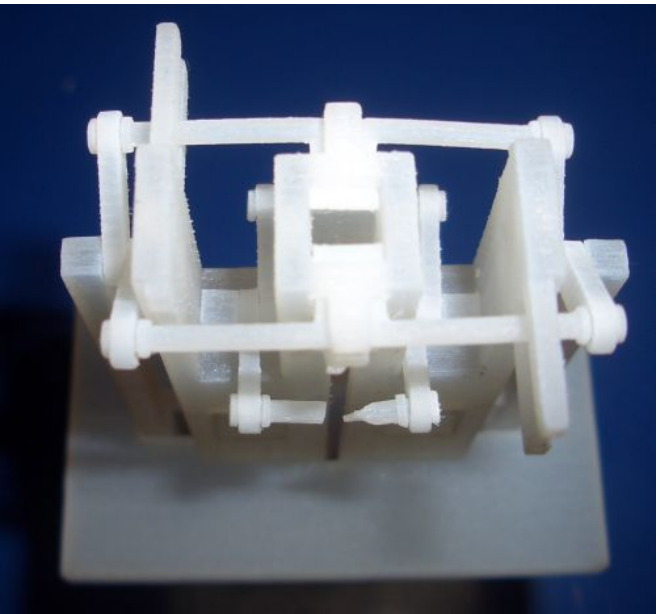
-X direction Move in X or Z (GIKu):

+X direction

Up

Down Move!

quit



thtp.py

incoming packet:

source address: 10 . 5 . 0 . 249

destination address: 192 . 0 . 0 . 1

source port: 1234 destination port: 6453

data: GET /192.0.0.1:64532 HTTP/1.1 Us

Web server port: 1234

outgoing packet:

source address: 10 . 0 . 0 . 1

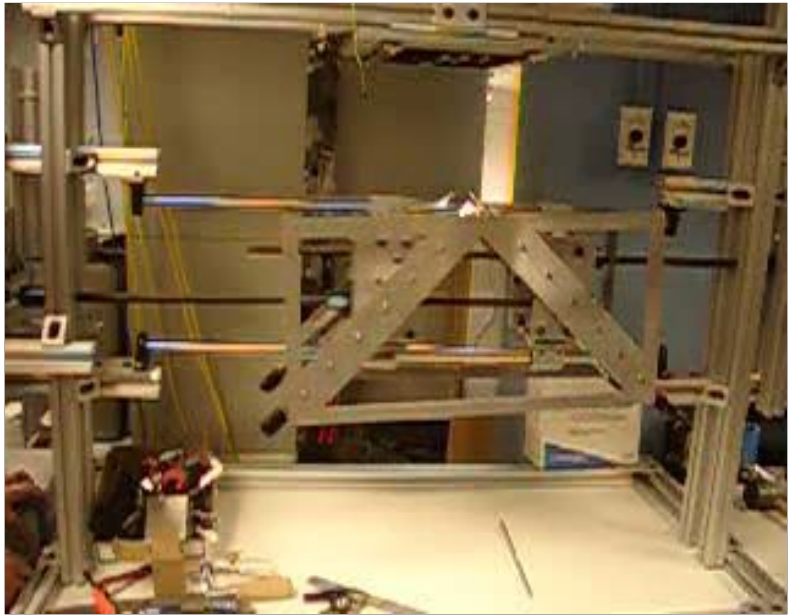
destination address: 192 . 0 . 0 . 1

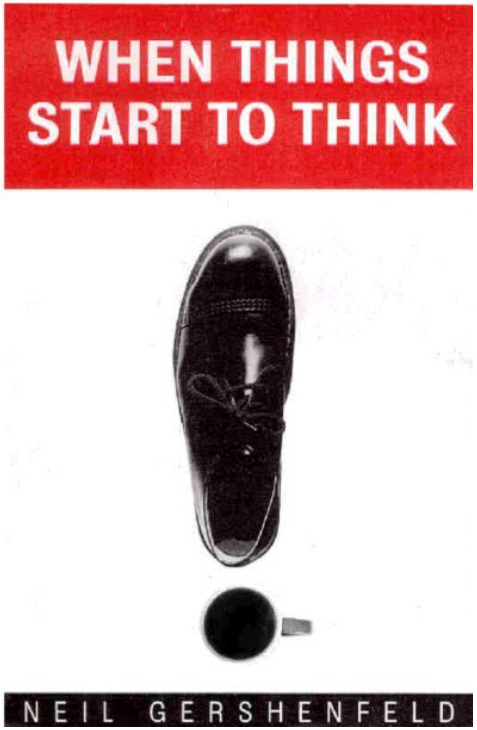
source port: 0 destination port: 6453

data:

send outgoing packet

quit

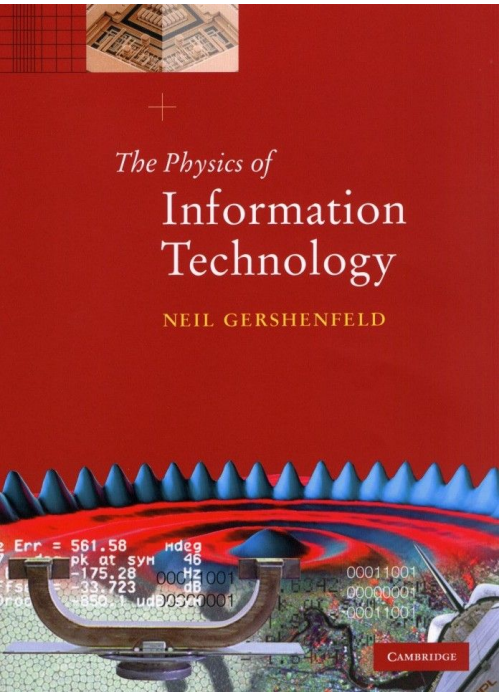


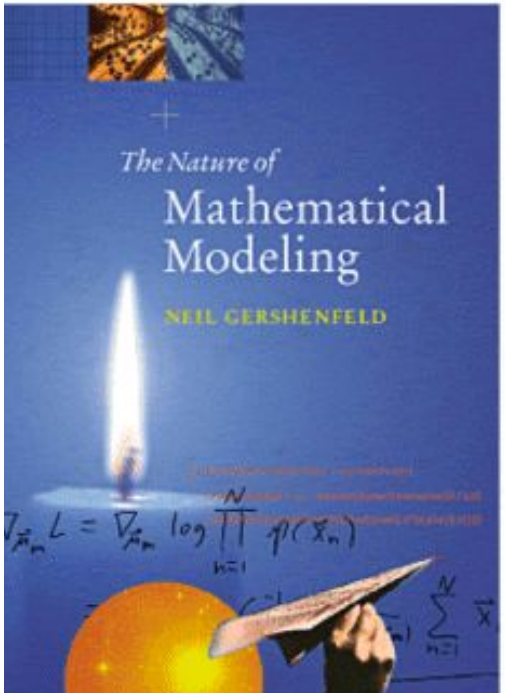


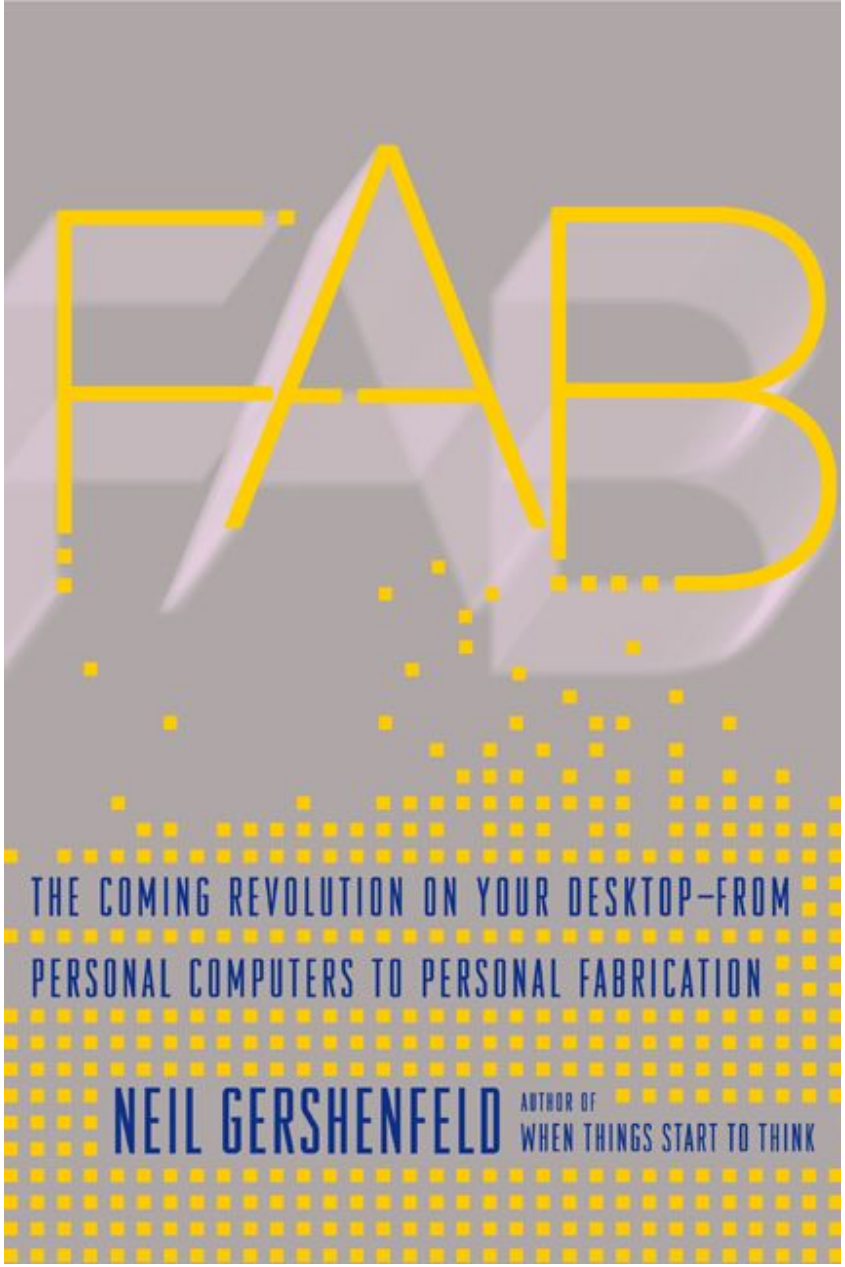
Henry Holt and Company
(Amazon top 10)

Basic Books
(BusinessWeek best of 2005)

Cambridge University Press







http://cba.mit.edu/~neilg