The Computer Revolution Hasn't Happened Yet!

Alan Kay

sd&m Conference 2001
Bonn, Germany 28th June
Most People Just "Think Normally"

I don't know who invented water, but it wasn't a fish!
— Marshall McLuhan
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It takes almost as much creative effort to understand a really new idea as it does to originally create it.
Molecular Biology of the Gene

James D. Watson
Molecular Biology of the Gene

E. coli
DNA = 5,000,000 base pairs = 1 MB
5 million proteins of 3000 types
Medium sized proteins rotate about 1,000,000 RPS
Enzymes catalyse 1000 to 1,000,000 reactions/sec
APT can migrate by diffusion from one end to the other in about .02 seconds
Lipids in the cell membrane exchange places with neighbors 10,000,000/sec
Flagella rotate at 6000 RPM
E. coli reproduces every 20 minutes

James D. Watson
Molecular Biology of the Gene

**E. coli**

- DNA = 5,000,000 base pairs = ~1MB
- 5 million proteins of 3000 types
- Medium-sized proteins rotate about 1,000,000 RPS
- Enzymes catalyse 1,000 to 1,000,000 reactions/sec
- APT can migrate by diffusion from one end to the other in about 0.02 seconds
- Lipids in the cell membrane exchange places with neighbors 10,000,000/sec
- Flagella rotate at 6000 RPM
- *E. coli* reproduces every 20 minutes

**James D. Watson**
MOLECULAR BIOLOGY OF THE GENE

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JAMES D. WATSON
Complexity - ca. 1966

Mainframes are ugly, huge, expensive, and "logically small"

while | x_n - x_{n-1} | > ε do x_{n+1} := 1/2 * (x_n + A/x_n)

Programming is like making simple, centrally controlled machinery

But ...
Complexity - ca. 1966

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while $|x_n - x_{n-1}| > e$ do $x_{n+1} := \frac{1}{2} \cdot (x_n + A/x_n)$

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But ...

1962 - Ivan Sutherland's Sketchpad
Sketchpad UI

**Figure 1.5. Illustrative Example**

A. Six Sided Figure  
B. To Be Inscribed In Circle

C. By Moving Each Corner  
D. On To Circle

E. Make Sides Equal  
F. Erase Circle

G. Call 7 Hexagons  
H. Join Corners

**Figure 6.1. Applying Two Constraints Indirectly To Two Lines**

- A. Operation Definition
- B. Picture To Constrain
- C. Definition Copied
- D. First Line Merged
- E. Second Line Merged
- F. Constraints Satisfied

**Parallelism**  
**Equal Length**
Sketchpad "Objects"

**Figure 3.7.** Instances Generic Block

**Figure 3.8.** Generic Structure
Complexity - ca. 1966

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But ...

1962 - Ivan Sutherland's Sketchpad

1965 - Doug Engelbart's NLS
Complexity - ca. 1966

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1962 - Wes Clark's LINC
Complexity - ca. 1966

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1962 - Ivan Sutherland's Sketchpad
1965 - Doug Engelbart's NLS
1965 - Gordon Moore's Law
1962 - Wes Clark's LINC

Silicon is going to scale like crazy
Mainframes are ugly, huge, expensive, and "logically small"

Programming is like making simple, centrally controlled machinery

But ...

1962 - Ivan Sutherland's Sketchpad

1965 - Doug Engelbart's NLS

1965 - Gordon Moore's Law

1962 - Wes Clark's LINC

There's going to be a world wide "information utility" that can't be centrally controlled.

Silicon is going to scale like crazy
A Happy Thought — 1966

A Better Old Thing?

SIMULA

ALGOL

Programming Languages

SIMULA—an ALGOL-Based Simulation Language

Ole-Johan Dahl and Kristen Nygaard
Norwegian Computing Center, Oslo, Norway

This doesn't work — Make it work...
A Happy Thought — 1966

A Better Old Thing?

SIMULA

ALGOL

Programming Languages

SIMULA—an ALGOL-Based Simulation Language

This doesn't work — Make it work...

Molecular Biology of the Gene

From Gears to Biology

Cells
A Happy Thought — 1966

Why not just computers all the way down!? 

KERPOW! Almost A New Thing? 

A Better Old Thing? 

SIMULA 

ALGOL 

Programming Languages 

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Molecular Biology of the Gene 

From Gears to Biology 

Cells 

From Data-PROCedure to Obejcts 

This doesn't work. Make it work.
RAND Tablet — 1964
JOSS (Johnniac Open Shop System) 1962-70
The Flex Machine — 1967

Object Insights + Algol

Simula 1965

Sketchpad + Simula Insights + Euler

Flex 1967

Memcor-Montek MM-8000 (The Flex Machine)
A "Flexible Personal Computer" 1967-9

FLEX Machine
Alan Kay & Ed Cheadle

Object Oriented OS, Development, Interface and End-User Simulation System

Virtual Screen CRT Tablet

Clipping Windows

Multiple Windows

Graphical Iconic Interface
Simulate "Everything"
Every object is a complete little SW computer
Every part of an object is an object

Confine the messy workings
Communicate safely by sending messages

The "DNA" can be shared
Control can be distributed

DNA needs a cell to make a cell
From "building" to "growing"

Object and file structures
RESISTOR
EP1
BODY
EP2

Graphics instances

Computer Graphics

Multiple windows for multiple views

EXTENSIBLE END USER PROGRAMMING

Objects Instead Of An OS?
The Summer of 1968

Flat Panel Plasma Display

GRAIL System at RAND
A Blue Idea

"Should the computer program the kid, or should the kid program the computer?"

ZEN and the art of computing

The music is not in the piano!
A Happy Thought – 1968

The Dynabook: An Instrument Whose Music is Ideas

Learning math and science by making your own collaborative Spacewar game

The Dynabook at the tidepools

The Computer As Metamedia

We have intimate relationships with our media
There's a Big Gap between a Technology and its Powerful Media
There's a Big Gap between a Technology and its Powerful Media
There's a Big Gap between a Technology and its Powerful Media

1400

1500

1600

1700

1800

The Real Printing Revolution!

Dialogue on Two New Sciences

The Principles

Constitutional Government

1800

1900

2000

2100

2200

The Origin of Species

The Meaning of Relativity

Molecular Biology of the Gene
There's a Big Gap between a Technology and its Powerful Media

The Real Printing Revolution!

1400 1500 1600 1700 1800

1800 1900 2000 2100 2200

The Origin of Species
Darwin

The Meaning of Relativity

Multiple Bigs of the Gene
James D. Watson

Dialogue on Two New Sciences
Galileo

The Principia
Newton

Constitution

The Federalist Papers
There's a Big Gap between a Technology and its Powerful Media

1400 - 1500 - 1600 - 1700 - 1800

The Real Printing Revolution!

1800 - 1900 - 2000 - 2100 - 2200+
There's a Big Gap between a Technology and its Powerful Media

The Real Printing Revolution!

The Real Computer Revolution?
Just As Things Get Interesting ...

When you learn this

Can you easily go back and change this?

The answer is "Yes", if you late bind ...

Easy reformulation is the key (until SE)
Personal Computing at PARC — 1970-80

KiddiKomp — 1970

miniCOM — 1971

"Iconic Programming" — ca. 1971
The "Old Character Generator" — 1971-2

The AGONY
and The ECSTASY
A NOVEL OF MICHELANGELO

by Irving Stone

THE STUDIO

He sat before the mirror of the second-floor bedroom sketching his lean cheeks with their high bone ridges, the flat broad forehead, and ears too far back on the head, the dark hair curling forward in thatches, the amber colored eyes wide-set but heavy-lidded.

"I'm not well designed," thought the thirteen-year-old with serious concentration. "My head is out of rule, with the forehead weighing my mouth and chin. Someone should have used a plumb line."

He shifted his very body lightly so as not to wake:

A B C
Smalltalk In The Schools
Objects and GUI

**Objects**
- Only Objects
- Objects send and receive Messages
- Objects Remember
- Objects belong to a Kind
- Kind objects contain Similarities

**GUI**
- Anything on display is an object
- a mouse click sends a message
- a menu contains the messages that can be sent
- an edit changes the object
- GUI messages are as few and similar as possible
Doing with Images makes Symbols

Sages

Piaget "Stages"

Sketchpad Icons

Doing Images Symbols

Bruner "Mentalities"

The "Lincoln Wand"
Doing with Images makes Symbols

Sages

Piaget "Stages"

Sketchpad Icons

Doing  Images  Symbols

Doing with Images makes Symbols

Bruner "Mentalities"

The "Lincoln Wand"
Modeless

WYSIWYG

If you can see it, you can change it

Overlapping Views

Iconic Referents

Projects

Select Object - Choose Command

Same names for similar behaviors

All levels of authoring always on
"Media" Interfacing — 75-....

"Everything" is media layout and compositing

Embedded objects have own iconic menu bars
WYSIWYG Object Retrieval

Template is filled in

Object is retrieved
Simulation UI Scripting

Hospital Simulation
by a 13 year old child

PC Board Line Simulation
by a Xerox Executive
Direct Manipulation Of Objects

Pygmalion Programming By Example

Thinglab Programming By Constraints
This is the Smalltalk text editor controlled by a handwriting character recognizer. To use it, press the middle button (yellow bug) on the mouse and draw the character to be recognized. Press blue bug (on the right) to recognize the character. A single dot will backspace. When a character is not recognized, you may train the recognizer to add the new character to its dictionary.

The "cut" sign is given to cut out the extra word from the text.

The user decides to experiment with different formatting alignments. A vertical line drawn through the center tells the system to center the text.
The Notetaker — 76-79

Early Notetaker Design

Doug Fairbairn & his Notetaker

Notetaker UI Design