Opening the Beige Box: Materiality and the Evolution of the IBM PC, 1981-1995

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Structure

- The PC Story (well known)
- The IBM PC/AT as a Standard
- Innovation Within Material Constraints
- Initial Conceptualizations
  - Very preliminary

THE WELL KNOWN PC STORY

1981: The IBM PC

- Massively successful
  - Displaces Apple II and CP/M in business world
- Major departure from std. IBM practices
  - Obscure team in Flordia
  - Rapid development
  - Standard, externally developed parts
    - Incl. non-exclusive OS license
- BIOS chip (ROM) is the only unique intellectual property

Platform Extension

PC/XT, 1983
(Hard Disk std.)

PC/AT, 1984
(80286, Powerful Expensive)

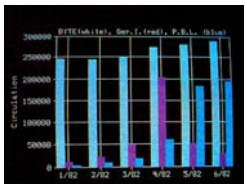
PC JR, 1984
(cut down)

Clones

- First clones appear in 1982
  - Cheaper
  - Address niches, esp. portable
- Specialized vendors supply
  - Reverse engineered BIOS chips
  - "Chipsets" integrating the capabilities of many standard chips in original IBM designs
- Other components can be ordered to same specifications as original IBM units
  - Sometimes from same suppliers
  - Economies of scale drive down costs rapidly

Two Popular Tests

Microsoft Flight Simulator



Lotus 1-2-3

Both optimized performance by working at a low level with undocumented hardware features. So only a "100% compatible" machine could run them.

The PS/2 Fiasco

- IBM announces entire new line of PCs
- Abandons existing standards for
  - Cases, power supplies
  - Slots (MCA bus)
  - Graphics (VGA)
  - Keyboard/Mouse connectors
- Protects design, demands license fees
- New complex, expensive, integrated physical construction
- The market mostly ignores
  - VGA, keyboard connectors are transplanted
  - Compaq launched 386 machine based on old standards

What is an "IBM PC?"

- Answer changes over time
  - Work by James Sumner, Shane Greenstein
- 1981: Actual IBM PC
  - Circa 1982: Microsoft and DEC, Apricot, etc. launch MS-DOS incompatible machines, fail
- 1984: One of IBM range or "100% compatible)
- 1992: "Industry Standard" machine
  - Evolved from IBM's obsolete models
  - Current IBM models were NOT "IBM PC Compatible"

THE IBM PC/AT AS A STANDARD

Inside the Box: IBM PC/AT

Back of the Box

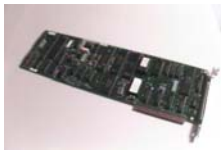
The PC/AT as Standard

- IBM's last successful attempt to advance the platform
  - 80286 processor
  - Extends some slots to 16 bit
  - Adds switches, lights to front of case
  - New keyboard – Caps Lock light, etc.
  - High Density (1.2MB) floppy disks
- Every component changed from PC
  - But backwardly compatible

Motherboard

Expansion Cards

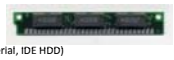
Typical Configuration:
- EGA Graphics card
- Hard Drive Controller card (shown)
- Parallel Port card
- Serial ports card



By 1990 also common:
- Extended Memory card
- Network Card
- Sound Card

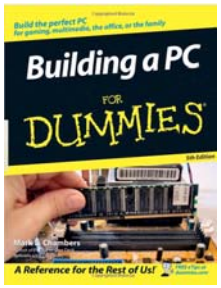
Components of a 1990 Clone

- All are probably from different firms.
- The Case
  - Power supply unit (screwed into case)
  - Motherboard (bundled with BIOS, chipset)
    - Processor
    - RAM chips
    - Expansion Cards
      - Multi/IO Card (parallel, 2xserial, IDE HDD)
      - Graphics Card
  - On little rails in drive bays
    - Hard Disk Drive
    - Floppy disk drive
- Monitor
- Keyboard
- MS-DOS 3.3



PC "Manufacturers"

- Only one piece of custom equipment:
  - A little badge for the front
- Barriers to entry
  - Screwdriver
  - Table or floor
  - Enough money to order parts
- Thousands of PC firms
  - Little individual leverage with suppliers
- Dell – founded 1984 in a dorm room
  - Did have a rich family…



User Innovations

- Users and PC "manufacturers" have similar positions
  - No absolute distinctions between build, tinker, upgrade
  - DIY can be cheaper
- Users choose among huge variety of expansion cards
  - A handful become part of the standard, e.g.
    - Hercules Graphics
    - Ad-lib and SoundBlaster audio capabilities
- Later (1990s) a culture of overclocking, cooling, and case modifications develops
  - Strong parallels with hi-fi and automobile cultures

PC vs. Stereo Stack

- Not as different as most people think
  - Pick compatible components (a dozen for PC, maybe 8 for stereo)
  - Connect them together
- But the packaging is different
  - One box versus many
  - Why? Could it be otherwise?

INNOVATION WITHIN MATERIAL CONSTRAINTS

The PC/AT, 1984-1996

- Typical RAM: 0.25 MB -> 32 MB
- High End Processor: 6 Mhz 286 -> 90 Mhz Pentium
- Hard Disk Drive: 30MB -> 2,000 MB
- OS: DOS 3.0 -> Windows 95 or NT
- New Standard Components:
  - Sound
  - CD-ROM
  - Mouse

Innovation within a node

- Happens all the time
  - Higher capacity memory chips
  - Faster processors
  - Bigger hard disk drives (20MB -> 30MB)
  - New revision of DOS (3.0 -> 3.1)
  - Cheaper and more reliable substitutes
- Fairly easy to accommodate
  - Existing interfaces between nodes are unchanged,
  - Or minor tweaks may be needed to other nodes

"Bilaterial" Innovation

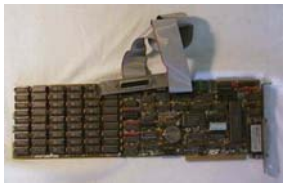
- Joint innovations between firms occupying related nodes
  - RAM & Motherboard vendors agree shift from chip packaging to SIMs
  - HDD, controller card, motherboard vendors shift from Seagate to IDE drive interface
  - 3.5 floppy disk: Sony with support from BIOS vendors and Microsoft.
  - Lotus, Intel and Microsoft agree standard for Expanded Memory (RAM > 640 KB)
  - VESA Local Bus: New slot design, same physical size.

System Innovation

- Amazing innovation
  - Within standard
  - Without a dominant firm to dictate designs
- What defines a system is what you CAN'T change about it
  - That's what makes it a standard!
- Connections between nodes are hard to change
- Case layout is the hardest
  - Involves many different components
  - Case/PSU market highly fragmented
  - Major disruption – lose ability to upgrade

Limits to Integration

- No way to add new connectors except on expansion card. Limited to
  - Power
  - Keyboard
- Limits integration
- Multi I/O combines Serial x 2, Parallel, HDD controller, FDD Controller, etc
  - By 1990s, increasingly building these & others onto motherboard itself
  - But have to cover expansion slots to use them.



Material Constraints

- Arbitrary decisions from PC or PC/AT teams
- Standard attachment points for components
  - Motherboard can shrink somewhat as long as holes, slots stay in same place
- Height of box is fixed – bulky, ugly
- Position/number of holes is fixed
- Position of power switch is fixed

ATX – The Box Changes

- Case design is barrier to innovation by mid-1990s
  - The ONLY thing unchanged from original design!
- Intel expands into motherboard design
  - 1995: Introduces "ATX form factor"
- Many improvements
  - Smaller board size = more elegant boxes
  - Space for parallel, serial, graphics, sound connectors on motherboard
  - Power supply under software control
  - New power connectors

Wintel

- By early 1990s the idea of " IBM PC Compatible" is becoming strained
  - Shift to just "PC", which is incoherent
  - Industry analysts use "Wintel PC"
    - MS Windows
    - Intel Processors
- Emphasizes growing power of these two suppliers
  - In some ways assume the former role of IBM
  - Control the two nodes for which substitution is hardest. Shifting OS or processor = HARD.
  - Interesting question: was this inevitable?

Initial Conceptualization

Business/Econ Literature

- Various terms used to describe these issues
  - Platform Competition
  - Modular Innovation
  - Standards Based Competition
  - Flexible networks of specialized producers
- Hits some fundamental questions
  - Markets vs. hierarchies
  - Vertical integration
- Tend to lack
  - Users
  - Materiality
  - Historical richness
- So what can History of Tech/STS perspectives add?

Artifact with Politics?

- Personal computing is often claimed to embed countercultural values
- Hard sell in this case
  - IBM did not want to create an open standard
  - Evolution without clear agency from individual actors
  - Capitalist/libertarian values?

Sentient Scallop?

- The case does have all the power
  - Does it *want* to thwart innovation and freeze industry structures?

Hughesian System?

- "Large Scale Technological System"
  - Doesn't fit precisely
- Some elements appear useful
  - Technological momentum
  - Reverse Salients
  - Co-evolution of system and social institutions
  - System endures after fall of system builder
- But
  - Complex hierarchy of subsystems
  - Virtuality, abstraction, emulation, backward compatibility
  - Subsystems vying for power – Intel vs. Microsoft vs. IBM

Kuhnian Paradigm?

- Not fashionable, but actually works!
- Core meaning of paradigm: exemplar
  - Successful paradigm (IBM PC) is extended, becomes hub of community, directs future work
    - Social institutions grow around it
  - Eventually the very success of the paradigm creates conditions for its replacement
    - "Anomalies" accumulate
    - A wrenching change is made to a new paradigm

Summary

- Let's look at the materiality of standards
- The things you can't change set standards
  - These are the ones that cannot be made virtual
- Co-evolution of physical structure of PC and industry ecosystem of suppliers and producers
- We need better theories to deal with systems made up of subsystems struggling for dominance