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“Standards and compatibility: the rise of the PC computing platform”

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# Standards and Compatibility: The Rise of the PC Computing Platform

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JAMES SUMNER

## INTRODUCTION

Most mass-market computers today follow a single technical archetype: what used to be known as the ‘IBM PC standard’, but has extended so far beyond its original specifications and become so ubiquitous as scarcely to require definition. A computer for individual use, typically, is a box with separate keyboard and monitor, or else a flat notebook with a fold-out screen; employs a Microsoft operating system, on an International Business Machines (IBM)-derived hardware architecture, using an Intel-derived microprocessor; and is primarily set up for use as an office tool, though it can be coaxed into performing many other tasks. Compatibility or interoperability with these norms and expectations is a principal consideration for office, educational and home users.

The ‘PC’ did not reach its commanding position through legislative intervention or formalized regulatory guidance. It emerged as a *de facto* standard in the early to mid-1980s, well before such developments as Microsoft’s series of Windows operating systems. Its trigger was the 1981 entry<sup>62</sup> of IBM, the globally pre-eminent producer of large computers for commercial use, into the personal microcomputer market, which at that time belonged to numerous producers committed to a diverse range of incompatible systems. IBM’s tremendous capital resources, reputation for market dominance and pre-existing penetration of the white-collar world led commentators to assume that its product, the Personal Computer (PC) 5150, would succeed over its established competitors. This prophecy self-fulfilled. The IBM PC sold far beyond expectation, causing many (eventually most) other producers either to leave the desktop computer market altogether, or to produce ‘IBM-compatible’ or ‘clone’ machines.

In certain computing fields, rarely glimpsed by non-experts, alternative archetypes have endured: powerful workstations for specialized commercial and scientific applications, for instance, and large multi-user systems. In the mass market, however, the only arguable challenge to the PC is the Macintosh platform promoted by Apple Incorporated. Into the 1990s, as other alternatives faded, Apple based its marketing increasingly on a

rhetoric of defiant difference from an undesirable PC hegemony, portrayed as buttoned-down, user-hostile and monopolistic. Yet, today's Macintoshes, though promoted in similar terms, are themselves built around Intel processors, and run Microsoft's operating systems alongside Apple's: the strategy is not to reject the PC norm, but to co-opt it.<sup>63</sup>

In characterizing the rise of the PC as a shift away from heterogeneous development, and towards convergence on a uniform standard, we may be tempted to see the two positions as highly distinct, mutually exclusive states. On this reading, the PC's triumph seems an inevitability. Popular histories usually present it as a positive development, banishing a confused Babel of unworkably incompatible devices that made users overly dependent on their proprietors.<sup>64</sup> Counter-narratives are occasionally voiced by partisans of Apple and various extinct proprietary systems, along the lines of the 'VHS/Beta' and 'QWERTY/Dvorak' fables familiar from path-dependency literature.<sup>65</sup> Such accounts accuse IBM of battering a sub-optimal standard into market dominance by dint of something other than technical merit (capitalization, sales force, exploitation of the ignorant), stifling a technically superior standard that would have been better for everyone; or else, by sluggish monopoly development of a dominant design, of frustrating diligent competitors keen to innovate.<sup>66</sup> In both 'pro-PC' and 'anti-PC' accounts, an either/or dichotomy is assumed.

This paper aims to develop a more subtle approach. Standardization cases of the QWERTY variety invoke a straightforward acceptance/rejection binary, but the more complex case of a computer *system* offers diverse possibilities of co-option, assimilation and compromise.<sup>67</sup> The PC was not (and is not) a single standard, but a broad constellation of specifications, varying in exactitude, across the levels of hardware, operating software, applications software and user culture.<sup>68</sup> At all of these levels, possibilities exist ranging from conformity, through compatibility and interoperability, to outright rejection. When we examine the rise of the PC in more detail, we discover a complex range of strategies played out in the service of a variety of interest groups.

The PC itself, moreover, was (and is) highly mutable over time. In the taxonomy promoted by David and Greenstein, *de facto* standards may be 'sponsored', promoted by specific proprietary interest groups (producers, mediators, users), or 'unsponsored', accepted by general consensus (usually in the 'general good').<sup>69</sup> The PC's trajectory cuts repeatedly across these categories. When first introduced, predominantly as a hardware specification, it was strongly IBM-sponsored, but, as various competitors routinized the cloning process, it became essentially unsponsored by the mid-1980s. This very 'unsponsoring' focused attention on the software elements, with the result that the PC became increasingly Microsoft-sponsored – a situation that endured as IBM's role faded. Application software producers, meanwhile, began by expecting the level-playing-field opportunities of an unsponsored standard, only to find that Microsoft's dominance at the operating system level gave it the financial and technical advantages to gain control of various applications sectors.<sup>70</sup>

I begin my study with a brief overview of IBM's entry to the microcomputer market. This is a familiar case in the secondary literature, but there has been a tendency to treat IBM's manoeuvre as a logical, almost predestined success story – a problematic reading, given that IBM lost control of its platform within a few years. I highlight the contingency in the situation, stressing that the corporation entered a mature market with an existing *de facto* standard, built around Digital Research's CP/M system, and was obliged to choose one of various available responses to it. In the next section, I outline analytically the wide range of possible responses to standardization initiatives, all of which were economically or culturally 'rational' to some producers or users at some point. The following two sections offer a counterpoint to the established (mostly US-oriented) literature with a focus on the British case, including some complexities thrown up by the 'jilted' DR's attempts to retain or regain elements of its product's standard status. Finally, I reassess the nature and decline of heterogeneity in personal computing culture. The 'PC hegemony' did not arise inevitably, through some technologically determined industry logic. Its development mutated across space and time, with economic, cultural and political factors clearly at work.

#### STANDARDS VERSUS STANDARDS: THE ENTRY OF IBM

The very notion of a 'standard business microcomputer' requires historical explanation: at the end of the 1970s, the 'standard' business approach was not to use microcomputers at all. Large commercial organizations had mostly automated their information-processing activities with what seemed the appropriate tools for the job: central mainframe computers running batch operations, often on specialized sites, with a distinct labour force, separated from the executives and clerical staff by mutual consent. Devolving computing power to the level of the individual desktop not only implied a mammoth retraining exercise, but seemed to fly in the face of the economies of scale enjoyed by a large firm. Smaller businesses with only a few staff might use no computer equipment at all, except perhaps through shared access to large-scale equipment provided by a service bureau. Often, as in the information-intensive banking sector, personal computers were seen to lack the power and flexibility of older, specialized equipment.<sup>71</sup>

Indeed, the popular-culture fashion for personal microcomputing that flourished around 1977–82 was sometimes seen as prejudicial to established business needs. In the United Kingdom, especially, what David Skinner termed the 'millennial' position – information technology, embodied by the microcomputer, somehow holding the key to the struggling nation's wider fortunes – enjoyed support at national policy level and was seized upon by a number of established and start-up manufacturers.<sup>72</sup> Consultants with experience of pre-'micro' business computing spent much of their time damping what they saw as hype, dissuading customers from buying inappropriately basic systems or assuming that a computer

would ‘solve the problem’ without extensive (and expensive) custom coding and user training.<sup>73</sup>

Nonetheless, particularly in the United States, microcomputers were put to use in various office roles. Word-processing presented a relatively easy transition, as the stand-alone computer replaced the stand-alone typewriter. Conventional book-keeping tasks (payroll, sales ledger, purchase ledger) had been heavily standardized as information management tasks in the pre-computer age, and were accordingly easy to transfer.<sup>74</sup> By around 1977, a *de facto* standard configuration of hardware and software was emerging to meet these needs in the United States. Its most visible component was the software operating system, CP/M (‘Control Program/Monitor’, later ‘Control Program for Microcomputers’), developed from 1973 by the computer scientist Gary Kildall and marketed through his company, Digital Research (DR).

CP/M allowed use of the expensive, but fast and versatile, ‘floppy disc’ storage systems that were invaluable for information-heavy commercial tasks. A piece of application software developed on one CP/M computer could typically – though not always – be run on another, of different manufacture, with little or no adjustment. This allowed the growth of a sector of office-oriented software, notably the word-processor WordStar (from 1978) and the database manager dBASE (from 1980), among the first microcomputer applications to be tagged as ‘industry-standard’.<sup>75</sup>

CP/M was barely fully commercialized, however, when, in 1977, the US corporations Apple, Commodore and Tandy RadioShack began, almost simultaneously, to push microcomputers as volume commodities into a market that was rapidly growing out of its hobbyist beginnings to encompass family homes, education and small business. Cheaper and more basic than CP/M computers, these machines were highly incompatible with CP/M, and also with each other. Notably, in unexpanded form, they relied on cheap cassette-based storage rather than floppy discs. To the manufacturers and most users, however, these were not significant disadvantages. The new machine architectures found enthusiastic support communities of their own, partly thanks to the inexpensive volume manufacturing made possible by closed proprietary standards.<sup>76</sup>

IBM’s 1981 entry to the business microcomputer market, then, took place at a time when that market was well developed, and the concept of a microcomputer widely familiar in the United States. IBM had played little part in this culture; while its dealership networks were superbly effective, they had been built around long-term support relationships, not the high-volume retail box-shifting that now dictated the movement of most individual computers. IBM’s lack of an established microcomputing presence was reflected, too, in the 5150’s heavy reliance on off-the-shelf components from third-party manufacturers (most conspicuously, the Intel microprocessor). This approach, which contrasted strongly with the corporation’s norm of closed internal production, allowed rapid, low-risk development and straightforward third-party expansion. (It has even been

characterized as an ‘open-standards initiative’ on the part of IBM, though this is surely an overstatement: as we shall see, the PC architecture became fully ‘open’ only later, as the original proprietary intentions were subverted by other producers.)<sup>77</sup>

One feature setting it apart from both the established CP/M base and the 1977 proprietary machines was the choice of a new-generation (‘16-bit’) microprocessor. Even here, the model used was the slowest and least powerful of the new breed, chosen largely on grounds of established third-party support and concern about drawing trade from IBM’s larger-computer divisions.<sup>78</sup> Technically speaking, the machine was not only unoriginal, but underwhelming given a list price above \$1500 for the most basic (non-disc) specification. Yet, the PC was never intended as an ‘advanced’ machine – as its creators freely admitted<sup>79</sup> – but as a robust one: its defining advantage lay in the IBM name underwriting a solid overall specification.<sup>80</sup>

In one crucial respect, however, the IBM PC ignored convention and, in doing so, ultimately redefined it. CP/M, as we have noted, dominated the established business market for machines using older (‘8-bit’) processors. DR was then in the process of engineering a 16-bit version, CP/M-86, to be compatible with the IBM PC’s processor. Following the strategy already used for hardware components would have led IBM simply to co-opt CP/M-86. Yet, IBM also addressed its enquiry to Microsoft, a much smaller software company, then known mainly for its version of the hobbyist programming language, Basic. Microsoft had little experience in developing operating systems, and no product to offer, but was able to buy out a system from another Seattle-area firm. With some swift modifications, this became ‘PC-DOS’ for the purposes of the IBM deal, while Microsoft retained the right to adapt it for sale to third parties as ‘MS-DOS’. It was under the latter name that this most unexpected system – which bore some resemblance to CP/M, but offered no direct compatibility or interoperability – endured for over a decade as the most widely used software product in personal computing, single-handedly securing Microsoft’s long-term future. Digital Research and CP/M, meanwhile, descended slowly into obscurity.

Accounts of this episode often assume the character of folk legend, presupposing for IBM a single moment of decision between Microsoft and DR in which happenstance details of corporate etiquette acquired vast significance.<sup>81</sup> In fact, IBM endorsed both CP/M-86 and PC-DOS at the PC’s launch (as well as a third option, the UCSD p-System), and negotiations with DR rumbled on for months afterwards. Indeed, the influential market report, *Billion Dollar Baby*, released the month of the launch, praised IBM for the uncharacteristic step of throwing its weight behind the ‘largest and best defacto standard which is the CP/M software base’.<sup>82</sup> Nonetheless, CP/M-86 was unavailable for a few crucial months after the machine’s launch, and retailed at \$240 as against \$40 for the immediately available Microsoft system. It appears that DR’s Gary Kildall attached significant royalty demands, quite reasonably assuming a

position of strength for his industry-standard product. IBM, however, while paying lip service to the importance of this installed base, seems deliberately to have fostered the smaller and (ostensibly) more pliable Microsoft, correctly reasoning that its own unique scale and reputation would inspire a sufficient user base.<sup>83</sup>

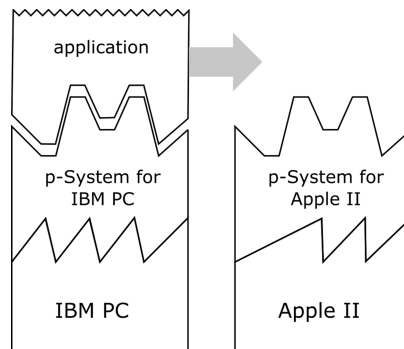
Microsoft's second-hand system, as the standard that killed a standard, has inevitably been controversial. Its initial value to IBM, like that of the PC's hardware, lay not in technical sophistication, but in rapid availability. The sense that corners were cut has fuelled long-standing criticism both of its limitations – it constrained users, for instance, to running a single application at any one time – and of its similarities to CP/M. To DR partisans, MS-DOS was nothing more than 'an unauthorized clone of CP/M', and even Microsoft's successor products such as Windows 95 and 98 'are still Digital Research CP/M at their essential core'.<sup>84</sup>

For this reason above all, the meaning of the PC was open to question and redefinition. As presented to buyers, it was simply a logical extension of IBM's large-computing provision into microcomputing. Members of the PC's development group sometimes spoke in different terms: their distinctly un-IBM-like machine was an almost independent development, for which IBM merely served as 'venture capitalist'.<sup>85</sup> Bill Gates of Microsoft, meanwhile, moved remarkably fast to emphasize his company's contribution to the design – a manoeuvre that would eventually lead, with the development of the clone industry, to Microsoft's eclipse of IBM as principal gatekeeper of the archetype.<sup>86</sup>

Concurrently with this shift, a birthright mentality incubated within Digital Research. Kildall and others believed that CP/M not only *should* but practically *could* regain its 'industry standard' role, if only the IBM-endorsed complex supporting Microsoft could be effectively challenged at the machine archetype level. This determination played a significant role in stirring up the heterogeneous platform developments of the 1980s, as we will see in the following sections. First, however, it is necessary to clarify some of the ways in which a 'platform battle' might be fought. The issue at stake is not, in fact, standards-compliance, but the rather broader concept of *compatibility*.<sup>87</sup>

#### THE COMPLEXITIES OF COMPATIBILITY

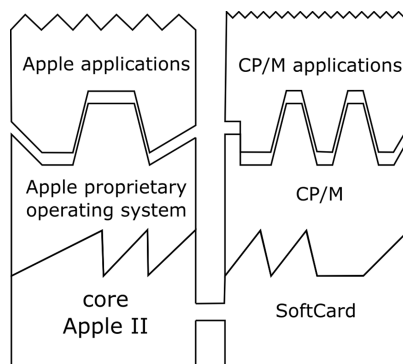
Archetypally, an engineering standard is something in the nature of the Whitworth screw, or the standard rail gauge.<sup>88</sup> On the face of it, such standards can only be accepted or rejected; once accepted, they tend to persist, because the price of switching to an incompatible standard is top-to-bottom re-engineering. Microcomputers display a broader range of possibilities, not because they feature 'more complex' technology – the securing of Whitworth's standards was a project of awesome complexity – but because they are highly underdetermined.<sup>89</sup> Computer hardware is typically able to interpret code, or software, designed for purposes unguessed by the hardware designers. One consequence is that software



**Figure 1** Idealized schematic of the compatibility principle underlying the UCSD p-System. Despite the dissimilarity of the hardware, users should be able to use applications software (e.g. a word-processor) identically on both machines.

compatibility may be engineered between hardware systems designed in isolation from each other, and having few or no elements in common.

This principle was elegantly demonstrated by the UCSD p-System (Figure 1), the third option announced for the IBM PC in 1981, and also engineered for the Apple II and the most popular mini- and mainframe computers. The software performed a remarkable feat of translation, persuading each of the very different hardware platforms to behave like a common ‘pseudo-machine’ (‘p-Machine’). Developing this complex system was time-consuming, however, and the advantages to the user might be outweighed by need for additional resources such as memory, and a loss of speed or convenience compared to a machine’s ‘native’ behaviour.<sup>90</sup> This was especially true where the hardware bases were radically different. CP/M had succeeded as a software *lingua franca* where the p-System did not, because it was limited to machines with one specific processor architecture.



**Figure 2** Idealized schematic of the SoftCard’s compatibility principle. Here, there are, in essence, two distinct machines, from the hardware level up, within the same physical box.



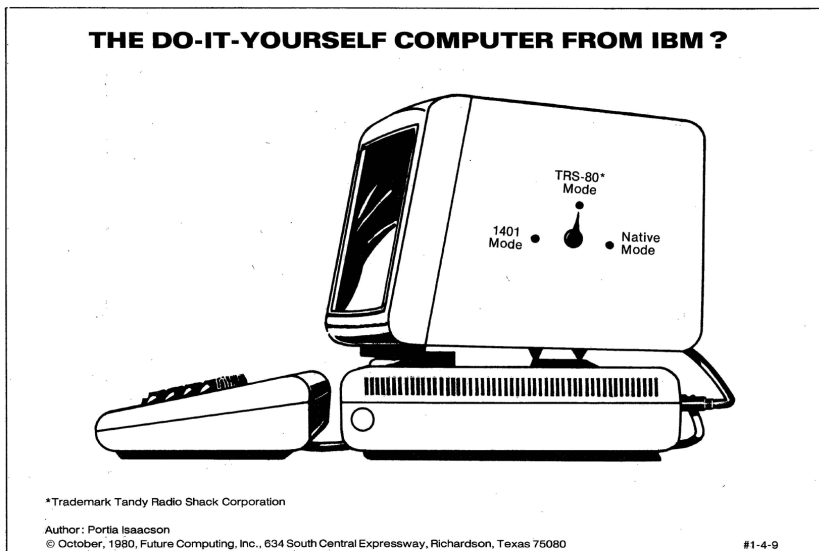
Many attempts to engineer compatibility, for this reason, followed a hybrid hardware and software approach: the most practical way to run CP/M on a machine without an appropriate processor was usually to plug an appropriate processor into it. Shortly prior to the PC-DOS deal, Microsoft – primarily motivated by the desire to expand the market for its CP/M Basic – launched the Z-80 SoftCard, a device by which CP/M could be run on the popular Apple II computer (Figure 2).<sup>91</sup> The resulting entity, with two microprocessors in one box, could operate both the ‘industry-standard’ CP/M business packages and the considerable range of Apple titles, with its greater focus on education and leisure software.

The SoftCard illustrates an important ambiguity. It extended the functionality of Apple’s machines, but reduced their users’ dependence on the Apple-proprietary software base (‘lock-in’). It was not at all obvious whether the ultimate consequences for the survival of Apple’s proprietary platform would be positive or negative.<sup>92</sup> Manufacturers’ attempts to answer this kind of question are key to understanding the heterogeneity of microcomputer systems in the mid-1980s, as we shall see later.

The marketing advantages of servicing multiple platforms lay not only in the breadth of software available: hardware manufacturers could play on customers’ fears of ‘backing the wrong horse’, ending up with heavy investment in a marginalized platform. The now familiar term ‘future-proof’ was apparently coined in 1982 by a small British producer, Tycom Corporation, in advance publicity for a system known as Microframe. Aimed at research and business users, the device was underdetermined to the point of having no default configuration at all. Interchangeable processors mounted on standard circuit boards would run all the major commercial and research-oriented operating systems of the day, including MS-DOS, the entire CP/M range and p-System, to cover ‘over 85 per cent of currently available software’.<sup>93</sup>

An important element of cross-compatibility rhetoric was the ‘switch’ metaphor (Figure 3). In the mechanical world, ingenious attempts to engineer flexible or dual-running approaches to incompatible systems are frequently proposed, as in the attempts to surmount breaks of rail gauge using large-wheeled ‘compromise cars’, or wheels capable of sliding on their axles; yet, such approaches are often found unwieldy or impractical.<sup>94</sup> In microcomputing, this should not be a problem. With the material form of the machine unchanged, the flick of a switch (or some relatively simple keyboard command) might set the charges dancing through another processor, or perhaps merely in another pattern, to effectively give the user a different computer.

Though seductive to users, the position-switch concept may mislead as an account of compatibility. It not only distracts attention from more subtle forms of compatibility that operated by other means, but also overplays the simplicity of making use of a ‘compatible’ system in most practical cases.<sup>95</sup> A system advertised as compatible with, say, CP/M might in fact display any of the following behaviours:



There are certainly even lower cost desktop computers on the way from IBM. IBM, like anyone else, faces the huge installed base and associated software base of the Radio Shack TRS-80. Emulation modes are a time-proven technique used by IBM when faced with such problems. So, when introduced, the IBM Personal Computer, will of course, emulate the 1401 (nearly all IBM

computers emulate the 1401) and may be forced to emulate the TRS-80.

The drawing above is actually IBM's Do-it-yourself terminal. Look's a lot like most computers I use. Already IBM has introduced an optional printer. Are the CPU and Disks next?

**Figure 3** The position-switch concept. First published in *Future Computing Illustrated* for October 1980, before IBM's Personal Computer plans were generally known. The presentation is tongue-in-cheek, playing on the contrast between IBM's dominance in large computing – the 1401 was an old mainframe warhorse, produced 1959–71 – and the unfamiliar markets opened up by new micro-computers such as the TRS-80. Reprinted in Isaacson and Juliussen, *Billion Dollar Baby*, 39. Reproduced by kind permission of Portia Isaacson Bass.

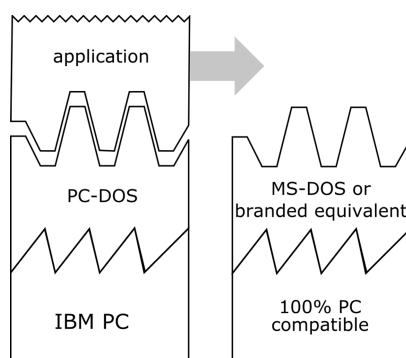
- software products advertised for CP/M systems, and sold in a standard format (such as the 8-inch floppy discs popular in the late 1970s), could be run directly
- standard distributed copies of CP/M software could be bought directly, but required a relatively simple and uniform 'translation' process before use
- the machine could not run any CP/M software from the open retail market, but 'translation' of existing products could be undertaken quickly and straightforwardly by the hardware manufacturer's agents, or other niche suppliers.

In addition, variations in visual display, memory and various other factors meant that some applications would fail to run on some 'compatible' systems, while others would behave idiosyncratically. Often, these problems were resolvable by software methods, but suppliers were by no means obliged to resolve them.

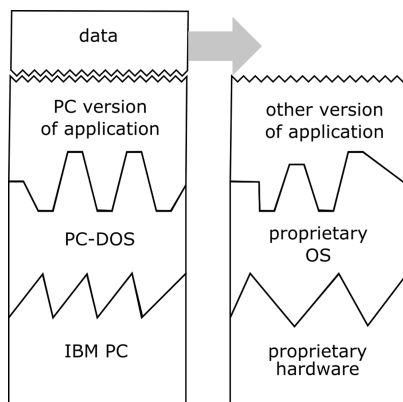
Such complexities received increasing attention from market analysts with the rise of the IBM PC and its compatible-by-design imitators. The

business information agency Future Computing distinguished *operationally compatible* machines, the true ‘clones’ that could run software sold for the proprietary PC, from those set up to be *functionally compatible*.<sup>96</sup> The latter approach, like the pseudo-machine, worked by inserting a compatible layer above an incompatible base, but at a different level: the machine would run technically distinct (but functionally similar) versions of the software packages used on true IBM machines, and could thus exchange data files with them (Figures 4 and 5). Functional compatibility was a minority option because of the capital and time investment needed to rewrite the applications, and obviously varied in its degree.

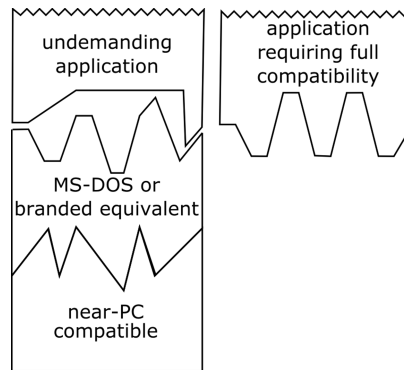
What was less obvious, on account of the widespread promotion of the ‘clone’ metaphor, was that operational compatibility, too, varied greatly:



**Figure 4** Operational compatibility. Applications for the ‘true’ IBM PC will run identically on the compatible machine. Packaged ‘IBM PC’ software off the retail shelf can therefore be used directly by users.



**Figure 5** Functional compatibility. The two users here can exchange data freely, although the technical bases of their computer use need have little or nothing in common.



**Figure 6** Partial operational compatibility. Here, although it is impossible to provide a truly equivalent hardware/operating system base, some applications will ‘fit’ because the points of difference are not relevant to their functioning. This was often the case with text-only software that did not use the IBM PC’s graphics facilities. Applications requiring very high compatibility, such as Microsoft Flight Simulator, were enshrined as compatibility benchmarks.

different machines would run varying proportions of true-IBM software given varying degrees of hardware reconfiguration, software modification and user tolerance of limitations or surprising effects (Figure 6).

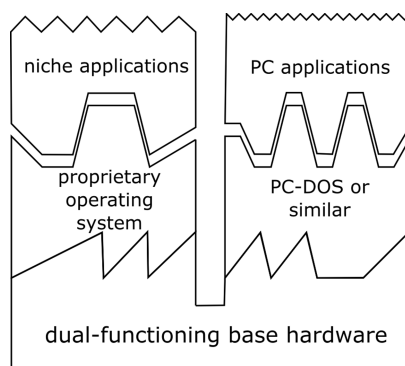
Less closely analysed in the technical press, but equally important, were the similarities and associations, strong and weak, that would never have been identified as ‘compatibilities’ yet clearly operated in the same way. MS-DOS, for instance, was rather like CP/M in its behaviour. There was no operational compatibility at all between the two, but the similarities made it relatively easy for users to switch between them, and also for software producers to rewrite their CP/M software for MS-DOS. Tim Paterson, the originator of MS-DOS, firmly denies that the product was based directly on CP/M code, but there is no secret that it was partly inspired by a CP/M instruction manual.<sup>97</sup> Such features as documentation, user support, suppliers’ pre-existing reputations in other fields and the physical form of the computer must not be written off as ‘external’ if we are to understand why users accept, reject or partially assimilate systems.<sup>98</sup> A non-standard keyboard layout, in fact, was the most controversial feature of the PC 5150 after launch.<sup>99</sup>

Given this understanding, we are in a position to address the concept of *niche*.<sup>100</sup> In the large-computing era, when IBM consistently held over 70 per cent of the US market, its competitors commonly depended on catering to the needs or expectations of specialized groups. This niche approach might as easily be social or geopolitical as technical: whereas Control Data Corporation specialized in fast-processing machines adapted to the scientific markets that IBM’s range did not address,<sup>101</sup> European producers such as ICL, Philips and Olivetti capitalized on local knowledge and national flagship status. As microcomputing became possible, Apple,

Commodore and Tandy RadioShack had successfully built a ‘home’ niche in the United States, enticing non-corporate users with relatively low pricing, a preponderance of educational and leisure software, early availability of colour graphics and direct retail sales.<sup>102</sup> Evidently, the archetypically white-collar IBM could not attack this market as easily as it could the CP/M base.

The undeniable rise of the IBM PC platform placed niche producers in a precarious but interesting position. By continuing to promote non-IBM-compatible hardware and software, these producers could hope to maintain the ‘lock-in’ of their users; but there was an ever increasing chance that the users would rebel, preferring even a difficult migration across platform boundaries to the risks of a fading standard. To go to the other extreme and embrace the PC wholeheartedly – to join the ‘clone’ manufacturers – was even more problematic: the existing ‘lock-in’ would be thrown away, and the producer would become the newest entrant to a bear-pit of vendors offering near-identical products at minimal profit margins.

Unsurprisingly, producers looked to the complexities of compatibility as a means to avert this dilemma. The goal, usually, was to retain the original niche appeal whilst securing some or all of the advantages of the increasingly generic PC – an approach I will refer to as *niche-compatibility* (Figure 7). *Compatibility* does not necessarily imply simple acceptance of a standard: it may mean toleration, co-option or even subversion. Such choices were greatly complicated by the number of elements in play – hardware, operating system, applications software, user cultures – and, specifically, by the looming spectre of the jilted CP/M.



**Figure 7** Schematic of typical niche-compatibility approach in the early PC era. In essence, this approach differs from the SoftCard (Figure 2) only in that the hardware elements are supplied as a pre-assembled unit. In some cases, both operating systems employed the same hardware.

## THE BRITISH CONTEXT

It is particularly instructive to address the case of the United Kingdom, where (as throughout Europe) the 'PC' platform was never wholly tethered to IBM moorings, and where the unusual influence of indigenous manufacturers illustrates a wide range of both non-compatible and niche-compatible approaches. By the time of the IBM PC's international launch, the British computer market was not only well established, but qualitatively different from that in the United States. In a mood of severe post-industrial decline, 'millennial' assumptions informed both the fledgling Thatcher government's scheme for a post-industrial 'information revolution' and the more humanistic initiatives clustered around the publicly owned British Broadcasting Corporation (BBC)'s Computer Literacy Project.<sup>103</sup> 1982, designated 'Information Technology Year', was marked by a round of public events, education initiatives and state-funded research commissioning.

At this time, the Commodore, Apple and TRS machines of 1977 were available through local dealers, but were promoted at higher than dollar-equivalent prices to a public with significantly less disposable income. Correspondingly, though CP/M disc systems were likewise readily available, established small businesses were less likely to spend heavily on computerization. Public notions of microcomputing were more patterned by the indigenous Sinclair firm's radical strategy of design (in Leslie Haddon's phrase) 'down to a price point', pursuing low-cost architecture with little regard to conventional expectations.<sup>104</sup> In 1980, when the 1977 US models were retailing for around £350–£700 at their minimum specifications,<sup>105</sup> Sinclair launched the ZX-80, a tiny vacuum-moulded microcomputer with a membrane keyboard, at £99.95 pre-assembled. The following year's ZX-81 offered an improved system below £70 and was a conspicuous success, selling over 300,000 units by January 1982.<sup>106</sup> This cost-cutting crucially relied on assembling as many hardware functions as possible on large custom-made chips – the opposite of the IBM PC's design philosophy of standard parts, large-box design and conservative pricing.

Though technically limited, even by comparison to the 1977 microcomputers, Sinclair's machines were hugely popular home purchases and attracted much attention in schools education, fuelled by the enthusiasm of practitioner advocates such as Eric Deeson.<sup>107</sup> Sinclair dominated Britain's direct-retail computer market for around two years, ceding ground only when Commodore, apparently directly inspired by Sinclair's example,<sup>108</sup> began to follow similar price-point tactics. Commodore carved a large chunk of Sinclair's 'home computer' market in the United Kingdom and practically defined analogous sectors in other European countries, notably West Germany.<sup>109</sup> Meanwhile, the indigenous Acorn Computers, which shared its Cambridge roots with Sinclair, focused on more robust and expensive machines; Acorn was contracted to provide the Computer Literacy Project's officially endorsed machine (dubbed the 'BBC Micro') and subsequently took most of the schools trade, settling into a long-lasting niche based on education and specialized research needs.

Across the first half of the 1980s, a variety of established electronics manufacturers, computer service firms and start-ups were similarly inspired to promote distinctive, usually incompatible microcomputers. Several in the 'home' market, notably Dragon Data and Tangerine/Oric, achieved sales above 100,000 units and exported their machines to France, the Netherlands and elsewhere.<sup>110</sup> Governmental exhortations to 'Buy British', a long-established factor in information-technology appropriation decisions, were undimmed.<sup>111</sup> Union Flags sprouted incessantly in marketing graphics, while national identity was manifest in such producer names as British Micro and Dragon (of Port Talbot, Wales).

In the context of evolving computer standards, the very mention of this episode may require justification. The United Kingdom's early-1980s production culture, though remembered with much affectionate nostalgia, is commonly viewed through a presentist lens that makes its differences into foibles or errors.<sup>112</sup> Against the looming challenge of the IBM PC, Britain seemingly responded with an uncoordinated patchwork of eccentric proprietary technology, most of it drastically underpowered for the great information adventure evoked in political rhetoric. The early Sinclair machines' cut-price positioning (the very cause of their success) forced the exclusion of most of the plug-in components necessary for broad compatibility, while the alternative approach typified by Acorn is stereotyped – in a microcosm of the 'British problem'<sup>113</sup> – as engendering hardware that, though innovative and reliable, was expensive, esoteric and commercially unappealing.

Yet, this perception ignores the fact that many low-cost models in the British market were designed with a high degree of expansibility in mind: not as closed proprietary machines, but as niche-compatibles. That the contrary is widely assumed is a consequence of the tremendous initial impact of the cheap Sinclair models. Yet, Sinclair was also the birthplace of an expansible computer, the NewBrain, ultimately commercialized by Grundy Business Systems in 1982. Like the early Sinclairs, the NewBrain was ostensibly a 'quirky' home computer: a tiny portable unit priced at £267, it gave output when not plugged into a monitor through an idiosyncratic, calculator-style fluorescent matrix. The base machine's modest 32-kilobyte memory was, however, designed as expandable to two megabytes – an incomprehensible figure for any but a research or commercial application (compare the original-series IBM PC's limit of 640 kilobytes), and it was always intended to run CP/M.<sup>114</sup>

We find another demonstration of the niche-compatible philosophy in the complex formed by Acorn and its partner/competitor, Torch Computers, which had emerged from the same Cambridge University-oriented context with the initial intent of selling Acorn-derived models to the business market.<sup>115</sup> Acorn's BBC Micro, on the received view, epitomizes the 'eccentric' ethic of lofty indifference to the compatibility agenda: incompatible with CP/M and other US standards, reliant on Acorn-specific operating and file systems, with a specially written dialect of the Basic programming language. This characterization, however, ignores

the machine's tremendous inherent expansibility. Among its multifarious connector sockets sat a port cryptically labelled 'the Tube' – a connector for an external unit housing a second microprocessor. In an elegant variation on the SoftCard principle, the base unit would continue to handle mundane input/output tasks, but the computer overall would take on the character of the added processor, running its associated software; and it could readily be swapped for an alternative unit.<sup>116</sup>

The acquisition of a second processor was promoted as a probable *routine* aspect of the microcomputer experience: early user-group literature, addressing new purchasers, describes the base machine as 'only really half a computer'.<sup>117</sup> The separation of parts was a positive advantage, not only to break up the expenditure, but because processor choice would depend on intended use (what would shortly be labelled 'future-proofing'). Acorn's initial second processor, bundled with a version of CP/M licensed directly from Digital Research, was slow to arrive, but Torch stepped into the breach. The Torch Disc Pack combined a Z80 second processor and extra memory with twin disc drives in a flat rectangular unit that sat beneath the computer, and ran a reasonably effective CP/M clone.<sup>118</sup> Torch marketed this unit, mainly to small business, as part of a compatible range of personal computers, workstations and communications systems; machines at the higher end combined three processors in a single box and could flip between CP/M and UNIX, the dominant system in multi-user research computing. The full range was launched on 4 July 1983, with advertisements celebrating 'Independence of America Day'.<sup>119</sup>

In assessing the British response to US developments, it is crucial to note that at the end of 1982 – Information Technology Year – the IBM PC was absent from British soil. Whereas the 5150 had been available through US dealers from the autumn of 1981, limitations on production capacity and a priority for supplying the home market meant that it was not formally launched or supplied internationally, barring limited and irregular exports, until early 1983. The first PCs to roll off IBM UK's Greenock production lines encountered a diverse, well entrenched proprietary cultures; several competitive CP/M suppliers at the higher end of the market, and direct home-grown competition, in the shape of Applied Computer Techniques (ACT).

Established in 1965 as a computer time-sharing bureau, ACT built on its commercial contacts to distribute, from 1982, a machine named the ACT Sirius 1. This was a licensed equivalent to the Victor 9000 produced by Sirius Systems Technology, founded by the Commodore PET's designer, Chuck Peddle; its usual operating system was MS-DOS, although, like several other such machines, it had no underlying IBM compatibility. Launched in the United States shortly before the IBM PC, it made little headway there; but, in Britain, ACT scooped up a substantial portion of the emerging market for 'business' microcomputers in the year of grace before the PC's arrival, later developing a successful Sirius-compatible machine of its own, the Apricot. Also pressing into the 1982 gap was Olivetti, the Italian national flagship with a background in



pre-micro business computing, with the M20 – yet another proprietary system.

The rapid growth of IBM PC sales in the United States, therefore, did not lead Britons to assume automatically that a new hegemonic standard was in prospect. In 1982, even literature aimed purely at business emphasized CP/M, reflecting the strength of the installed base of 8-bit machines; sometimes, CP/M was noted as the ‘8-bit standard’, with the question of the new 16-bit machines unresolved. IBM, of course, was highly recognizable: it had established a formidable large-computer presence in the United Kingdom, as in most of Western Europe. Yet, while its entry into microcomputing was duly noted, its favoured system was understood as merely one possibility, with DR’s CP/M-86 at least equally worthy of attention.<sup>120</sup>

When, then, did the PC hegemony reach Britain? Unfortunately, we cannot assess the progress of the switch from available sales data, because the IBM machine’s late arrival meant that it was vulnerable to diverse clone competitors almost immediately. An impression can be gained from editorial comments in the computer press: *Practical Computing* (launched for hobbyists but, by around 1983, largely oriented to business and professional users) waited until its June 1984 issue to declare the tipping-point reached. Its indicators were Olivetti’s shift to PC-compatibility (carefully euphemized in advertising copy as ‘industry standard’), the growing list of clone models more generally and the US Victor/Sirius liquidation (a point of doubtful relevance, given ACT’s independent success).<sup>121</sup> In a national market without underlying IBM compatibility, MS-DOS could still be challenged by CP/M-86; both were offered on the ACT Apricot, and advertising copy for Ferranti’s Argus Pro-personal described its CP/M-86 operating system as ‘industry standard’ well into 1984. This characterization (presumably invoking the large surviving 8-bit CP/M base) was perhaps slightly disingenuous even for Britain, but suggests a surviving uncertainty that had altogether expired in the United States.<sup>122</sup>

United Kingdom-based columnists watching the well established IBM PC transfer to its new market showed a conspicuous lack of enthusiasm for a machine most of them were now advising their commercial readers to buy. In a *Practical Computing* survey of competing models, the terse encapsulation of the case in favour – ‘It is the IBM PC’ – indicated weakness as well as strength.<sup>123</sup> The benefits of the new *de facto* standard were spelt out, but the machine itself was stressed to be conservatively designed (inevitably, given the standardization strategy), relatively expensive (not inevitably) and, most importantly, not the only machine that could be claimed, or at least suggested, to ‘be’ the PC.

Unsurprisingly, the establishment of the PC standard produced new versions of the niche-compatible modification approach. In 1984, for instance, Torch followed up its CP/M Disc Pack with the Graduate, which made a BBC Micro approximately IBM-compatible by means of a second processor.<sup>124</sup> Perhaps the most interesting approach came from Ferranti,

an old-established electrical engineering firm that had pioneered some of the United Kingdom's earliest commercial computing endeavours. Ferranti's Advance 86, announced in 1983, was available in two models. The 86a, costing £399, was the size and weight of a large home computer and presented firmly as such, distributed alongside Commodore, Sinclair and Acorn machines by W. H. Smith, the retail stationery chain.<sup>125</sup> The 86b, at a guide price of £1,500, was available both from Smith's and through specialist dealers, and was more specifically promoted as IBM-compatible. All that distinguished the two was a top-mounted unit, much like the Torch Disc Pack, containing twin disc drives and expansion ports; owners of the 86a could easily upgrade by attaching this unit. The strategy, then, was to enter the established 'home computer' and 'IBM-compatible' markets simultaneously, in a manner that allowed the gap between the two to be easily bridged.

#### DR'S REVENGE?

As CP/M wilted in the face of the PC-DOS/MS-DOS complex, Digital Research wondered how to reverse its unexpected reversal. One possibility was to exploit surviving areas of heterogeneity. Apple was then opening a new niche with the Macintosh, released in 1984, with a blaze of marketing presenting it as a corrective to the hegemonic IBM. By contemporary US standards, the Mac was almost aggressively PC-incompatible, yet its impressive mouse-driven graphical user interface (GUI) commanded immediate attention: at the time, Microsoft and IBM offered nothing comparable. DR's Graphical Environment Manager (GEM) was a similar, if more limited, GUI system, initially for CP/M, but with a PC version available from 1985. GEM may be regarded as a 'conceptual compatible': it was not designed to offer any Macintosh-compatibility in technical terms, yet offered the user an environment similar to the Mac's GUI (sufficiently so to spark litigation from Apple). Its appeal was not, however, strong enough to overcome the very widespread lock-in to the text-based MS-DOS.

The alternative strategy, which DR pursued in parallel, was to achieve some form of niche-compatible synthesis between CP/M and MS-DOS. This development track ran through various elaborations of CP/M-86 to DOS-Plus (1985), which could run CP/M-86 and MS-DOS 2.11 software simultaneously, and ultimately to DR-DOS (1988), positioned purely as an alternative to MS-DOS, which it battled on grounds of supplementary features into the early 1990s. So far as the United States was concerned, DR's primary goal in these developments was survival. In the less settled European markets of the mid-1980s, however, it could realistically aim – briefly – for something more: killing MS-DOS through compatibility.

A new opportunity arose following the 1984 entry into the micro-computer market of Amstrad, a British electronics firm known previously for volume retail hi-fi equipment. Led by the charismatic Alan Sugar, by reputation a walking archetype of the hard-headed entrepreneur, Amstrad

took Sinclair and Commodore's price-point philosophy as virtually its sole development criterion, promoting a cheerfully cynical take on the business of box-shifting. Sugar is on record as endorsing the marketing principle of the 'mug's eyeful': Amstrad's CPC-464, positioned as an affordable home micro, was not to be small and sleek like the Sinclair machines, but as bulky and impressive as possible to the inexperienced first-time buyer.<sup>126</sup> Amstrad secured unusual success in breaking into the mature and apparently saturated market by offering the appearances of a 'real computer', complete with monitor, at the home-user price of £350. There was no room for technological purity in the Amstrad vision. Legendarily, certain of the firm's models featured a technically redundant fan, included purely to assuage fears of overheating and meet received notions of how a personal computer should be.<sup>127</sup>

Amstrad's price-point philosophy, like Sinclair's before it, militated against standards-compliance. Sugar followed Sinclair in favouring custom chips over standard components; he also made a habit of buying up technologies that, though perfectly serviceable in isolation, were being dumped at bargain prices as the wider industry embraced their rivals. Most notably, Amstrad adopted Hitachi's 3-inch disc drive specification at the point of its evident eclipse by 3½-inch models in the United States and Asia. Analogously, on the software side, Amstrad secured an inexpensive license on CP/M (not CP/M-86: the machine used the Z80A processor of the old 8-bit generation). Typically, the machine would be used in proprietary 'home micro' mode, but Amstrad saw at least rhetorical advantage in connecting the machine to the long-established business software base.

The connection established here was maintained with the follow-up PCW8256, marketed as a dedicated word-processor. As Sugar's biographer, David Thomas, notes, there was no significant market for such machines in the United Kingdom until Amstrad single-handedly created one through cut-price tactics, selling 350,000 PCWs within 8 months of the 1985 launch.<sup>128</sup> Though addressed to an almost disjoint market from the CPC-464's, the £399 PCW was another Z80A machine supplied with CP/M, and was, in fact, widely used outside its core word-processor configuration to run established CP/M software. The suggestion that this was somehow technologically inappropriate or 'backward', in a climate of IBM-compatible hegemony and 16-bit processors, was rebuffed by Sugar in characteristic style:

We had some very funny comments from the snobs in the market about the Z80: 'Doesn't Mr Sugar know there is such a thing as an 8086 or even a 286 processor available for such applications?' What they'd missed is that the people who bought them didn't give a shit whether there was an elastic band or an 8086 or a 286 driving the thing. They wouldn't know what you were talking about. It was bringing computing to people who never even thought they would use a computer.<sup>129</sup>

Specifically, the machine was to displace hundreds of thousands of manual typewriters from home and office desks across Britain and continental Europe. The result was a late-flowering island of Z80A-CP/M (and 3-inch disc) users, for whom technical ‘advancement’ and IBM compatibility were simply not meaningful considerations. To insist on excluding this group from ‘real’ computing culture is circular, as indeed it is for the contemporaneous home micros.

Of course, none of this implied an aversion to the IBM standard on the part of Amstrad: the next logical step was a cut-price PC. What almost followed was an ironic reversal of the crucial 1980 decision, with Amstrad rather than IBM standing as kingmaker in Europe. Microsoft, buoyed by its deals with the US clone-makers, and beginning to assert itself as the arbiter of the PC standard, offered MS-DOS at a price Amstrad was not prepared to pay; DR, whose UK operatives had an established relationship with Amstrad through the two CP/M machines, stood ready with DOS-Plus, the MS-DOS (near-)compatible that maintained a bridge back to the CP/M base. Amstrad duly licensed DOS-Plus, adding in GEM on the rationale that the graphical environment offered a useful ‘mug’s eyeful’ for buyers loosely familiar with the Macintosh.

The result *could*, we must appreciate, have been the long-term entrenchment of DOS-Plus in Western Europe, DR surviving as a US software corporation with a largely overseas base (as for Commodore in the hardware market). The similarities between MS-DOS and DOS-Plus would have permitted extensive *de facto* worldwide conventions on operating system behaviour, but this would not have prevented a persistent market duopoly. It was not to be. The very plausibility of this vision induced Microsoft to offer MS-DOS on more favourable terms, and Amstrad’s machine was announced at £499 with both systems included. Only at this point did the ascendancy of MS-DOS in Europe become an inevitability.<sup>130</sup> Yet, the runaway success of the machine was also a crucial blow for the value of ‘true IBM’ equipment, and thus contributed to Microsoft’s eclipse of IBM.

By this point, established IBM PC purchasers were moving to the more powerful PC-AT launched in 1984. The AT was based on the Intel 80286 microprocessor, strongly compatible with the earlier 16-bit chips but offering new features. DR saw in the 80286 another opportunity to assault MS-DOS through compatibility. A product named Concurrent DOS 286 was intended to emulate MS-DOS perfectly, whilst also running GEM and making use of advanced possibilities of the 80286 not seen on the IBM/Microsoft platform. This development coincided with moves by Acorn to re-address the commercial and research workstation sectors it had once delegated to Torch, through a range of niche-compatibles derived from the expandable BBC Micro principle and pre-announced under the designation ‘ABC’ (for ‘Acorn Business Computer’).<sup>131</sup> Acorn and DR were reported to be working closely together to engineer Concurrent DOS for ABCs as well as for PC-AT clones, permitting full data interchange capability between the two communities.<sup>132</sup>

This approach – compatibilism promoted so as to retain some distinctness of form – was probably the most rational available to a company in Acorn's position. Its established platform was increasingly dependent on a rhetoric of difference, like Apple's, and was, if anything, more strongly identified with a specific niche area. To suggest that such a firm should have moved to embrace the obvious emerging *de facto* standard, by developing a straightforward PC clone, is to miss the point. There would have been nothing to lead customers to favour such a machine over the IBM PC itself. Acorn did not have the price-cutting instincts of an Amstrad or Sinclair; indeed, it had grown by supplying specifically those areas that did not respond to Sinclair's approach. The ABC range represented an attempt to co-opt the emerging IBM-compatible generation whilst maintaining a link to its strong established niche.

#### THE END OF HETEROGENEITY?

The collapse of a proprietary niche does not necessarily indicate that the user community is not viable: if the producer ceases to produce, for whatever reason, there may be little the users can do. Over the course of the 1980s, Britain's various non-clone computer producers were steadily driven out of business by a variety of factors, often as simple as managerial inexperience or unavoidable economic happenstance. Contrary to received opinion, it is difficult to confirm naïve incompatibility as a significant factor: designers were closely attuned to the emerging standards (hence the niche-compatibles), and usually ignored them only in reasonable expectation of building an alternative market (as for the low-end Sinclair machines). We may, however, perceive a tendency to underestimate the work needed to engineer a successful niche-compatible, and its often fatal consequences in terms of poor performance or product delay.

Grundy Business Systems, producer of the Newbrain, went into liquidation in mid-1983, before the promised expansion units to take advantage of CP/M compatibility could be brought to market, after over-expanding production against optimistic sales projections.<sup>133</sup> Sinclair suffered a notorious fall from grace in 1984 with its new model, the QL, aimed at small business and more 'serious' home users but maintaining the Sinclair ethic of unusual proprietary design. Again, it is important to realize that this was not irrational. Boasting a new-generation 32-bit processor and priced at £399 (compare the almost simultaneous UK launch price of £1,795 for the Apple Macintosh), the machine could have followed previous Sinclair models in building a new user market. It failed principally through embarrassing supply delays,<sup>134</sup> which, alongside costly failures in Sinclair's non-computer activities, triggered a loss of shareholder confidence, resulting ultimately in the sale of Sinclair's computer business (including the still successful Spectrum home micro) to Amstrad in 1986.<sup>135</sup>

Ferranti's Advance (offering expansion from 'home micro' to fully

fledged PC) was a quiet failure, illustrating the limitations of the expandable approach. Whereas Commodore and Sinclair's cheap, complete home systems were supported by an extensive, well marketed (if less than 'serious') range of software, the Advance 86a offered a limited gateway to software possibilities that, though similarly extensive, were barely promoted at all to home-user audiences, particularly outside the United States. If W. H. Smith had hoped to rely on clip-on expansibility as a selling-point for a 'small business' market intersecting with the home field it knew best, no such market emerged.<sup>136</sup> Subsequent Ferranti micros were PC clones of conventional design. ACT/Apricot, likewise, made the jump to straightforward PC-compatibility in 1986.

The cheap, non-compatible 'home user' niches, in fact, present the commercial success stories of this era in Britain. When first-generation Sinclair and Commodore users upgraded, in the mid-late 1980s, it was generally not to IBM-compatibles, but to new, 16-bit proprietary models offered by Atari, an established US videogames and home micro specialist, and again by Commodore. In another example of the DR push into non-established markets, Atari's proprietary operating system, TOS, was in large part an adaptation of GEM.

The principal survivor among 'serious' adaptable niche producers, and arguably in the British microcomputer industry in general, was Acorn. Holding the core education market with its BBC Micro, the Cambridge firm continued to find purchasers, often with school-aged children, who valued its reputation and software base. Moderately enhanced versions of the machine appeared until 1986 (prompting bewilderment from some technically minded reviewers, as the processor and core architecture were now very old indeed; this, of course, as for the Amstrad machines, was to miss the point). Acorn suffered the same classic crisis as Grundy, however, overstocking heavily on a new, cheaper 'home' machine that proved unsaleable. In February 1985 – after the ABC pre-announcement, but before the new machines, and the fruits of the DR partnership, could be brought to market – Acorn was rescued, on an arrangement amounting virtually to acquisition, by Olivetti of Italy.

Far from representing a consolidation of the microcomputer industry, this development gave rise to one of the most interesting turns in its twisting saga. Acorn maintained its identity, and was not so much allowed to continue heterodox development as positively *constrained* to do so. Olivetti, now manufacturing PC clones under its own badge, could support a small, research-oriented manufacturer, whose ideas could serve local niches and might be of long-term benefit; not so an expansionist operation targeting Olivetti's existing, congested demographic.<sup>137</sup> The niche-compatible ABC series was dropped, rapidly forgotten and Acorn thereafter focused on its existing home and educational markets, alongside a number of high-specification, low-volume research niches.

Non-compatible approaches, then, could be resilient; yet none of the platforms discussed here endured indefinitely. In the mid-1990s, Commodore collapsed and Atari left the market, while even Acorn had faded

gradually from existence by decade's end. A factor in these developments, we must admit, was the growing cheapness of generic PC hardware thanks to the mass-production feedback effect (rising demand and falling production costs reinforcing each other): ultimately, some users decided that the relative cost of niche loyalty was too high.

Such are the complexities of computing platforms, however, that this economic factor must be treated as double-edged. Mass-production logic may, to some degree, determine *component* homogeneity: virtually all microprocessors in small computers today follow the Intel archetype. At the *platform* level experienced by users, however, this development may facilitate either uniformity – more use of standard PCs – or heterogeneity. Apple's 2006 co-option of Intel processors to run Microsoft Windows alongside its own proprietary operating system is a classic niche-compatible manoeuvre, which so far seems viable. As ever, a range of social, economic and happenstance factors will decide the case.

#### CONCLUSION

The hegemony of the IBM PC archetype was not inevitable. It has always faced sustained competition from niche alternatives, presented at various technical levels through both incompatible and compatible approaches. Its uniformity in practice has been widely overstated, especially as regards the early years of its incubation and markets outside the United States. Since the PC's origination, its form has been contested and transmuted; its explanatory power as a category now seems to be waning. If so, of the numerous heterodox platform proprietors, Apple at least has survived it; others might plausibly have done so but for various contingent developments.

A relatively unexamined area in my study is the issue of applications software, which became increasingly crucial with the eclipse of IBM and the fast-growing hegemonic role of Microsoft. There is an argument to be made that Microsoft enjoyed not so much a path-dependent apotheosis as a sustained run of luck in repulsing challenges to its special status. Beyond Digital Research, we might consider software applications such as WordStar or Lotus 1-2-3, which showed clear market dominance in the CP/M or early PC eras, and whose proprietors sought to make them integral to the PC standard.<sup>138</sup> Perhaps the strongest example arose much later: the Netscape web browser, around 1995–97, presented a non-Microsoft hegemony in a field that seemed, to many, to be fundamentally redefining the personal computer. Microsoft's deflection of this challenge, though successful, drew on its monopolist advantages to an extent that directly triggered the antitrust civil actions of 1998, which nearly saw the corporation disaggregated into separate operating systems and applications arms.

I do not deny, of course, the genuine uniformity that was established in the wake of IBM's intervention. The PC platform, after all, displays the signal feature of uniform standardization: it has become invisible. To the rising generation of non-expert users, the artefact is merely 'a computer'. Computers, with the possible exception of Apple Macs, do not possess

kinds, and ‘PC’ is merely an initialism, its specific association with the 5150 long forgotten. Yet, this uniformity has its limits. Microsoft today offers the dominant product in some, but by no means most applications sectors; sometimes, there is no dominant product. Microsoft’s Windows operating system, offered in a limited range of configurations, is challenged by a variegated panoply of open-source alternatives, while user customization through software ‘extensions’ is a key promotional feature of the Firefox browser. The personal computer’s material form, meanwhile, is *vastly* more heterogeneous than it was in 1981.

What defines the limits of uniformity? The mistaken belief that convergence is inevitable rests on the assumption that it is *generally desirable* – an uncontroversial matter of convenience, evidently helpful in the eyes of producers, mediators and users alike. If we instead locate particular and contingent causes for convergence (such as mass-production logic or commercial monopoly-seeking), we may expect uniformity to be absent where these features cannot gain traction. This is often the case where specialisms present strong niche identity, where heterogeneity has little apparent cost or where high-volume commercial activity cannot easily demonstrate gains.

To give just one example, the idea of a hegemonic standard *coding language* is unknown. Partisans of competing languages still enthusiastically debate their efficiency, intelligibility, fitness to specific purpose and aesthetics, while languages differing only moderately from their predecessors continue to be incarnated under new names. While this element of personal computing activity may be unfamiliar to most users, it is hard to think of a case more obviously crucial to the way computer systems evolve. Homogeneity, as noted, has a habit of becoming invisible; but so, too, does heterogeneity, if we make the mistake of reducing the computer to its most uniform elements. The uniform and the diverse, as ever, stand in complex and creative tension.

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#### Notes and references

1. While it is frequently noted that IBM had already released single-user microcomputers, the 5100 Portable (1975) and 5110 (1978) range, these models had little direct influence on later developments. Costing in the region \$10,000–\$20,000, they sold in small numbers and were not addressed to the emerging personal microcomputer sector.
2. A brief investigation of this shift is given in J. Sumner, ‘What Makes a PC? Thoughts on Computing Platforms, Standards and Compatibility’, *IEEE Annals of the History of Computing*, 2007, 29(2): 87–8.



3. J. Schofield, 'Happy Birthday to the PC, a Tool that Changed the World', *The Guardian*, Technology supplement, 2006, 17 August, 6.
4. P. A. David, 'Clio and the Economics of QWERTY', *Economic History*, 75(2): 332–7, presents the hegemony of the QWERTY keyboard as the result of path-dependent standardization on the '*wrong system*' (336, David's italics). David's concern was to demonstrate the historicity of economic processes, rather than to advocate for unadopted alternatives. Such advocacy is, however, a persistent feature of both professional and enthusiast technical literatures: see, e.g. R. Parkinson, 'The Dvorak Simplified Keyboard: Forty Years of Frustration', *Computers and Automation Magazine*, 1972, November: 18–25, available online at <http://infohost.nmt.edu/~shipman/ergo/parkinson.html>, accessed 31 January 2008. The validity of the technical inferiority claim is challenged in S. J. Liebowitz and S. E. Margolis, 'The Fable of the Keys', *Journal of Law and Economics*, 1990, 33: 1–26. A typically intense response from the technical advocate position is M. W. Brooks, 'Dissenting Opinions', 1996, rev. 1999, available online at [www.mwbrooks.com/dvorak/dissent.html](http://www.mwbrooks.com/dvorak/dissent.html), accessed 31 January 2008.
5. Andrew Russell's chapter in this volume critiques a similar 'sluggish monopoly' characterization applied to AT&T.
6. My concern to address the systems context inevitably draws on the theoretical framework of Thomas P. Hughes. For present purposes, this is best seen via his treatment of computer networking: T. P. Hughes, *Rescuing Prometheus: Four Monumental Projects that Changed the Modern World* (New York, 1998), 255–300.
7. My approach here bears similarities to the concept of system *modularity* found in some of the more use-oriented economic literature: R. Langlois and P. Robertson, 'Networks and Innovation in a Modular System: Lessons from the Microcomputer and Stereo Component Industries', *Research Policy*, 1992, 21: 297–313. This literature, however, addresses only the more readily specified hardware and software levels.
8. P. A. David and S. Greenstein, 'The Economics of Compatibility Standards: An Introduction to Recent Research', *Economics of Innovation and New Technology*, 1990, 1: 3–41, on p. 4.
9. M. Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge, MA, 2003), 231–66.
10. My thanks to Ian Martin for his comments on this point.
11. D. Skinner, 'Technology, Consumption and the Future: The Experience of Home Computing', Ph.D. thesis, Brunel University, 1992, 32–69.
12. See in particular L. Antill, 'The Systems Approach', in D. Olney (ed.), *Microcomputing for Business: A User's Guide* (London, 1982), 9–82, esp. 11–13.
13. For the pre-digital and early digital systematization of corporate information management and exchange, see J. Yates, *Control through Communication: The Rise of System in American Management* (Baltimore, 1989); J. Yates, *Structuring the Information Age: Life Insurance and Technology in the Twentieth Century* (Baltimore, 2005). On pre-digital systematization as a gateway to computerization in general, see also J. Agar, *The Government Machine: A Revolutionary History of the Computer* (Cambridge, MA, 2003).
14. Campbell-Kelly, *op. cit.* (9), 215–21.
15. The essence of the TRS-80 user community is well characterized in C. Lindsay, 'From the Shadows: Users as Designers, Producers, Marketers, Distributors, and Technical Support', in N. Oudshoorn and T. Pinch (eds), *How Users Matter: The Co-Construction of Users and Technology* (Cambridge, MA, 2003), 29–50.
16. P. Grindley, *Standards Strategy and Policy: Cases and Stories* (Oxford, 1995), 131–55. I accept Grindley's characterization of the subsequent PS/2 architecture, which I do not address here, as an unsuccessful attempt by IBM to 'reclose' the standard.
17. J. Chposky and T. Leonsis, *Blue Magic: The People, Power and Politics behind the IBM Personal Computer* (London, 1989), 23–4.
18. 'IBM's Estridge' (interview with Don Estridge), *Byte*, 1983, 8(11): 88–97, esp. 89.
19. Note also the machine's conservatism at the aesthetic design level: P. Atkinson, 'The (In)Difference Engine: Explaining the Disappearance of Diversity in the Design of the Personal Computer', *Journal of Design History*, 2000, 13(1): 59–72, on 65.
20. One widely distributed version of the legendary account is R. X. Cringely, *Accidental Empires: How the Boys of Silicon Valley Make their Millions, Battle Foreign Competition and Still Can't Get a Date*, 2nd revised edn (London, 1996), 128–9.

21. P. Isaacson and E. Juliussen, 'IBM's Billion Dollar Baby: The Personal Computer', 1981, 1. (Not currently available online. Richardson, Texas: Future Computing Inc.)
22. The episode is covered in Chposky and Leonsis, *op. cit.* (17), 39–53; Cringely, *op. cit.* (20), 127–34; Campbell-Kelly, *op. cit.* (9), 239–40.
23. 'CP/M, the First PC Operating System', Digital Research website, n.d., available online at [www.digitalresearch.biz/CPM.HTM](http://www.digitalresearch.biz/CPM.HTM), accessed 27 September 2007. Tim Paterson, author of the project that became MS-DOS, repudiates this characterization: see P. Ceruzzi, *A History of Modern Computing*, second edn (Cambridge, MA, 2003), 270–1.
24. R. Langlois, 'External Economics and Economic Progress: The Case of the Microcomputer Industry', *Business History Review*, 1992, 66(1): 1–50, on 21.
25. Gates to Portia Isaacson, 29 September 1981 (personal archives of Portia Isaacson Bass).
26. By 'compatibility' in this paper, I generally intend what David and Bunn term 'substitute' compatibility (as between an IBM and a clone PC, one of which may be used in place of the other). 'Complement' or 'vertical' compatibility (as between the PC and its software) is, however, a crucial element of system or platform definition, as will become clear. P. David and J. Bunn, 'The Economics of Gateway Technologies and Network Evolution: Lessons from Electricity Supply History', *Information Economics and Policy*, 1988, 3(2): 165–202, on 171.
27. R. C. Brooks, 'Standard Screw Threads for Scientific Instruments', *History and Technology*, 1988, 5: 59–76; D. Puffert, 'Path Dependence in Spatial Networks: The Standardization of Railway Track Gauge', *Explorations in Economic History*, 2002, 39: 282–314.
28. A defining influence in the development of electronic digital computing technology was the concept of the *universal machine*, a tool whose purpose and behaviour, understood in terms of symbolic manipulation, are not determined by its form or circumstances but could (within various material constraints) be extended to encompass anything. For the universalizing shift, see, e.g. A. Hodges, *Alan Turing: The Enigma*, revised edn (London, 1992), 290–305.
29. Frank Veraart's contribution to this volume discusses a rather different version of the universal translation principle. 'Basicode' achieved acceptable speed and convenience by deliberately constraining the possibilities of the system, in a manner that suited hobbyists rather than professional users.
30. The Apple II, often noted as a 'closed-architecture' machine, was in fact designed from the outset to be 'open' to modular expansion possibilities such as the SoftCard: Langlois and Robertson, *op. cit.* (7), 307.
31. Compare Apple's dilemma over the licensing of its Macintosh user interface in 1987, in which the lock-in existed at the hardware level: Grindley, *op. cit.* (16), 152.
32. 'Has the Future-Proof Computer Arrived?', *New Scientist*, 1982, 23/30 December: 800; 'Tycom Offer a Free Computer' (advertisement), *The Times*, 1983, 27 September: 21A. Tycom claimed 'future-proof' as a trademark; the earliest documented use of the term traced by the *Oxford English Dictionary* occurs in an advance report on the Microframe from February 1983.
33. G. R. Taylor and I. D. Neu, *The American Railroad Network, 1861–1890* (Cambridge, 1956), 59–60.
34. Cf. David and Bunn, *op. cit.* (26), 170–1. David and Bunn's characterization of the 'gateway' goes beyond most economic literature in capturing the looseness of compatibility in practice, but does not address less technically formalized modes of 'compatibility'.
35. Summarized in R. Ward, 'Levels of PC Compatibility', *Byte*, 1983, 8(11): 248–9.
36. Ceruzzi, *op. cit.* (23), 270.
37. An excellent study addressing physical form is P. Atkinson, 'Man in a Briefcase: The Social Construction of the Laptop Computer and the Emergence of a Type Form', *Journal of Design History*, 2005, 18(2): 191–205. See also Atkinson, *op. cit.* (19), esp. 64–67, 70.
38. 'IBM's Estridge', *op. cit.* (18), 90.
39. Grindley, *op. cit.* (16), 142–4, offers some useful comments on Apple's niche presence from an economic perspective.
40. M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine*, 2nd edn (Boulder, CO, 2004), 121–2.
41. Schmidt and Werle have applied the social constructivist's concept of interpretive

flexibility to the microcomputer, noting its various meanings as perceived by different user groups. Their principal distinction, between the 'stand-alone' and 'networked' machine concepts, is not addressed here, as it only became significant in the mass market towards the end of my study's timeframe. S. Schmidt and R. Werle, *Coordinating Technology: Studies in the International Standardization of Telecommunications* (Cambridge, MA, 1998), 74.

42. N. Selwyn, 'Learning to Love the Micro: The Discursive Construction of 'Educational' Computing in the UK, 1979–89', *British Journal of Sociology of Education*, 2002, 23(3): 427–43. A useful contemporary source on the emergence of this ethos is P. Kriwaczek, 'BBC Television's *The Computer Programme*: Evolution and Aims', in 'The BBC Computer Literacy Project: Has It Succeeded?', papers of Professional Group Committee C6 of the IEE, December, 1982, copy in British Library.

43. L. Haddon, 'The Home Computer: The Making of a Consumer Electronic', *Science as Culture*, 1988, 2(1): 5–51, on 30. For Sinclair as a national success story, see R. Dale, *The Sinclair Story* (London, 1985); and for the problematics of this characterization, I. Adamson and R. Kennedy, *Sinclair and the Sunrise Technology: The Deconstruction of a Myth* (Harmondsworth, 1986). See also T. Lean, "'What Would I Do with a Computer?'" The Shaping of the Sinclair Computer, 1980–1986', MA thesis, University of Kent, 2004, 14–34.

44. For instance: [Microcomputers Etc. advertisement], *Computer Age*, 1(9), August 1980: 2.

45. Dale, *op. cit.* (43), 107.

46. For instance, E. Deeson, 'The Sinclair ZX-81: Toy or Treasure?', *Physics Education*, 1981, 16: 294–5. Veraart's chapter in this volume examines the hobbyist cultures that also helped to sustain such machines.

47. B. Bagnall, *On the Edge: The Spectacular Rise and Fall of Commodore* (Winnipeg, 2005), 152, 159.

48. Haddon, *op. cit.* (43), 36–42, 45–9.

49. These products await serious analysis, but are often already the subject of chronicles by insiders or enthusiasts. See, e.g. D. Linsley, 'A Slayed Beast: History of the Dragon Computer', revised edn, n.d., available online at [www.dragon-archive.co.uk/index.php?option=com\\_content&task=view&id=8&Itemid=27](http://www.dragon-archive.co.uk/index.php?option=com_content&task=view&id=8&Itemid=27), accessed 25 September 2007; J. Harworth, *Oric: The Story So Far* (Cambridge, 1992), available online at <http://oric.ifrance.com/oric/story/contents.html>, accessed 3 October 2007.

50. The assertion of thorough-going 'Britishness' in parts and manufacture was a running theme in the punched-card era: M. Campbell-Kelly, *ICL: A Business and Technical History* (Oxford, 1989), 79–81, 100–2. Governmental promotion and subsidy of British equipment are perhaps most closely associated with the Wilson administration's 1960s Ministry of Technology: *op. cit.*, 246–8.

51. G. Laing, *Digital Retro* (Lewes, 2004), back cover, provides an evocative, rather tongue-in-cheek characterization: 'Long before Microsoft and Intel ruled the PC world, a multitude of often quaint home computers were battling for supremacy .... Products from established electronics giants clashed with machines which often appeared to have been knocked together in a backyard shed by an eccentric man from Cambridgeshire. Plenty actually were. Compatibility? Forget it!'

52. For which (defined with respect to the earlier, large-computer case), see J. Hendry, *Innovating for Failure: Government Policy and the Early British Computer Industry*. (Cambridge, MA, 1989).

53. T. Lloyd, *Dinosaur & Co.: Studies in Corporate Evolution* (London, 1984), 106, 109–10, 114–15; Dale, *op. cit.* (43), 85. Specifications as given in Laing, *op. cit.* (51), 102–5, referring to the higher-specified of two models launched.

54. R. Woolnough, 'Starting Young', *The Times*, 1983, 7 June: 23G. From a founding basis of direct collaboration with Acorn, Torch moved to be a largely independent OEM client. In 1984, however, Acorn acquired what amounted to a controlling stake in the smaller firm.

55. Lloyd, *op. cit.* (53), 113–14, presents the Tube concept as emerging as a means to avoid conflict among the broad range of expert constituencies within Acorn.

56. *Beebug* [BBC Micro user group newsletter], 1982, October, 1(6): 22.

57. For example, [Torch Disc Pack advertisement], *Micro User*, 1983, April, 1(2): 3.

58. [Torch advertisement], *The Times*, 1983, 4 July: 25A.

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59. For instance, J. Derrick and P. Oppenheim, *What to Buy for Business* (London, 1982), 122–3 and passim.
  60. *Practical Computing*, 1984, 7(6), June: 67.
  61. [Ferranti Argus Pro-personal advertisement], *Practical Computing*, 1984, January, 7(1): 74–5.
  62. *Personal Computer World*, 1984, April, 7(4), Supplement: 15.
  63. R. Cullis, ‘To the BBC by Bus and Tube’, *Practical Computing*, 1984, December, 7(12): 81–5.
  64. M. May, ‘New Micro for Small Business’, *The Times*, 1984, 8 May: 23H; P. Liptrot, ‘W H S Goes for the Advance’, *Home Computing Weekly*, 1984, 15 May: 5.
  65. D. Thomas, *Alan Sugar: The Amstrad Story* (London, 1990), 123–4.
  66. Thomas, *op. cit.* (65), 230.
  67. Thomas, *op. cit.* (65), 184.
  68. Quoted in Thomas, *op. cit.* (65), 176.
  69. Thomas, *op. cit.* (65), 224–6.
  70. G. Kewney, ‘Newsprint’, *Personal Computer World*, 1984, October, 7(10): 86.
  71. ‘New Acorn Micro’, *Acorn User*, 1984, October, 3(3): 7–8; G. Kewney, *Personal Computer World*, 1984, 7(12): 100–1; P. Bright [ABC 310 benchtest], *Personal Computer World*, 1985, 8(4): 121–6.
  72. C. Cookson, ‘Micro Boom’s First Victim’, *The Times*, 1983, 31 August: 1H.
  73. Dale, *op. cit.* (43), 133–42; Adamson and Kennedy, *op. cit.* (43), 153–82.
  74. Adamson and Kennedy, *op. cit.* (43), 217–24; Thomas, *op. cit.* (65), 188–206.
  75. ‘Smiths: Advance Backs Out’, *The Times*, 1984, 24 October: 34B.
  76. M. Banks, ‘Making Acorn Fit the Space’, *The Times*, 1985, 6 August: 23A.
  77. Campbell-Kelly, *op. cit.* (9), 216–19, 251–66.

