Exploring the evolution and relationship between Mobile and Desktop UI efficiency and effectiveness

Abstract

This secondary research paper looks at the origin and evolution of desktop application user interfaces as well as the origin and evolution of mobile application user interfaces. It looks at which elements have made the transition from desktop to mobile, in both functionality and form. The research explores and concludes that a user's chronological familiarity with either system is being inverted overtime, where users will have traditionally started using desktop and then used a mobile user interface, this pattern is now reversed. Finally the analysis of sources explored has shown that being able to tap into the users past experience will allow a developer to make assumptions around user behaviour.

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Introduction

Modern mobile telephones or, using the interchangeable name, smart phones to make use of the term coined by Savage (1995) are power houses of processing power. The recent Snapdragon 888 5G processor boasts a compliment of eight cores and features clock rates of up to 2840mhz, Hinum (2021). These formidable attributes place the computing power of handheld smartphones within the same scope of the average computational power of desktop computers. Looking to harness and capitalise on the decades of research and engineering that has been applied to these small silicon based mathematical masterpieces, are an ever growing legion of application developers.

When an application is imagined, it is rarely done so without some level of interaction with one or more users. Identification and capture of user input into the application is of fundamental importance to the overall development process. It can be noted that as computers have evolved so to have the various methods of input capture these include keyboards, mice, voice, ocular tracking, gesture tracking and touch screens to highlight a selection of the most commonly used methods.

Combining these various approaches of user input with the development of an application, regardless of the platform, mobile or desktop, requires that consideration is given to the user interface. This paper looks at the evolution of user interfaces, firstly from the development of desktop applications, then from the perspective of mobile application development. Exploring how the latter has informed the former in both established user behaviours and user practices. In addition to this retrospective, the more practical considerations of modern cross platform application user interface design have been explored with a focus on the factors that correlate to the overall effectiveness and efficiency of the user interface.

Literature Review

Origin of desktop UI

When evaluating the origins of modern desktop application user interfaces, the essential core trilogy of elements that is most commonly found across the majority of systems is a screen, mouse and keyboard as seen in the Apple advert from 1984 showing the IIe and IIc models.

1964 was the year that saw the first prototype for a mouse, carved from wood by the electrical engineer Douglas Engelbart. This initial prototype was then moved around several research laboratories at Stanford Research Institute before emerging into the commercial world in 1982 (Wigley, 2010). Now it is hard to imagine a desktop computer including a mouse, indeed it can be argued that as users we almost reach for it without thought.

The foundation of the QWERY style keyboard can be traced back to Christopher Latham Sholes who patented an idea for the typewriter in 1868. Just nine years later in 1877 the Remington Company began selling the first typewriters to the public on mass. From this starting point over the following centaury aided by the application of technological advancements the original concept of the typewriter evolved into the standard design for a keyboard that is known the world over. (Bellis 2020)

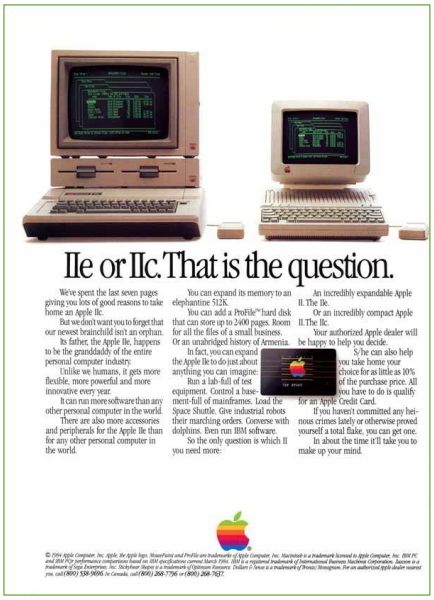

Fig 1: Apple press advert 1984, showing the IIe and IIc

Making up the final element of the trilogy is the screen or computer monitor. Original computer monitors used cathode ray tube technology to display an output from the computer to the end user. Over time the Video Graphics Adapter or VGA system was developed by IBM and introduced to the consumer market in 1987. The VGA standard allowed for a resolution of 640 x 480 pixels coupled with a refresh rate of up to 60hz. Whilst at that higher resolution it was possible to display up to sixteen colours. If the resolution was

dropped to 320 x 200 pixels, then the display was capable of showing two hundred and fifty-six colours. (Computer Hope 2021).

From a desktop application development standpoint having these core elements, that could potentially be taken for granted in the least and accepted as the norm at best, allows developers to create more effective and efficient user interfaces.

Evolution of desktop UI

Given that, at a higher level, the main methods of user interaction with a desktop computer system and at the lower level, interaction with desktop computer applications have been established, it then follows that the environment for evolution can occur, and indeed has. Possibly the most fundamental change in user interfaces was the move from command line to a more user-friendly graphical user interface approach. To highlight one of the most prolific examples of this would be to shine a light upon Microsoft and more specifically their Windows operating system. Currently Microsoft (2021) boasts that their Windows 10 operating system is being used by over one billion users globally.

Windows itself being one of the first things that a user will interact with has both consciously and sub- consciously informed application development over the several decades since its version 1 release in 1985. Indeed, the marketplace dominance that Microsoft has had over the following 36 years has had an impact upon user behaviour. Whilst it is of worthy note that Microsoft themselves have not always been the original source of all elements of UI and user behaviour, it is hard to argue that they have not by virtue of adoption, made said elements common place.

To list some of the most common UI assumptions that a user may make when using a desktop application.

- The X symbol will be located in the top right and when clicked with the left mouse button, the application or "window" will be closed.
- The menus for the application will be found along the top edge of the window, usually from left to right.
- A single right click within the window for the application will display a menu of commands/functions for the user.
- The _ symbol will be located in the top right and when clicked will minimise the application window.
- The 🗗 symbol will be located in the top right and when clicked will toggle the window between full screen and window mode.
- That a left click will select an item or confirm a selection of a menu item.

Another evolution that has occurred with UI over the years is the adoption of keyboard shortcuts. These will commonly utilise the ctrl or alt keys in combination with another key on the keyboard. Arguably the three most commonly used almost universal keyboard shortcuts are ctrl + c to copy something, ctrl + v to paste something and ctrl + alt + del when your windows-based system freezes, to bring up access to the task manager.

Origin of mobile UI

There was a clear point in time when mobile telephones made the shift from being a device whose primary purpose was that of voice communication with other users to more of an all-round multifunctional tool. Looking at the earliest mobile devices one of the main differences that stands out is the with the hardware of the device itself. Older handsets did not have touch screens, instead having a numerical pad, occasionally the manufacturer would include additional navigational buttons along with a select and or back/undo button. An example of this can be seen in the image of the Nokia 3310 in Fig 2, the device includes a single left/right button to allow the user to navigate through menus, whilst also including a cancel button and a larger select button. It can also be observed that on the numerical pad there are several other functions that can be accessed by using a long press instead of a short press, such as holding the number 1 key will trigger the phone to attempt to access its voice mail.

Fig 2: Nokia 3310 Handset

Bhagat in his 2015 article looks at how the world of smartphones has changed over the two decades since IBM released what he describes as the first real smartphone. Indeed, the device released by IBM on 16th August 1994 combined the technology of a Personal Data Assistant and mobile telephone. At the time the IBM Simon utilised a Datalight ROM-DOS operating system and boasted 32kb of memory, but perhaps more importantly it featured a touch screen. This was a new way for the user to interact with the device, interestingly the main functions initially used by early touchscreen devices were the same ones that manufacturer had added hardware buttons for also, selecting items and scrolling.

Another milestone in the origins of mobile device user interface was that of the addition of a qwerty keyboard, this time it was Nokia almost exactly two years after IBM's Simon with their Communicator 9000 whose flip open design presented the user with a functional qwerty keyboard. In addition to the normal alphabet and numerical buttons Nokia also included quick launch buttons for some of the devices pre-packaged applications such as Tel., Fax, SMS, Internet and Calendar.

Perhaps one of the final advancements that opened many doors for developers of applications for mobile devices was the inclusion of a colour screen, Kendrick (2010) comments that HTC with their O2 XDA was the first 3.5-inch colour touch screen device released in 2003. Having the ability to add colour into the toolbox of the application developer, greatly increases the scope of user interface design, the effective and efficient use of colour cannot be overstated.

Evolution of mobile UI

Over the last 25 years, sales of smartphone devices have soared with sales in excess of one billion units each year, every year since 2014, peaking at 1.5 billion in 2018 (statista, 2021). As the manufacturers have revised the hardware for their devices one of the trends that could be observed, over that period of time, was the reduction in size of the included qwerty keyboard devices. From the original Nokia Communicator keyboard that was 173mm wide (NokiaMuseumInfo 2021) manufacturers made the keyboard smaller and smaller, non-more so than Blackberry with their curve range of phones whose keyboards were smaller than 100mm. Indeed, Blackberry could be argued to be the last holdout for inclusion of a physical qwerty style keyboard. It is worth noting that there was a strong

leaning towards more business-based sales for these devices rather than the general public, this could be seen in marketing and UI functionality.

As the manufacturers started to remove the keyboard from their devices, this then allowed for a larger screen, a screen that could be utilised in many different ways. One of the common elements of modern smartphones, the virtual keyboard, essential for any UI experience involving writing messages, was not originally included with android for the first six months of its release. It was not until Android 1.5 before a virtual keyboard was included, unlike Apple who launched with a virtual keyboard included with their IOS (Victor, 2015).

At this point the main way that users interact with their smartphones is still tactile based touching of the screen and or buttons. With some manufacturers opting to replace button-based inputs with gestures on the touch screen. One such example of this is between Samsung and their phone range and the Google Pixel phone range. On Samsung devices it is common to find a "back" button, usually located in the lower left corner of the device, originally separate from the screen and in more recent times replicated on the screen as a button that can be hidden and shown depending on the software. This button when pressed would typically take the user back or undo an action. Google on the other hand have not included this button, either physically or virtually on the screen. Instead, users of the Pixel smartphone achieve the same functionality by swiping from right to left on the screen in the central third of the screen.

When exploring the evolution of UI on smartphones one of the primary components that must be looked at is the gestures beyond a simple touch selection on the screen. Material.io (2021) Googles design system that looks to help developers create intuitive and efficient user interfaces, categorise gestures into three core groups:

- Navigational gestures
    - Tap
    - Scroll and pan
    - Pinch
    - Drag
    - Swipe
- Action Gestures
    - Tap
    - Long press
    - Swipe
- Transform Gestures
    - Double tap
    - Pinch
    - Compound gesture
    - Pick up and move

As can be observed, reviewing the above list there are duplications of gesture type, this could indicate that developers should show consideration for a user's pre-conceived notion as to how a gesture will work. Conversely it is possible that a developer is able to create a new gesture that will simply be accepted as the norm moving forward after a period of time. A clear example of this would be the American software developer Loren Brichter, who in 2008

created the "Pull-to-Refresh" interaction technique, now 13 years on this same element of usability has been duplicated across the mobile application landscape and is so commonplace that users will assume its presence in most applications.

How desktop informed mobile

By simple virtue of chronological order users of a certain age will have had access to and used desktop applications for some time before having access to mobile applications. This would indicate that early developers of mobile applications would be guided in their logic and approach to mobile application development by their experience with desktop applications. Indeed, it is incredibly likely that the majority of the first mobile application developers were existing developers for non-mobile based applications.

Though that almost certainly was the reality during the infancy of mobile application development, it must be acknowledged that the landscape has most certainly shifted. During the period of time between the mid 1980's and up to the late 1990's an individuals first interaction with a computer would typically take place within the education system. With home computers being more commonplace during the late 1990's, this would indicate that a user would experience a more educational based user interface, from which to build their likes, dislikes and expectations from. Now in the year 2021 given the volume of mobile devices, it is exponentially more likely that an individuals first interaction with a computer will be via a mobile device. Typically, a parent allowing a child to "play" with their phone, even schools now widely have adopted using tablets for education and interaction at a very young age.

What this indicates is that where desktop application user interfaces may have originally informed design choices made by mobile developers, such as having the ability to copy and paste or mimicking certain mouse operations. For example, within most word processing applications on a desktop when you double click on a word in a document it will select that word, this same interaction can occur on a mobile based word processor when a user double taps a word on the touch screen, the word will be selected. These signs of desktop user interfaces guiding and influencing mobile user interfaces can be found readily.

Cross platform UI

Looking at the subject of cross platform development and software solutions commercially available there seems to be several key groupings of target application as well as target platforms. Within the gaming industry, software such as Unity allows a developer to work on an application/game and with little work make the same application/game work across any number of desktop, mobile, console and even appliance based platforms (Unity 2021).

The desire for developers to be able to create applications for more than one platform and arguably be able to increase the reach of their product by expansion into wider or more niche user bases, has led to a number of platform independent graphical user interface libraries. Usually these libraries will be free or open source, one of the most popular is the Chromium Embedded Framework (CEF) that covers Linux, macOS and Microsoft Windows, this library allows a developer to embed a web browser and all of its functionality into their application

Within the mobile application development space one of the more prominent cross platform tools is the Google product Flutter (Google 2021). This open-source user interface software development kit allows for applications to be created across platforms such as Android, iOS, Linux, Mac, MS Windows and Google Fuchsia all from a single code base. The Flutter software is still being worked on and actively developed further with the latest stable release

v2.0.3 being released on March 20th 2021. The foundation of Flutter is the Dart language with some C++ also. It is worthy of note that Google has announced Flutter 2 in March 2021, though rather than being a new product it will simply be an evolution of the original Flutter but including further cross platform support for web-based applications as well as Linux, MacOS and Windows.

Shneiderman and Nielson

It would, arguably, be remiss of any author when researching the subject of user interfaces within the scope of software development to not highlight the work by Ben Shneiderman and Jakub Neilson. In 1986 Shneiderman first published his "eight golden rules of interface design", eight years later Neilson released his own "ten useability heuristics". Though the work of Nielsen, could be seen as advancing upon the original work of Shneiderman, rather than being 'original' in its own right, both pieces of work are still incredibly relevant to the developers of today's applications.

Whilst it is clear that when these papers were first authored, mobile application development had not occurred yet. The impact of both of these papers can be seen and felt in almost all commercially successful software. Take Shneiderman's third rule "Offer informative feedback", when you look at early smartphone user interfaces, it was commonplace that the user would receive feedback in the form of a tone or vibration of the device itself, when a button was pressed. Equally one of the more prominent points made by Nielson, would be number six on his list "Recognition rather than recall" this approach holds very true for mobile application development, especially when there is such limited screen real estate.

Discussion

Looking at the current state of development of application interfaces be that on a mobile platform or a desktop platform, it would be more than fair to say that developers have been able to leverage a prospective user's potential history of interaction with other applications. This can be seen in the most basic of user interface functionality, specifically in how a user will look to the top right corner of the screen for the X symbol to close a window or tab. This inherited almost instinctual behaviour on the part of the user's also shows testament of what elements have worked over the decades that user interfaces have been being produced. In an almost survival of the fittest scenario a modern developer striving to create a user interface has that benefit where they will be able to research and find examples of what has worked and more importantly perhaps what has not worked with user interfaces in the past.

When considering what specific elements have made the jump from desktop application user interface development to mobile device-based user interface application development, no item is more prevalent than the button. The simple ubiquitous button that can be found in any number of dialog boxes or user interface elements on a desktop application has been used with ease on mobile devices. Typical interaction with a button on desktop application would require the user to left click with a mouse. This same interaction is replicated on a mobile device touch screen, with a simple tap, that same tap that a finger would make on the mouse button. The almost basic level of symmetry speaks to the efficiency and effectiveness of the gesture. Similarly, staying with the mouse as a primary user interface tool, one of the additions to the mouse was the scroll wheel, allowing users to move the focus of the window or application display pane along the vertical axis, shifting content up or down in relation to the user's input. This core user interface functionality is able to be replicated on a touch screen, whereby the user will swipe up or down to achieve the same output as with the mouse wheel. Indeed, mobile application user interfaces have taken

this and developed it further and will typically allow a user to not only navigate on the vertical axis but also by swiping left and right on the horizontal axis. This user interface functionality has even transcended its original self to become synonymous within pop culture when referring to online dating applications.

It is apparent from the research carried out that mobile based application users outweigh desktop-based application users by some margin. Certainly, if smartphone sales are an indicator, then the vast majority of adults will have or have had access to a smartphone/mobile device. Unlike a desktop application which typically requires the user to be sat at a desk with a screen, mouse and keyboard a mobile device user could with very few restrictions be able to access that platform specific application anywhere. This could indicate that developers should give consideration that the user may not even be in a stationary position when using the application. There are a large number of applications targeted at the more physically active user, perhaps a song streaming service or a fitness tracking suite. Certainly, in these examples it is more than fair to say regard should be given to the user interface and what the user may actually be doing, this could manifest in larger buttons depending on the application state.

Another element that became apparent from the research conducted was that it is more likely, today in 2021, that a user's first interaction with an application would occur on a mobile based device over the traditional desktop computer with a standard input array. Within British education establishments adoption of tablets as a tool to aid in education is now widespread. This generationally based shift in how and when users start to build their individual experience with computers and by extension applications is something that should be factored in when a developer implements a user interface.

One consideration that focuses on the specific issues that a mobile application developer should potentially be giving regard to is the specificity of the device's dimensions. If the device is a smartphone over a tablet, then it is feasible that a user may be interacting with the application via the user interface with a single hand. In the case of a tablet then this would typically indicate that two hands would be interacting with the application. When looking at the single-handed possibility then further thought should be given over to the user's hand size and reach.

Conclusion/recommendations

It is possible to conclude that when a developer is creating a user interface for an application then there are several key factors that should be considered. Firstly, which specific device they will be creating the user interface for, this will inform the developer how much space they have to work with in terms of screen real estate and ability to show and display information to the user. In the case of a desktop application user interface the developer will obviously have more space to show more to the user than in the case of a smartphone application.

It can be further evidenced that one of the core considerations when designing the user interface should be around the profile of the user interacting with the application. Extending this further to the situations that the user is likely to be interacting with the application. Beyond this there is also merit to be had in exploring other possible scenarios where a user may be interacting with the user interface that are equally common to user behaviour, if not as intended by the developer.

There is currently a window of time where a newly released applications prospective user base is one that had initially first used a traditional desktop computer over a mobile device-based experience. This indicates that that specific demographic's computer interaction history could be harnessed to the advantage of the developer in making an

efficient and effective user interface. Though this possible boon of expected user behaviour undeniably exists, it must equally be acknowledged that the very same window of time is shrinking and will soon, if not already, be closed and the majority of computer users will have a familiarity with mobile devices that is primary to the secondary desktop device.

If further research were to be carried out in this area, then one clear line of enquiry would be that of minority access to user interfaces, be that due to age, physical impairment or mental impairment. This paper has focused on the typically able user and not given consideration to individuals with any external boundaries that would have any impact with that user's interaction with a user interface.

Finally, this paper can be treated as an overview of the subject of mobile and desktop application user interfaces, it has been looking at the subject from a higher more generic level, there is scope for further research to be carried out on a more lower granular level, perhaps focusing on a single platform.

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