Demo: Enhancing Smartphone Productivity and Reliability with an Integrated Display Cover

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Abstract
We describe a concept smartphone Display Cover, a secondary screen designed to improve productivity and convenience. Motivated by user research highlighting some of the limitations of current smartphones, the aim of this concept was to explore a practical solution which allows users to be more productive.

ACM Classification Keywords
H.5.2 User Interfaces; K.8.2 Personal Computing Hardware.

Introduction
The smartphone is used for everyday tasks ranging from grocery shopping to managing diaries, as well as keeping in touch. Smartphones are also used for information work including email, web search, reading and increasingly for document editing and creation in situations and locations where a laptop or tablet is not convenient. However, the small size of a smartphone's display and input surface constrain many tasks.

Users Want a Larger, Always-on Screen
A wealth of research and many products aim to provide easier, faster and/or more reliable access to, and manipulation of, information using a smartphone.

Prototype Display Cover

Figure 1: Our working prototype Display Cover is fully integrated with a Lumia 640 smartphone. The cover is less than 3mm thick in total, making it comparable to a regular protective cover.

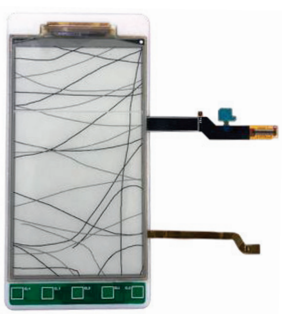

Figure 2: Between the grey soft-touch fabric which forms the display bezel and the Alcantara fabric on the outside of the cover, the e-ink display module and the touch buttons are mounted in a rigid 3D-printed housing to give the cover a uniform thickness (below).

We carried out a series of interviews to learn from users what smartphone tasks they would like to improve. These highlighted a need for more information to be displayed, and for input which didn't compromise so much of the display. Another recurring theme was the desire to access information stored on smartphones more quickly, easily and reliably. At the same time, our participants were unwilling to compromise on form-factory – they didn't want a physically larger phone.

Based on these insights we explored several 'second screen' design concepts with our participants. We focused on technologies which would be cost effective and reliable. The most popular concept was the Display Cover described here, a touch-enabled e-ink second screen built into a regular protective flip-cover.

Related Work

A wide variety of technologies and techniques to extend display real estate and enhance smartphone interaction have been presented. Pohl et al. created a large virtual display by dynamically adapting the content on a real display as it moves [6]. Ramakers et al. introduced a continuously folding display and envisaged many interaction possibilities for it, leveraging projection to illustrate what is not yet practical [8]. Gomes and Vertegaal also presented a folding tiled display by way of a tethered e-ink prototype [2]. Gomes et al. then showed how an e-ink display can be used to extend the interactive display surface of a laptop [3]. Rendl et al. and Lahey et al. used 'tethered display' prototyping techniques to create smartphone secondary e-ink displays, exploring various interaction techniques [9], [5]. A recurring theme is the use of a low-power display to supplement an existing device, either fully integrated or as an accessory of some kind.

In addition to the above research projects, a variety of dual-display smartphones and second-screen accessories have been launched in the market over the past decade. These include: YotaPhone [11], NEC Medias W N-05E, Oaxis InkCase [4], PopSlate [7], and Siswoo R9. None has yet established a new interaction paradigm. Our Display Cover concept, see above, builds on these previous research ideas and products.

Prototype Display Cover

Our prototype, shown in Figure 1, uses a pre-existing flexible e-ink display module. For expediency we didn't integrate a touch overlay; instead we incorporated five touch 'buttons' at the bottom of the display. The touch buttons and display connect to interface circuitry added to the rear of the phone – a Lumia 640 – via flat-flex cables which run through the flip cover 'hinge' along with a bend sensor. The cover itself consists of a bezel of soft-touch fabric which is heat-bonded to the display and to the rear surface of Alcantara [1] using custom-made heated tooling. To reduce cost and lead time we 3D printed this tooling in stainless steel at Shapeways [10]. Our interface circuit is powered via a connection to the phone's battery and we used Bluetooth for communication with the phone. We designed a slightly larger rear cover for the phone to house the interface electronics. We 3D-printed the first prototype covers but moved to vacuum-casting for improved strength.

The software experience for our concept allows the user to press-and-hold any touch button to initiate a primary screen capture which is then associated with or 'pinned' to that button and rendered on the e-ink display. A short press of any touch button re-renders that button's previously pinned screen capture. Several usage scenarios are shown overleaf in Figure 3.

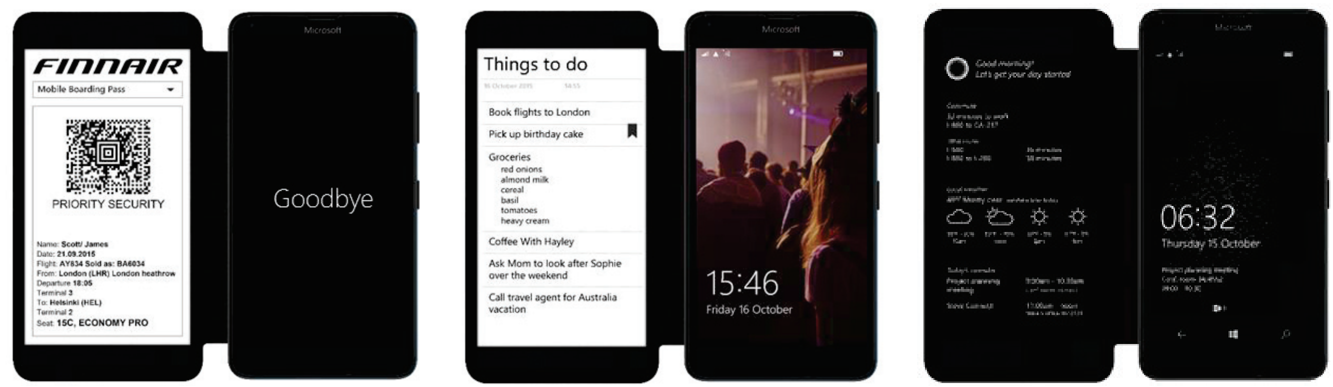

Figure 3: With our research concept, important information may be 'pinned' to the secondary display for instant, reliable access, e.g. e-tickets (which may be accessed even when the phone battery is depleted, left), to-do lists (middle) and a digital assistant (right). Manual 'pinning' of main display screenshots is supported by our prototype.

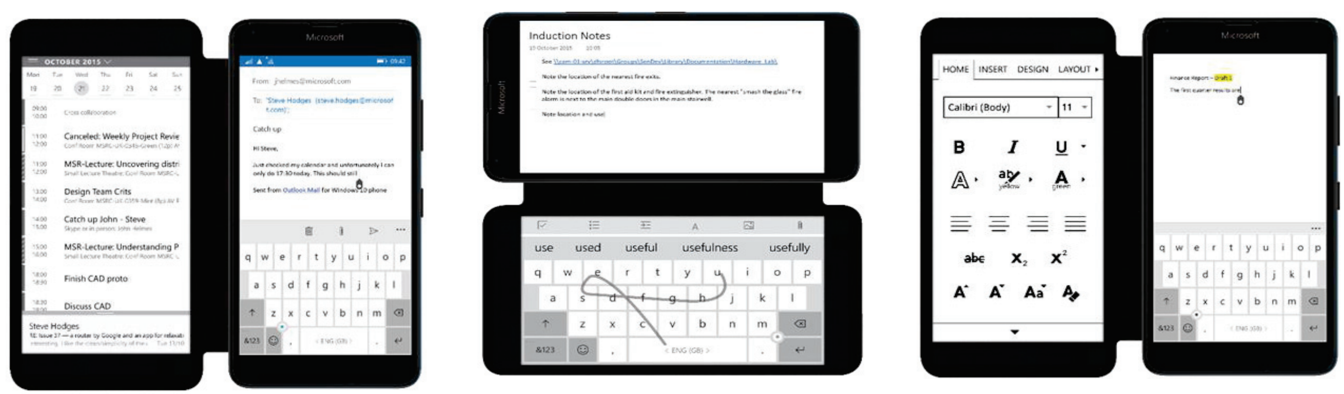

Figure 4: Our research concept can accommodate "laptop-class" tasks which require larger screen real estate than traditionally available on a smartphone. Examples include cross-referencing while authoring (left), a touch keyboard (middle) and a dual-screen application (right). In each case the e-ink Display Cover is used to extend the interaction surface. Note that these envisioned scenarios would require an e-ink touch overlay which our prototype does not have.

Early Evaluation, Future Ideas and Conclusions

To our knowledge this concept Display Cover is the first smartphone flip-cover with a fully integrated interactive e-ink display. The standalone, untethered nature of our concept allowed users to adopt our prototypes as a replacement smartphone and thereby evaluate them in everyday, real-world scenarios. The users we worked with during this project were genuinely surprised to learn that a display could be integrated in such a thin form factor and without materially affecting battery life.

Despite the limitations of our basic 'screen shot' experience and the lack of full screen touch interaction, anecdotal evidence from our user trials showed the value of easy access to previously stored information such as electronic boarding passes, train timetables and shopping lists. Using the prototypes led to a variety of suggested future applications which are depicted in Figure 4 on the previous page.

One limitation raised by users was the monochrome nature of the Display Cover; today's consumers expect full color displays. We believe this could be addressed in future with the use of color bi-stable displays.

References

1. Alcantara, https://en.wikipedia.org/wiki/Alcantara_(material), accessed 21 August 2018.
2. A. Gomes and R. Vertegaal, PaperFold: Evaluating Shape Changes for Viewport Transformations in Foldable Thin-Film Display Devices. In Proceedings of ACM TEI'15 Conference on Tangible, Embedded and Embodied Interaction. ACM Press, 2015, pp 153–160.
3. A. Gomes et al. DisplayCover: A Tablet Keyboard with an Embedded Thin-Film Touchscreen Display. In Proceedings of MobileHCI '15 Conference on Human-computer interaction with mobile devices & services. ACM Press, 2015, pp 531-535.
4. InkCase, https://oaxis.com/en/products/inkcase-for-iphone/, accessed 21 August 2018.
5. B. Lahey et al. 2011. PaperPhone: understanding the use of bend gestures in mobile devices with flexible electronic paper displays. In Proceedings of SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM Press, 2011, pp 1303-1312.
6. N. Pohl et al. 2013. An interactive belt-worn badge with a retractable string-based input mechanism. In Proceedings of SIGCHI Conference on Human Factors in Computing Systems (CHI '13). ACM Press, 2013, pp 1465-1468.
7. PopSlate, https://www.indiegogo.com/projects/popslate-2-smart-second-screen-for-iphone#, accessed 21 August 2018.
8. R. Ramakers et al. Paddle: Highly Deformable Mobile Devices with Physical Controls. In Proceedings of SIGCHI Conference on Human Factors in Computing Systems (CHI '14). ACM Press, 2014.
9. C. Rendl et al. 2016. FlexCase: Enhancing Mobile Interaction with a Flexible Sensing and Display Cover. In Proceedings of SIGCHI Conference on Human Factors in Computing Systems (CHI '16). ACM Press, 2016.
10. Shapeways, https://en.wikipedia.org/wiki/Shapeways, accessed 21 August 2018.
11. YotaPhone, https://yotaphone.com, accessed 21 August 2018.