Employing and extending mass-market platforms as core tangibles

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Abstract
Core tangibles are tangible interface elements that support common behaviors across diverse computational systems. Where prior examples have centered upon passive tagged physical artifacts, we introduce complementary approaches employing and extending mass-market computational platforms. First, we show how several common smartphone platforms can serve core tangibles roles interoperably with other tagged objects. Second, we illustrate how the core tangibles concept can be used to extend the interactive real estate and capabilities of digital tablets and other mass-market devices.

Keywords
Core tangibles; cartouches; casiers; tangible interfaces; smartphones; tablets; tabletop interfaces

ACM Classification Keywords
H5.2. User Interfaces (D.2.2, H.1.2, I.3.6).

Introduction
Both ubiquitous computing and tangible interfaces draw deeply from visions of interoperating ecologies of complementary devices (cf. Weiser [12] and Bishop [6]). However, at present few tangible interfaces realize such styles of interaction. We see this as a

critical challenge the TEI community must collectively address as a precursor to broader use and adoption of tangible interfaces. Toward this, a stream of work has begun to investigate *core tangibles* as a means to "provide common, interoperable interface elements for physically embodying digital information within and between a variety of interactive systems" [9].

Earlier steps toward core tangibles proposed *cartouches* and *casiers* [9, 10]. Cartouches provide a means for physically representing computationally-mediated information, operations, people, devices, etc., in fashions compatible with a variety of technologies and platforms [10]. Complementing these, casiers facilitate the use of cartouches and other tangibles in combination with other interaction elements [10], again in broadly interoperable manners. Alternately expressed, cartouches can provide embodiments of "words," and casiers "sentences," within simple tangible grammars.

Prior work has illustrated cartouches made of paper, wood, glass, plastic, metal, etc. [9,10]. While these tangibles were sometimes back-illuminated and often embedded with RFID tags, early examples were largely passive physical elements. Moreover, most examples of core tangibles have been realized as a single embodiment in a specific media.

In parallel, the concept and pragmatics of tangibles aspirationally useful across diverse platforms and mediations suggests prospects for "editions" of varying media and mediation. For example, in the context of paintings, an original or reproduction might be rendered upon paper, canvas, or screen; or with videos, in VHS, DVD, Blu-ray, or online streaming form.

Related ideas have been considered briefly for tangible interfaces in discussions of tokens and constraints [11]. There, both physical and graphical (or "hard" and "soft") tokens, and physical and graphical constraints, were considered. (We see relationships between tokens with cartouches, and constraints with casiers; we leave elaborations for later discussions.)

Figure 1. *Smartphone cartouches used with Microsoft Surface and wall display. Two smartphones – one Android, one iOS – are used as "containers" for Skype (voice/video/chat) handles to people. Each smartphone employs native apps communicating via the OSC protocol. The location within the Surface's grid where these are placed, and how they are manipulated, controls which actions and mediations are executed.*

These examples seem relevant to the core tangibles concept. A cartouche representing (say) one or several Wikipedia pages might be embodied in physical (e.g., paper, wood, glass, or stone) or graphical form. Among other prospects, graphical cartouches seem particularly relevant toward disembodied representations on multitouch tables and surfaces; and in embodied fashions on (e.g.) smartphones and tablets.

Here, we describe work in progress investigating how smartphones and tablet computers can be used as kinds of cartouches and casiers (e.g., see Figure 1). Also, we consider how core tangibles can usefully complement some of the mainstream functionalities of these mass-market technology platforms. We feel these approaches advance the realization of core tangibles, and make steps toward combining mass-market mobile platforms with diverse tangible interfaces.

Employing mass platforms as core tangibles

The rise and widespread adoption of mass-market smartphone and tablet technologies have encouraged us to consider complementary opportunities for core tangibles. Early casier implementations integrated Apple iPad tablet computers beneath slotted widgets [9]. In these examples, the TouchOSC app (targeted toward providing customizable controls for digital music mixing and manipulation [1]) was used as a mechanism for mediating ensembles of interactors (sliders, buttons, wheels, etc.) interfaced to external machines via the OSC protocol. (OSC is also a core mechanism of the tangibles-oriented TUIO framework [5].)

The screens and overall form factors of many smartphones are similar to an earlier suggested cartouche footprint. (The include the DG6 “playing card,” at 3.5”x2.5”; similar to the ISO B8 CG6 format, at 62x88 mm. DG6 and CG6 are examples of common form factors discussed in [10].) Building on the “containers, tools, tokens, faucets” taxonomy of [4] and the tile language of [7], we have made several iterations of smartphone cartouches. First, we implemented several core tangibles candidates using tabbed TouchOSC layouts [1] (Figure 2a). Per [4, 7], we implemented two genres of core tangibles: containers and tools. As a container, we implemented a four-slot cartouche (Figure 2a). As tools, we created three variations.

Two employ continuous interactors (“wheels” and “bars,” as rotary and linear sliders). The third uses discrete interactors, dividing the smartphone screen into a 4x4 labeled grid. We used these smartphones and tablets with TouchOSC-based cartouches and casiers in a class and at several public events. Several lessons are most relevant. First, the TouchOSC app requires several somewhat laborious, PC-associated configuration steps to load content and bind itself to target devices.

While reasonable in the context of (e.g.) one or a few musicians in a performance context, these seemed problematic for broader deployments, where rapid, minimal-knowledge set-up/tear-down seem key. Also, TouchOSC’s limited media capabilities (e.g., inability to display images) is at odds with earlier image-intensive cartouche examples [10]. These experiences lead us to implement native smartphone implementations of cartouche and casier functionality on several platforms. We have made prototype implementations using Apple iOS and Google Android (Figure 2b, c), partly in concert with the Microsoft Surface (Figure 1). As example content, we have implemented smartphone cartouche “containers” representing users of the Skype teleconferencing platform. Our prototype implementation allows both monitoring Skype partner status, and initiating Skype communications.

Several widely used apps already exist with related behaviors. In most respects, these specialized applications far exceed the capabilities of our early implementation. Several facets distinguish our approach. In Figure 1, two smartphones (one Android, one iOS) are used in combination with a Microsoft Surface and a proximal wall display. Today, when Skype is used on a smartphone or tablet, the resulting text, audio, or video session is typically mediated by the same mobile device.

What if users wish video links to be displayed upon the Surface, wall display, or both – with a set-up time of several seconds, in the context of divided visual attention, and/or absent a keyboard or pointer? What if multiple users wish to simultaneously initiate video links? What if the users wish to use the larger interaction real estate of the Surface or wall displays to access, navigate, or manipulate contents of their mobile device – without users necessarily having priorly used, or even trusting, these alternate platforms?

Figure 2. *Three editions of smartphone cartouches. Screens are in the context of the Skype teleconferencing example. a) Existing TouchOSC app, implemented with several container and tool templates; here with four slots bound to people, displaying their Skype status. b, c) Google Android and Apple iOS apps implementing the same functionality, augmented with image labels. d) Prototype network configuration screen.*

We have begun to realize responses that leverage tangible interaction techniques. In Figure 1, the Surface is divided into a grid reminscent of both computer spreadsheets and the counting tables ("tabula") central to commerce for many centuries. Here, some cells on the table have fixed behaviors: e.g., displaying contents upon the wall display, or the Surface itself. Other cells have evolving, context-dependent contents. Following this approach, where the smartphone cartouches are placed, and how the smartphones are physically relocated upon the table, can govern the interpretation of present and future interactions.

While we have discussed a simple Skype usage scenario, past cartouche examples and discussion describe broader existing and prospective applications of cartouches (most with little connection to Skype) [10]. We feel the malleability of smartphones' dynamic sensate display further broadens the diversity of content types appropriate for these dynamic cartouches. Also, as demonstrated by the DataTiles system [7], when the types of tools, containers, and associated contents diversify, the prospects for multi-tangible composition increase correspondingly, often with network externalities.

Extending mass platforms with core tangibles

In the last section, we considered use of smartphones as core tangibles, focusing upon container behaviors. We are optimistic about the potential for this approach. However, when the phone's limited real estate is used for core tangibles behavior, the screen typically becomes unavailable for other co-present apps.

An alternate approach is illustrated in Figure 3. Here, a tablet computer is used for reading a digital book. The tablet is seated within a casier (here, a letter-sized FH7) flanked by several physical cartouches. On the top-left is Skype people-content (specifically, the same people-handles illustrated on smartphone cartouches in

Figure 2). On the right, a cartouche represents RSS feeds tied to the United Nations Millenium Development Goals. Bottom-left, a cartouche prototype references regionally-tagged content from the 140,000 hour `c-spanvideo.org` Internet-based video archive.

No screen real estate is consumed. The removable cartouches are back-illuminated by LEDs, with touch selection sensed by capacitive sensors. As with the smartphone cartouches, user selection of content in these physical cartouche sideboards can invoke (e.g.) video or web content to be displayed internally, or upon one or more external surfaces (as with Figure 1). As with smartphone cartouches, this approach is not limited to Skype or conferencing/messaging.

With our current implementation, the tablet is flanked by 16 cartouche cells. This is clearly an insufficient number to physically represent "all" friends, apps, etc. – or even all "favorites." One can argue 16 is an infinitely larger number than 0. Similarly, this is potentially a reasonable number for a few "key objects of interest" – a spouse and immediate family, a few key work colleagues or projects, a few topics of key personal interest. Also importantly, these 16 flanking cartouche cells relate to a particular piece of physical real estate surrounding a typical present-day tablet device. When consideration is scaled down toward a smartphone or jewelry, or up toward a building corridor or campus, the available real estate varies widely.

In a related variation, a somewhat recent trend for laptops, smartphones, and other electronic devices involves physical "skins," often celebrating a particular theme or motif, used to personalize and protect the device. Our proposed use of physical cartouches as a medium for extending mass-market platforms complements these trends, going beyond surface appearance to provide functional viewports and handles for monitoring and engaging dynamic net-linked systems.

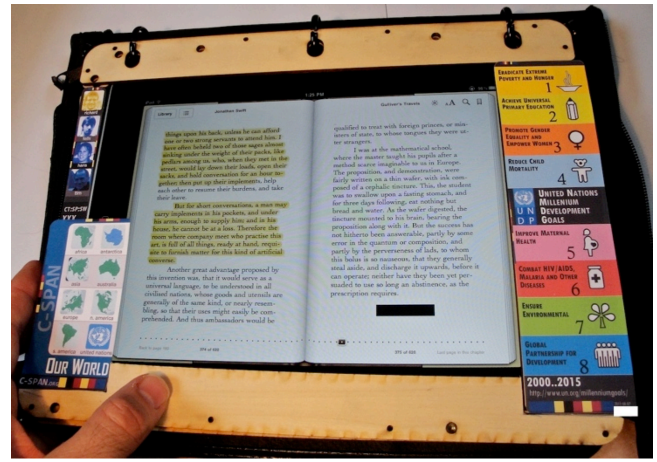

Figure 3. *Electronically-enhanced casier containing a tablet computer with two physical cartouches, all within a three-ring binder. The casier includes four RFID readers, 16 LEDs, and 16 capacitive sensors (8 per side). Right: an 8-cell DH5a cartouche, withUnited Nations Millenium Development Goals; left: DG4, DG5a cartouches bound to Skype and TEI content.*

Discussion and Future Work

A great deal of related research and commercial work has been conducted on mobile mass-market platforms and upon multi-touch surfaces. We expect others have realized some of the behaviors we have discussed. Our emphasis and contributions have centered on the prospective use and extension of these platforms as core tangibles. Full implementation of the scenarios we have discussed, and especially their generalization, implies ambitious software architectures, security model, etc., which would require substantial community involvement to realize.

An important implicit theme of this paper – and perhaps of tangibles more generally – relates to physical real estate. While "size matters," two other adages regarding space and time – "location, location, location" and "timing is everything" – are of particular relevance, as illustrated in this paper's examples. These also suggest relations between this work and context-aware computing [3].

Are smartphone-based cartouches "tangibles?" Several responses seem appropriate. Among these are "it depends;" "your mileage may vary;" and "some more, others less." Another, borrowing from Chaucer's ~1390 "The Wyves Tale of Bathe:" "tangible is as tangible does." We find our example of smartphone cartouches on the Microsoft Surface to employ tangible interaction techniques. Other handheld uses are more debatable. Recalling the wisdom "don't be dogmatic" from considerations of the desktop metaphor [8], we see pragmatic value in new, time-varying roles for widely deployed artifacts. By providing "less tangible" access to key system behaviors using (e.g.) smartphones, we hope to both expand and deepen the prospects realizable by other "more tangible" interaction artifacts and techniques.

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