Video: Heterogeneous Multi-Mobile Computing

Naser AlDuaij
Department of Computer Science
Columbia University
New York, New York, USA
alduaij@cs.columbia.edu

Alexander Van't Hof
Department of Computer Science
Columbia University
New York, New York, USA
alexvh@cs.columbia.edu

Jason Nieh
Department of Computer Science
Columbia University
New York, New York, USA
nieh@cs.columbia.edu

CCS CONCEPTS

• **Human-centered computing** → **Mobile computing**; Ubiquitous and mobile computing systems and tools; Mobile devices; • **Software and its engineering** → *Client-server architectures*; Operating systems; Peer-to-peer architectures.

KEYWORDS

Mobile computing; distributed computing; operating systems; mobile devices; remote display; Android; iOS

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1 BACKGROUND

As smartphones and tablets proliferate, there is a growing demand for multi-mobile computing [1, 2], the ability to combine multiple commodity mobile systems into more capable ones, including using multiple hardware devices such as cameras, displays, speakers, microphones, sensors, GPS, and input. However, the tremendous device, hardware, and software heterogeneity of mobile systems makes this difficult. In this demo, we present M2, a system for multi-mobile computing that enables existing unmodified mobile apps to make use of new ways of sharing and combining multiple devices. M2 introduces a new data-centric approach that leverages higher-level device abstractions and encoding/decoding hardware to efficiently share device data as opposed to low-level device-specific APIs. To support heterogeneous devices, M2 introduces device transformation, a new technique to mix and match different types of device data. Example device transformations include fused display, which can combine multiple displays into a single larger display for better viewing as shown in Figure 1, and translated input, which can substitute accelerometer for touchscreen input to provide a Nintendo Wii-like experience with existing mobile gaming apps. M2 shows that it (1) operates across heterogeneous hardware and software, including multiple versions of Android and iOS devices, (2) can enable unmodified Android apps to use multiple mobile devices in new and powerful ways, including supporting users with disabilities, better audio

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Figure 1: Multi-mobile computing using fused devices

conferencing, and motion-based gaming, and (3) can run device-intensive apps across multiple commodity mobile systems with modest overhead and qualitative performance indistinguishable from using local device hardware. Under M2, a mobile system is a *device server* if it has a device that is being shared with other systems, and is a *device client* if it is accessing a device being shared by another server.

2 VIDEO DEMO

Our video demonstration [3] shows M2 running in different scenarios with heterogeneous systems. The first case shows a Nexus 9 using its display and displays of three other Nexus 9 systems in a 2x2 grid running Android Lollipop 5.0 and Android Marshmallow 6.0. M2 uses indoor localization [4] to automatically configure and add the fourth system to the respective location. Moving the systems will automatically configure which portion to show in each of the quarters. Next, Epic Swords 2, a sword fighting game, accepts touchscreen input for sword swings. In this video segment, we show an accelerometer sensor to touchscreen input device transformation that shows controlling the sword game by swinging a Nexus 4 smartphone running Android KitKat 4.4 to reflect sword swings on the game playing on a Nexus 9 running Android Lollipop 5.0. We show a physical stabbing motion that is otherwise only represented as an unintuitive "V" swipe on the game. Finally, we show an iPhone 6S smartphone running iOS 11.4.1 accessing and controlling Android apps, such as playing a video on Android's VLC media player, on a Nexus 7 (2013) running Android Marshmallow 6.0. None of the apps were modified.

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