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Venice: eschewing the cloud by leveraging local communication channels (extended abstract)

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Abstract

Venice is a *device-to-device* (D2D) abstraction leveraging proven communication channels, such as Wi-Fi and Bluetooth, to allow communication between Android smartphones and virtually any other device. As an alternative implementation of the *link* layer, it is an attempt to fill the missing gap between D2D network configurations and the diversity of nodes, allowing widespread adoption of the D2D paradigm in heterogeneous systems.

Keywords

device-to-device, mobile, protocol, communication, link layer

1. Introduction and motivation

Mobile digital lifestyles pervaded societies: a large share of the world population actively uses smartphones to communicate, access information, and partake in a variety of digital activities. On the one hand, most of these activities go through these vast infrastructures of digital networks and data centers that we call the *cloud*. On the other hand, the environmental footprint of the digital sector is tremendous: its global greenhouse gas emissions notably account for 2.1% to 3.9% of the whole anthropic emissions [1]. A concrete pathway to reduce our sector's environmental impact would be to lessen digital activities' dependency to the cloud, where it is not needed—e.g., in scenarii such as proximity sensing or face-to-face media sharing, where direct *Device-to-Device* (D2D) interactions would suffice.

Leveraging D2D communication, when applicable, would bring in several advantages: (i) *security guarantees*, since D2D requires physical proximity between peers, the attack surface of the data exchange is lesser than using classical network topologies [2]; (ii) *privacy protection*, as trusting a cloud provider with personal information has proven subject to privacy intrusions which are alleviated in the D2D setting [3, 4]; (iii) *environmental friendliness*, eschewing any dependence to the Internet lowers the pressure on its infrastructures.

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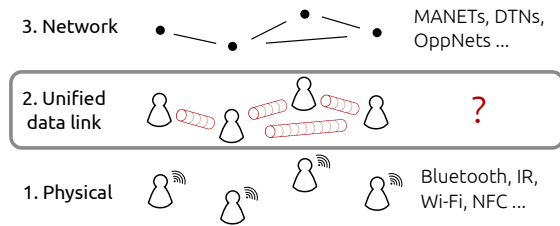


Figure 1: Direct mobile communication suffers from the lack of an agreed upon “data link” layer to bridge physical and network layers. Such an abstraction should encompass the heterogeneity of both device platforms and communication channels. VENICE proposes to bridge this gap, and currently supports a variety of communication channels on the Android platform.

Commercial solutions for D2D communication already exist, notably through Apple’s AirDrop and Google’s *Google Nearby Connections* (GNC) frameworks. However, these proprietary solutions are not interoperable, and their usage in development is hindered by the variable goodwill these platforms display in their APIs over operating systems’ versions. Interestingly, the *security-through-obscurity* strategy these two frameworks exhibit do not protect them from *man-in-the-middle* (MITM), *denial-of-service* (DOS), privacy and network traffic redirection attacks [5, 6]. The long-term lack of interoperability of Apple and Google’s software ecosystem is however being challenged by multiple actors including the European Commission [7].

At the physical layer, D2D is enabled by a variety of mature communication channels, e.g. Wi-Fi, Bluetooth, RFID/NFC... Even QR codes are commonly used to exchanges short pulses of data. At the network layer, many approaches have been proposed to route D2D traffic, including *Mobile Ad hoc Networks* (MANETs), *Delay-Tolerant Networks* (DTNs), and *Opportunistic Networks* (OppNets) [8, 9, 10]. However, as illustrated in Figure 1, providing a D2D *unified data link* layer remains an open issue, due to the challenge of abstracting the vast heterogeneity of physical channels and platforms to the eye of upper application layers.

In this tool demo paper, we introduce VENICE, a D2D framework enabling interoperable communications between smartphones and computers. We demonstrate its features by using it in a demo app that enables data exchange, while taking into account the technical capabilities of nodes.

2. A device-to-device communication framework

VENICE aims to abstract the physical layer of local wireless communication, allowing developers to reason in terms of connection without having to delve into the specifics of the users’ hardware stack. Being the missing piece between physical and network layers in a D2D setting, VENICE intends to play the role of the **OSI model “data link” layer 2 for D2D**.

Implemented using Google’s cross-platform framework Flutter¹, VENICE presents a set of abstractions, including tech-agnostic schedulers; its core feature is the *channel* abstraction. VENICE encapsulates each communication technology in a `BootstrapChannel` or a `DataChannel`, depending on whether it is used for connection initialisation or to transmit payload data. VENICE

¹<https://flutter.dev/>

Table 1
Preferred communication type per channel

Chan. type	Physical channel				
	QR	Infrared	RFID	Bluetooth	Wi-Fi
Bootstrap	☑	☑	☑	☑	☒
Data	☐	☒ [12]	☒ [13]	☑	☑

☐: not implemented; ☒: possible; ☑: widely deployed.

thus remains agnostic to concrete channel implementations, which can be implemented independently and used interchangeably. Channels can be used to transmit any kind of payload from the sender to the receiver: the application is thus responsible for implementing its data transmission scheduling algorithm, once the D2D link is set.

Some physical channels are more suited for discovery or connection, a selection of which is shown on Table 1. Bluetooth for instance has a very low throughput in connected mode compared to Wi-Fi, but is widely used for connection-less advertising and scanning. In the wild, this bootstrap process is notably deployed in *Wi-Fi Easy Connect* (WEC) [11] (that leverages a QR code to make a device join a Wi-Fi network through an already connected smartphone), and in the aforementioned GNC and AirDrop (that claim to transfer credentials on BLE to establish a Wi-Fi Direct connection).

VENICE was implemented in a demonstration app requiring manual selection of bootstrap and data channels, the same on both participating devices. Since VENICE uses a stream of bytes to transmit information between agents, any use-case can be implemented with it; this application however focuses on the exchange of files.

3. Relevance and novelty

Venice is a device-to-device framework designed to allow communication between devices in the same vicinity. One of the key features of Venice is its multi-platform architecture, virtually allowing communication between any kind of desktop and smartphone devices. Another advantage of Venice is its channel abstraction, allowing developers to directly program the interaction between agents, and not the technical implementation details, that vary from platform to platform and from one OS version to another. This behavior allows the framework to think abstractly of the available communication technologies, and serves our end goal to abstract physical channels from developers and users, automating their selection so as to simply spawn a functioning D2D link.

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Online Resources

The source code of Venice is available via the associated GitHub organization (<https://github.com/Venice-D2D>).

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