

Demo: Establishing Mobile Ad-Hoc Networks in 802.11 Infrastructure Mode

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ABSTRACT

Mobile Ad-Hoc Networks (MANETs) rely on the 802.11 ad-hoc mode to establish communication with nearby peers. In practice, this makes MANETs hard to realize. While 802.11-compliant mobile devices implement the ad-hoc mode on the hardware layer, the software layer typically does not implement support for ad-hoc networking in terms of ad-hoc routing and name resolution protocols. Modern mobile operating systems, such as Android and iOS, even hide the inherent ad-hoc functionality of the wireless card through restrictions in the OS. In contrast to this, support for the 802.11 infrastructure mode is a commodity.

We propose establishing ad-hoc networks using the 802.11 infrastructure mode. In MA-Fi (Mobile Ad-Hoc Wi-Fi), a small core of mobile router nodes (RONs) provides infrastructure mode network access to mobile station nodes (STANs). As RONs also act as a station in infrastructure networks of other RONs, MA-Fi achieves multi-hop communication between RON and STAN devices in the overall network.

We show the creation and operation of mobile ad-hoc networks using MA-Fi. We focus on mobility of RONs and STANs as well as topology control in the overall network.

Categories and Subject Descriptors

C.2.1 [Computer Communication Networks]: Network Architecture and Design—*Wireless Communication*

General Terms

Design, Measurement, Performance

Keywords

Mobile Ad-Hoc Networks, Network Virtualization

1. MA-Fi NETWORKING

In contrast to IEEE 802.11 ad-hoc mode networks, we establish a mobile ad-hoc network using the 802.11 **infrastructure mode**. Our approach is motivated by three observations that hinder the creation and use of mobile ad-hoc networks as defined by the standard: *i*) In contrast to the 802.11 ad-hoc mode [2], the hardware and software layers of most mobile wireless devices support the 802.11 infrastructure mode. *ii*) Typical mobile devices expect a one-hop Wi-Fi environment for routing and host configuration. Thus,

*This work is supported by the Ziel2.NRW program and the ERDF fund of the European Union.

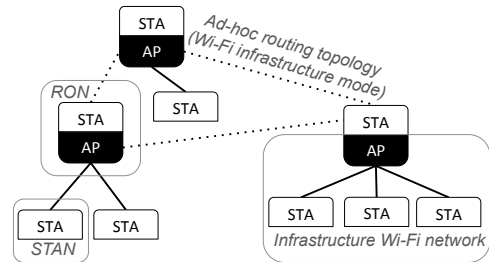


Figure 1: RONs provide 802.11 infrastructure mode networks to STANs and connect as stations to other RONs to achieve multi-hop communication.

they do not natively support ad-hoc routing protocols, such as OLSR or DYMO. *iii*) Ad-hoc mode, per 802.11 standard, supports data rates of 11 MBit/s while 802.11g/n infrastructure mode supports data rates of 54 MBit/s and above.

In MA-Fi we distinguish between two classes of devices, as shown in Figure 1. First, RONs are mobile devices, such as netbooks and notebooks, that simultaneously serve as an infrastructure mode access point (AP) and as a station device (STA). To this end, RONs create multiple *virtual network interfaces* on a single wireless network card [1, 4] that either run in AP mode or in station (STA) mode. A RON thus serves two purposes. First, by associating to multiple other networks as a station, it establishes a multi-hop *ad-hoc routing topology* between the currently active RONs, using a custom ad-hoc routing protocol. Second, all RONs provide *one uniform 802.11 infrastructure network* that STANs can connect to. STANs are commodity 802.11-compliant devices such as smartphones or laptops that connect to the ad-hoc network via an infrastructure mode association to a RON. We only require STANs to be able to associate to one 802.11 infrastructure mode network at a time. In MA-Fi, mobile devices are thus able to participate in the network without having to support the 802.11 ad-hoc mode. Figure 1 shows an exemplary network scenario.

By acting as an AP in a common infrastructure network, RONs serve as the gateway to the rest of the network. Hence, they hide the routing and protocol complexity of the ad-hoc routing topology from connected STANs. They furthermore provide typical AP services such as host configuration, gateway and name resolution functionality in their respective networks. A STAN thus perceives the whole ad-hoc network as a single-hop, AP-based Wi-Fi network.

We assume both STANs and RONs to be mobile devices. In order to provide traditional MANET-like functionality, our network approach needs to account for the inherent device mobility. In the case of STAN mobility, this amounts

to preserving connections during mobility events, i.e., when a STAN moves to another RON. RON mobility, however, alters the ad-hoc routing topology between RONs and may lead to voids in the network coverage as well as over-saturation of the coverage area. This requires control over the roles of RONs and the ad-hoc routing topology with regard to RON mobility as well as a sufficient network coverage. We thus handle RON and STAN mobility separately.

1.1 RON Mobility

RON mobility changes the location and availability of infrastructure networks for STANs. Such mobility may either be caused by a RON joining the network, leaving the network or moving within the network. If a RON *joins* the MA-Fi network, e.g. in the bootstrapping phase, it scans the available networks in its vicinity. A RON then creates an infrastructure network if few or only weakly received networks are available, i.e. if network coverage at the current location is low. Furthermore, it connects as a station to other RONs in order to establish multi-hop communication between the available networks. The same applies to a RON that *moves* into an area in which network coverage is poor. Node *R4* in Figure 2 is an example for such an active RON.

If a RON joins in or moves into an area in which a sufficient number of networks is available, it does not establish an own network. While an excessive number of networks does not disrupt the network scenario, it reduces the overall network performance [3] as more networks need to be traversed in routing and more networks need to be managed by single RONs. Thus, if a RON joins in or moves into an area in which a sufficient number of networks is available, it does not establish an own network. Instead, it acts as a station in an available network as RON* activating only STAN functionality until the number or quality of the perceived nearby networks falls below a certain threshold. The mobility event in Figure 2 (1) shows this scenario. As *R4* moves into an area that is covered by *R1*, it associates to this network.

A mobility event further alters the ad-hoc routing topology between RONs. We employ a reactive routing protocol to discover routes to devices in the network and maintain them over mobility events. To achieve a quick adaptation to the current network topology, RONs periodically scan for wireless networks using standard Linux tools such as *iwlist*.

1.2 STAN Mobility

To provide a continuous network access to STANs, we need to support STAN mobility as well. Figure 2 depicts the exemplary scenarios of a moving STAN. Here, *S2* moves from the network of *R3* to the network of *R2*. Re-associations of STANs due to moving RONs do not differ from this scenario (e.g., node *S3*). To allow for a re-association of STANs independently of the current RON, we provide a uniform network at all RONs. We broadcast the same SSID at each node and provide the same IP-range for STAN IPs via DHCP. By using a large private IP-range, we greatly reduce the risk of collisions and allow mobile STANs to keep their assigned IP-addresses when re-associating with a new RON. We further use a uniform AP network interface in terms of the IP and MAC address, so that STANs always communicate with the same endpoint and thus avoid ARP requests or timeouts as well as Layer 3 handovers.

We furthermore need to preserve the connections of STANs over the change of APs, i.e. RONs. To this end, we adapt the route towards a given station, e.g. *S2*, in the ad-hoc routing

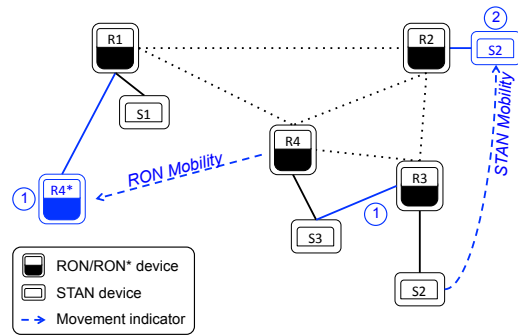


Figure 2: Exemplary dynamic network scenario. RON mobility (1) and STAN mobility (2) as well as the resulting changes to the ad-hoc routing topology and STAN associations need to be accounted for.

topology. In the topology shown in Figure 2, the originally discovered route towards *S2* ends at *R3* as the gateway to the infrastructure network that includes *S2*. Packet delivery from *R3* to *S2* will fail once *S2* associates with *R2*. Upon such a routing failure, *R3* executes a common fail-over mechanism to repair the route, i.e., by sending a route re-request to its neighbors. *R2* replies to this request by announcing itself as a direct neighbor of *S2* and thus repairs the route.

2. DEMONSTRATION

In our demonstration, we will show a working prototype of the described MA-Fi approach. This prototype consists of a small-scale, dynamic MA-Fi network representation that demonstrates the implementation and roles of RONs and STANs in the network. We demonstrate the ability of MA-Fi to establish and maintain MANET-like multi-hop ad-hoc networks that support unmodified 802.11 mobile devices. We provide a number of mobile RON devices, that make up the ad-hoc routing topology during the demonstration. Topology changes are thereby induced by the movement of demo participants that operate the provided MA-Fi devices. Furthermore, we provide a number of STAN devices that participants of the demo session may use to access the network while roaming. Additionally, we invite participants to join the network using their own commodity Wi-Fi devices.

To highlight the multi-hop network structure and the support for device mobility, we focus on continuous communication between arbitrary pairs of devices. We provide a selected set of services in the network that may serve as communication endpoints. Using these services, participants of the demo session may try out the support for device mobility and the performance of the overall network and the ad-hoc routing topology in terms of throughput and latency.

3. REFERENCES

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