MANET Internetworking: Problem Statement and Gap Analysis

IETF 124 MANET Session

https://datatracker.ietf.org/doc/draft-templin-manet-inet

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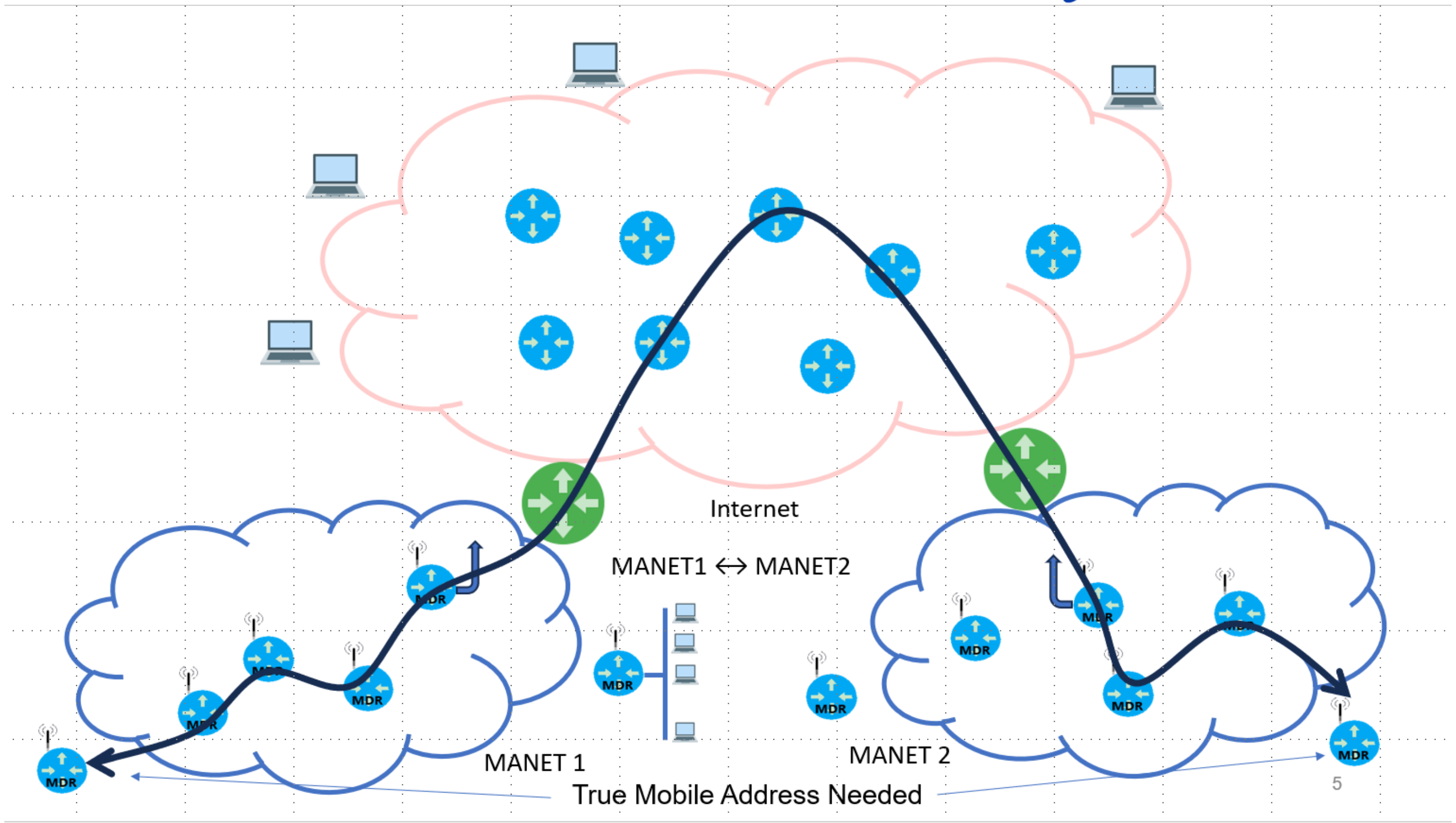
MANET Internetworking

- Global public Internet serves as transit between distinct MANETs



MANET Use Cases

MANETs have an important role in emergency response communications, disaster relief situations, communications in remote and rural areas, military operations, vehicular and swarm communications, and low-powered Internet of things (IoT) applications.

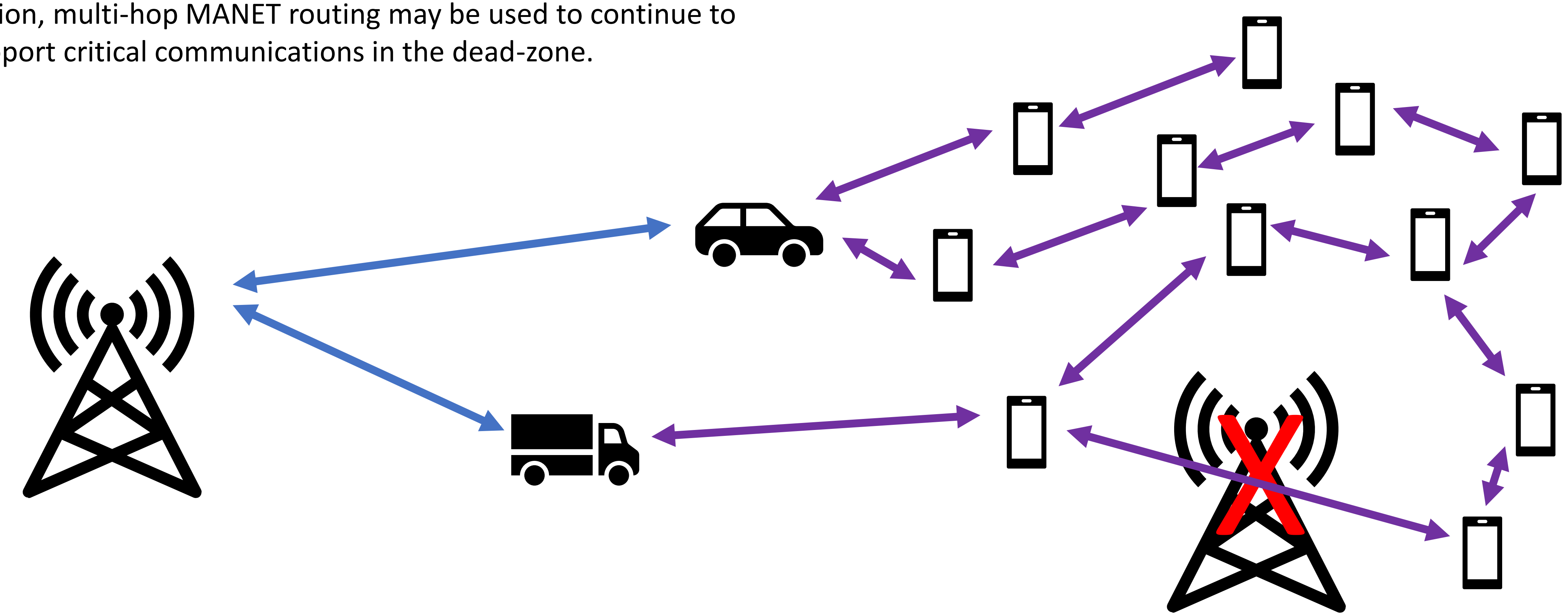
- MANETs provide the ability to establish and maintain communications when infrastructure-based networks, such as 5G cellular communication systems, are not accessible.
- As described above, MANETs may also provide Internet connectivity to internal nodes, for example, as a "stub" network via MANET routers which possess an internetworking capability and an external connection to a radio access network.

Example Use Case: Disaster Relief

Disaster situations may compromise network infrastructure, such as through the loss of base stations in a cellular radio access network (RAN). In this scenario, MANET networks can play a role in closing coverage gaps through multi-hop routing to nodes within the coverage area of uncompromised base stations. This use case is broadly applicable to any situation in which nodes are operating outside or at the periphery of RAN coverage.

Example Use Case: Disaster Relief

If radio access network (RAN) coverage is lost in a certain region, multi-hop MANET routing may be used to continue to support critical communications in the dead-zone.

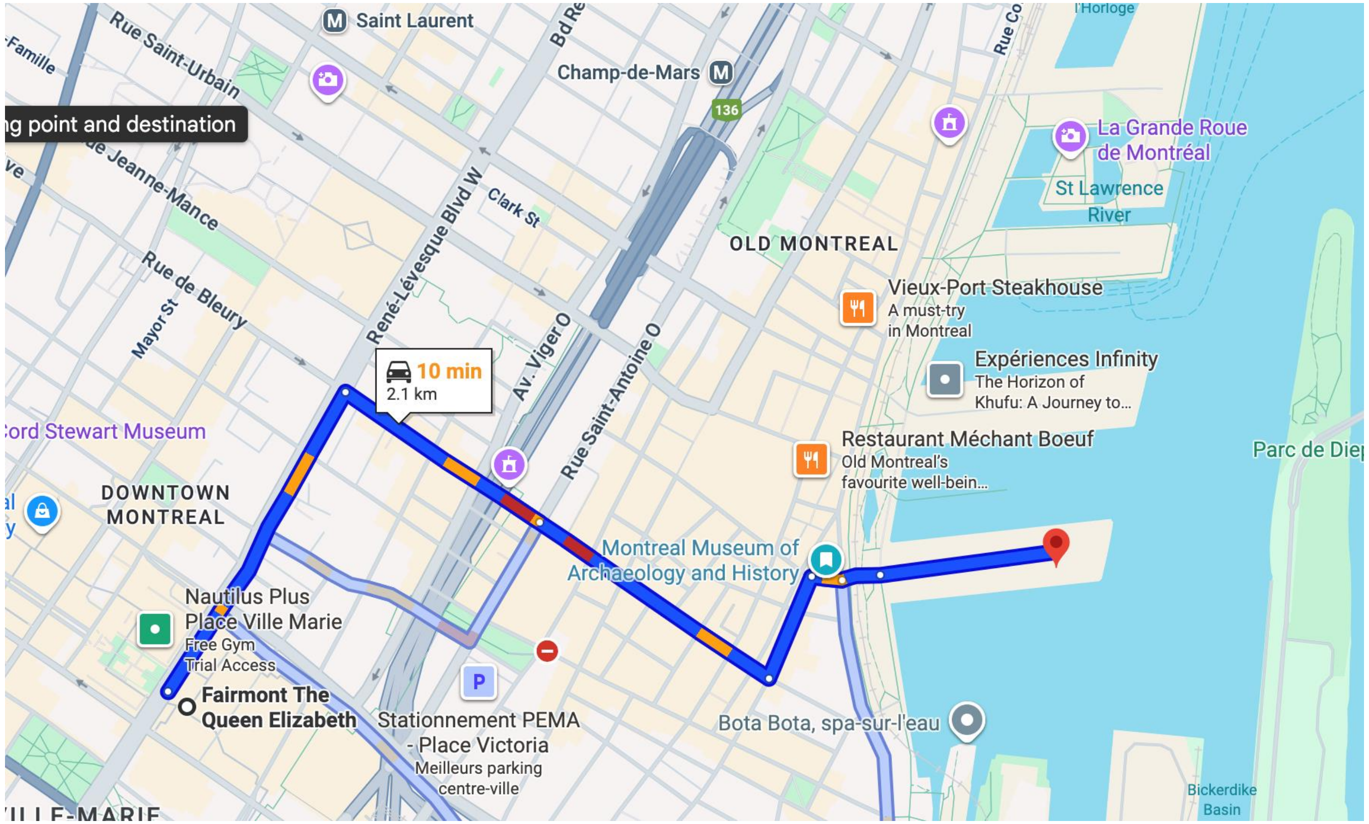


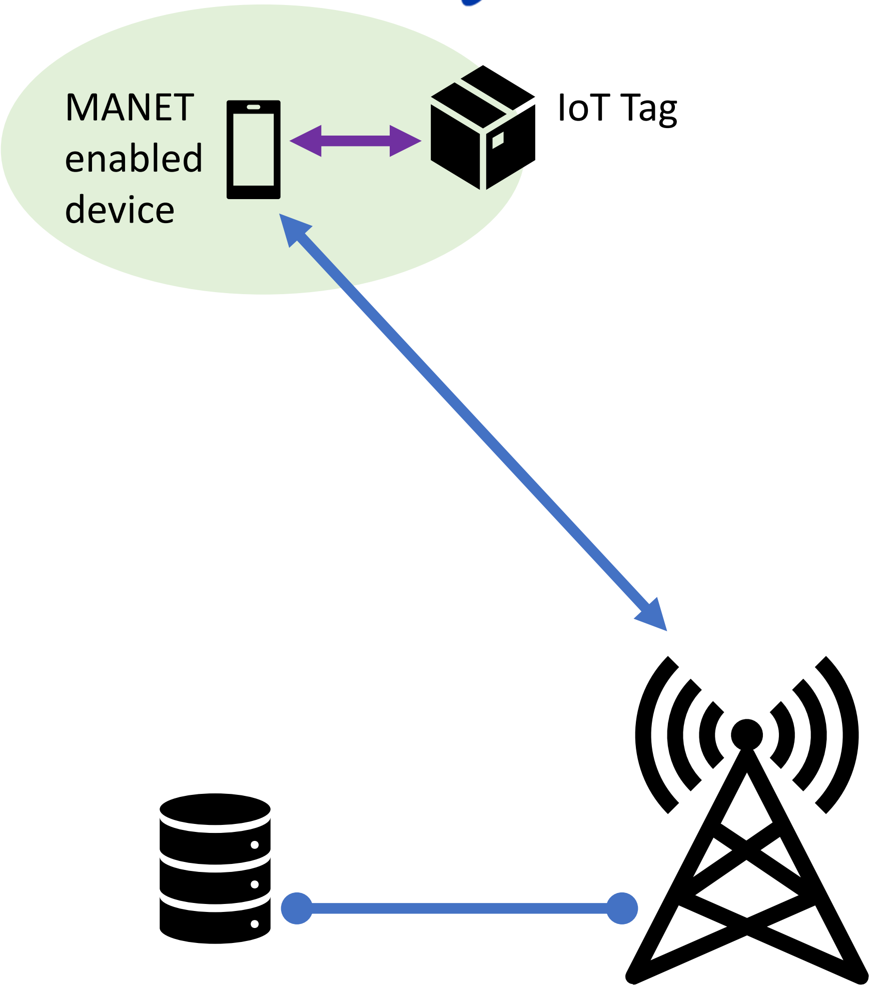
Example Use Case: Tracking Shipment

Another example use case is the tracking and monitoring of data from low-cost low-power IoT devices ("tags") which may be placed on packages during shipment or storage. Such devices may transition in and out of coverage of infrastructure-based networks, often being located in environments that are not conducive to RF propagation (e.g., shipping container, warehouse, etc.). The ability to discover and connect to neighboring MANET-enabled devices and to establish Internet connectivity through such MANETs, enables real-time logistics and inventory data to be collected opportunistically.

Example Use Case: Tracking Shipment

Ultra-low powered IoT tag on package in route to destination may opportunistically connect to nearby mobile devices to provide location and logistics data.

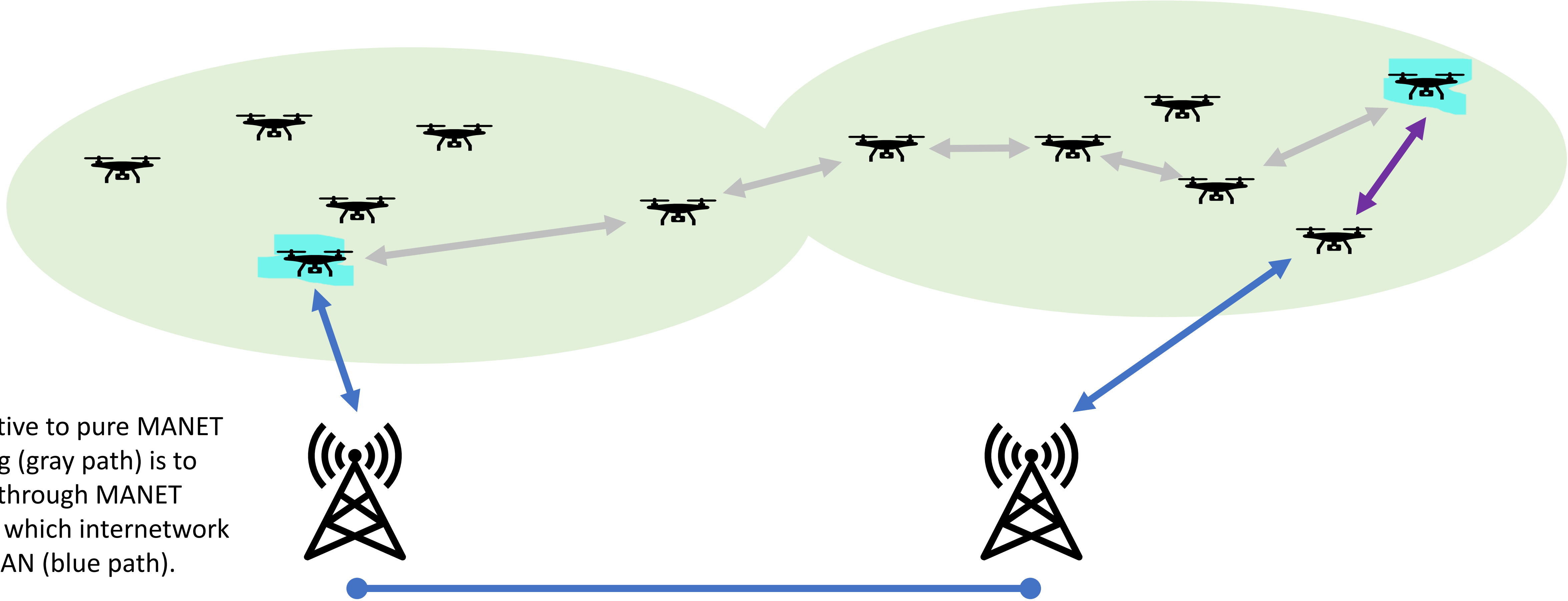




Example Use Case: UAV Swarms

Local communications within swarms for coordination and cooperation is a good use case for MANET networks due to the highly mobile dynamic nature of such networks. Yet swarms may also benefit from connectivity to the Internet, or other external networks. And in large swarm-based MANETs, routing of traffic through infrastructure networks to MANET endpoints, rather than traversing the entire MANET can improve communications throughput and reliability.

Example Use Case: UAV Swarms



Alterative to pure MANET routing (gray path) is to route through MANET nodes which internetwork with RAN (blue path).

MANET Internetworking

Problem 1: MANET Local Addressing

Each MANET router requires a unique IP address for MANET-local communications; the router often uses this same address to configure a unique "router ID". For MANETs that are only intermittently connected to an Internetwork, these addresses must be generated from IP prefixes of scope greater than link-local but not associated with infrastructure aggregation points. For all MANET types, each address/ID must be locally-unique within the (limited) local MANET routing domain. For not-so-stubby MANETs, the address/ID must also be globally-unique among all local MANET routing domains worldwide.

MANET Internetworking therefore regards the global public Internet as a "network of (mobile ad-hoc) networks", and with unbounded dynamic relationships between distinct local MANET routing regions joined by switched virtual circuits. This exposes the full world population of MANET local addresses as potential duplicates.

MANET Internetworking

Problem 2: Autoconfiguration

When a MANET comes in contact with a fixed Internetwork such as the global public Internet, nodes in the MANET that engage global mobile Internetworking services require some means of autoconfiguring global-scoped IP addresses and/or prefixes that are properly routable by network elements accessible from the current point of attachment. These network elements are typically proxies or routers of some variety that connect to the mobile routing system.

Nodes in the local MANET that are multiple IP hops away from an Internet connection sharing peer cannot use unmodified standard autoconfiguration services including IPv6 Neighbor Discovery (IPv6ND) [RFC4861] or DHCPv6 [RFC8415] over a MANET interface since these services are link-scoped in nature. (The DHCPv6 architecture includes a "relay" function, but the dynamic nature of links in (multi-link) local MANET routing regions precludes straightforward application of DHCPv6 relays.)

Two methods of supporting generalized autoconfiguration for nodes within a MANET have been suggested. In a first method (conducted directly over MANET interfaces) first-hop neighboring nodes within the MANET collectively participate to repeat link-scoped autoconfiguration discovery requests to other neighbors that are topologically closer to an Internet connection sharing node. In a second autoconfiguration method, the requesting node configures a (virtual) overlay multilink network interface over its (physical) MANET interface(s) and issues standard link-scoped IPv6ND and/or DHCPv6 requests over the virtual interface.

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Problem 3: MANET-internal Communications

Two nodes located within the same local MANET routing region should be able to communicate (across multiple hops if necessary) using MANET local addressing with no external Internetwork infrastructure reference points. As long as the MANET-local addresses configured by communicating peers are unique, the MANET local routing system maintains continuous multihop forwarding services to ensure session continuity.

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Problem 4: MANET Peer to Internetwork Correspondent

When an originating peer (or its stub MANET Internet connection-sharing node) within a not-so-stubby MANET needs to communicate with a correspondent connected elsewhere in an external Internetwork, the peer consults the global DNS which returns a (stable) globally-routable IP address for the correspondent. The peer can then use one of its MSP-provided IP addresses obtained through autoconfiguration and the global IP address of the Internetwork correspondent as the source and destination addresses for packet exchanges.

In this case, the originating peer's IP address need not appear in the global DNS since the correspondent discovers the address by examining the source of received packets. This means that the originating peer can use a PA address to initiate sessions. However, if the PA address changes (e.g., due to movement to a new Internetwork attachment point) any communication sessions in progress with Internetwork correspondents will fail and the peer will need to re-establish them under the new PA address.

MANET Internetworking

Problem 5: Internetwork Correspondent to MANET Peer

When an Internetwork correspondent needs to communicate with a target peer within a local MANET routing region, the correspondent consults the global DNS to determine an IP address for the peer.

IP addresses covered by delegated prefixes remain stable even across MANET-wide mobility events to the point that continuous dynamic updates to the DNS would not be necessary to maintain uninterruptable communications. While it is possible that mobility events may cause minor temporary disruptions, transport protocol retransmissions will maintain continuity for any ongoing sessions.

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Problem 6: Peer-to-Peer Between Different MANETs

When two prospective peer nodes are located in different MANET local routing regions with a common Internetwork as a transit network, both peers should include their IP addresses in their global DNS resource records for the same reasons cited in Section 3.5.

The MSP is responsible for ensuring that each peer remains reachable at its stable IP address/prefix through distributed mobility management.

MANET Internetworking

Problem 7: Stub MANET to Not-so-stubby MANET

When an Internet connection sharing MANET router connects a stub MANET, it can either delegate public IP addresses to stub MANET nodes or delegate private IP addresses then apply Network Address Translation (NAT) to support external communications.

In the public case, all manners of peer-to-peer communications are made possible due to the globally routable nature of the addresses. In the NAT case, only communications initiated by a stub network peer are supported since the reverse path terminates at the NAT.

The stub MANET itself may configure a local overlay that regards the (multihop) MANET as a single unified link. In that case, the stub network overlay link is distinct from the overlay link that spans the global public Internet and the two links are joined by an IPv6 router.