Border Router Discovery Protocol (BRDP) Based Routing

Exit routing for multi-homed networks

Teco Boot / 19 November 2008
Mobile Ad-hoc Networks (manet)
History and status

- Finding solution for scalable MANETs by using a backbone

- Connected MANETs have their problems:
  - Addressing (Autoconf)
  - Multi-homing (Autoconf & MANET & other WG)

- Autoconf I-D:
  - Current: `draft-boot-autoconf-brdp-01.txt`
  - Autoconf out-of-scope topics left out

- I-D on routing:
  - Current: `draft-boot-brdp-based-routing-01.txt`
  - Fixes problems with multi-homing and ingress filters

- More coming:
  - Source Address selection (related to RFC3484)
  - Tiny exit-routing IGP using routing headers
My illustrations are simplified

- Border Router is a router connecting the MANET to an ISP
- In practice, there is a Provider Edge (PE) and Customer Premises Equipment (CPE) router
- CPE – PE protocols are out of scope for this presentation
- PE may (should!) have ingress filter
My illustrations are simplified

- ISPs have their networks. Details on this are not important for BRDP
- Note the colors: Provider A is red, provider B is blue
Single-homed MANET: no problems 😊
Multi-homed MANET

Here, BRDP is born.
So far, so good. *But:*
In a MANET, nodes can move!

- MANET routing protocol converges to reflect the movement
- LFN is not aware of movement
Solution #1:
Direct traffic to BR that owns SA prefix

Feature of BRDP Based Routing!
Solution #2: Adjust BR-b ingress filter for prefix BR-a

Not sure ISP is cooperative, so this is not the goal
Solution #3:
Select SA that corresponds to BR used

LFN2 would use “metrics” of BRs

Session continuity problems, doesn’t work in a MANET because of movements
Solution #4: Address translation on BRs

Issues with IP header authentication and addresses in payload
Goal: support for multi-homed edge networks with multi-homed nodes

Feature of BRDP and BRDP Based Routing!

Benefits depend on transport layer or application layer adjustments

Make-before-break!
Download your files twice as fast!
How does it work?

Border Router Discovery Protocol (BRDP):
- Provides valid prefix information to interior routers
- Distributes Border Router Information Option (BRIO) via Neighbor Discovery Router Advertisements.
- BRIOs are distributed in the MANET
- BRIOs provide metrics for paths from and to DFZ (Default-Free Zone)
- BRDP uses link metrics from routing protocol or other source
  - Use link metrics for both directions
- BRIOs provide DHCP relay information
- BRDP is a Distance-Vector protocol
BRIO flooding using Neighbor Discovery Router Advertisements

- Routers already send RA
- BRIOs piggy-backed on RA

Results:
1. All routers learn prefixes for BRs, with metric information
2. All routers learn DHCP addresses for relay or prefix delegation
BRIO flooding with scoping (needed in large MANETs)

- Reduction of forwarded BRIO set is acceptable, as only the best paths would be used
BRIO format

D=1: BR is DHCP server or relay

BR address and valid prefix for this BR

Metric for this prefix
Is a bidirectional metric between DFZ and this BR

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IETF-73 - MANET - BRDP based Routing
RA with Prefix Information and BRIOs

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Prefix Information option
Router initiated

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BRIO
BR initiated

Prefix Information option
Router initiated

BRIO
BR initiated
RA in MANET with 3 ISP uplinks

Prefix Information
ISP-a

Prefix Information
ISP-b

Prefix Information
ISP-c

BRIO
ISP-a

BRIO
ISP-b

BRIO
ISP-c

OK, the RA packet size increases.
Directing packets to BR that correspond to source addresses

If an end host selected an upstream ISP, how can the routing system direct traffic to this ISP?

- Packets must have an earmark for indicating the to-be-used Border Router
- Source Address or additional tag (routing header, encapsulation)
- BRDP Based Routing:
  Edge networks, forwarding based on FIB and SA / BRIO cache
Legacy Internet Routing

RFC1812; Section 5.2.1.2 Unicast:

(5) The forwarder determines the next hop IP address for the packet, usually by looking up the packet's destination in the router's routing table. This procedure is described in more detail in Section [5.2.4]. This procedure also decides which network interface should be used to send the packet.

RFC1812; 5.2.4.3 Next Hop Address

(5) Default Route: This is a route to all networks for which there are no explicit routes. It is by definition the route whose prefix length is zero

- If a default route exists, legacy routing is used.
With BRDP Based Routing, the default route is removed.

New heuristic for finding a next hop, only used when first FIB lookup didn’t find a nexthop:

(6) BRDP Route: This is a route to all networks for which there are no explicit routes, and a default route is not used. The nexthop IP address is found by means of a Border Router Information Cache (BRIO-Cache) lookup based on the source address and, if a matching BRIO-Cache entry is found, a subsequent FIB lookup based on the selected Border Router address.
My example
Example

**FIB R3:**
- `2001:DB8:A::/64` $\rightarrow$ `FE80::1` # BR-a
- `2001:DB8:A:1::/64` $\rightarrow$ `FE80::1`
- `2001:DB8:A:2::/64` $\rightarrow$ `FE80::2`
- `2001:DB8:A:3::/64` $\rightarrow$ local
- `2001:DB8:B::/64` $\rightarrow$ `FE80::2` # BR-b
- `2001:DB8:B:1::/64` $\rightarrow$ `FE80::1`
- `2001:DB8:B:2::/64` $\rightarrow$ `FE80::2`
- `2001:DB8:B:3::/64` $\rightarrow$ local
- `2001:DB8:B:4::/64` $\rightarrow$ `FE80::2`

**BRIQ Cache R3:**
- `2001:DB8:A::A/48` $\leq$ `FE80::1` metric 100
- `2001:DB8:A::A/48` $\leq$ `FE80::2` metric 250
- `2001:DB8:B::B/48` $\leq$ `FE80::2` metric 150
- `2001:DB8:B::B/48` $\leq$ `FE80::1` metric 200

IETF-73 - MANET - BRDP based Routing
Example - FIB

FIB R3:
- 2001:DB8:A::/64 -> FE80::1 # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2 # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

BRIQ Cache R3:
- 2001:DB8:A::A/48 <= FE80::1 metric 100
- 2001:DB8:A::A/48 <= FE80::2 metric 250
- 2001:DB8:B::B/48 <= FE80::2 metric 150
- 2001:DB8:B::B/48 <= FE80::1 metric 200

All internal routes are found in FIB Forwarding based on DA
No default route !!
Example
BRIO-Cache

FIB R3:
- 2001:DB8:A::/64 -> FE80::1 # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2 # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

BRIO Cache R3:
- 2001:DB8:A::/48 <= FE80:1 metric 100
- 2001:DB8:A::/48 <= FE80:2 metric 250
- 2001:DB8:B::/48 <= FE80:2 metric 150
- 2001:DB8:B::/48 <= FE80:1 metric 200

Border Router information, with sender info and metrics
Node-a or Node-b sends to Node-4

FIB R3:
- 2001:DB8:A::/64 -> FE80::1 # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2 # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

BRIO Cache R3:
- 2001:DB8:A::A/48 <= FE80::1 metric 100
- 2001:DB8:A::A/48 <= FE80::2 metric 250
- 2001:DB8:B::B/48 <= FE80::2 metric 150
- 2001:DB8:B::B/48 <= FE80::1 metric 200

1) 2001:DB8:B:4::4 in FIB? Yes
Node-a sends to Babe

FIB R3:
2001:DB8:A::/64 -> FE80::1 # BR-a
2001:DB8:A:1::/64 -> FE80::1
2001:DB8:A:2::/64 -> FE80::2
2001:DB8:A:3::/64 -> local
2001:DB8:B::/64 -> FE80::2 # BR-b
2001:DB8:B:1::/64 -> FE80::1
2001:DB8:B:2::/64 -> FE80::2
2001:DB8:B:3::/64 -> local
2001:DB8:B:4::/64 -> FE80::2

BRIIO Cache R3:
2001:DB8:A::/48 <= FE80::1 metric 100
2001:DB8:A::/48 <= FE80::2 metric 250
2001:DB8:B::B/48 <= FE80::2 metric 150
2001:DB8:B::B/48 <= FE80::1 metric 200

1) 2001:DB8:BABE::BABE in FIB? NO
Node-a sends to Babe

2) 2001:DB8:A:3::A match in BRIO Cache?
   YES: 2001:DB8:A::A

FIB R3:
- 2001:DB8:A::/64 -> FE80::1 # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2 # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

BRIO Cache R3:
- 2001:DB8:A::A/48 <= FE80::1 metric 100
- 2001:DB8:A::A/48 <= FE80::2 metric 250
- 2001:DB8:B::B/48 <= FE80::2 metric 150
- 2001:DB8:B::B/48 <= FE80::1 metric 200
Node-a sends to Babe

FIB R3:
- 2001:DB8:A::/64 -> FE80::1 # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2 # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

BRIO Cache R3:
- 2001:DB8:A::A/48 <= FE80::1 metric 100
- 2001:DB8:A::A/48 <= FE80::2 metric 250
- 2001:DB8:B::B/48 <= FE80::2 metric 150
- 2001:DB8:B::B/48 <= FE80::1 metric 200

3) 2001:DB8:A::A in FIB?
YES: 2001:DB8:A::/64 -> FE80::1
Node-b sends to Babe

**FIB R3:**

1. \text{2001:DB8:BABE::BABE} in FIB: \text{NO}
2. \text{2001:DB8:B:3::B} match in BRIO Cache:
   - Yes, \text{2001:DB8:B::B}
3. \text{2001:DB8:B::B} in FIB: \text{Yes, FE80::2}

**BRIO Cache R3:**

- \text{2001:DB8:A::A/48} => FE80::1 metric 100
- \text{2001:DB8:A::A/48} => FE80::2 metric 250
- \text{2001:DB8:B::B/48} => FE80::2 metric 150
- \text{2001:DB8:B::B/48} => FE80::1 metric 200

\text{BRDP based Routing}
Bad sends to Babe

**FIB R3:**
- 2001:DB8:A::/64 -> FE80::1  # BR-a
- 2001:DB8:A:1::/64 -> FE80::1
- 2001:DB8:A:2::/64 -> FE80::2
- 2001:DB8:A:3::/64 -> local
- 2001:DB8:B::/64 -> FE80::2  # BR-b
- 2001:DB8:B:1::/64 -> FE80::1
- 2001:DB8:B:2::/64 -> FE80::2
- 2001:DB8:B:3::/64 -> local
- 2001:DB8:B:4::/64 -> FE80::2

**BRIIO Cache R3:**
- 2001:DB8:A::A/48 <= FE80::1 metric 100
- 2001:DB8:A::A/48 <= FE80::2 metric 250
- 2001:DB8:B::B/48 <= FE80::2 metric 150
- 2001:DB8:B::B/48 <= FE80::1 metric 200

1: 2001:DB8:BABE::BABE in FIB: NO
2: 2001:DB8:BAD::BAD match in BRIIO Cache: NO
3: DROP
BRDP Based Routing

Introduction

Analysis of the problem

How does it work?

Next steps
Next steps

- Support for IPv4
- Finish BRDP implementation (Linux, Opnet)
- Implement BRDP Based Routing (Linux, Opnet)
- Continue research on Border Router Routing Header
  - Website: [http://www.inf-net.nl/brdp.html](http://www.inf-net.nl/brdp.html)
  - Any help is welcome!
  - Any comment is welcome!
Thanks for your attention !