ASPA-based AS path verification [1] examples

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[1] "BGP AS_PATH Verification Based on Autonomous System Provider Authorization (ASPA) Objects,"
https://datatracker.ietf.org/doc/draft-ietf-sidrops-aspa-verification/

C2P = Customer to Provider
p2p = peer to peer (lateral peers)

ASPAs:

A, {C, D}
B, {E}
C, {F}
D, {F, G}
G, {AS0}

E and F have no ASPAs

The topology shown is ground truth, not deduced from ASPAs.

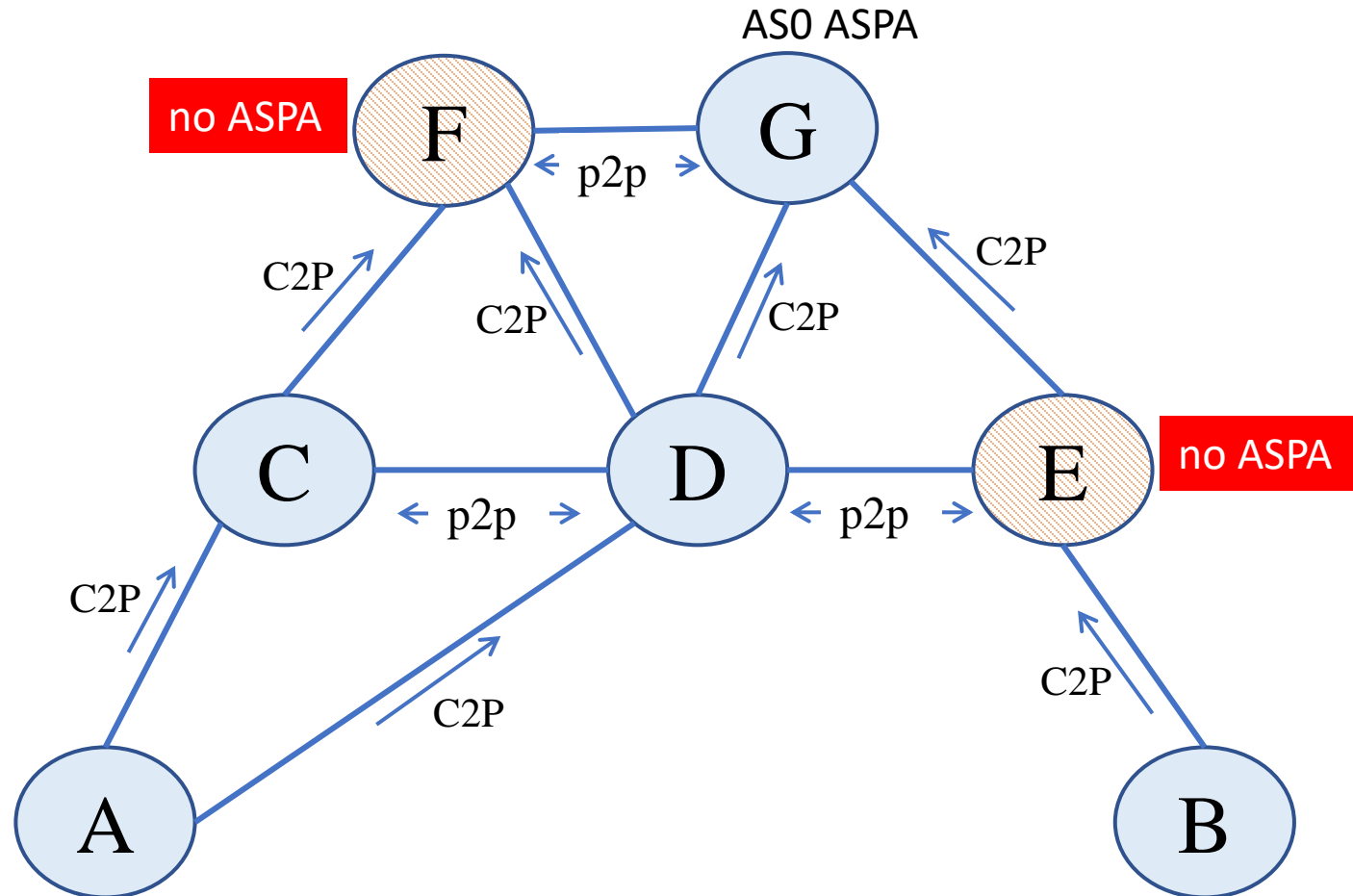If ASPA exists for an AS, it only asserts if another AS is its Provider or Not Provider.

Topology

no ASPA

F

G

AS0 ASPA

p2p

C2P

C2P

C2P

C2P

no ASPA

C

D

E

p2p

p2p

C2P

C2P

C2P

A

B

Table 1: Examples of Upstream Path Verification
(BGP update received from a customer or lateral peer)

#	Receiving/ Verifying AS	AS path (unique ASes)	AS path length	max_up_ramp	min_up_ramp	Upstream Path Verification Result
1	G	F C A	3	3	3	Valid
2	G	D C A	3	2	2	Invalid
3	G	D F C A	4	4	3	Unknown
4	C	D E B	3	3	2	Unknown
5	C	A D E B	4	3	2	Invalid
6	C	A D G E B	5	3	2	Invalid
7	D	A C F	3	2	1	Invalid
8	D	A C F G	4	1	1	Invalid
9	D	E B	2	2	2	Valid

Working out example #2 in Table 1 for upstream path
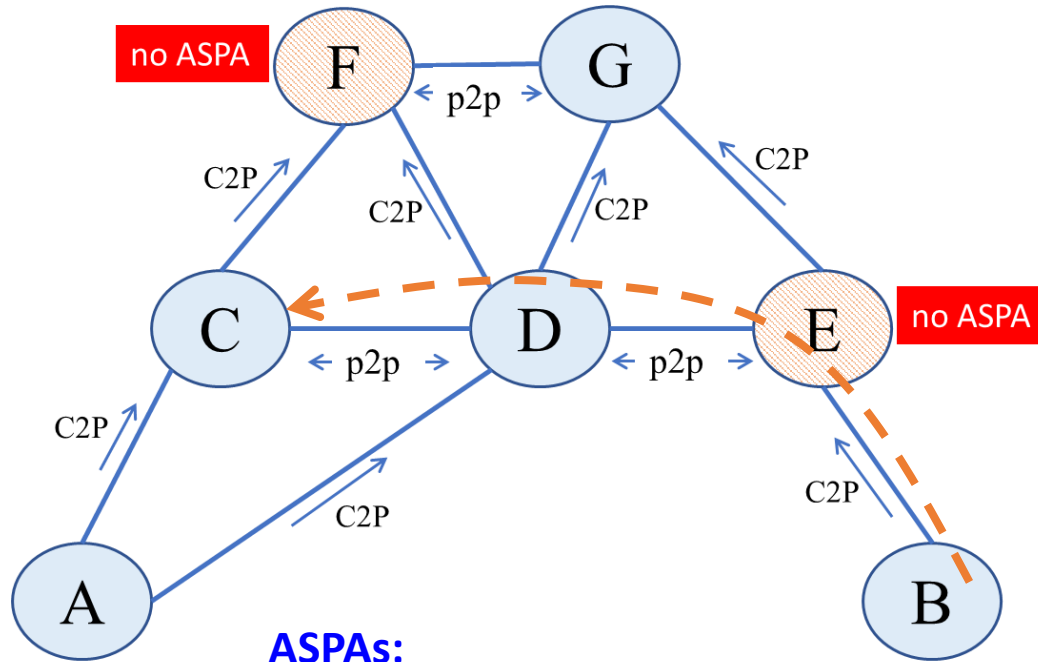## (BGP update received from customer or lateral peer)
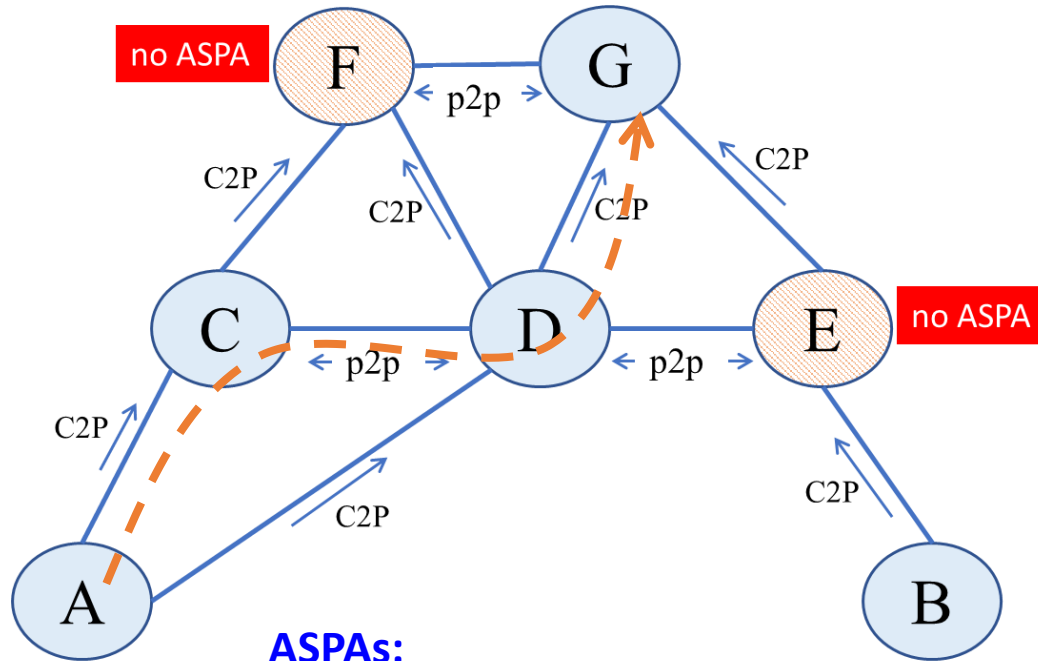
ASPAs:
A, {C, D}
B, {E}
C, {F}
D, {F, G}
G, {AS0}

E and F have no ASPAs

- G is the receiving/verifying AS

- G receives BGP update from D with AS path: D C A (simplified to contain only unique ASes)

- AS path length = 3

- Using the given ASPAs and the method in Section 6.1 of [1]:

  - max_up_ramp = 2 (A C)

  - min_up_ramp = 2 (A C)

- Using the procedure in Section 6.2 of [1]:

  - max_up_ramp < AS path length; hence verification outcome: Invalid

[1] "BGP AS_PATH Verification Based on Autonomous System Provider Authorization (ASPA) Objects," https://datatracker.ietf.org/doc/draft-ietf-sidrops-aspa-verification/

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Working out example #4 in Table 1 for upstream path
(BGP update received from customer or lateral peer)

no ASPA

F

G

C2P

C2P

← p2p →

C2P

C2P

C2P

C

D

E

no ASPA

← p2p →

← p2p →

C2P

C2P

C2P

A

B

ASPAs:
A, {C, D}
B, {E}
C, {F}
D, {F, G}
G, {AS0}

E and F have no ASPAs

- C is the receiving/verifying AS
- C receives BGP update from D with AS path: D E B (simplified to contain only unique ASes)
- AS path length = 3
- Using the given ASPAs and the method in Section 6.1 of [1]:
  - max_up_ramp = 3 (B E D)
  - min_up_ramp = 2   (B E)
- Using the procedure in Section 6.2 of [1]:
  - max_up_ramp is not less than AS path length; hence, AS path is not Invalid
  - min_up_ramp < AS path length; hence, verification outcome: Unknown

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Table 2: Examples of Downstream Path Verification
(BGP update received from a provider)

#	Receiving /Verifying AS	AS path (unique ASes)	AS path length	max_up _ramp	max_ down _ramp	min_up _ramp	min_down _ramp	Downstream Path Verification Result
1	B	E G F C A	5	4	2	3	1	Unknown
2	B	E G D A	4	3	2	3	1	Valid
3	B	E D C A	4	2	2	2	1	Unknown
4	B	E G D C A	5	2	2	2	1	Invalid
5	A	C F D G	4	1	4	1	2	Unknown
6	A	D G E B	4	3	2	2	2	Valid
7	A	C D G E B	5	3	1	2	1	Invalid
8	D	F C A	3	3	2	3	1	Valid
9	B	E A	2	1	2	1	1	Valid*
10	B	E A C	3	2	2	2	1	Valid**

*Forged-origin and **forged-path-segment hijacks (path manipulations) by a provider (E) towards a customer (B) are undetectable by ASPA (see Section 8.2 "Security Considerations" in [1]).

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Working out example #1 in Table 2 for downstream path
(BGP update received from a provider)

no ASPA

F

G

← p2p →

C2P

C2P

C2P

C2P

C

D

E

no ASPA

← p2p →

← p2p →

C2P

C2P

C2P

A

B
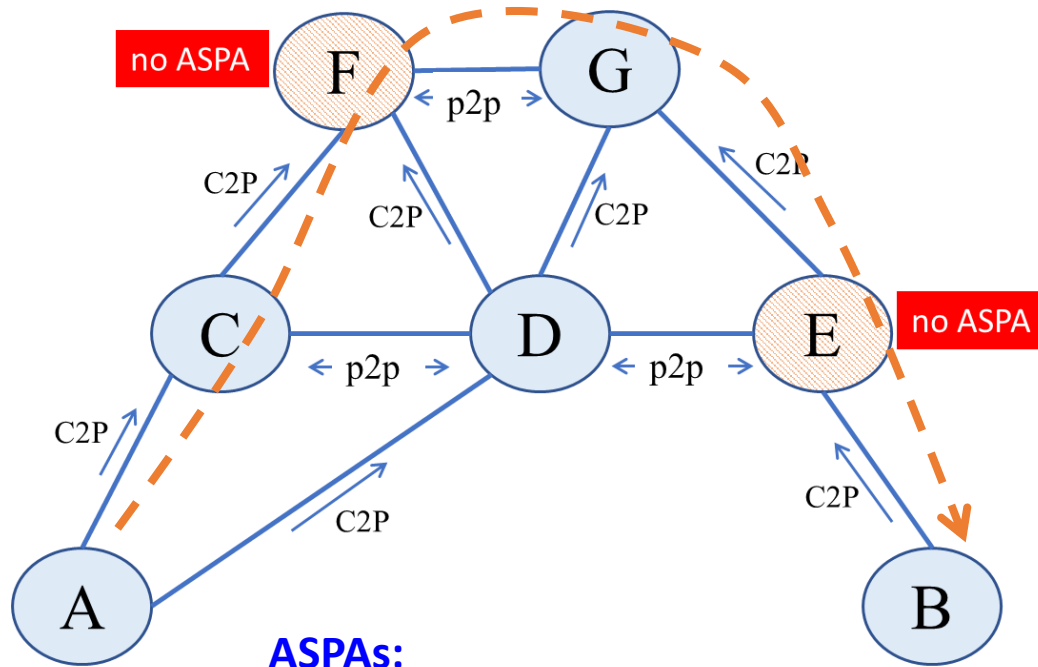
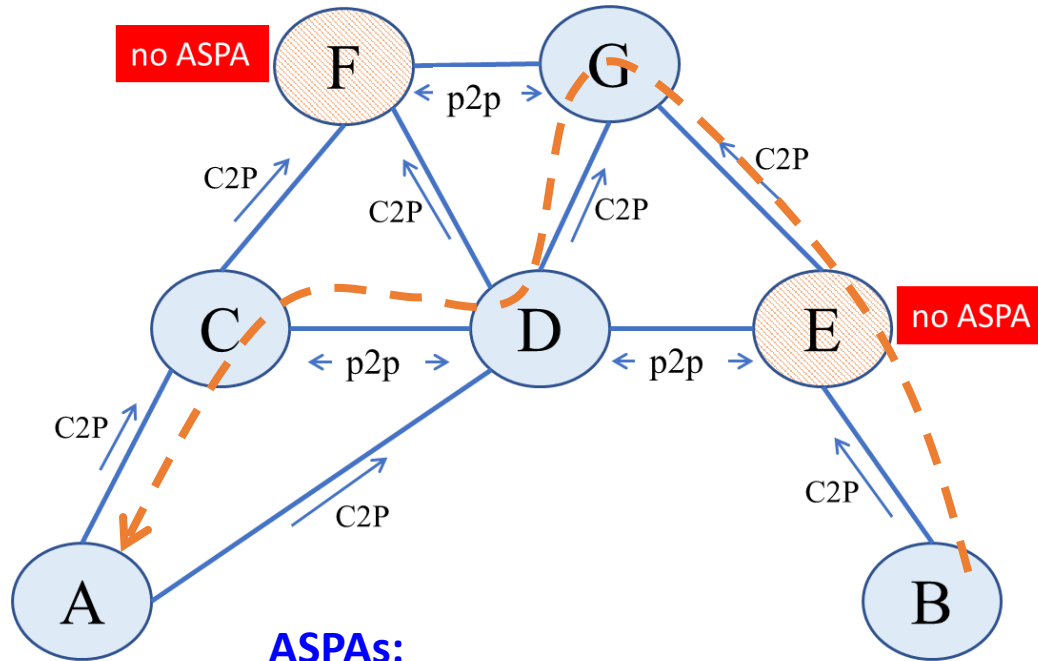**ASPAs:**
A, {C, D}
B, {E}
C, {F}
D, {F, G}
G, {AS0}

E and F have no ASPAs

- B is the receiving/verifying AS

- B receives BGP update from E with AS path: E G F C A (simplified to contain only unique ASes)

- AS path length = 5

- Using the given ASPAs and the method in Section 6.1 of [1]:

  - max_up_ramp = 4 (A C F G)

  - max_down_ramp = 2 (E G)

  - min_up_ramp = 3 (A C F)

  - min_down_ramp = 1 (E)

- Using the procedure in Section 6.3 of [1]:

  - max_up_ramp + max_down_ramp is not less than AS path length; hence, AS path is not Invalid

  - min_up_ramp + min_down_ramp < AS path length; hence, verification outcome: Unknown

Working out example #7 in Table 2 for downstream path
(BGP update received from a provider)

F

G

no ASPA

p2p

C2P

C2P

C2P

C2P

C

D

E

no ASPA

p2p

p2p

C2P

C2P

C2P

A

B

ASPAs:

A, {C, D}
B, {E}
C, {F}
D, {F, G}
G, {AS0}

E and F have no ASPAs

- A is the receiving/verifying AS

- A receives BGP update from C with AS path: C D G E B (simplified to contain only unique ASes)

- AS path length = 5

- Using the given ASPAs and the method in Section 6.1 of [1]:

  - max_up_ramp = 3 (B E G)

  - max_down_ramp = 1 (C)

  - min_up_ramp = 2 (B E)

  - min_down_ramp = 1 (C)

- Using the procedure in Section 6.3 of [1]:

  - max_up_ramp + max_down_ramp < AS path length; hence, verification outcome: Invalid

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