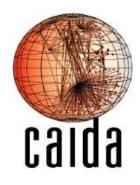# Atomised Routing

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CAIDA / NLnet Labs / RIPE NCC

http://www.caida.org/projects/routing/atoms/

Motivation

- Observation: many prefixes share AS path in all RouteViews / RIPE peers

- BGP policy atom: set of prefixes that share AS path

- Routed the same

Motivation

Fewer atoms than prefixes + atoms relatively stable:

- 8 May 2003 RouteViews data:
  - around 33000 atoms
  - covering around 113000 prefixes
  - (15400 ASes)

- Stability over 8 hours:
  - 4.9% of atoms undergo prefix membership change
  - 2-3% of prefixes change atom membership
    (Tel Aviv University, 2002)

Apply to routing?

- Summarise prefixes of atom into one routed object

- Incorporate into BGP

Reduce number of routed objects in Default-Free Zone (DFZ):

- Shrink routing tables and forwarding tables

- Perform routing updates per atom, not per prefix

- Potentially improved convergence

Remainder of talk

- Architecture
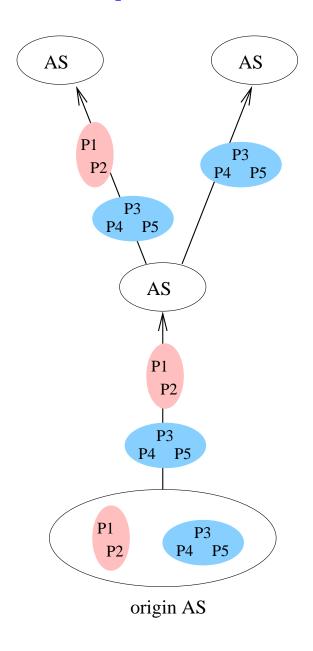
- Incremental deployment

- Status and unresolved issues

Architecture

- Origination of atoms

- Overview of routing and forwarding

- Routing outside DFZ

- Routing inside DFZ

- Forwarding inside DFZ

- Forwarding outside DFZ

Architecture — Origination of atoms

- To be *declared* by origin ASes

- These ASes partition prefixes into atoms and announce

- Prefixes can be IPv4 or IPv6

Architecture — Example of declared atom
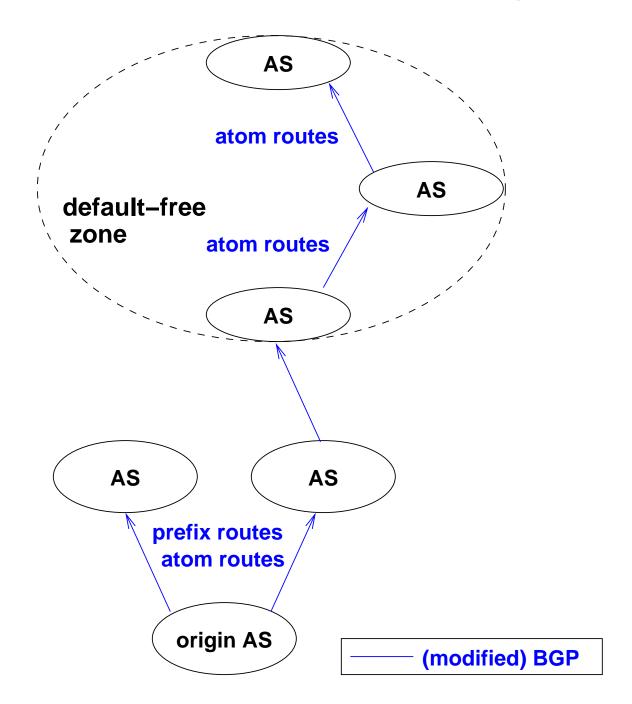
Architecture — Overview of routing
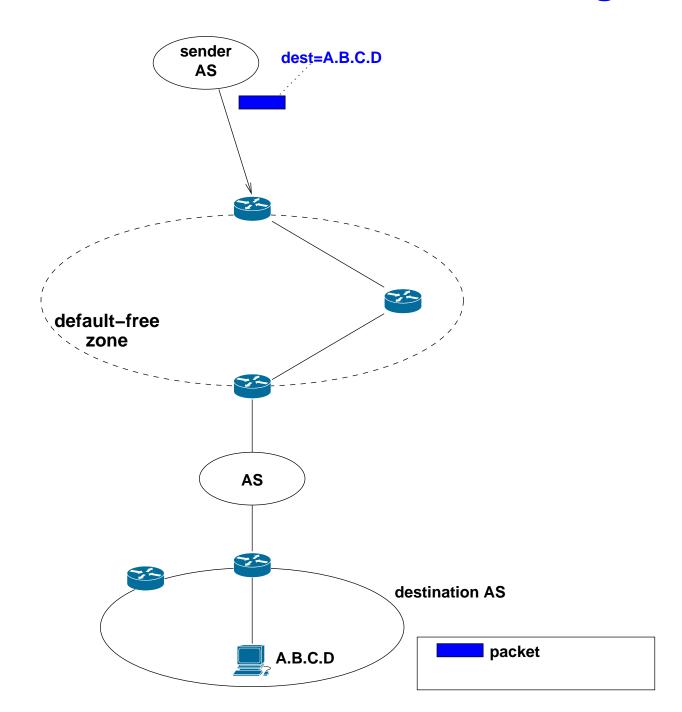
Two functions:

- Atom routing
    - Atom is represented by an atom ID
    - Atom ID syntactically a prefix
      (unrelated to prefixes in atom)
    - Reason: BGP can route atom IDs

- Atom membership
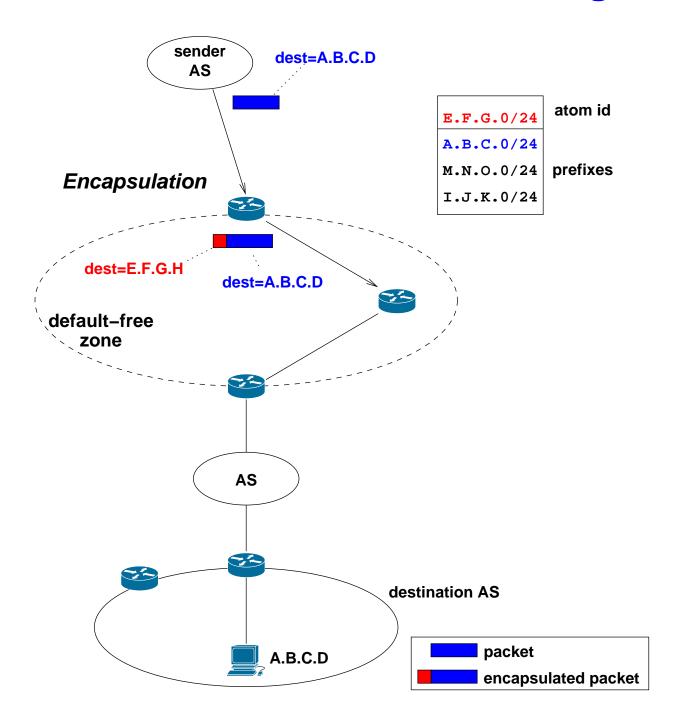   - Distributes {atom ID $\leftrightarrow$ prefix} mapping

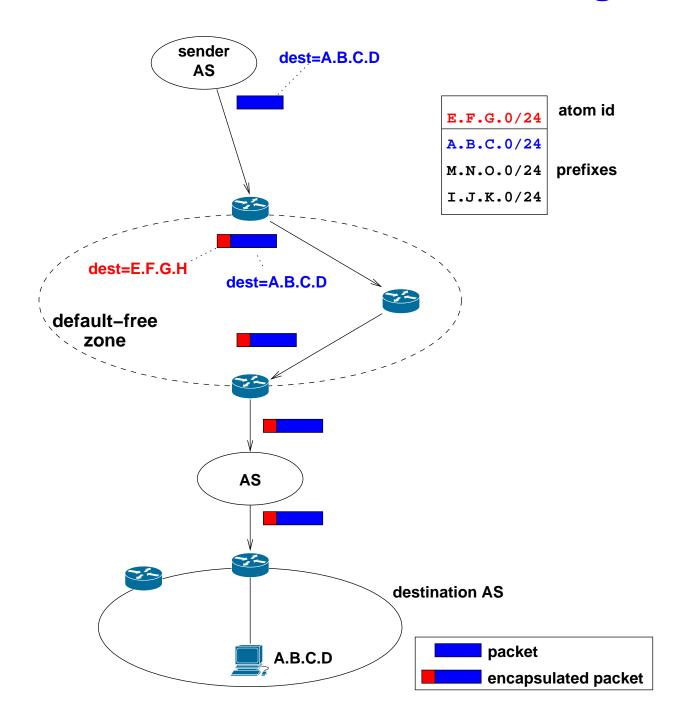Membership technically not a routing protocol:

- No routing computations

- Location-independent (compare DNS)

- Future optimisation: separate protocol

Architecture — Overview of routing

Architecture — Overview of forwarding

sender AS

dest=A.B.C.D

default−free zone

AS

destination AS

A.B.C.D

packet

Architecture — Overview of forwarding

Architecture — Overview of forwarding

Architecture — Overview of forwarding

sender AS

dest=A.B.C.D

E.F.G.0/24	atom id
A.B.C.0/24	
M.N.O.0/24	prefixes
I.J.K.0/24	

dest=E.F.G.H

dest=A.B.C.D

default−free zone

AS

De−encapsulation

destination AS

A.B.C.D

packet	
encapsulated packet	

Architecture — Overview of forwarding

default−free
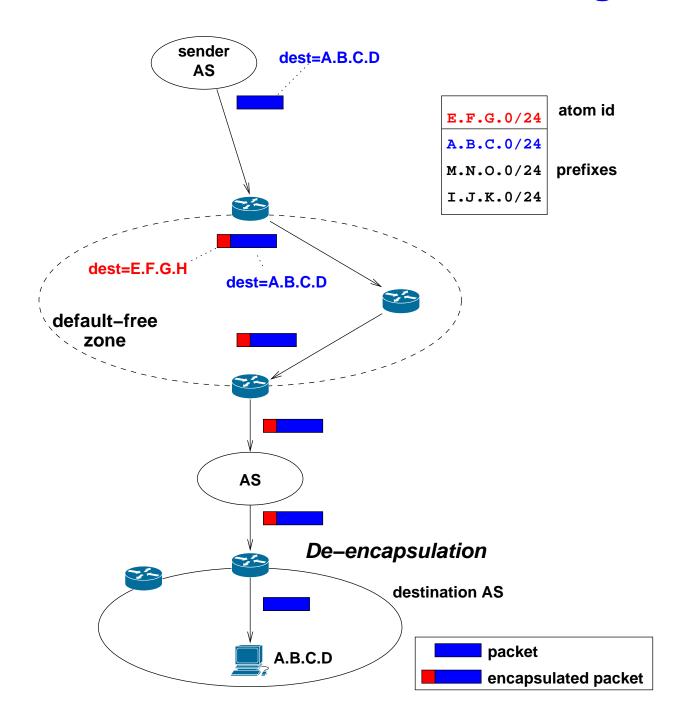zone

sender
AS

AS

destination AS

A.B.C.D
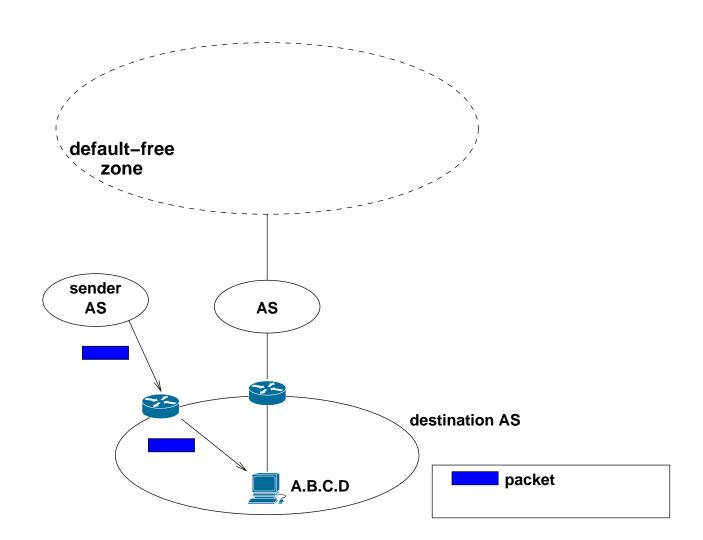
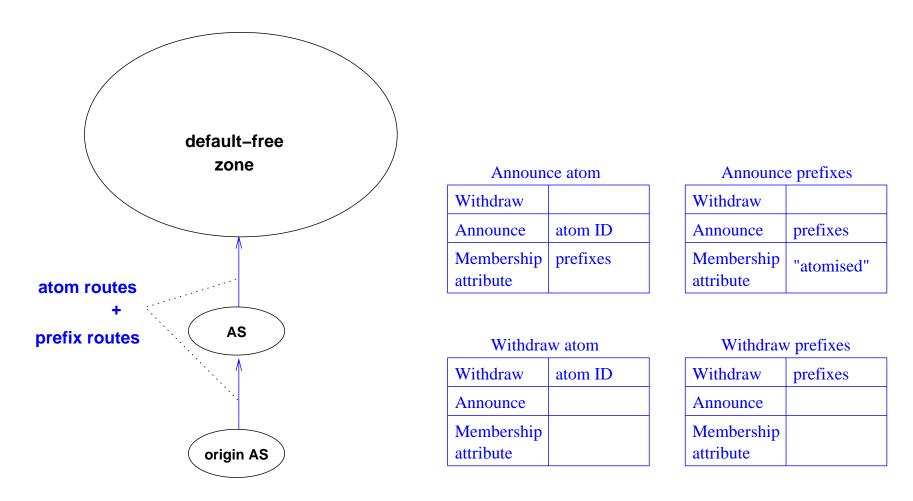packet

Architecture — Overview of forwarding
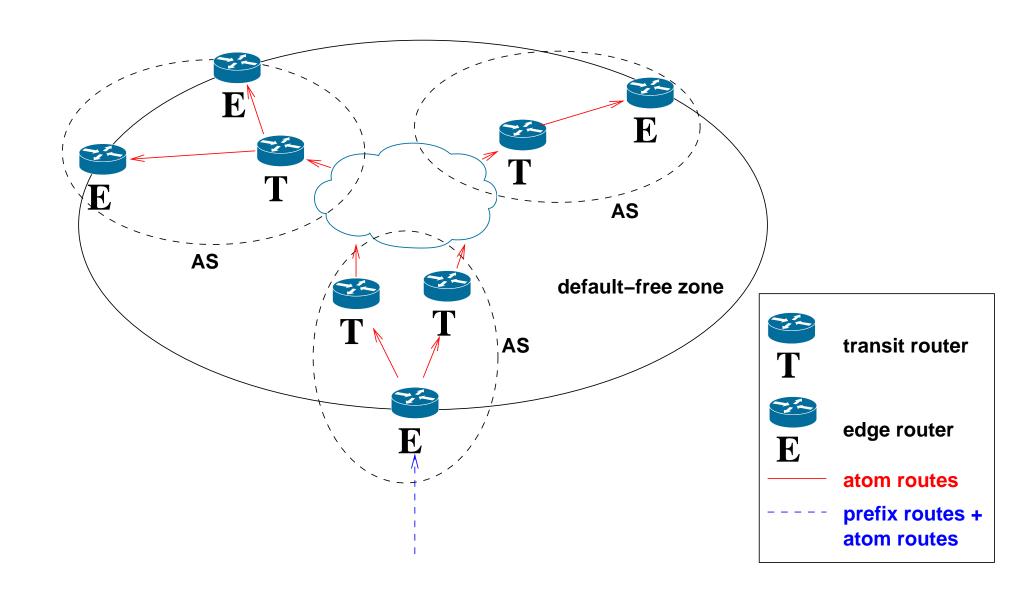
Comparing atom-based forwarding and MPLS:

- Atom ID similar to Forwarding Equivalence Class

- Encapsulation rather than label swapping

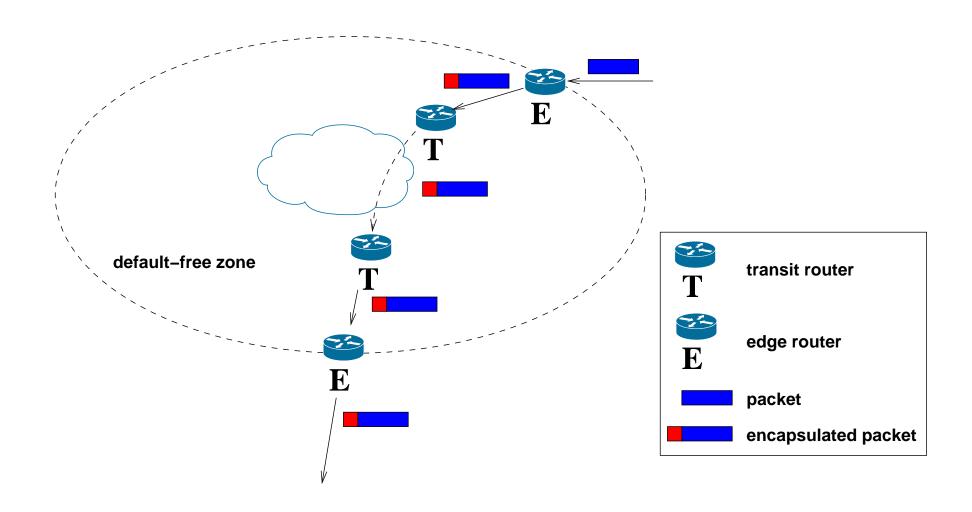- MPLS not applied interdomain

Architecture — Routing outside DFZ

default−free zone

atom routes
+
prefix routes

AS

origin AS

Announce atom	
Withdraw	
Announce	atom ID
Membership attribute	prefixes

Announce prefixes	
Withdraw	
Announce	prefixes
Membership attribute	"atomised"

Withdraw atom	
Withdraw	atom ID
Announce	
Membership attribute	

Withdraw prefixes	
Withdraw	prefixes
Announce	
Membership attribute	

- Atom announcement carries prefix membership in attribute
- Prefixes also routed separately

Architecture — Routing inside DFZ

transit router

edge router

atom routes

prefix routes +
atom routes

Architecture — Forwarding inside DFZ

default−free zone

transit router

edge router

packet

encapsulated packet

Architecture — Forwarding outside DFZ

default−free
zone

sender
AS

origin AS

packet

encapsulated packet

Incremental deployment

- Atomless prefixes

- ASes outside DFZ that are not atomised:
  - Nothing special happens between origin AS and DFZ
  - Forwarding is transparent
  - BGP attributes are *optional transitive*

- DFZ ASes that are not atomised: islands

Incremental deployment — Islands

default−free zone

E

E

E

T

T

E

E

	AS
	atomised island
	transit router
T	
	edge router
E	
	other router

Implementation

Status of implementation:

- Implemented previous architecture of atomised routing:
  - No notion of default-free zone
  - All routers prefix-aware
  - Implementing new architecture (fall 2003)
- In Zebra: free routing software (GNU license)
- Atoms declared using router configuration language

TODO

- A DFZ membership protocol

- Look at non-AS path policies

- Declare atoms upstream from origin AS

- Failures that force atom redeclaration

Questions?

http://www.caida.org/projects/routing/atoms/

Architecture — Overview of forwarding

sender
AS

dest=A.B.C.D

E.F.G.0/24	atom id
A.B.C.0/24	
M.N.O.0/24	prefixes
I.J.K.0/24	

Encapsulation

dest=E.F.G.H

dest=A.B.C.D

**default−free
zone**

sender
AS

AS

De−encapsulation

destination AS

A.B.C.D

▮	packet
▮▮	encapsulated packet