Edge-Aware Inter-domain Routing (EIR)

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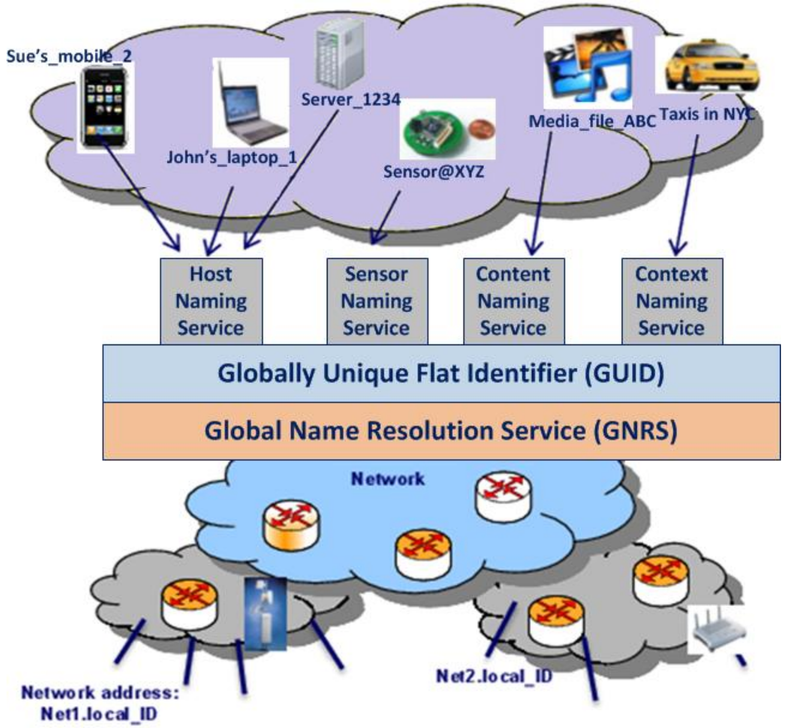
MobilityFirst Overview

- Name based communication
  - Flat self-certifying globally unique identifier (GUID)
- Dynamic name resolution
  - Mapping of GUID to network address maintained at the global name resolution service (GNRS)
- In-network storage
- Hop by hop reliable transport



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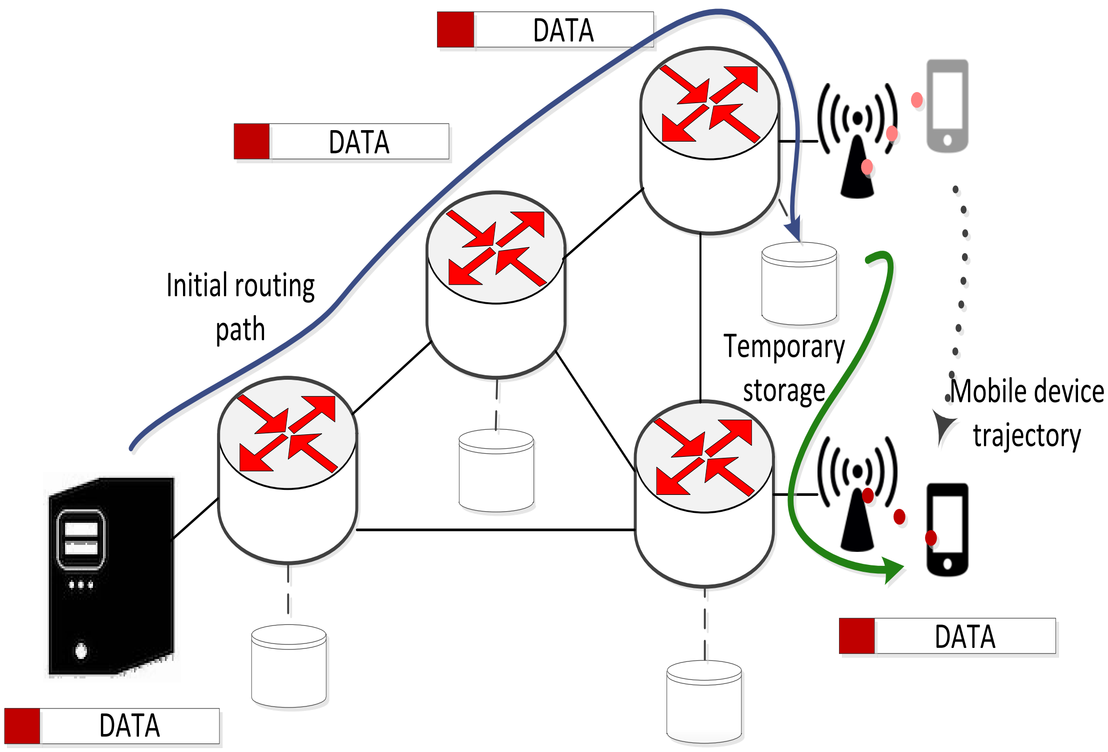
Intra-domain routing in MF

Generalized storage aware routing (GSTAR):

- Proactive link state routing
- Link quality information in terms of expected time of transmission (ETT)
- Directly accessible in-network storage
- Store or forward decisions based on short term and long term ETTs



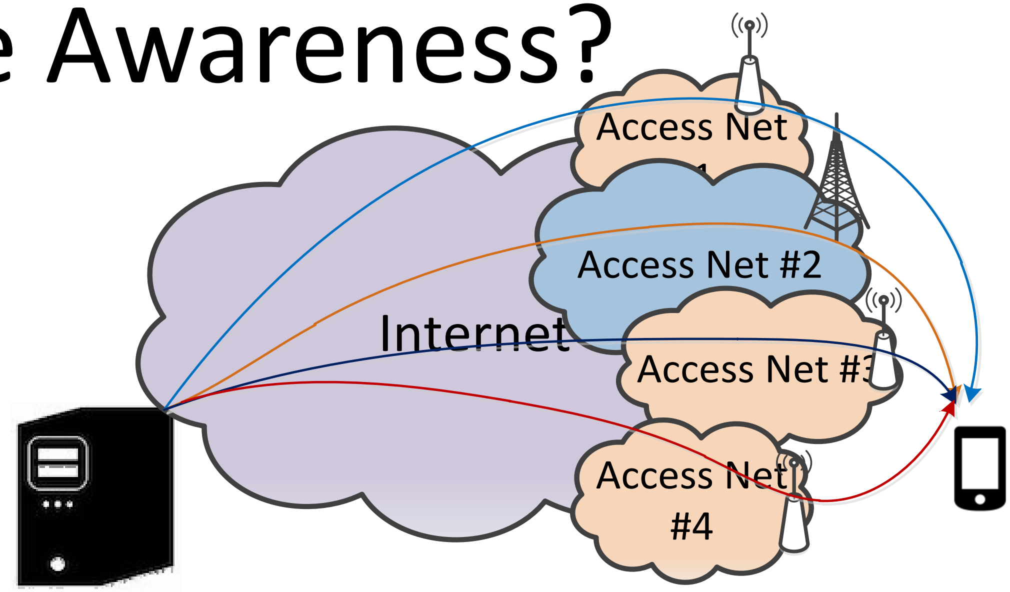
Clean-slate Inter-domain Routing

- Current inter-domain routing has poor support for
  - Edge mobility
  - Dynamic AS formation
  - Multipath routing
  - Intra-domain network visibility

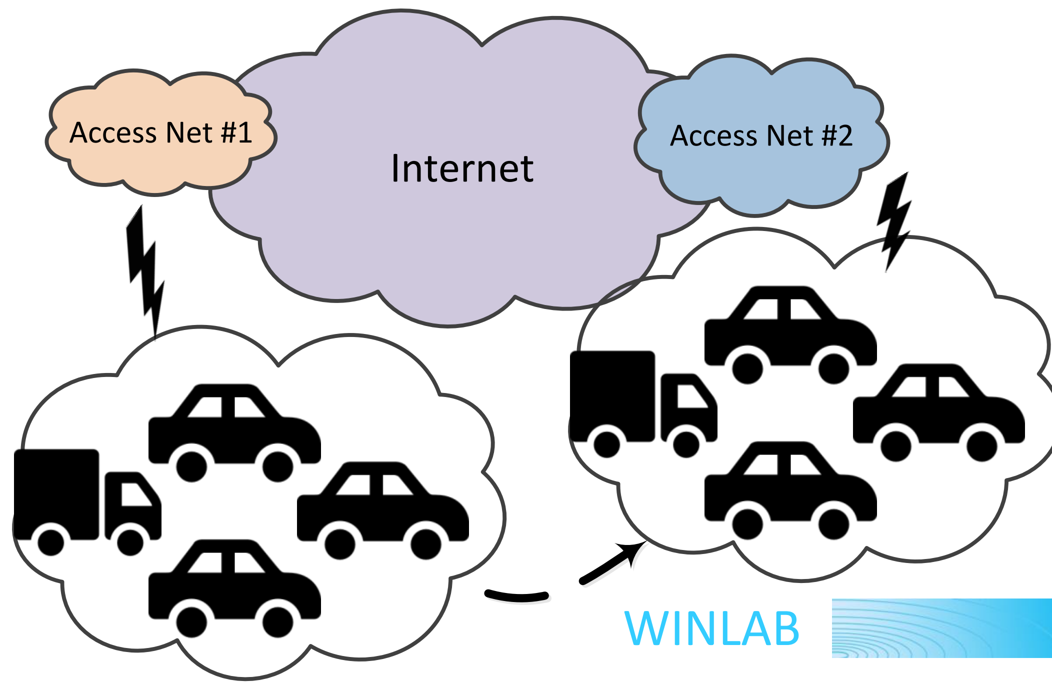
- EIR is a clean slate inter-domain routing framework designed for the MobilityFirst architecture

Why Edge Awareness?

- Basic property of a mobile device:
  - Multi-radio capability
  - Multiple available paths at the edge



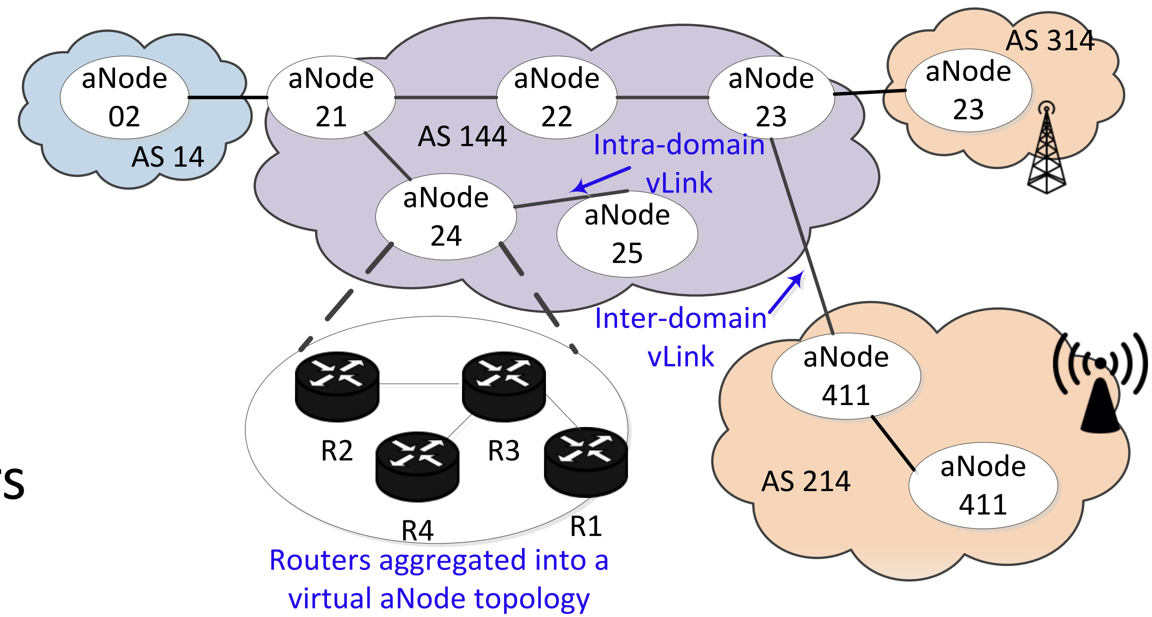
- Ad-hoc network formation without connectivity to the core
- Dynamic wireless edge peering with mobility



EIR Design Features

1. Aggregation nodes (aNodes) and virtual links (vLinks)

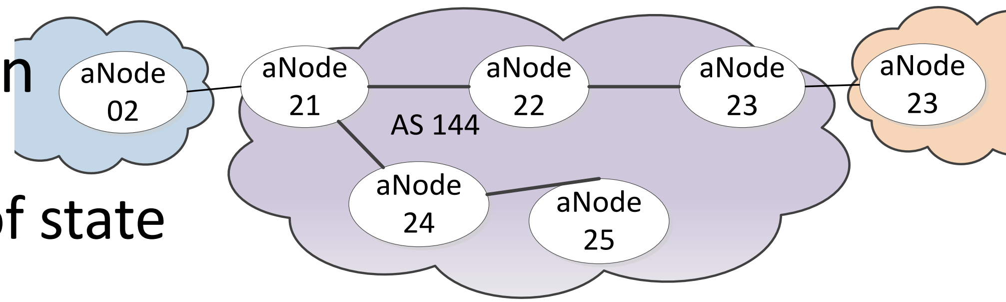
- aNodes and vLinks as abstractions to expose internal network topology of an AS
    - Aggregated information of a collection of routers and links
    - Flexible aggregation granularity



Aggregation of intra-network topology

EIR Design Features

2. Network state dissemination



Aggregated view of a network

- Network-wide propagation of state packets (nSPs)
- nSPs contain
  - aNode and vLink connectivity info
  - vLink properties (Mbps, % avail, estimated time of transmission (ETT), functional parameters, etc.)
- Shortest path routing based on global aggregated topology

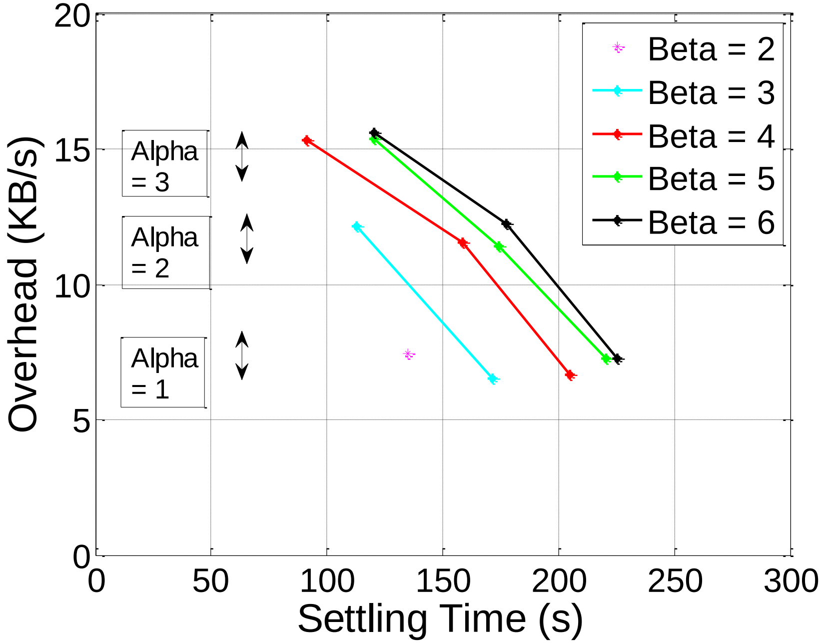
Msg_Type	AS_Num:Source_aNode	Hop_to_Src
Internal Topologies:		
aNode#1-vLink<B,V,A,L>-aNode#2 aNode#2-vLink<B,V,A,L>-aNode#3 ... aNode#x-vLink<B,V,A,L>-aNode#y		
Neighbor Info:		
Neighbor_aNode#1-vLink<B,V,A,L> Neighbor_aNode#2-vLink<B,V,A,L> ... Neighbor_aNode#z-vLink<B,V,A,L>		

Network state packet (nSP)

EIR Design Features

3. Telescopic flooding

- Border routers forward nSPs originated from other ASes in a telescopic manner
- The relaying rate is determined by the distance of the packet-source AS to the forwarding AS
- Nearby ASes will have a better view of the network than far-away ASes



Parametric evaluation of overhead for const-exp-const function

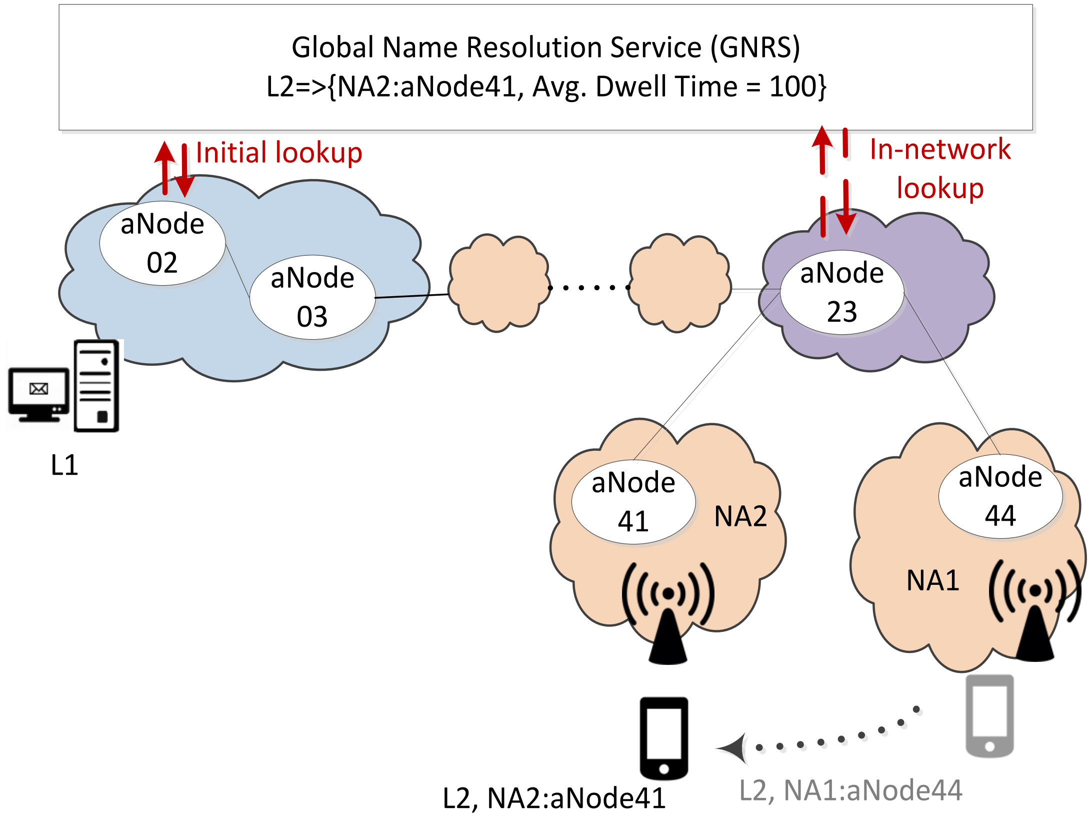
$$y_1 = A$$
$$y_2 = A * \exp(x-1)$$
$$y_3 = \begin{cases} A, x < \alpha \\ A * \exp(x-\alpha), \alpha \le x < \beta \\ A * \exp(\beta - \alpha), x \ge \beta \end{cases}$$

Different telescopic functions

EIR Design Features

4. Late binding support

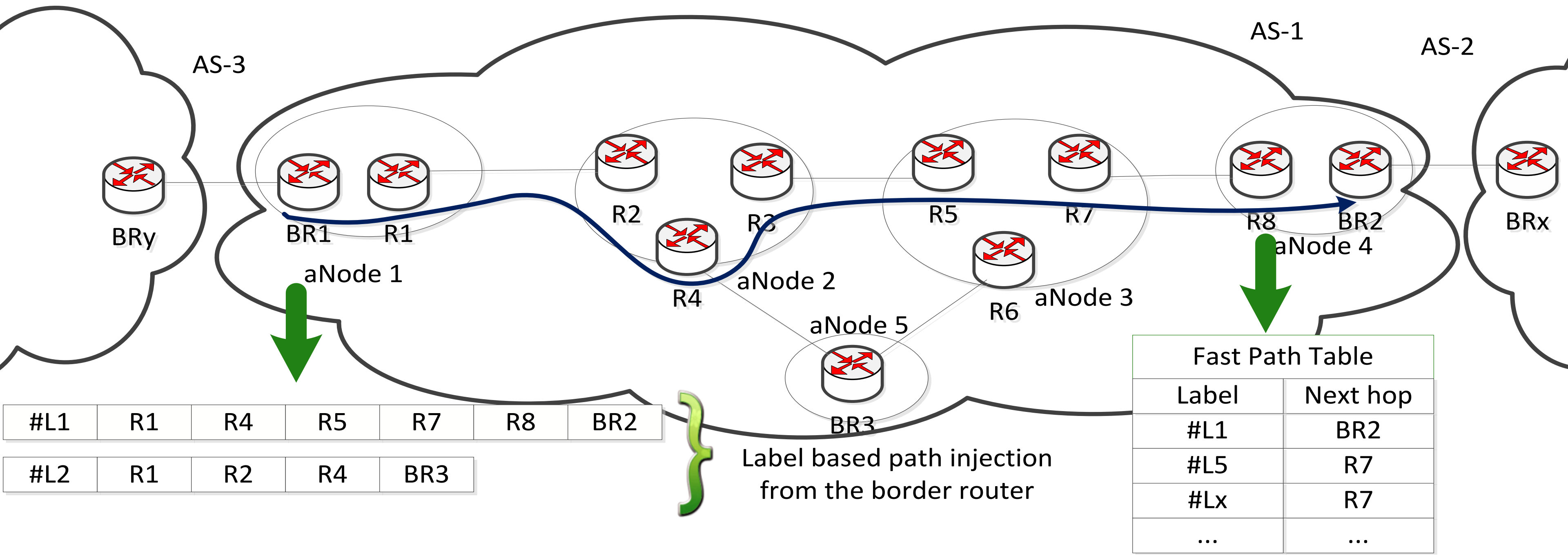
- At source early binding with re-resolution on failure
- In-network binding of names (GUIDs) to locations (aNodes) closer to the edge for more up-to-date information



Mobility support through late binding

EIR Design Features

5. Fast path for transit traffic



#L1	R1	R4	R5	R7	R8	BR2
#L2	R1	R2	R4	BR3		

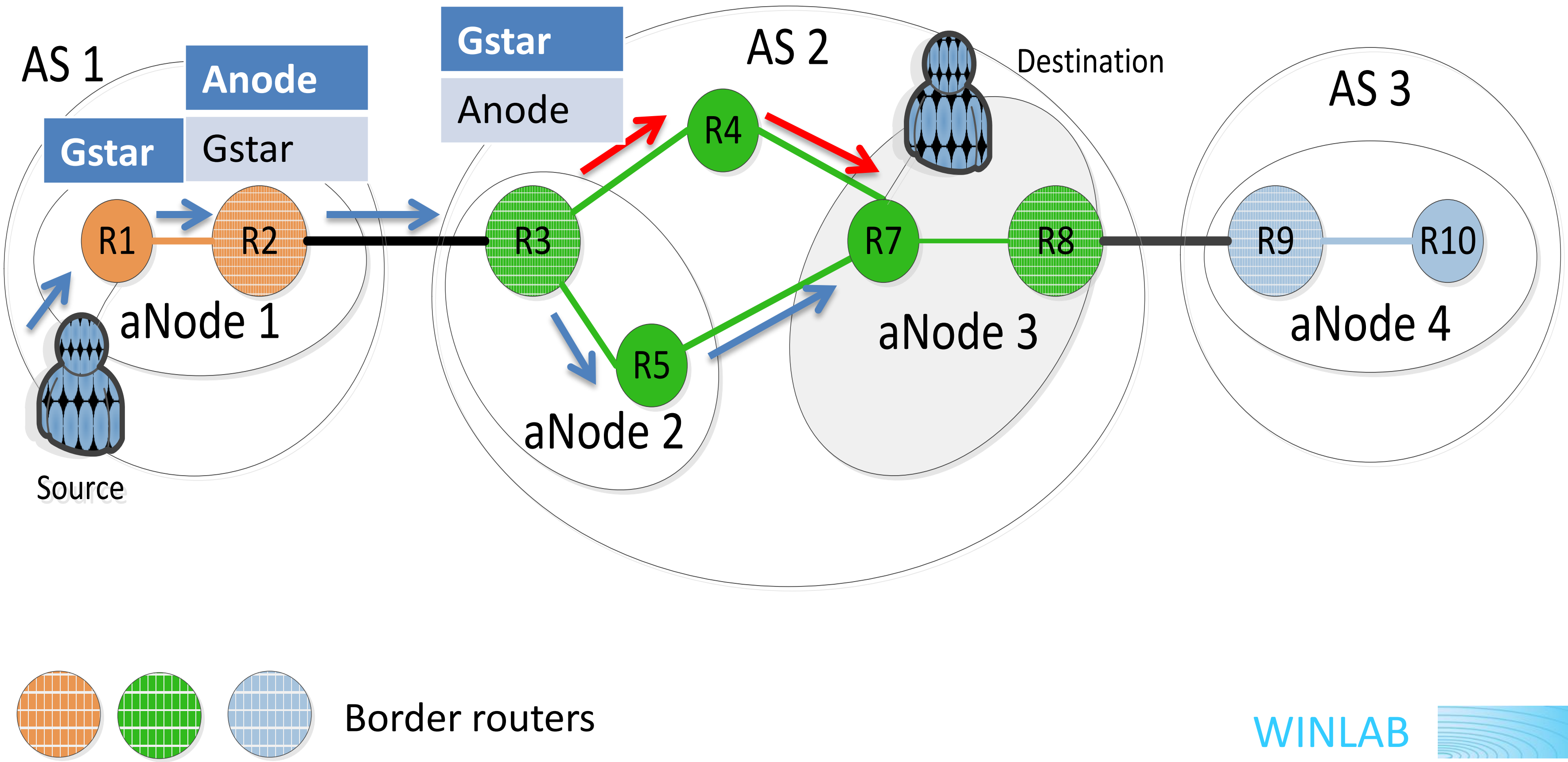
Fast Path Table

Label	Next hop
#L1	BR2
#L5	R7
#Lx	R7
...	...

- Border routers determine cut-through paths based on transit and local policies
- Route injection packets are pushed by border routers to inject label info in fast path forwarding table
- Transit traffic at the ingress border router is 'marked' transit and appended with the label
- No inter-domain routing/policy info required at the internal routers

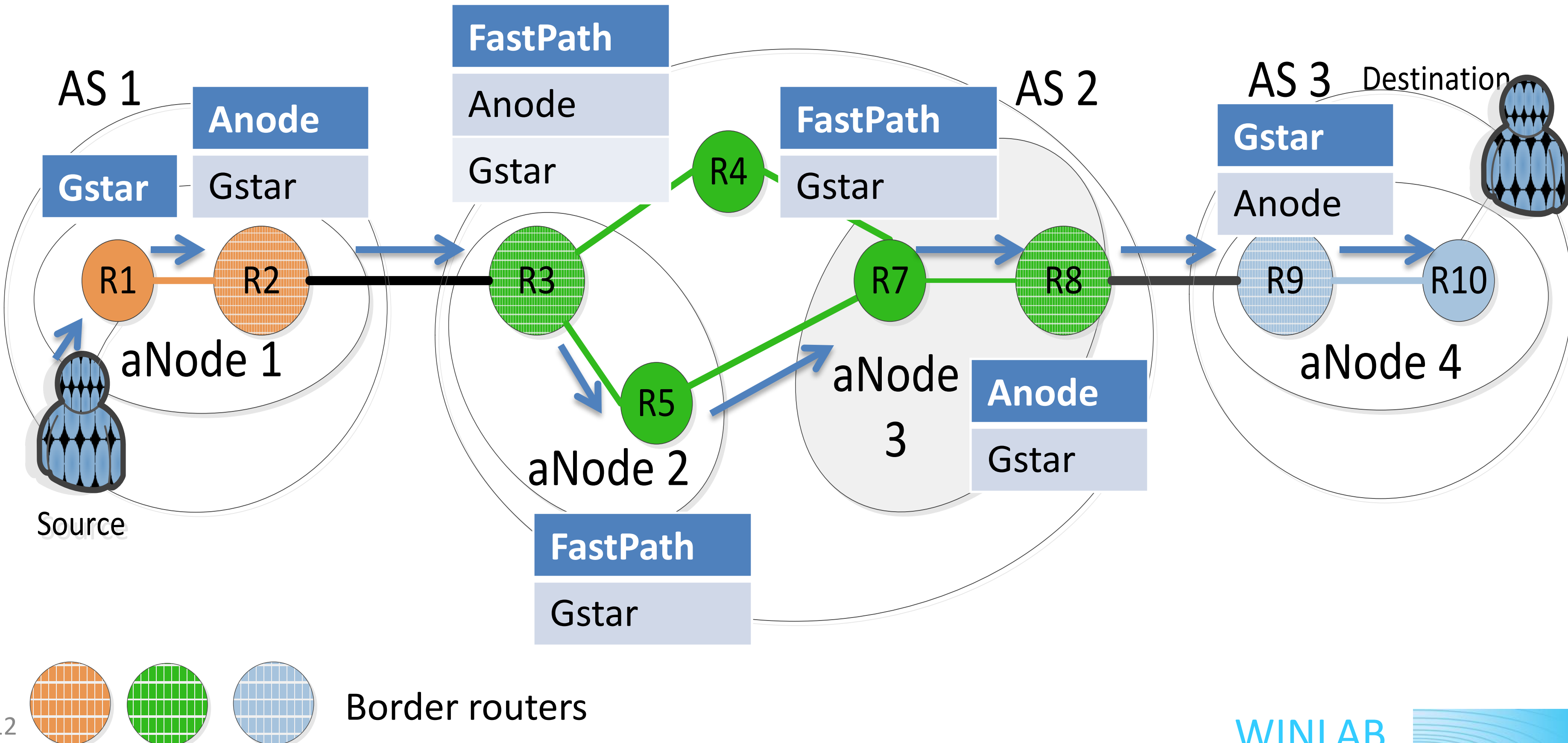
EIR Routing Scenarios

1. Source in AS 1 and destination in AS 2



EIR Routing Scenarios

2. Source in AS 1 and destination in AS 3



Implementation

- Working prototype implementation using Click modular routers on Orbit
  - Validated system performance for small to medium topologies
- Simulation implementation using NS-3
- Custom event driven simulator to simulate Internet scale topologies
  - Ongoing analysis of currently available topology datasets (Dimes, Caida) as well as future Internet topology generators (GeoTopo[1])

[1] Y. Hu, F. Zhang, K.K. Ramakrishnan and D. Raychaudhuri, "GeoTopo: A PoP-level Topology Generator for Future Internet Study", WINLAB Technical Report 2014

Evaluation Plan

- Analysis of mobile wireless use-case scenarios
  - End users with realistic dynamic mobility
  - Cross-domain multi-homing
  - Wireless edge peering
- Scalability and control overhead evaluation for large scale Internet topologies

Questions?

Thank you!