A System for Authenticated Policy-Compliant Routing

Barath Raghavan and Alex C. Snoeren
UC San Diego

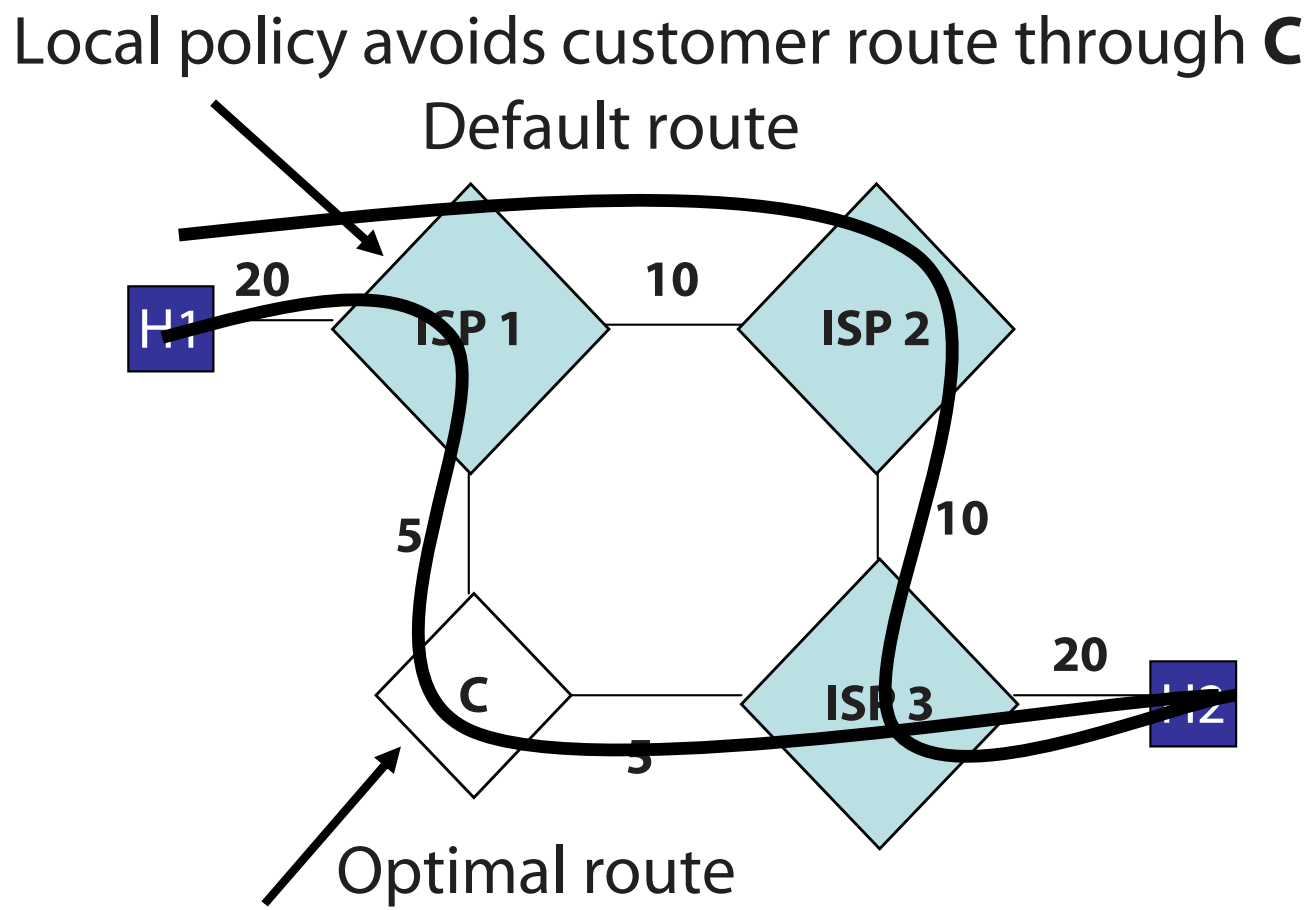
Routing Today

- ISPs perform wide-area routing through BGP
  - Used to express local policy and traffic eng.
  - Problem: users can't express routing preferences
- Overlay routing / IP source routing
  - Enables edge routing control
  - Allows pooling of resources
  - Problem: may interfere with ISP policy and traffic engineering

Our system: Platypus

- Loose source routing in which…
  - Users can pick their routes
  - ISPs control placement of indirection points
- … and authentication which enables…
  - ISPs to verify the policy-compliance of traffic
  - Is easily accountable
  - Delegation of source routing rights by users

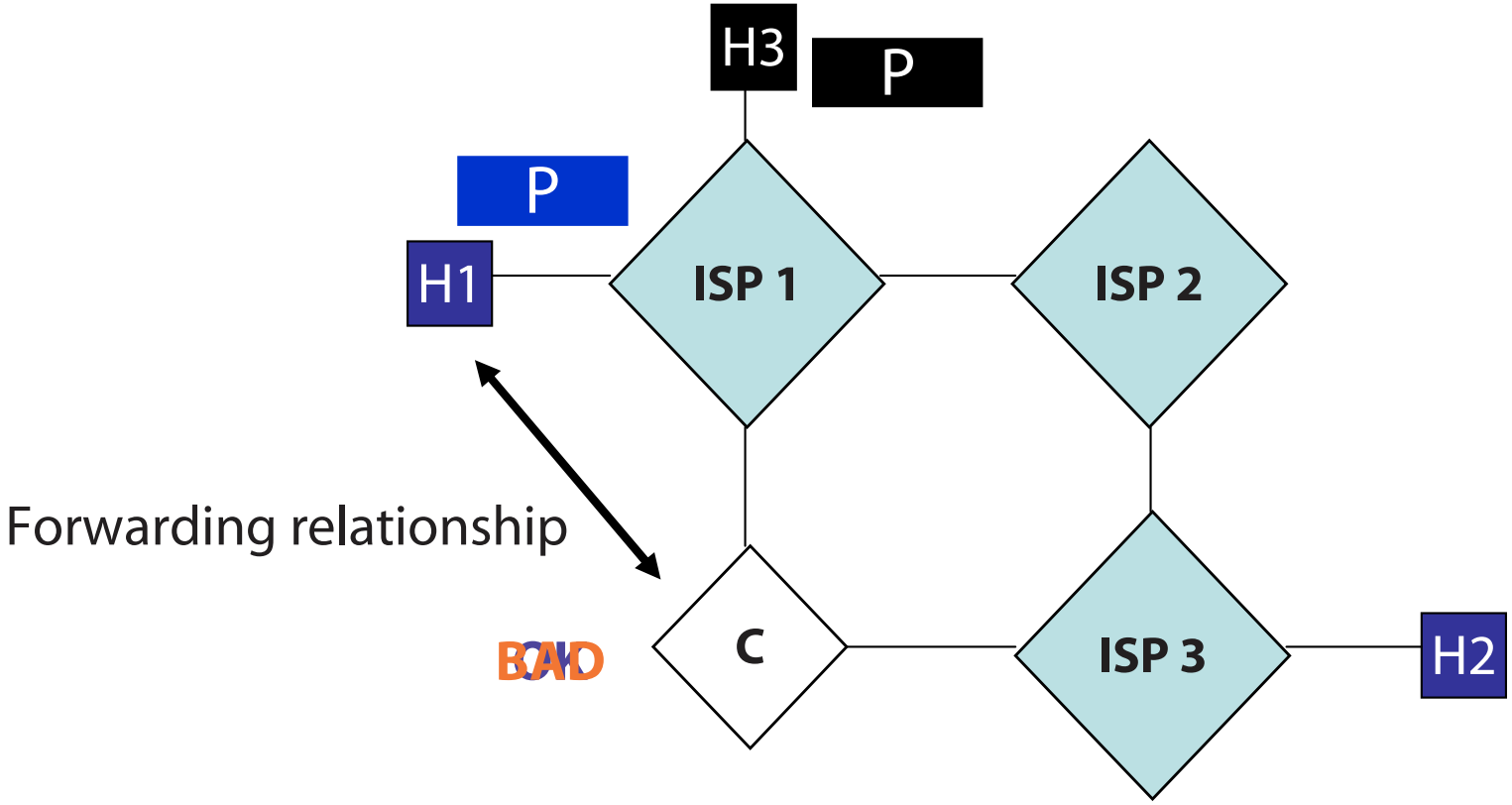
An example



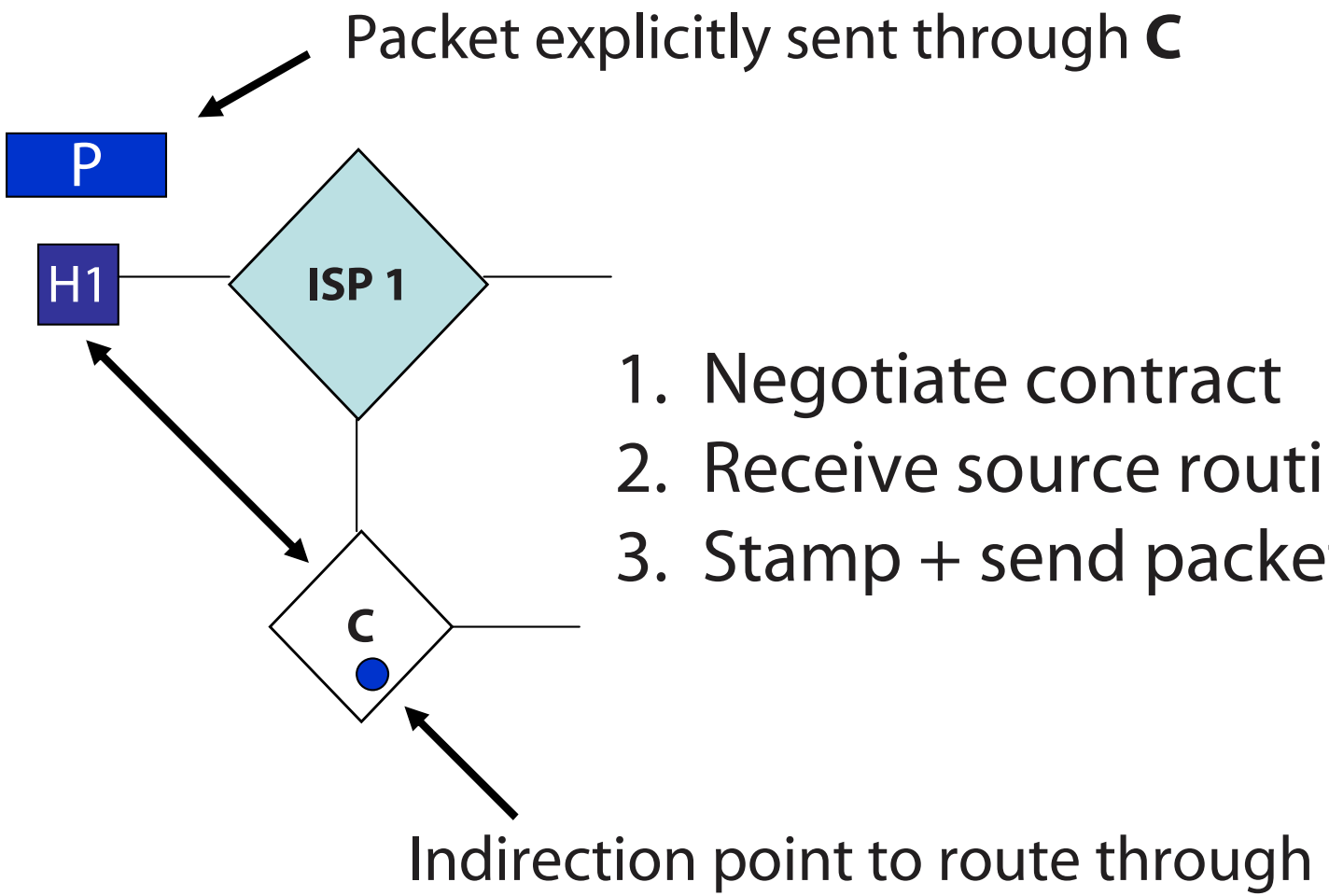
C *could* forward traffic

The challenge

How can **C** provide forwarding service?



Our system: Platypus



1. Negotiate contract
2. Receive source routing info
3. Stamp + send packets

Key building blocks

- Routing system providing basic connectivity
- Path discovery mechanisms / services
- Negotiation of business relationships
- Mechanism for authenticated loose source routing

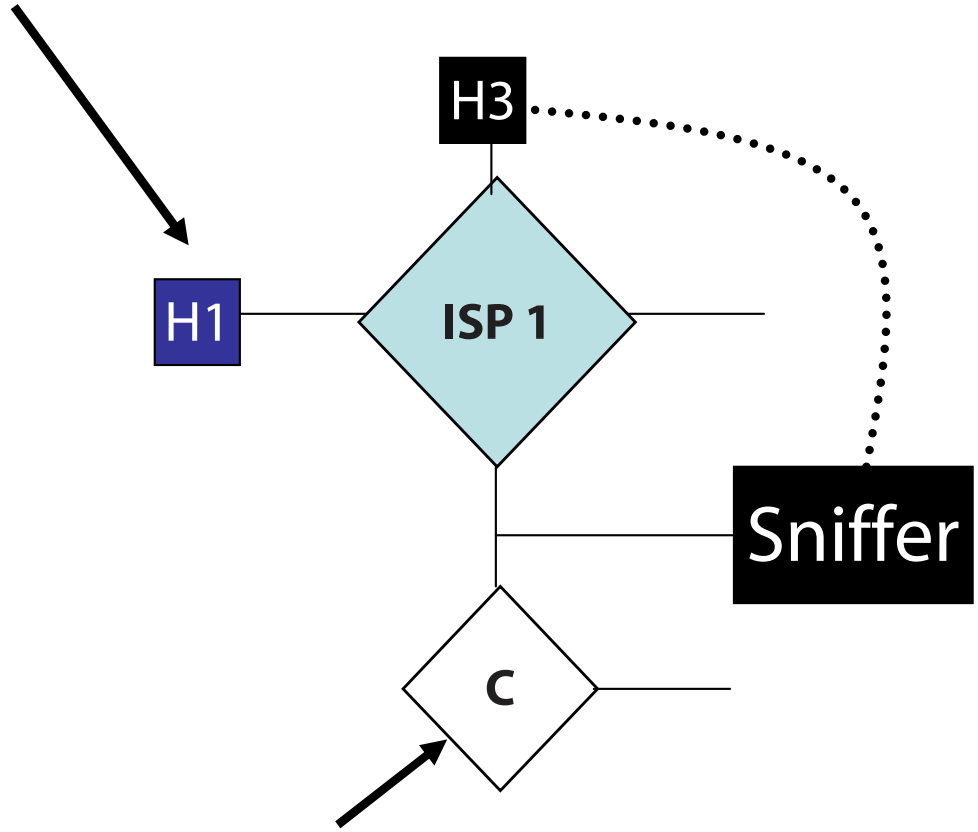
Network Capabilities

- Specify a hop of the source route, including:
  - Point of indirection, called a *waypoint*
  - The responsible party, called the *resource principal*
- Waypoints are:
  - Chosen by ISPs
  - Specified by a routable IP address

Waypoint ID
Resource Principal ID

Authentication

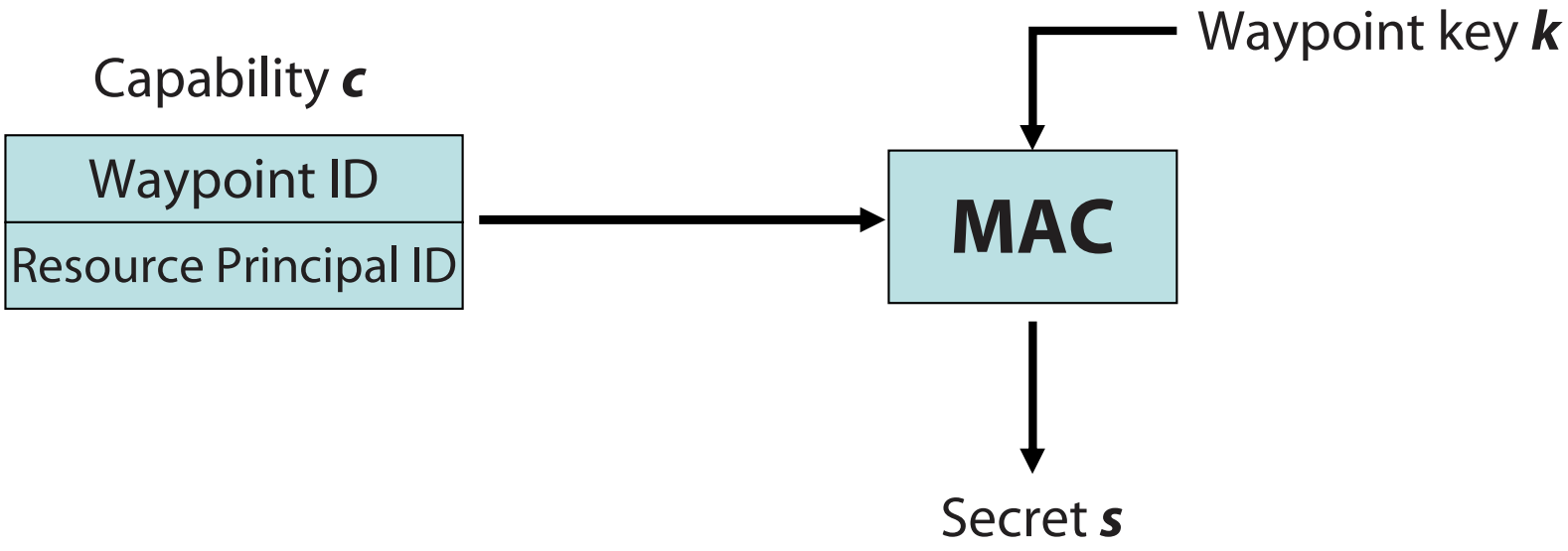
Requires asymmetry of information:
H1 must know more than H3



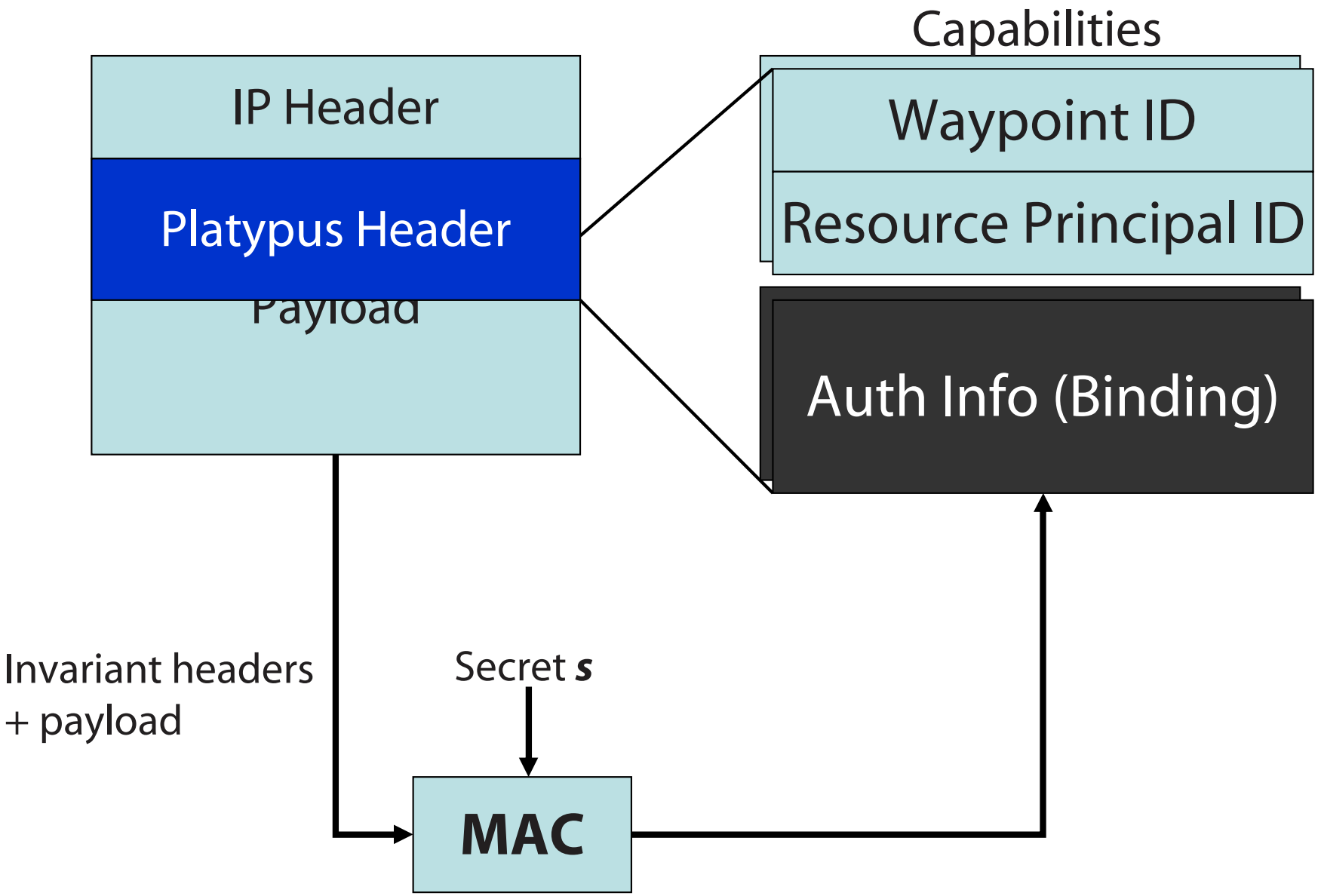
Goal: Distinguish between valid and invalid packets

Authentication keys

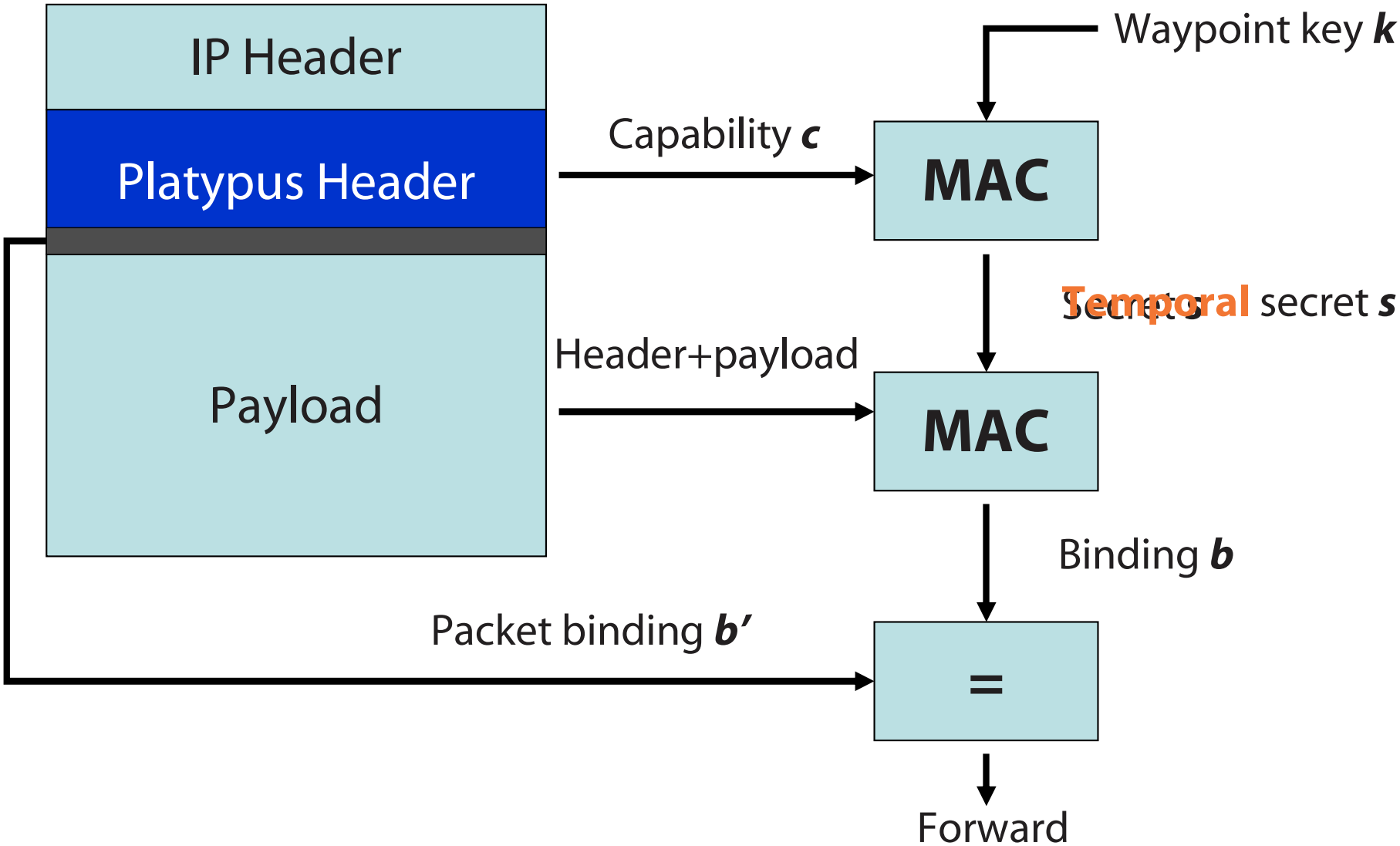
- Each waypoint has one waypoint key ***k***
- Each resource principal has a secret key ***s***
  - Derived from waypoint key using a keyed MAC
  - Unique given a waypoint and a capability



Packet Stamping



Packet Verification

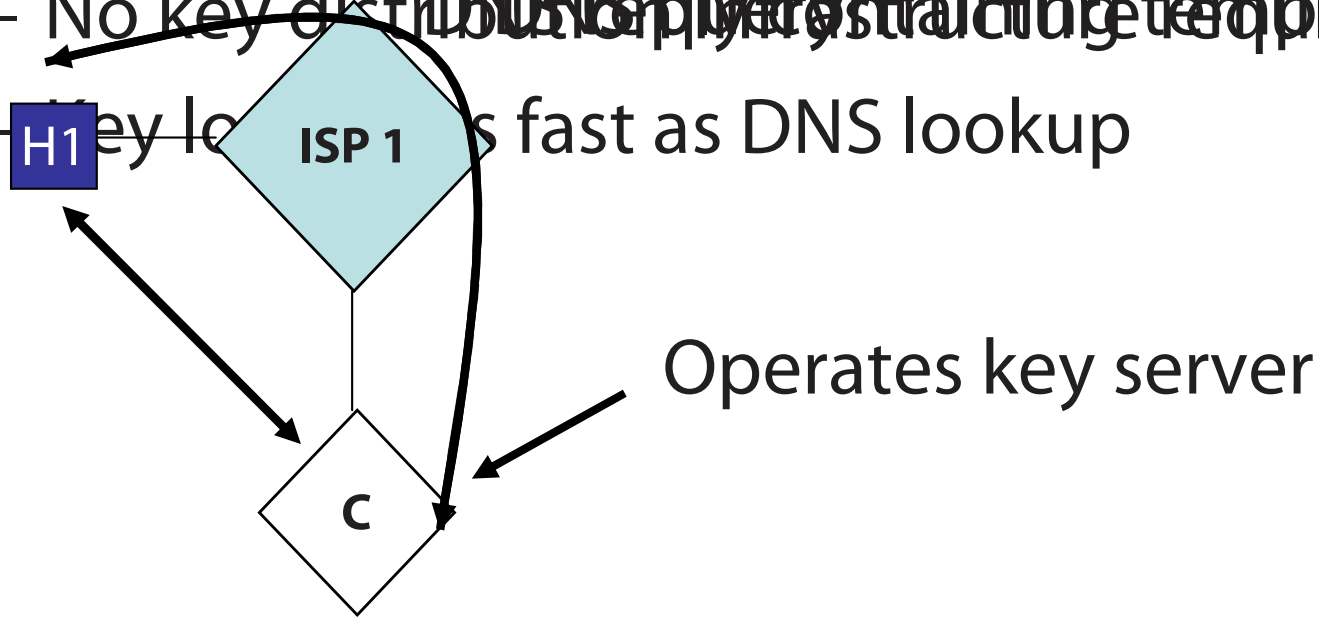


Temporal secrets

- *Temporal* secret keys expire periodically
  - Expiration allows for changing policies
- No time sync required
  - Secret computation includes Key ID/time
  - Enables expiration on order of clock drift
- Requires lookup of temporal secrets

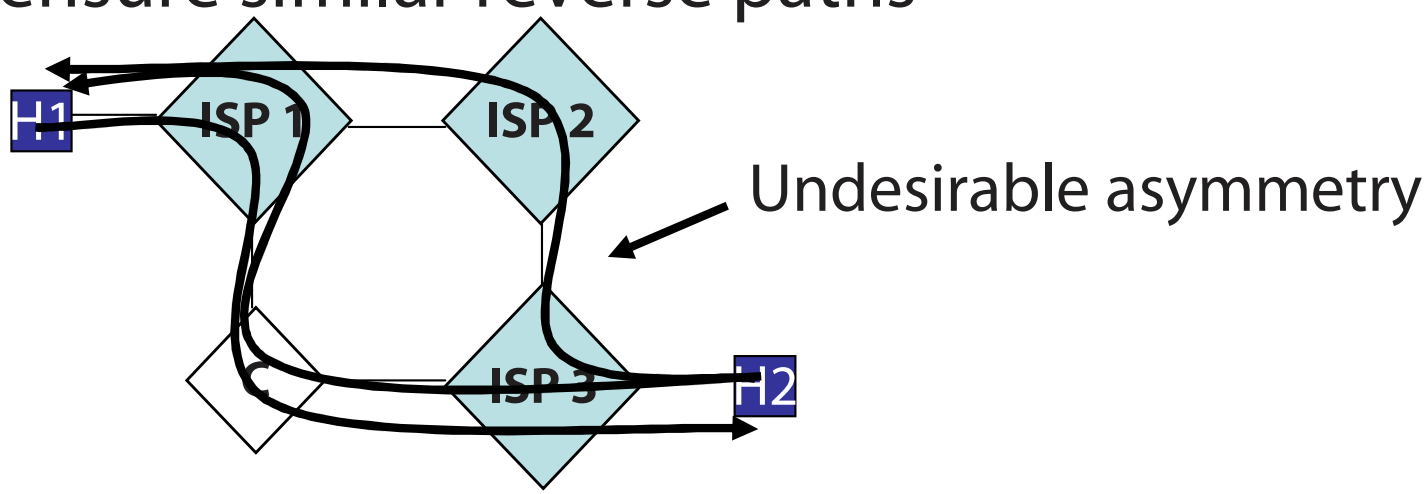
Key lookup

- DNS-based key lookup
  - DNS reply contains encrypted secret
  - No key distribution infrastructure required
  - DNS lookup establishes temporal secret
  - Key lookup as fast as DNS lookup



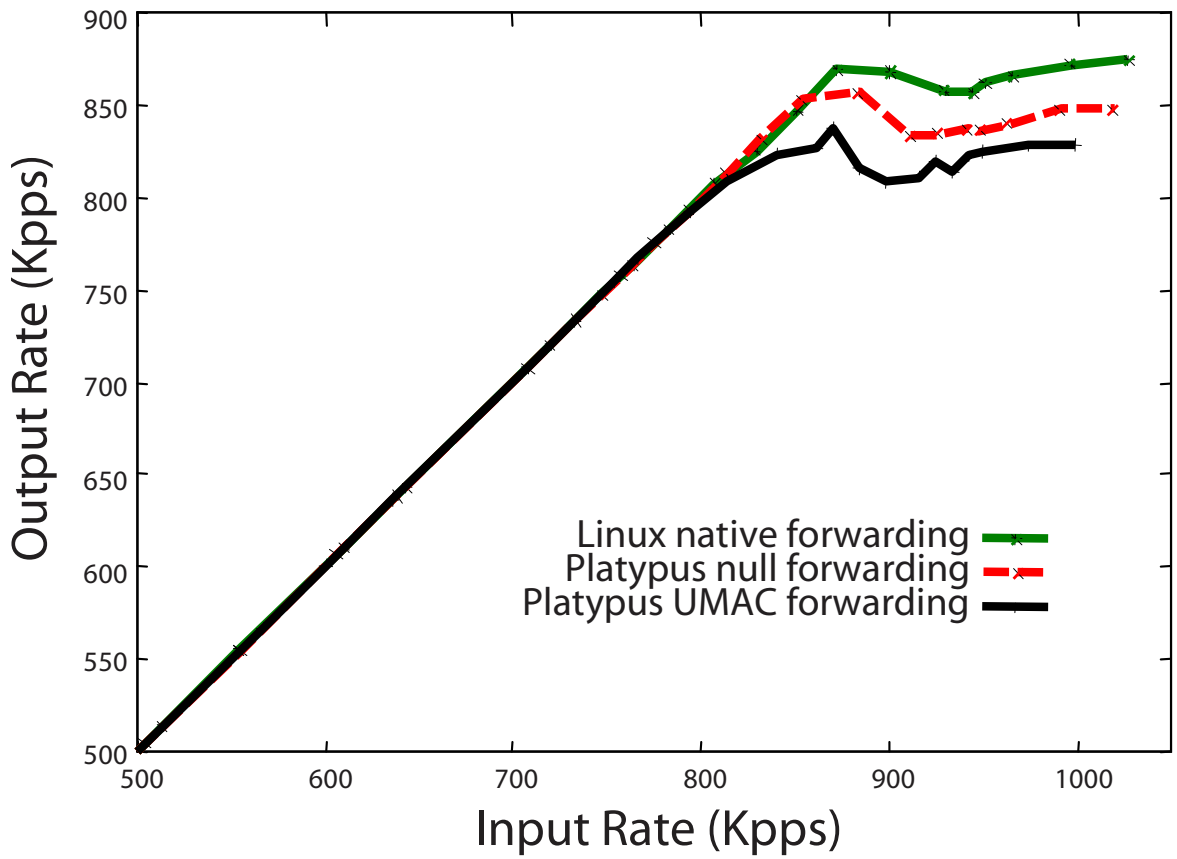
Delegation

- Users may pass out their capabilities
  - How might they restrict others' use?
- Capability delegation:
  - Principals can restrict capabilities
  - Limits holder to destinations within an IP prefix
  - Useful to ensure similar reverse paths



Implementation

- End-host based stamping/forwarding
- User-level and kernel module versions



Per-packet latency

- Total per-packet time = I/O time + header processing
- I/O time ~ 2 μs
- Worst-case header processing time < 2 μs

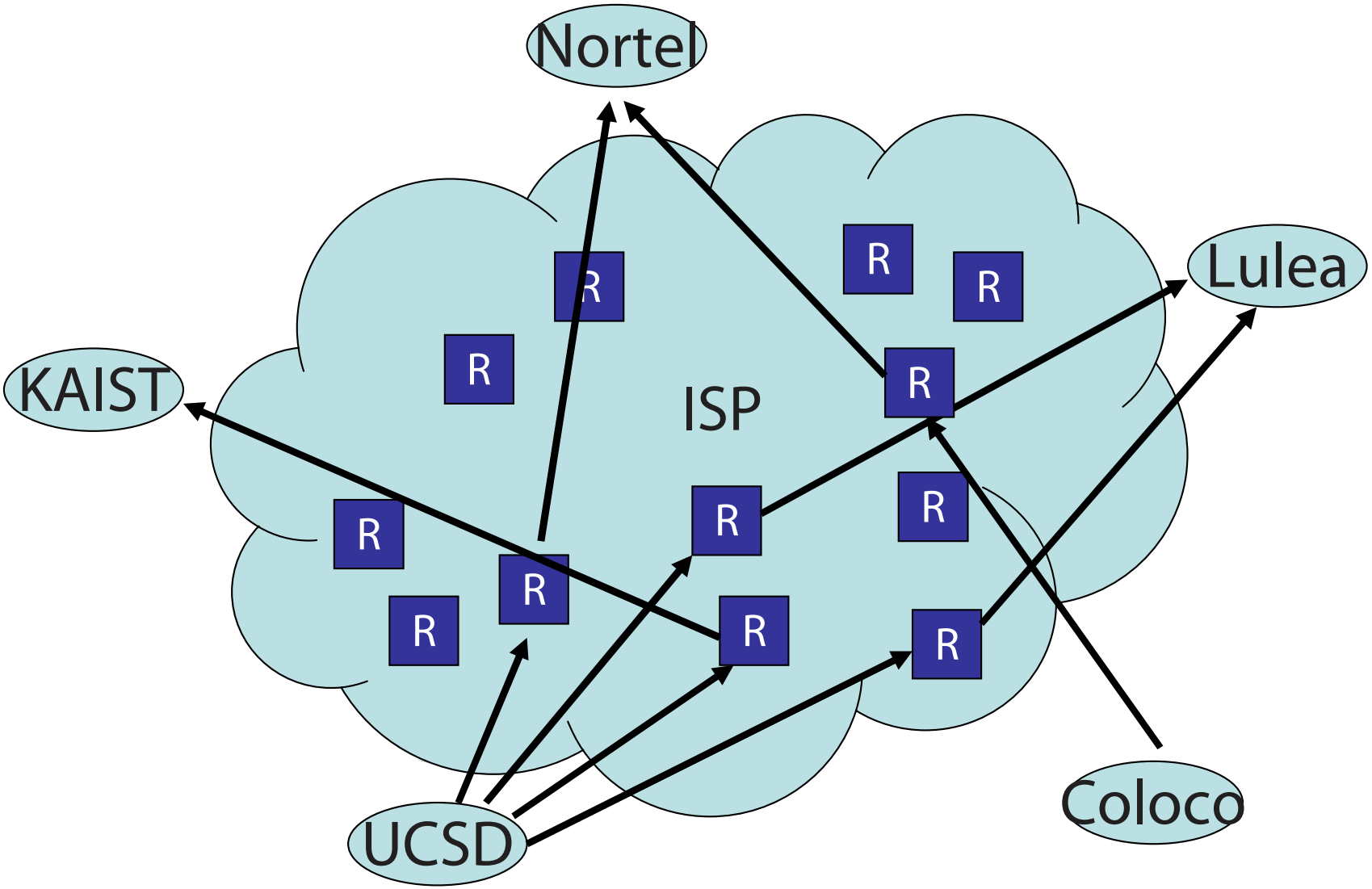
Header processing overhead

	68 byte	348 byte	1500 byte
Null	172 ns	173 ns	181 ns
UMAC	695 ns	998 ns	1908 ns

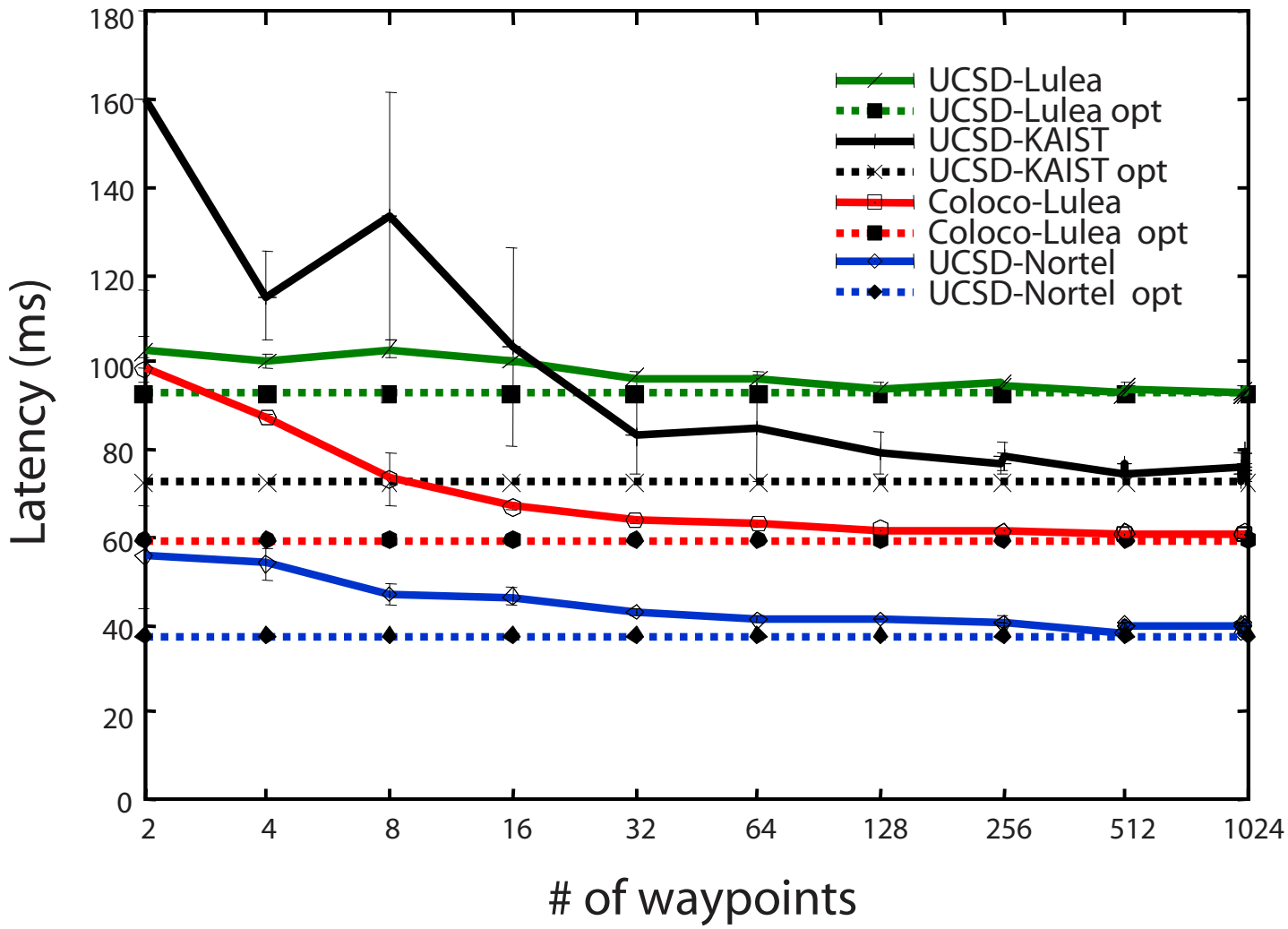
Deployment

- Incrementally deployable
  - Does not require inter-ISP cooperation
  - *Loose* source-routing based
- How might ISPs deploy Platypus?
  - Where should they be placed?
  - How many Platypus waypoints are needed?

Measurement study



Waypoint effectiveness (MCI)



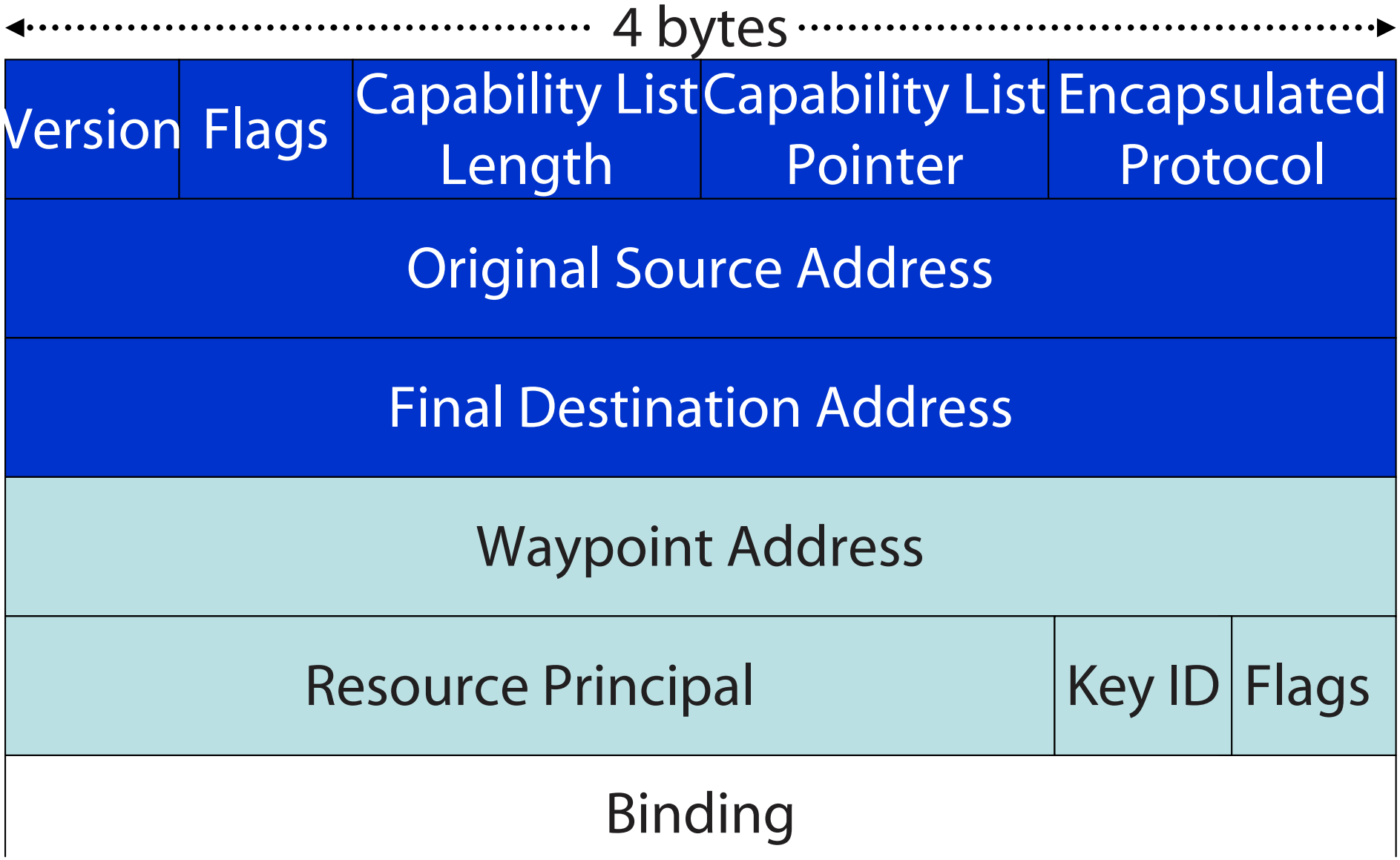
Summary and future work

- Platypus provides:
  - Source routing with ISP control of waypoints
  - Means for authenticating source routed packets
- Incremental deployment
  - Flow-based Platypus with existing hardware
- New forwarding business model
  - Anyone can sell/resell forwarding service
  - Real-time pricing of capabilities

Scalability

- Forwarding state
  - Waypoints only need O(1) state
- Key lookup
  - Lookup overhead is small (3 crypto operations)
  - One key server ~ 500,000 lookups / sec
- Per-principal accounting
  - High speed approx. per-flow counters [Kumar '04]

Platypus header format

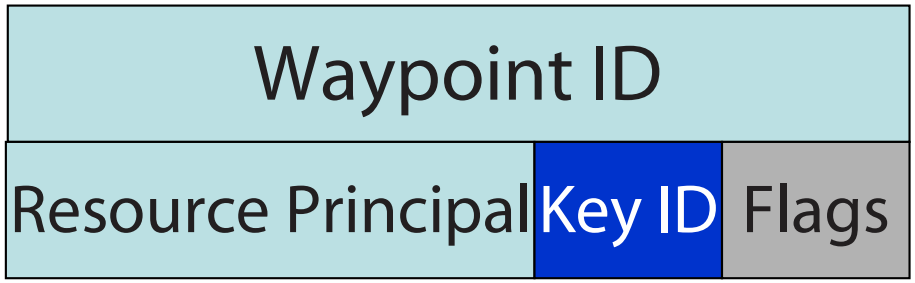


Temporal secret computation

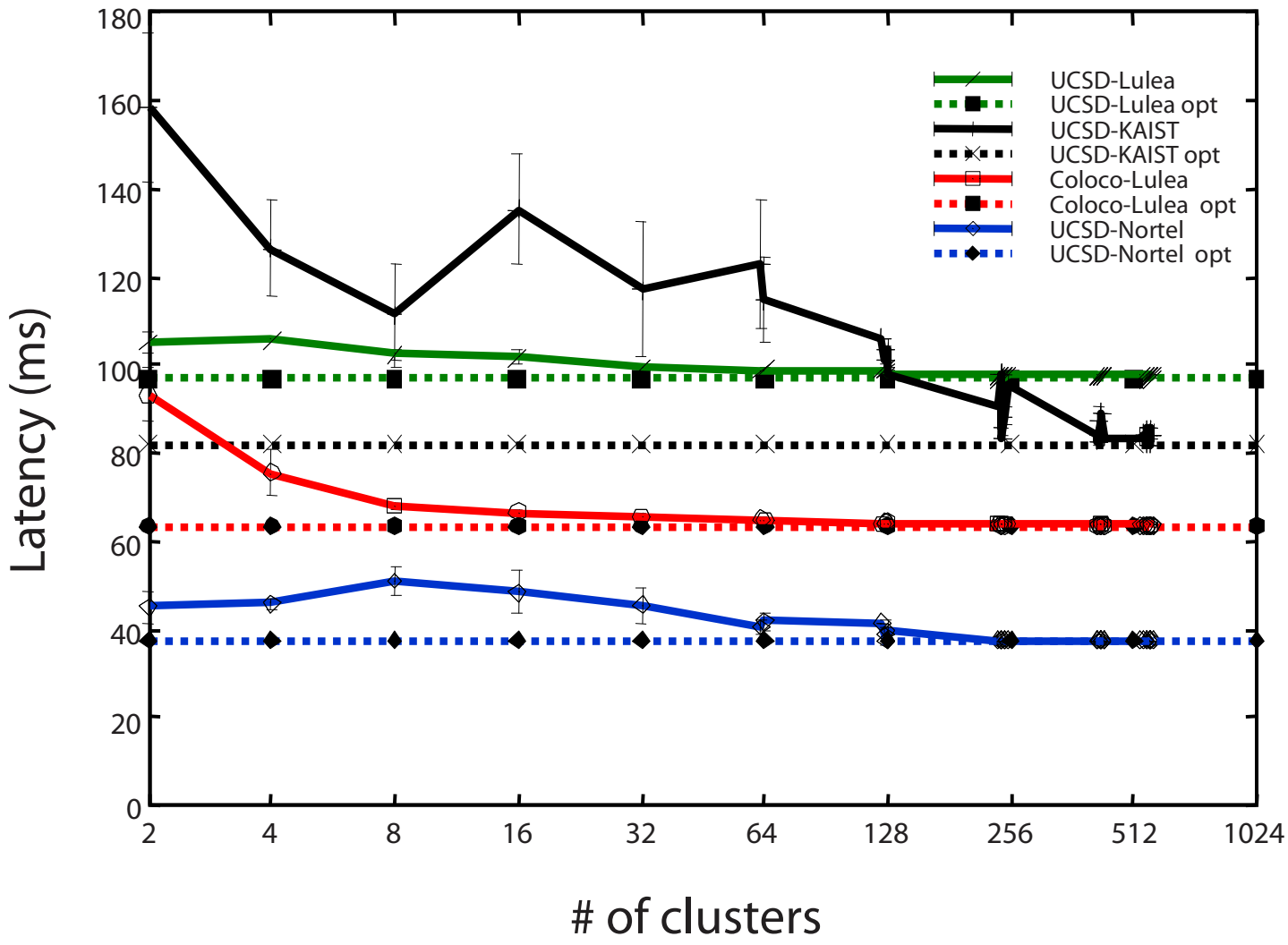
- For a capability ***c*** and waypoint key ***k***:

  $\boldsymbol{s} = \mathrm{MAC}_{\boldsymbol{k}}(\texttt{c.way||c.rp||(((t>>n) \& 0xFFFFFFF0) | c.id)})$

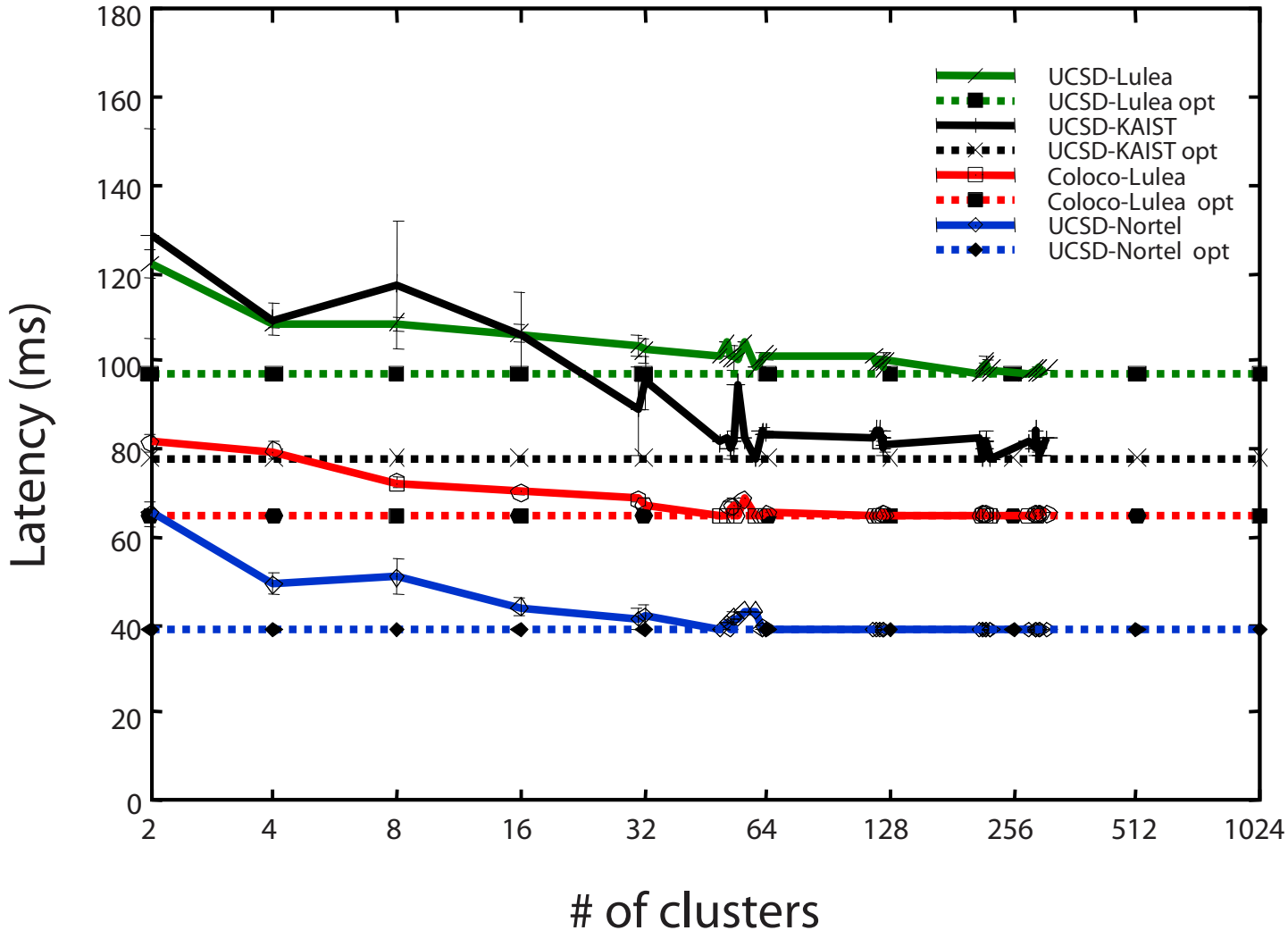
- The exception to this is at key ID wraparound
  - `(t>>n)` is either incremented or decremented by 1



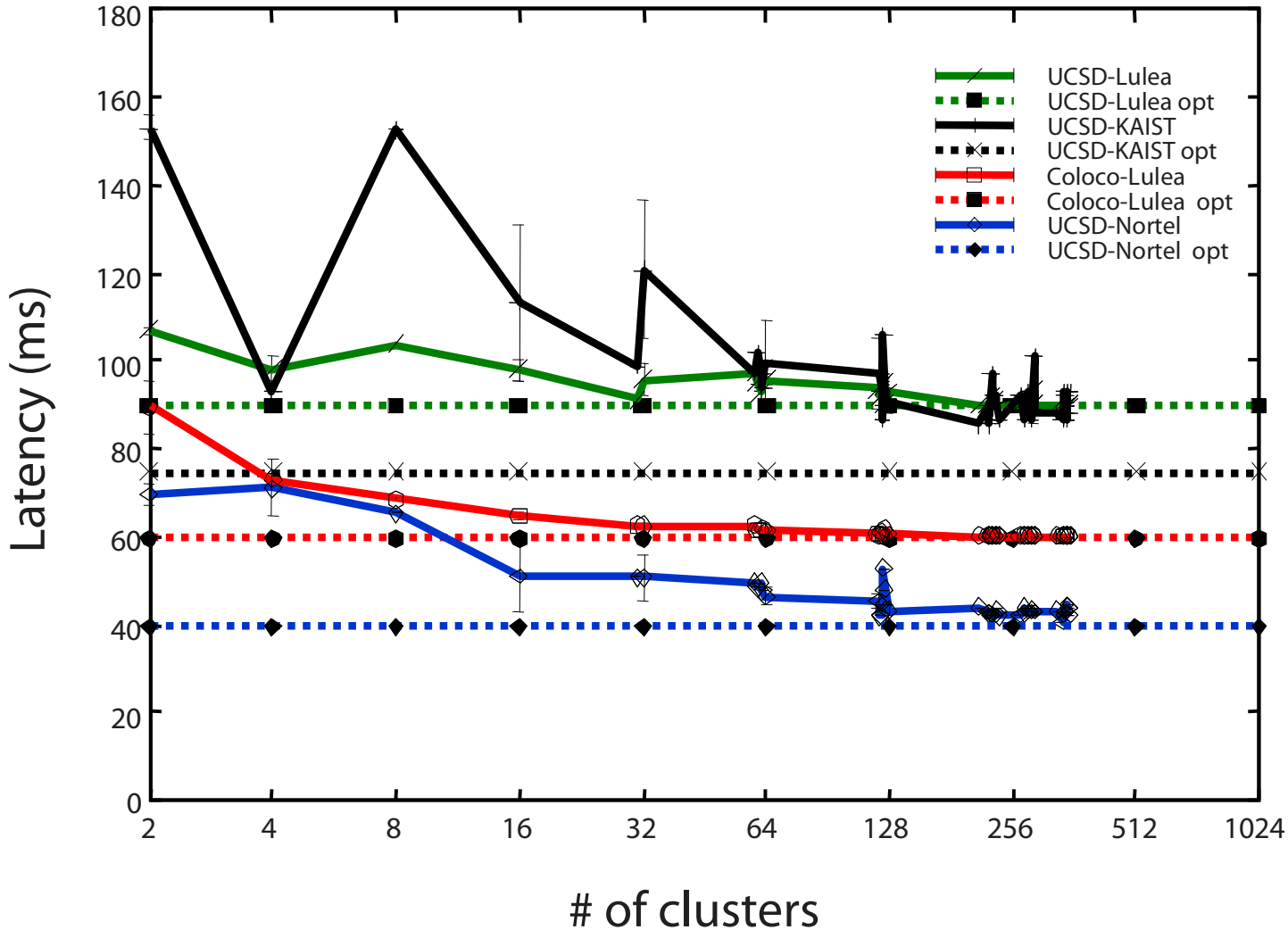
Measurement results (QWEST)



Measurement results (GBLX)

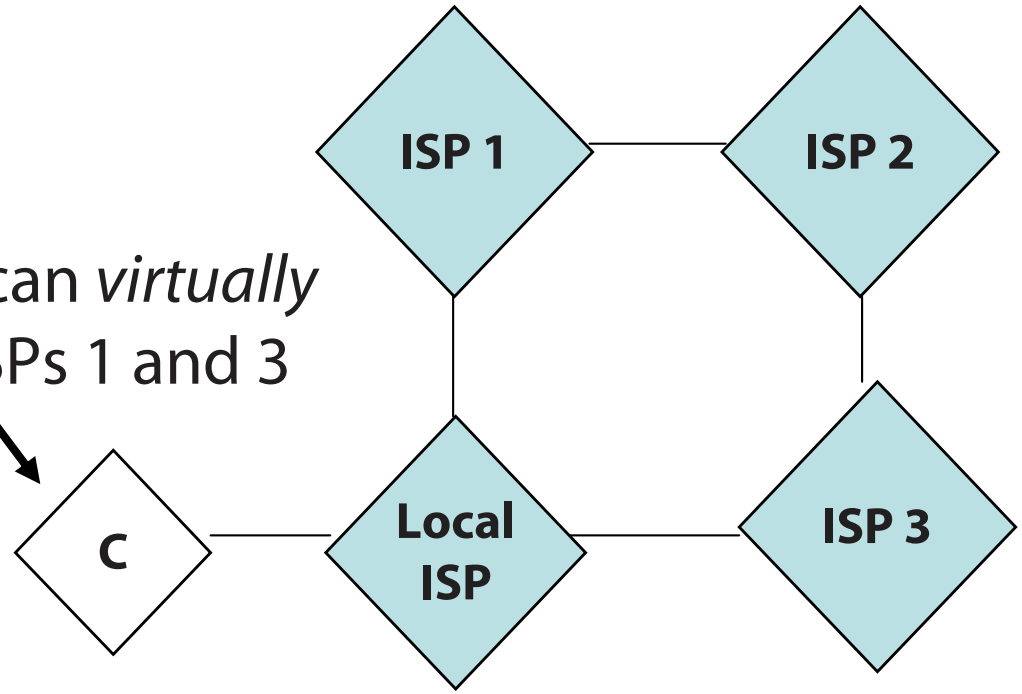


Measurement results (SPRINT)



Example: Virtual multihoming

Using Platypus, **C** can *virtually multihome* with ISPs 1 and 3



Example: Affecting Inbound Traffic

Using Platypus, **C** can distribute delegated capabilities that are restricted to send to prefixes within **C**