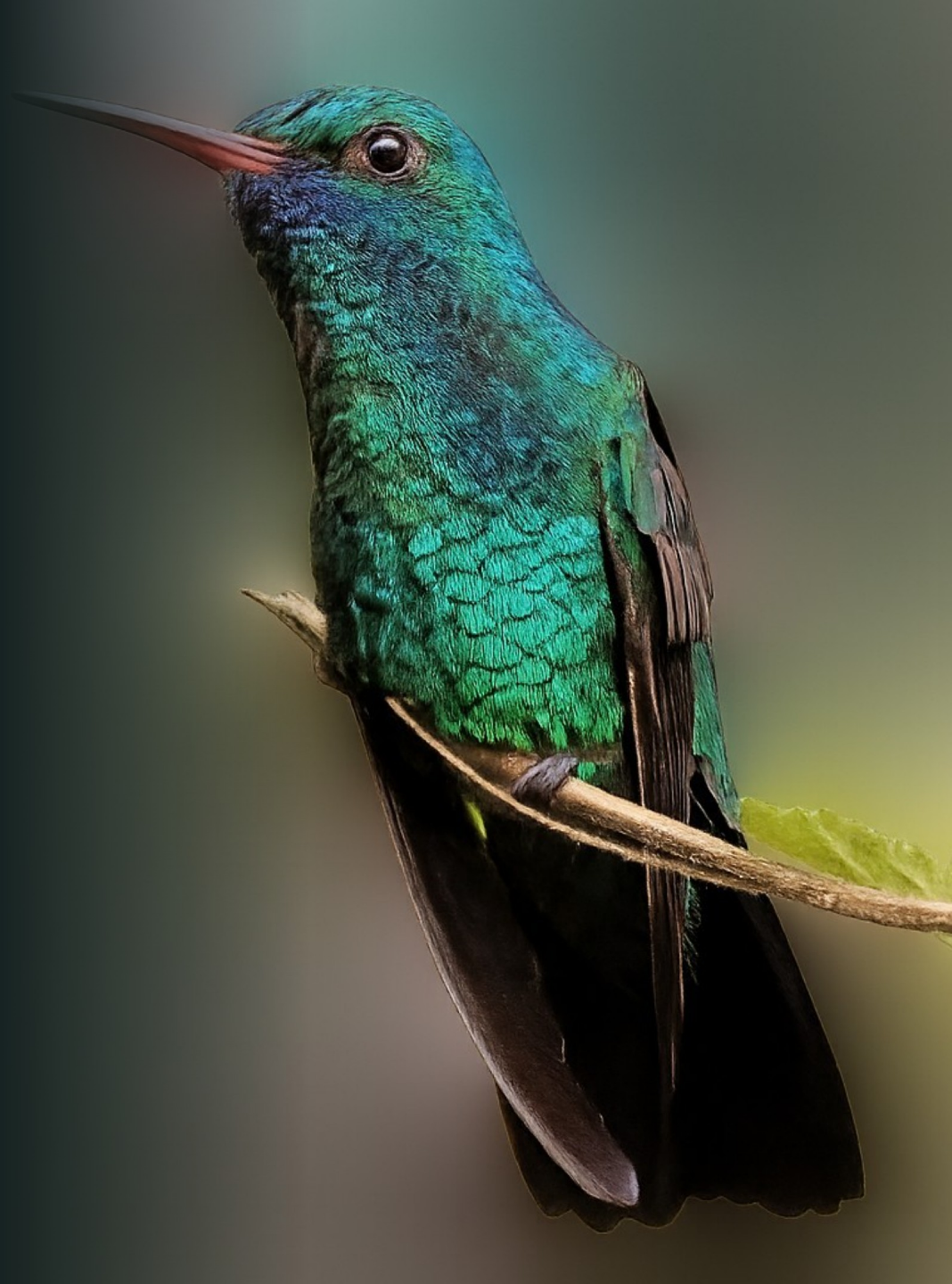
SCION · TECHNICAL OVERVIEW

Hummingbird

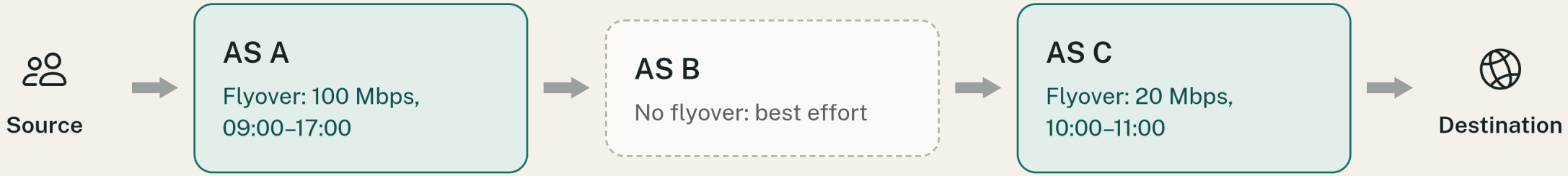
Inter-domain bandwidth reservations on the SCION Internet

ETH Zurich · Network Security Group



RESERVATION MODEL

Flyovers: one reservation per AS hop



Granted by one AS, from its ingress to its egress interface

```
ResInfo = (In, Eg, ResID, BW, StartTime, Duration)
```

- Per hop: no coordination between ASes
- Partial paths: reserve only congested hops
- Own size, start and duration per hop
- No source address: reusable across flows

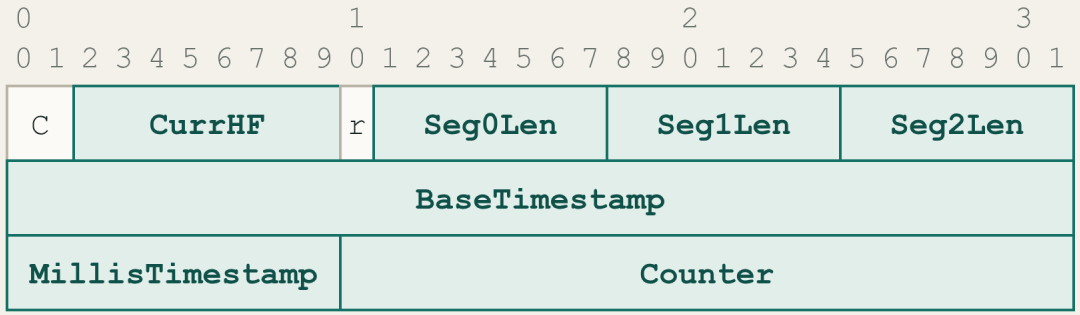
WIRE FORMAT

The Hummingbird path header

PathMetaHdr 12 B	InfoField 8 B, ≤ 3	HopField 12 B	FlyoverHopField 20 B	HopField 12 B

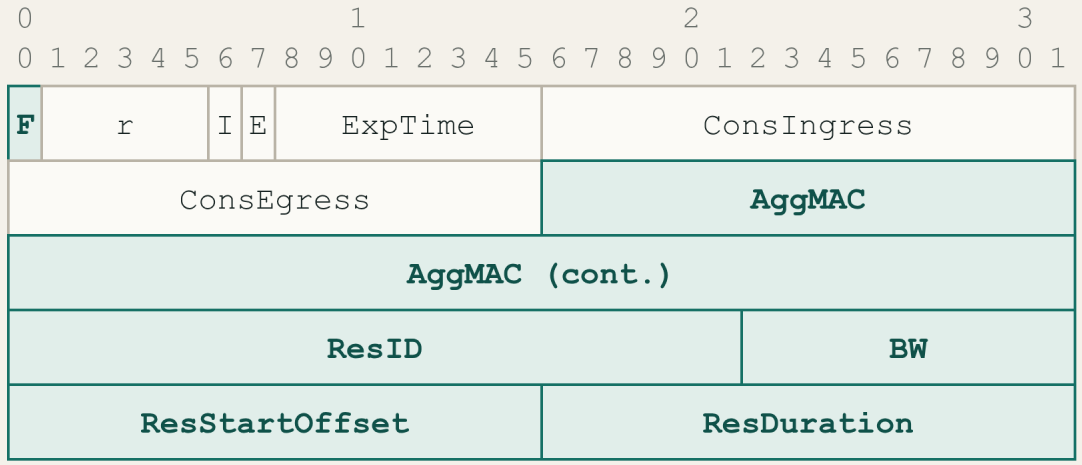
... up to 64 hop fields. A reserved hop uses a FlyoverHopField: 8 B more than a HopField.

PathMetaHdr · 12 B



The three timestamp fields make each packet unique: they feed the tag and the freshness check. CurrHF advances by 3 words per HopField, 5 per FlyoverHopField.

FlyoverHopField · 20 B



New or changed in Hummingbird Same as the SCION path type

DATA PLANE

What a border router does

STEP 1

Authenticate

Recompute the key and the packet tag

Bad tag: drop

STEP 2

Check timing

Packet fresh, reservation active

Not timely: best effort

STEP 3

Police

Token bucket indexed by ResID

Over budget: best effort

STEP 4

Forward

Priority queue, ahead of best effort

In profile: priority

```
A_K = PRF_SV(ResInfo)
V_K = PRF_A_K(Dst, Len, TS)[:6]
```

Reservation key: only AS K can derive it, so no per-reservation state is needed

Per-packet tag, XORed into the SCION hop-field MAC

FORWARDING GUARANTEES

What reserved traffic gets

Each AS maps the reserved class onto its existing internal QoS, such as DiffServ or MPLS. Hummingbird coordinates it across domains and at the peering points.

Priority

Scheduled ahead of all best-effort traffic at every AS that granted the flyover.

Low jitter

Never queued behind best-effort bursts, so delay stays flat when links are congested.

Zero drops

ASes sell only what they can carry, and the policer demotes rather than drops.

POLICING

Over the limit? Demoted, not dropped

> Packets beyond the reserved rate are forwarded as best effort. Excess traffic is never worse off than plain best effort.

> Deterministic policing at every AS: one 8-byte timestamp per reservation, in an array indexed by ResID.

> No punishment, so no framing attacks, no source-AS gateway and no duplicate suppression required for this.

```
now ← time()
TS ← max(T[ResID], now) + PktLen/BW
if TS ≤ now + BurstTime:
  T[ResID] ← TS  // priority
else:  // best effort
```

100 Gbps of reservations at a 4 Mbps minimum: a 600 kB array that fits in L2 cache.

Idle reservations are never wasted

A reservation is a priority claim, not a partition. Whenever reserved capacity is idle, the scheduler hands it straight to best-effort traffic.



PERFORMANCE

Line rate on commodity hardware

160

Gbps at line rate with 4 cores for 1500 B packets. With 32 cores, even 100 B packets run at line rate.

+185

ns per packet over plain SCION (308 vs 123 ns), mostly key derivation, tag and policing.

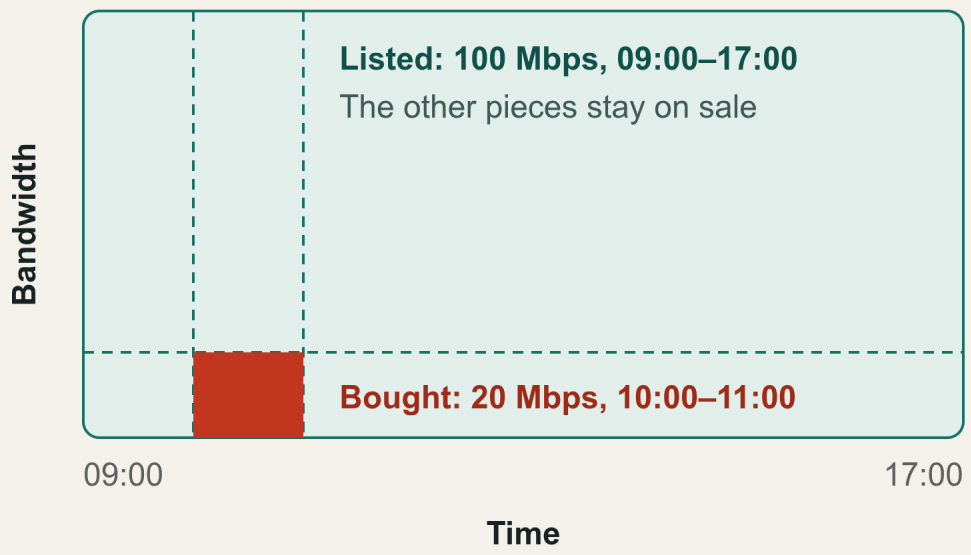
8

Bytes of extra header per reserved hop: the tag rides inside the existing hop-field MAC.

DPDK + AES-NI on a 2.1 GHz Intel Xeon, 4 × 40 Gbps links (Wüst et al., ACM SIGCOMM 2025)

MARKETPLACE POC

A marketplace that runs every step



Clients split assets in bandwidth and in time, down to the granularity the seller allows.

1 **Seller lists**
The AS puts its bandwidth assets on sale.

2 **Client splits**
Any slice in bandwidth and time.

3 **Client buys**
Payment and transfer of the asset.

4 **Redemption, if delegated**
The marketplace computes the A_K keys for the seller and delivers them to the client.

WHAT'S NEXT

Real demo in 2026

Demo with armasuisse

Before the end of this year, across the Swiss ISD and SCIERA, the international research and education ISD.

WireGuard, adapted

WireGuard now runs over Hummingbird, so any IP application gets reserved paths through the tunnel.

Open for demos and PoCs

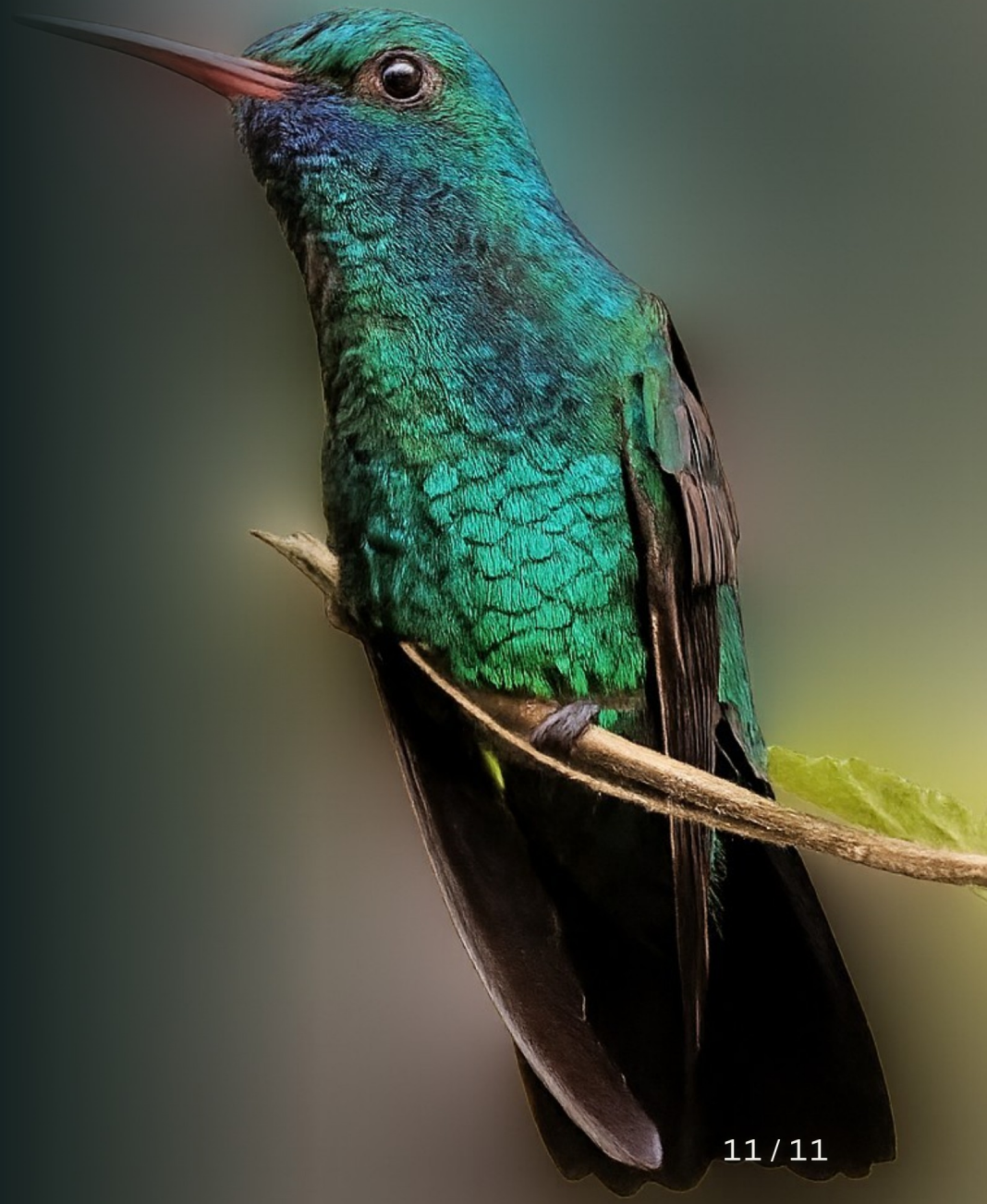
ISPs can offer flyovers on their SCION links; applications can run critical traffic over them. Let's talk.

HUMMINGBIRD

Thank you

Priority without waste.
No priority packet is ever dropped.
A working marketplace PoC.

Questions?



Wüst et al., “Hummingbird: Fast, Flexible, and Fair Inter-Domain Bandwidth Reservations”, ACM SIGCOMM 2025