Scaling container policy management with kernel features

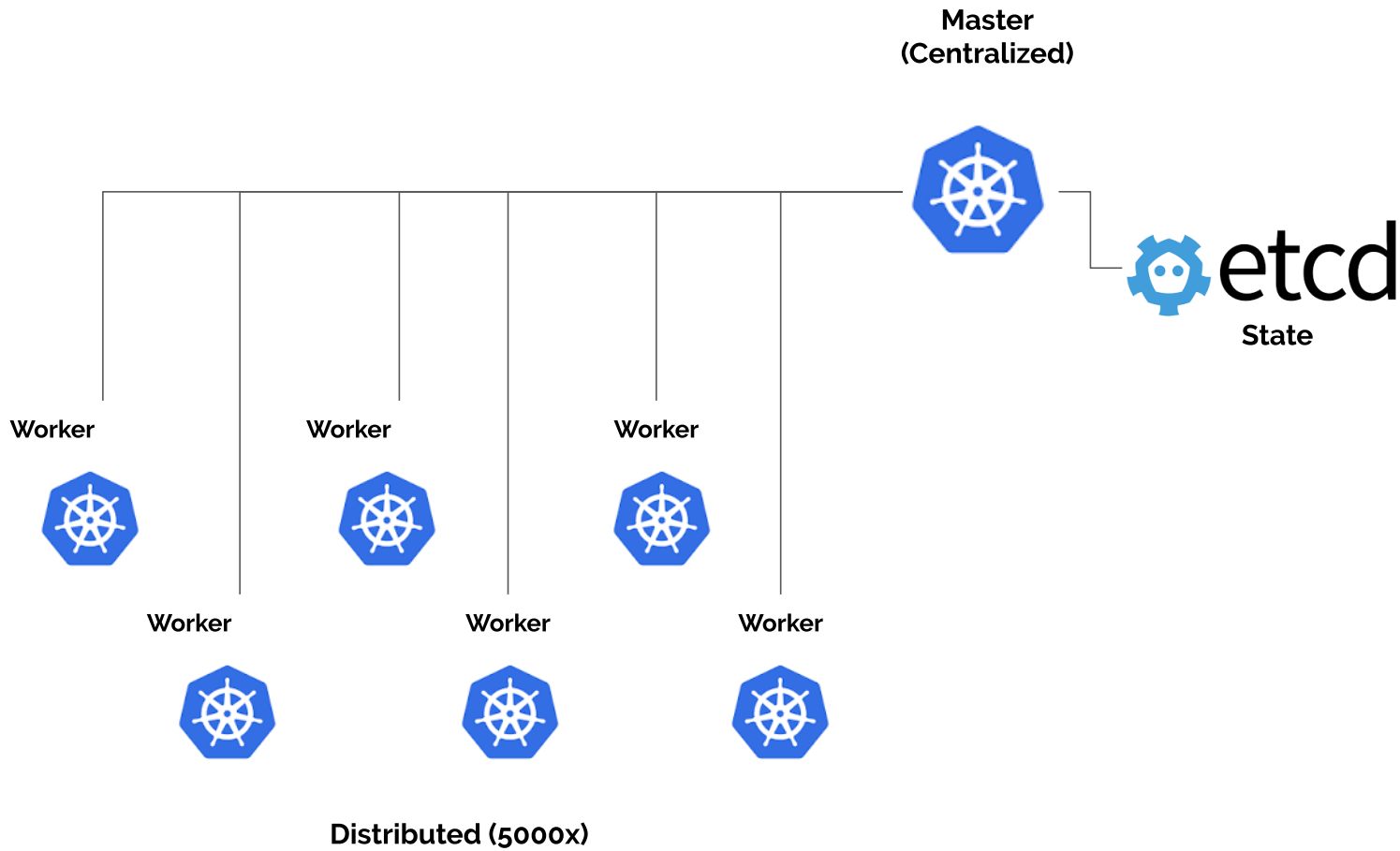
Joe Stringer

Cilium.io

Linux Plumbers 2019, Lisbon, Portugal

Overview

Kubernetes Architecture 101



Thomas Graf, *Scaling to 5k Kubernetes Nodes: Lessons Learned*, Cloud Native Rejekts EU 2019

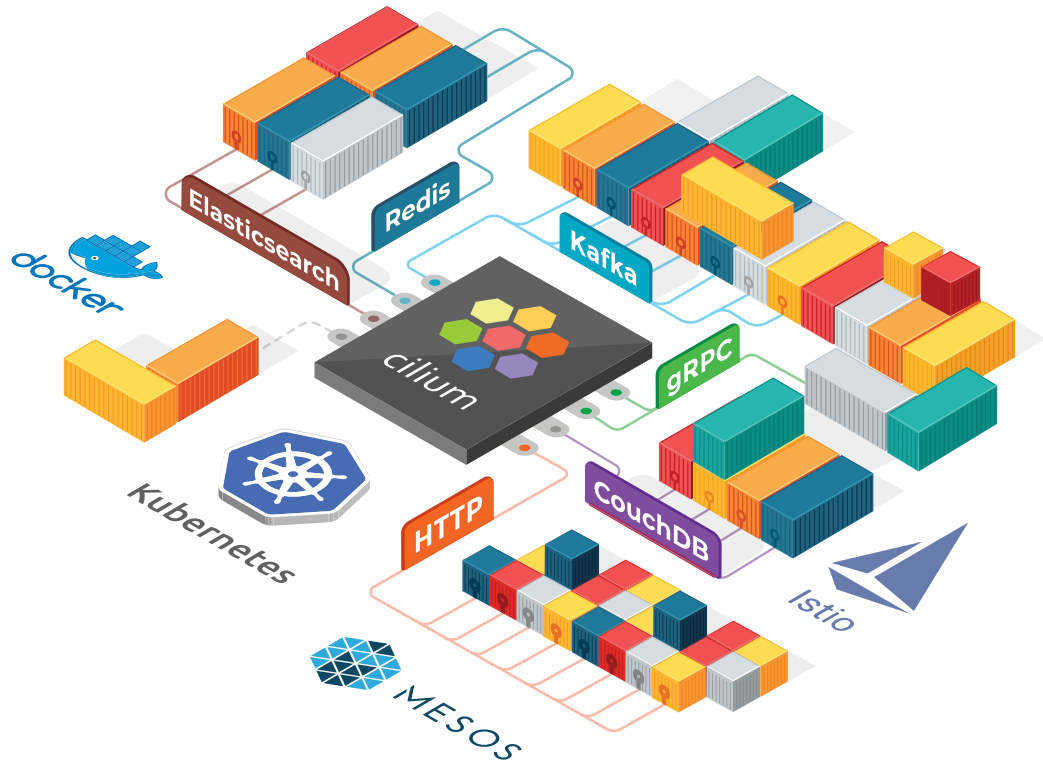
Kubernetes networking plugins

- Plumb local connectivity (CNI)
- Connect remote nodes
- Services / loadbalancing
- Network policy

https://kubernetes.io/docs/concepts/extend-kubernetes/compute-storage-net/network-plugins/

Cilium

- Native BPF dataplane
- Modular architecture
- API-aware authorization
- Scalability



Cluster events

- Nodes → Fabric connectivity
- Pods → End-to-end connectivity
- Services → Logical connectivity
- Network policies → Connectivity isolation

Cluster events

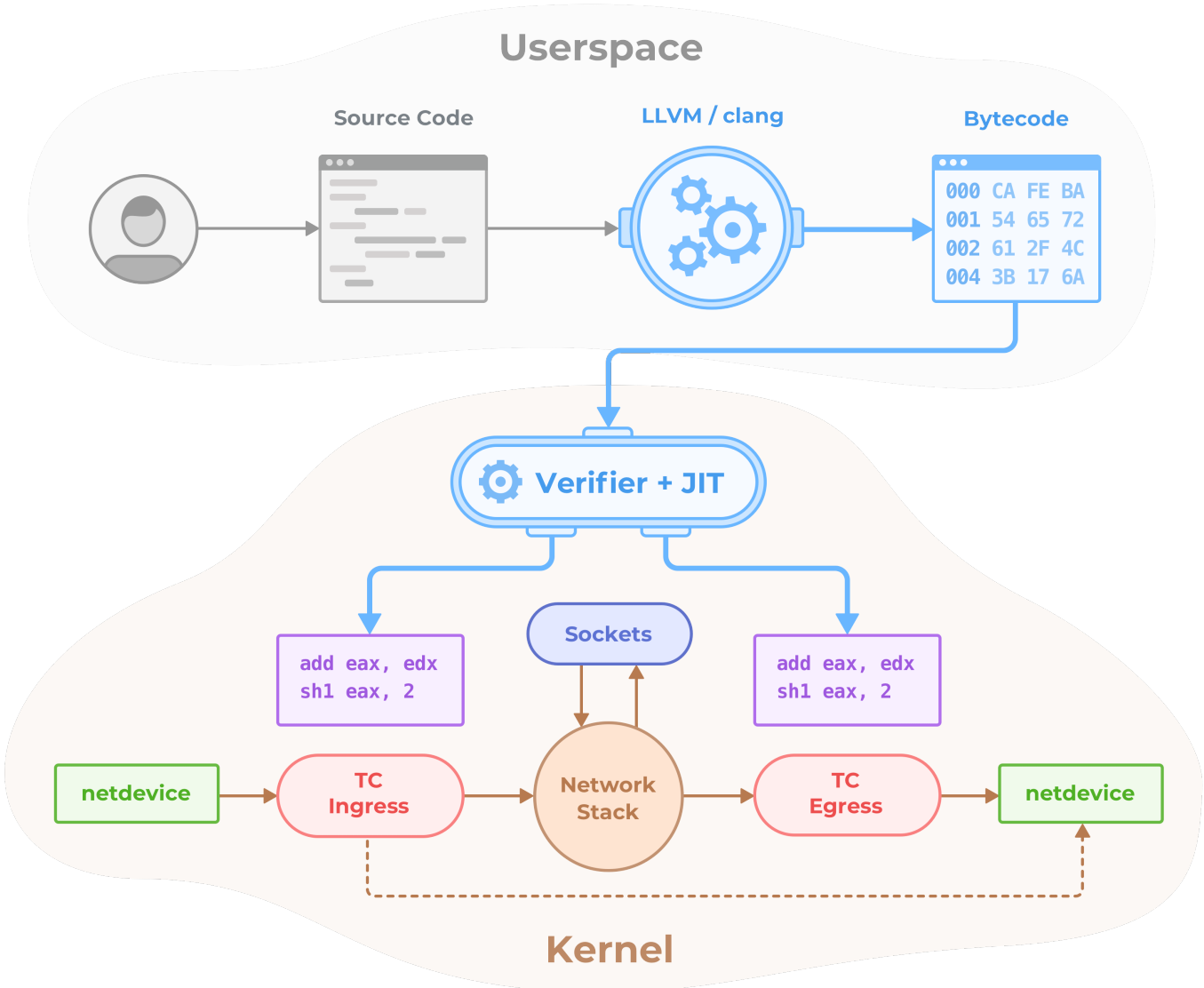
- Nodes → Fabric connectivity
- **Pods** → End-to-end connectivity
- Services → Logical connectivity
- **Network policies** → Connectivity isolation

Pod event processing

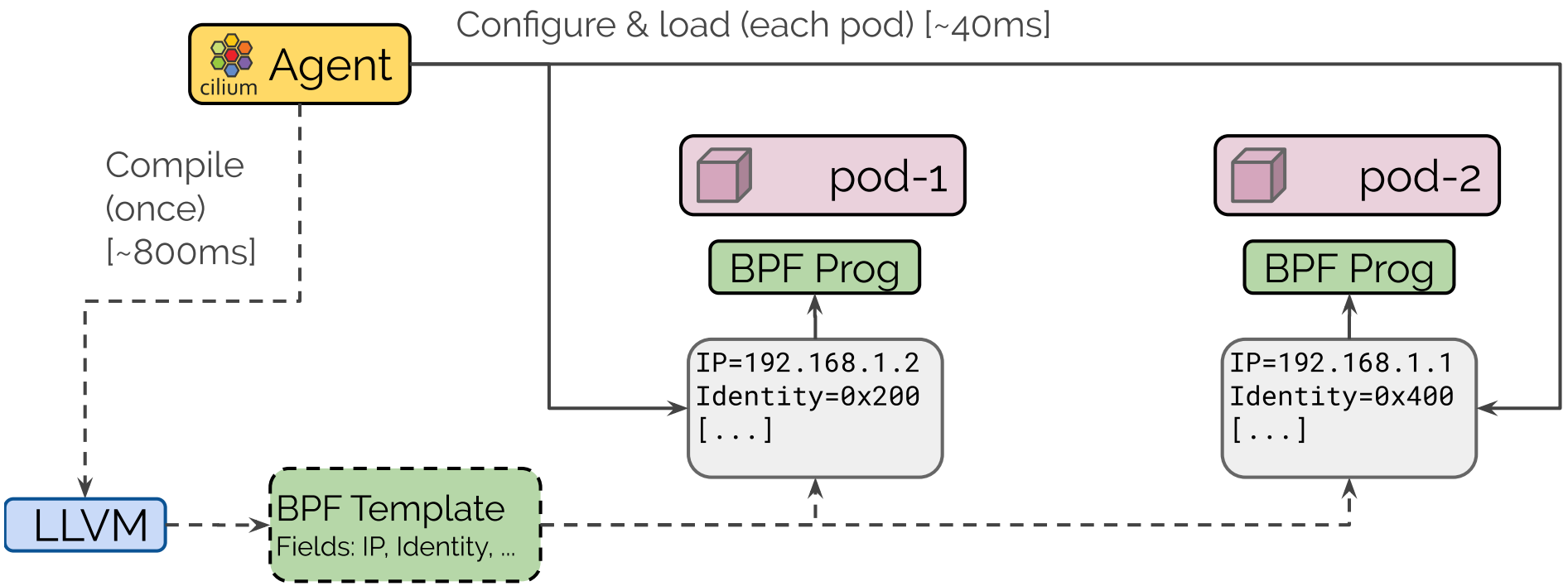
What does it mean to scale?

- Minimize unnecessary events
  - Reduce load on centralized components
  - Minimize event sizes
- Roll out bursty workloads quickly
- Reduce time from policy change to enforcement

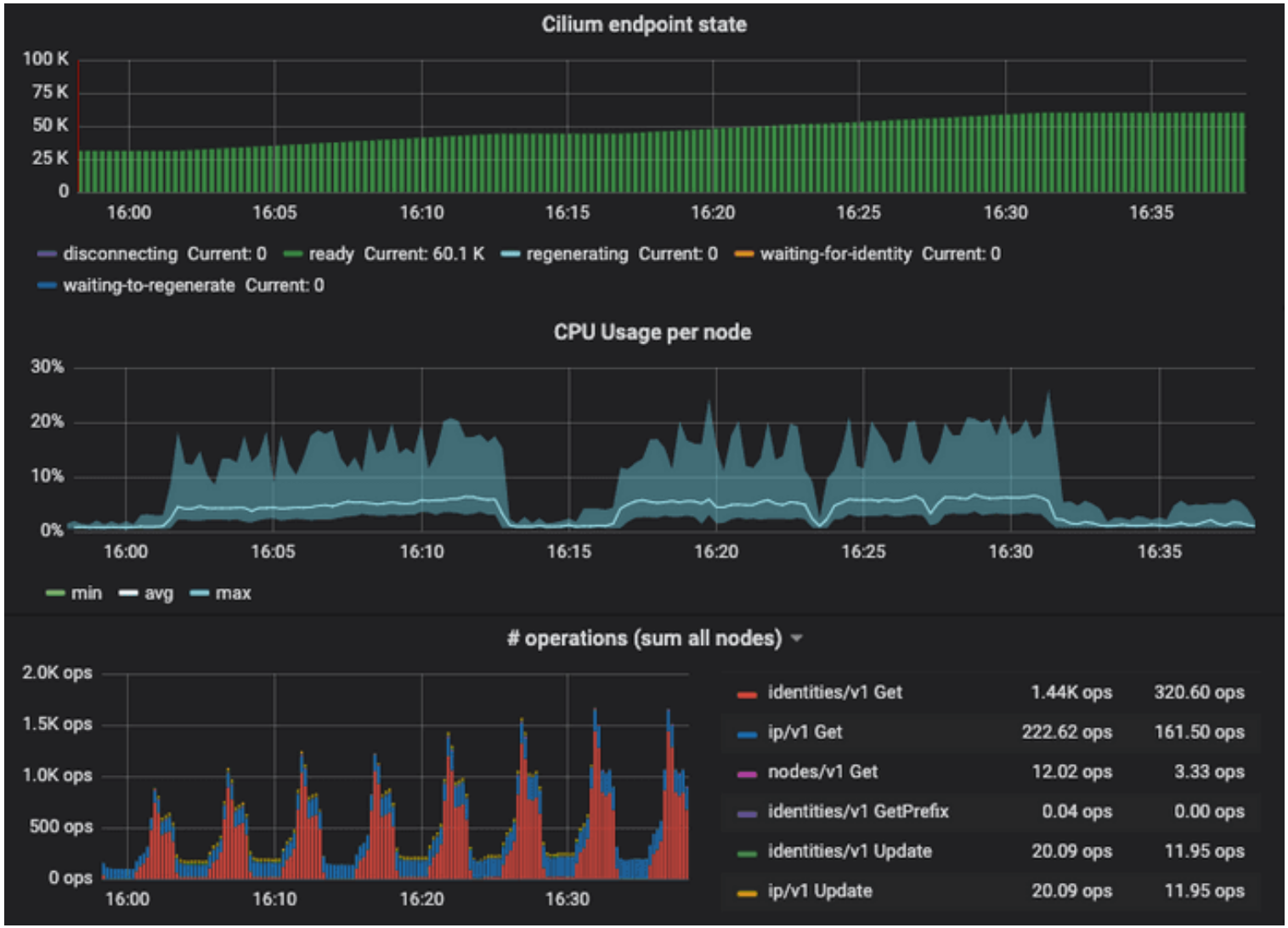
BPF plumbing



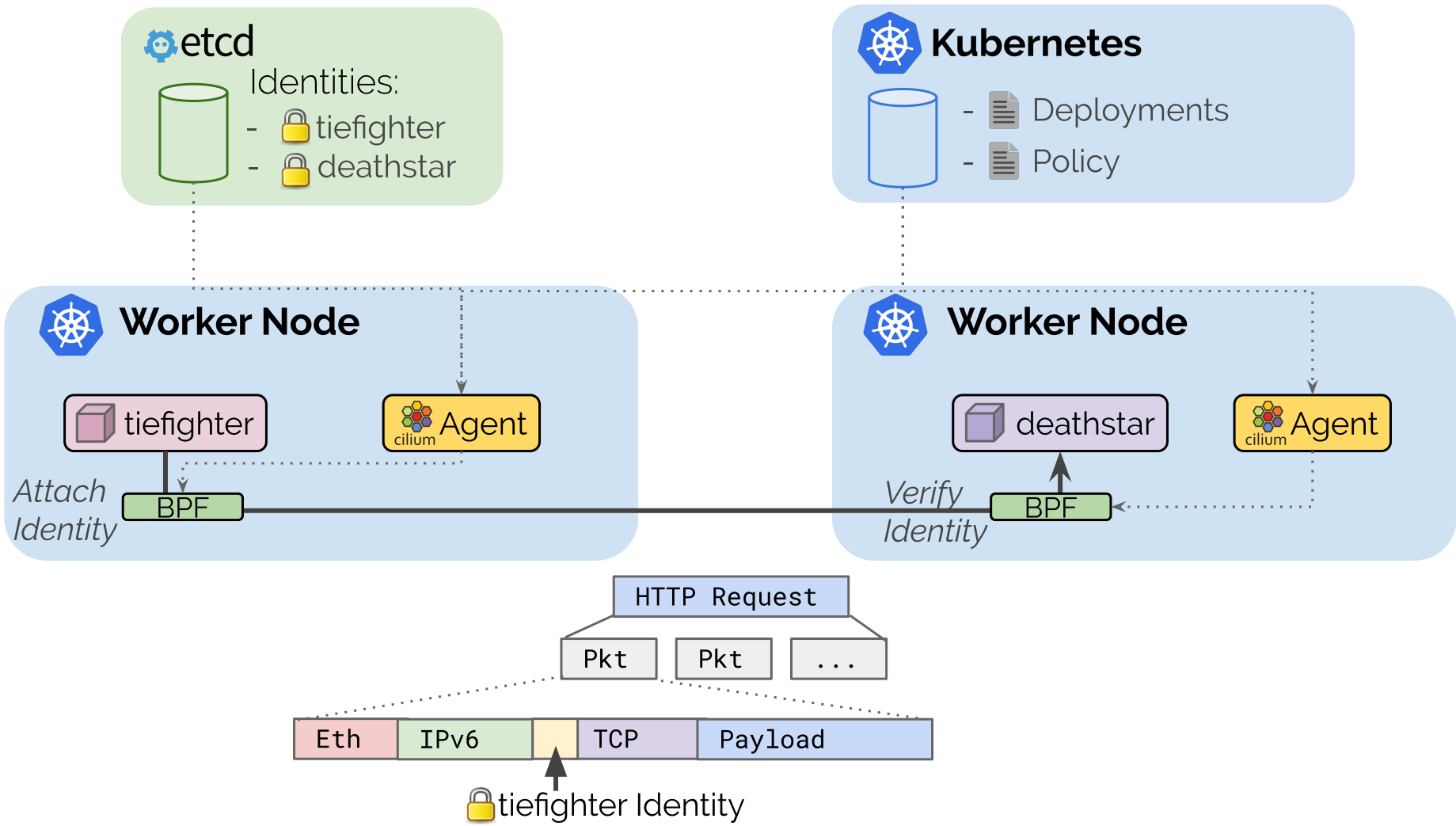
ELF Templating



1K nodes: Scaling to 60k pods



Identity-based security


etcd
Identities:
- tiefighter
- deathstar
Kubernetes
- Deployments
- Policy
Worker Node
tiefighter
Agent
cilium
Attach Identity
BPF
Worker Node
deathstar
Agent
cilium
Verify Identity
BPF
HTTP Request
Pkt
Pkt
...
Eth
IPv6
TCP
Payload
tiefighter Identity

Policy example

```
apiVersion: "cilium.io/v2"
kind: CiliumNetworkPolicy
description: "Restrict deathstar access to empire ships"
metadata:
  name: "deathstar-ingress"
spec:
  endpointSelector:
    matchLabels:
      org: empire
      class: deathstar
  ingress:
  - fromEndpoints:
    - matchLabels:
        org: empire
    toPorts:
    - ports:
      - port: "80"
        protocol: TCP
```

---

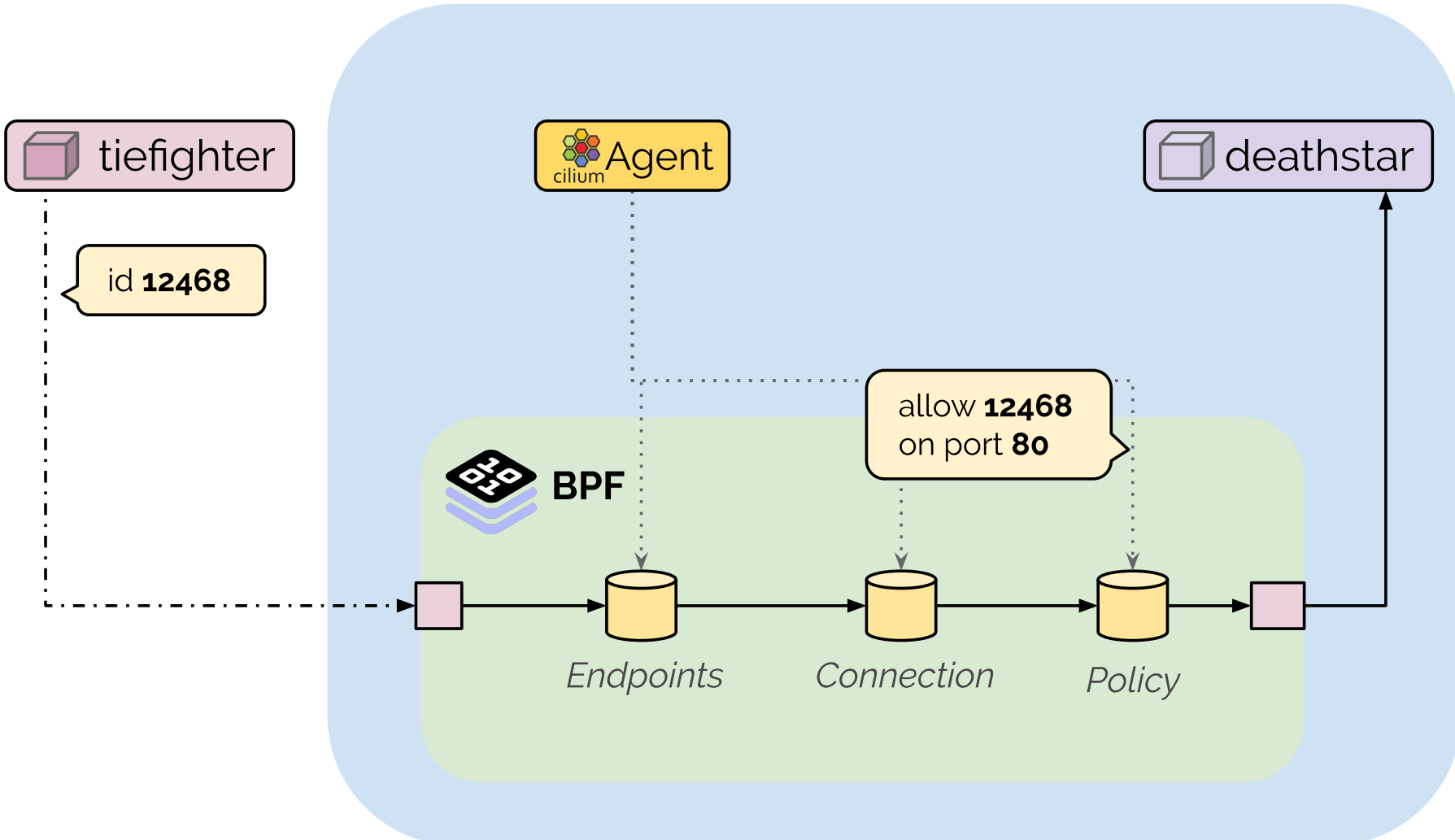
https://docs.cilium.io/en/stable/gettingstarted/http/

Label selectors

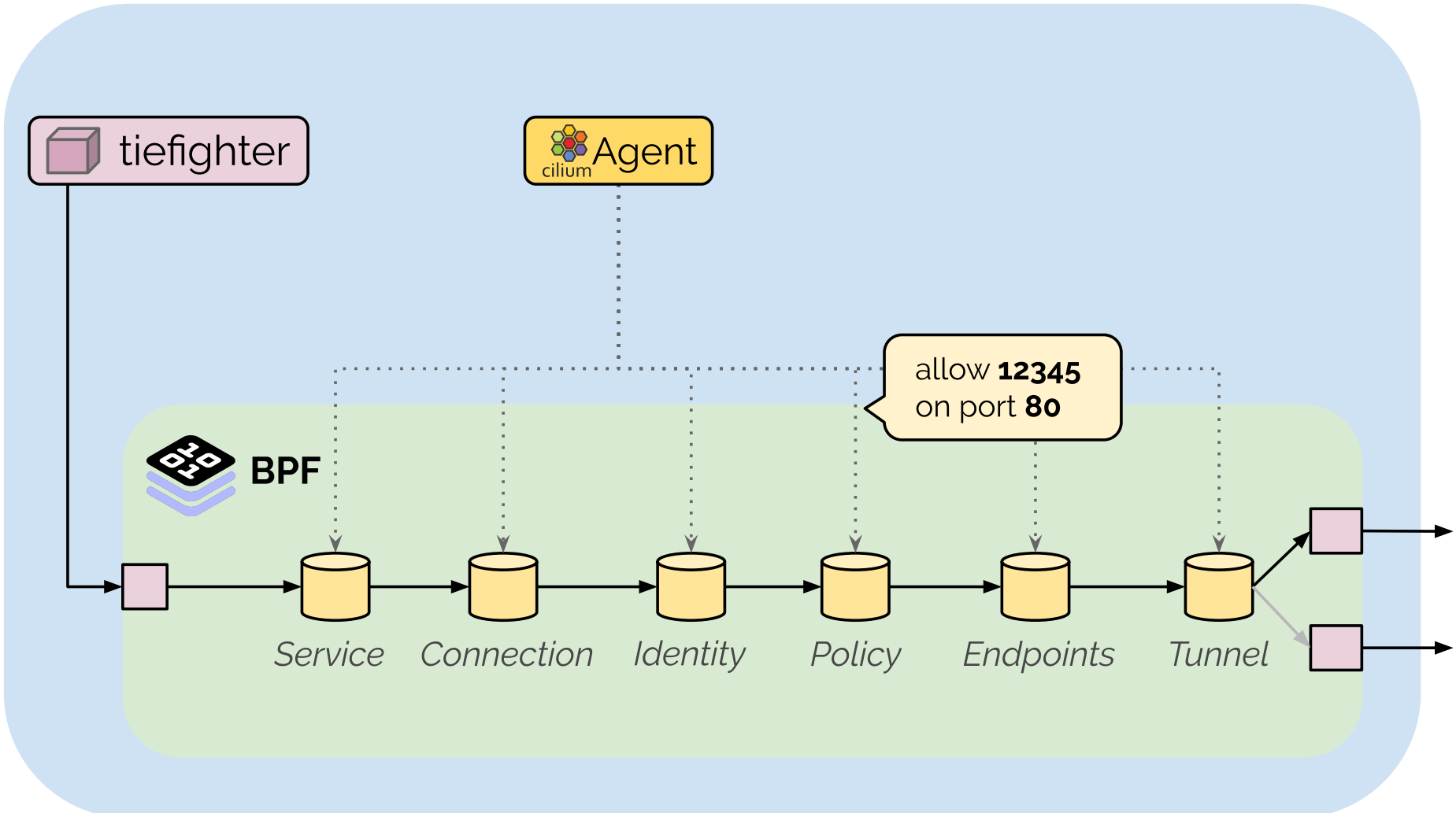
- 12345 {org:empire, class:deathstar}
- 12468 {org:empire, class:tiefighter}
- 12465 {org:alliance, class:xwing}

matchLabels: org: empire	12345 {org:empire, class:deathstar} 12468 {org:empire, class:tiefighter}
matchLabels: org: empire class: deathstar	12345 {org:empire, class:deathstar}

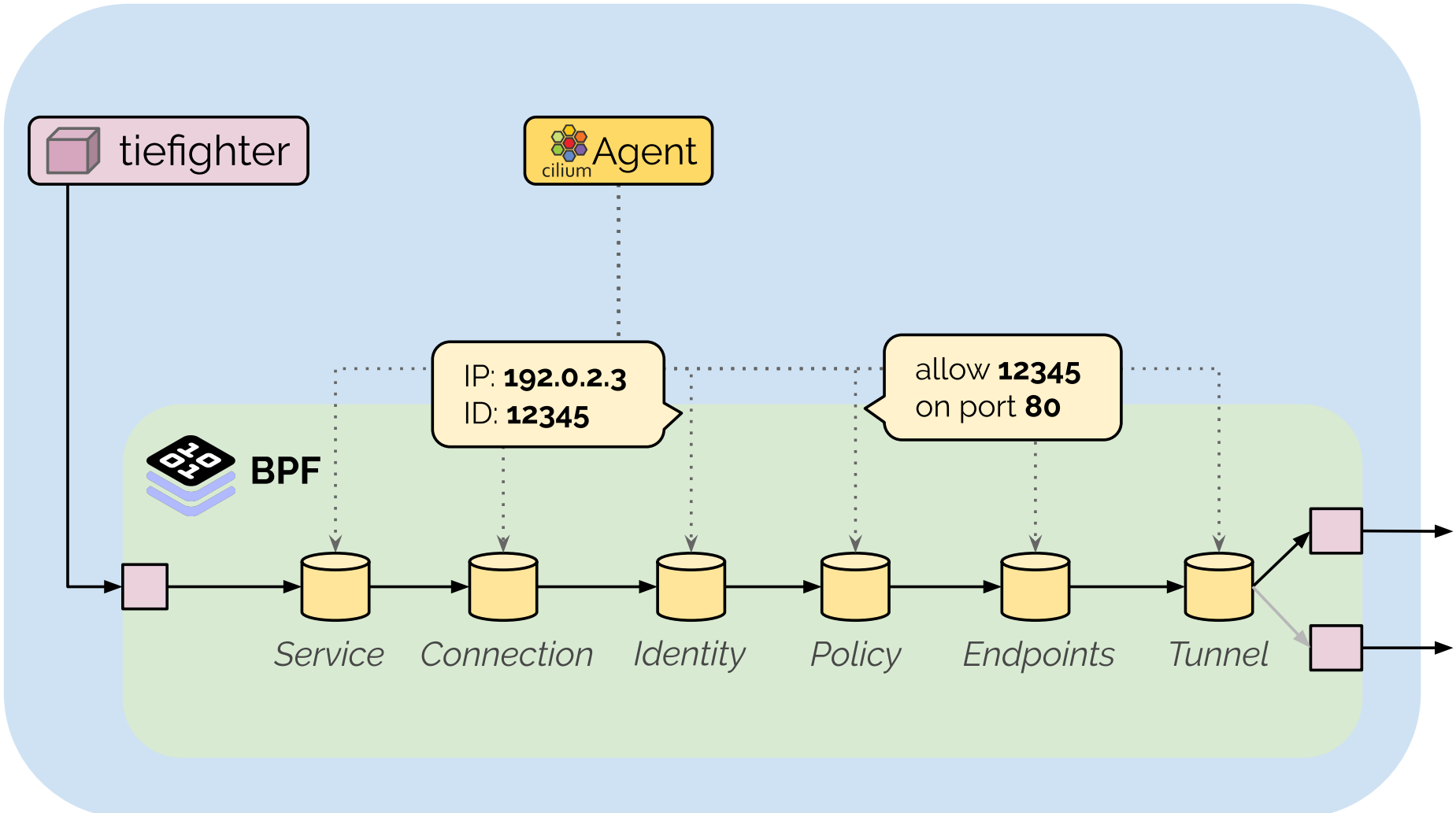
Datapath Configuration: Ingress



Datapath Configuration: Egress

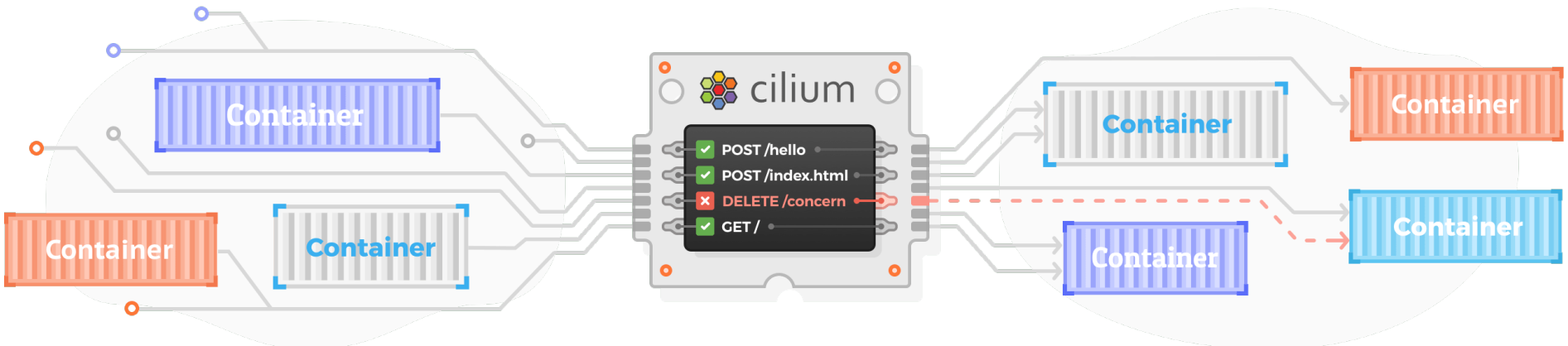


Datapath Configuration: Egress

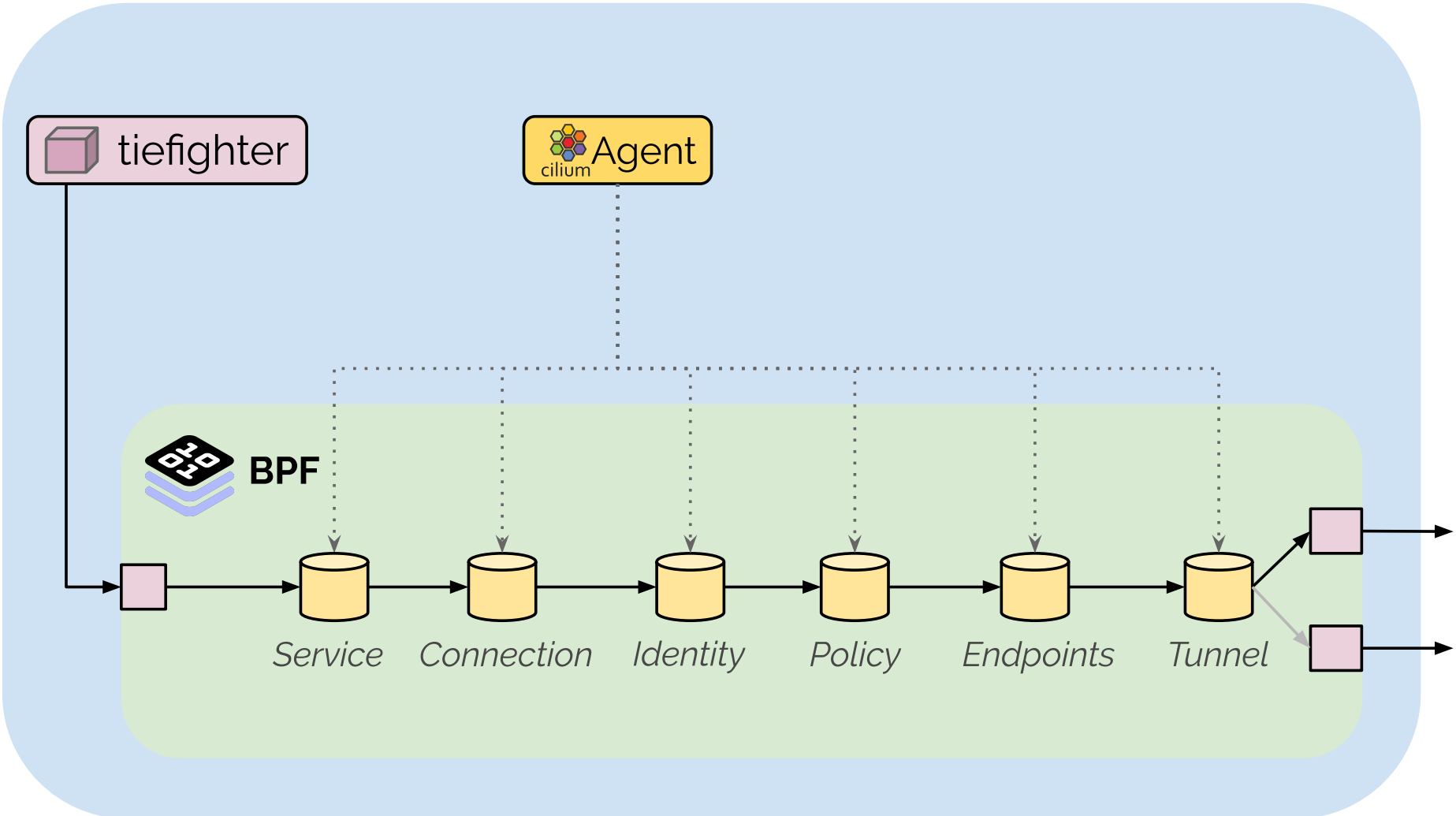


Layer 7 security

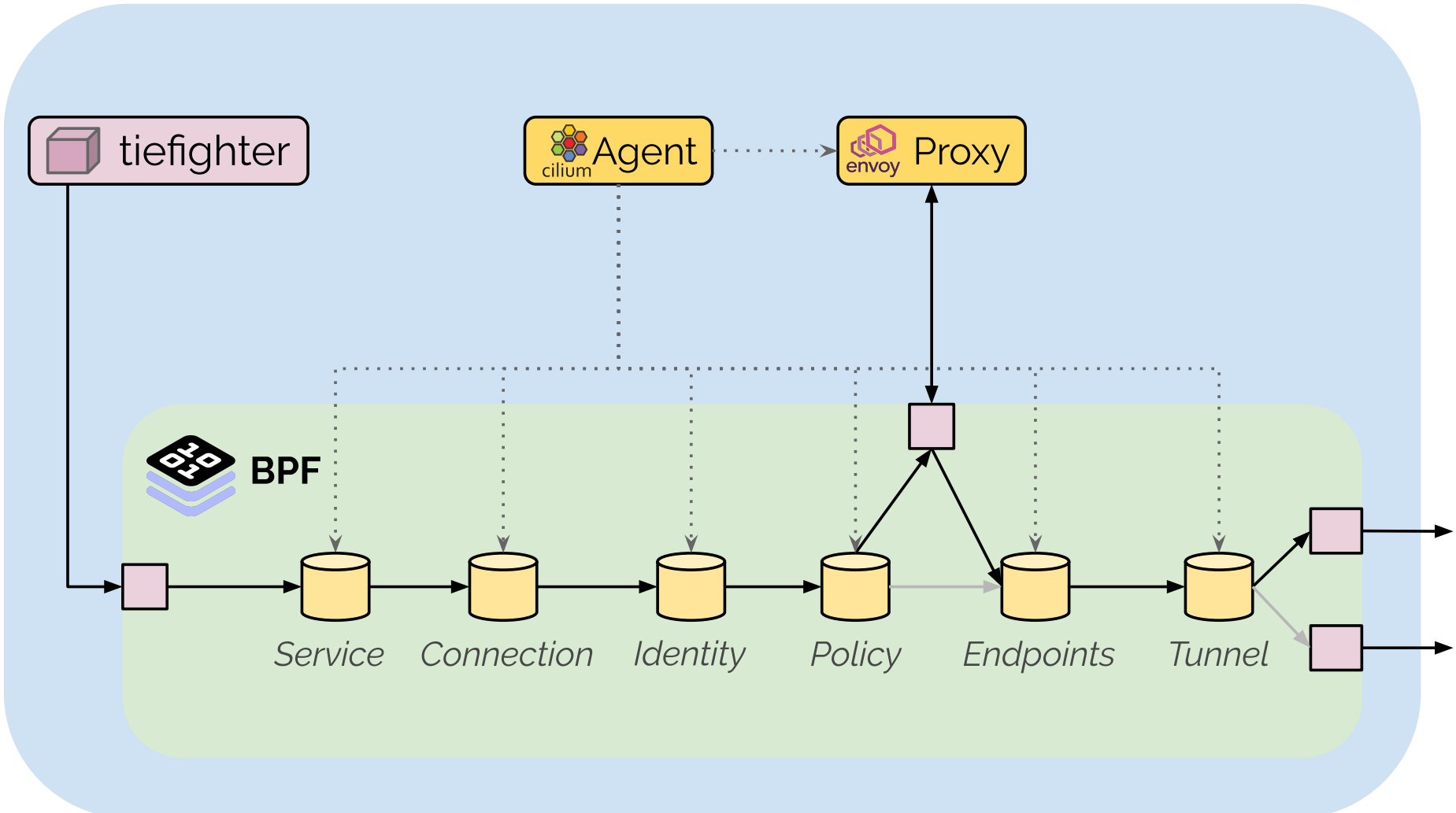
L7 is the new L4



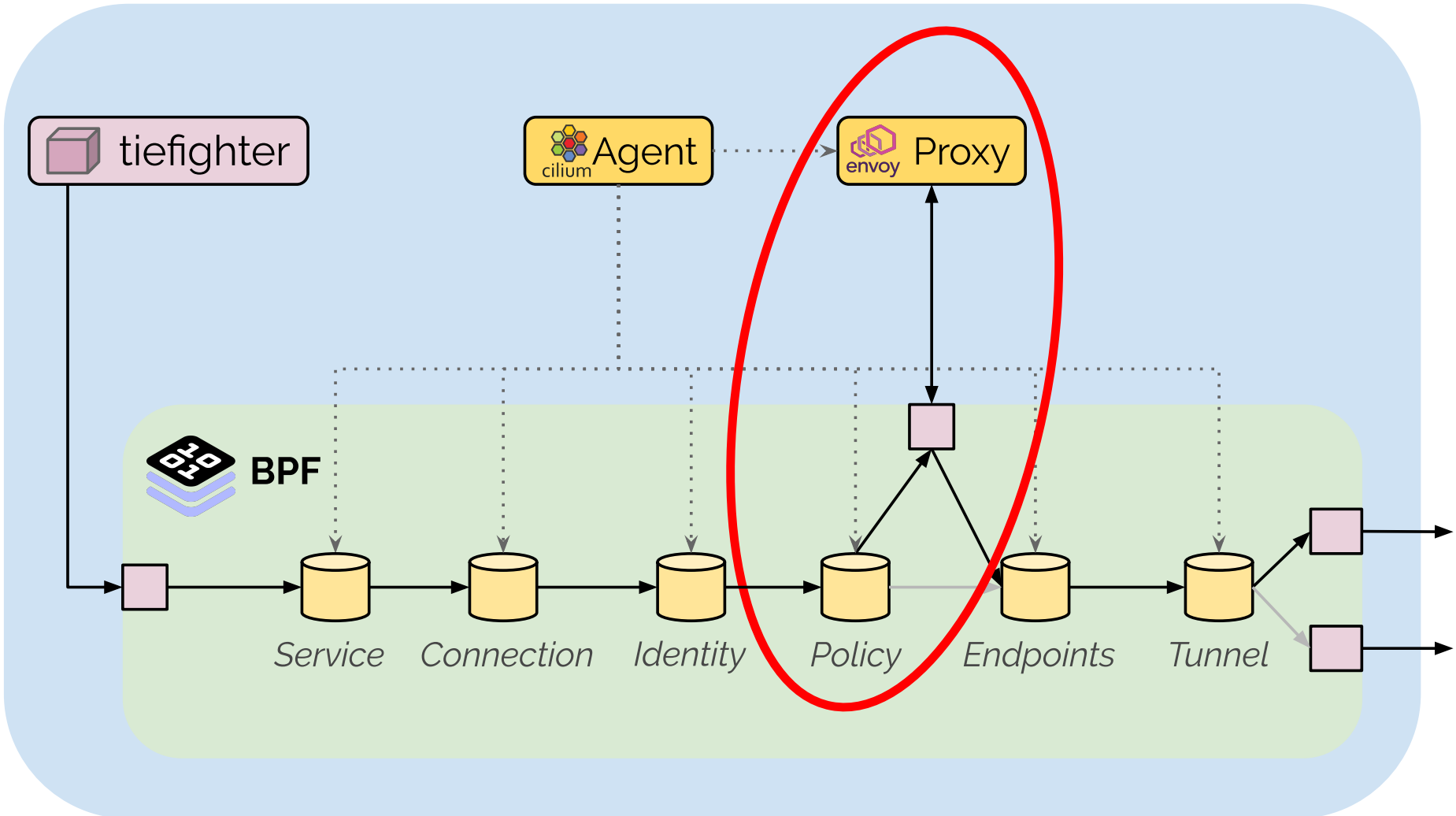
Datapath Configuration: L3 flow



Datapath Configuration: L7 flow

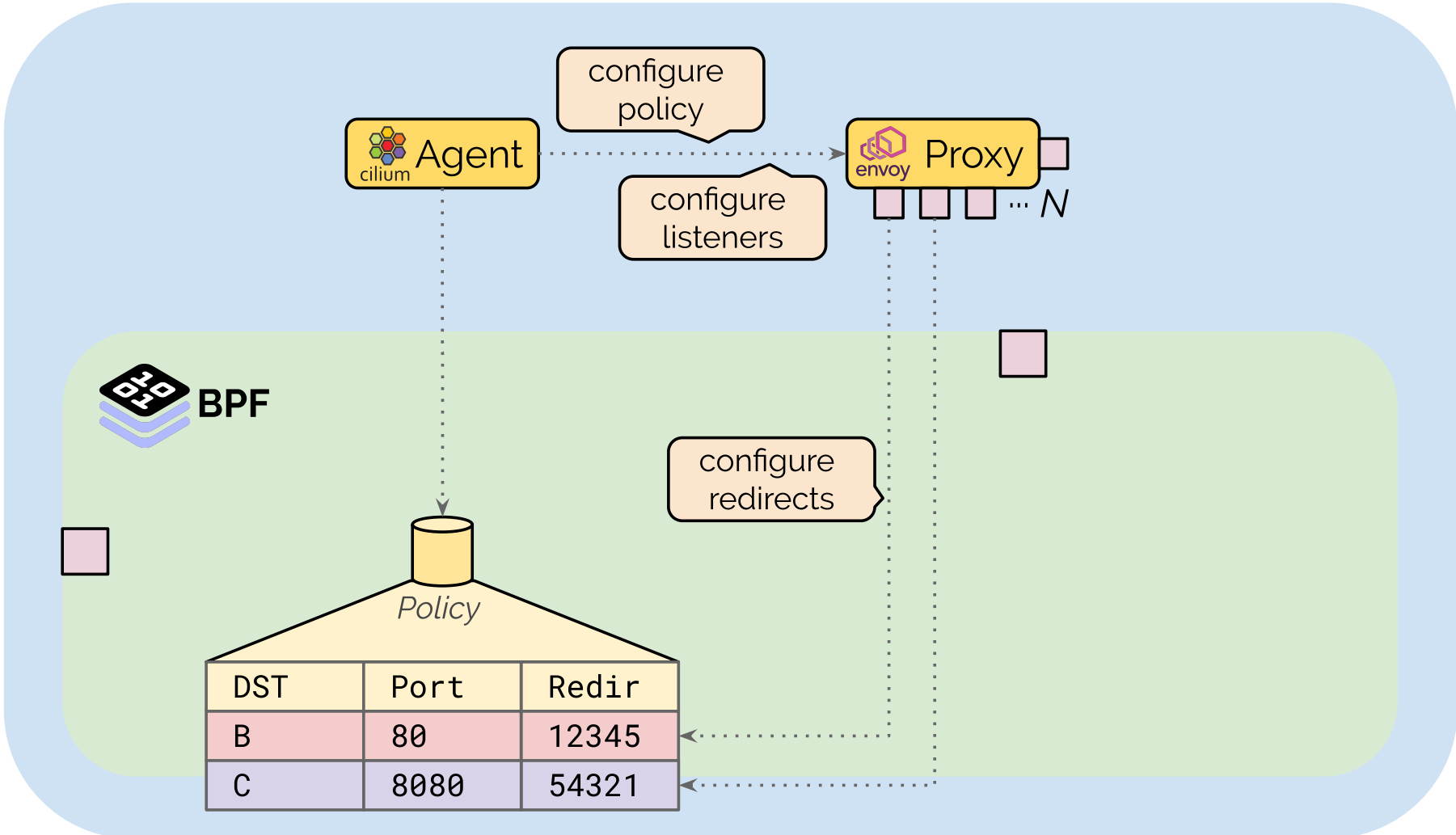


Datapath Configuration: L7 flow



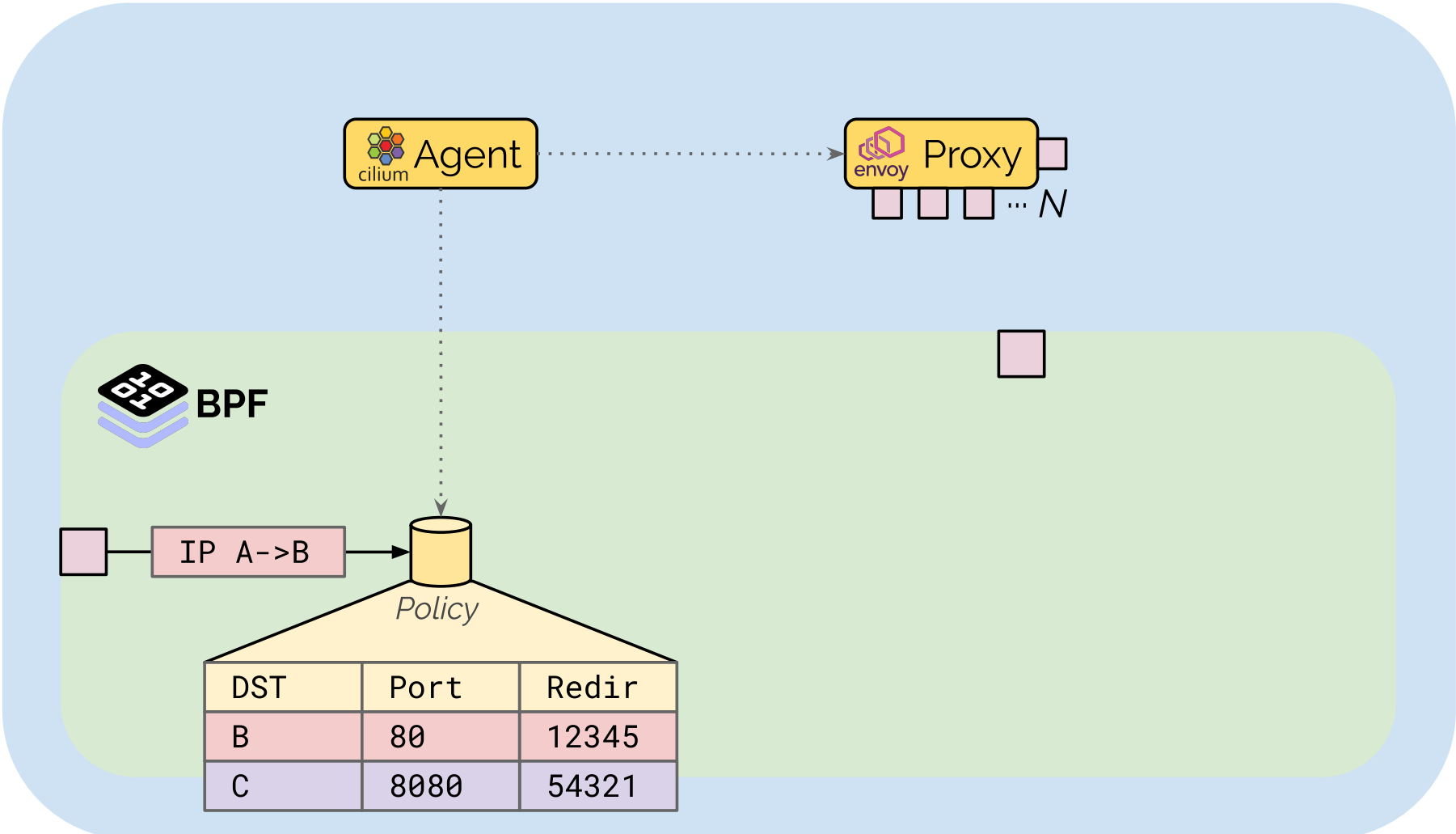
L7 Configuration: Past

Per-endpoint configuration



A: 192.0.2.3:33333 ; B: 192.0.2.4:80 ; L: 192.0.2.1:12345

L7 Configuration: Past



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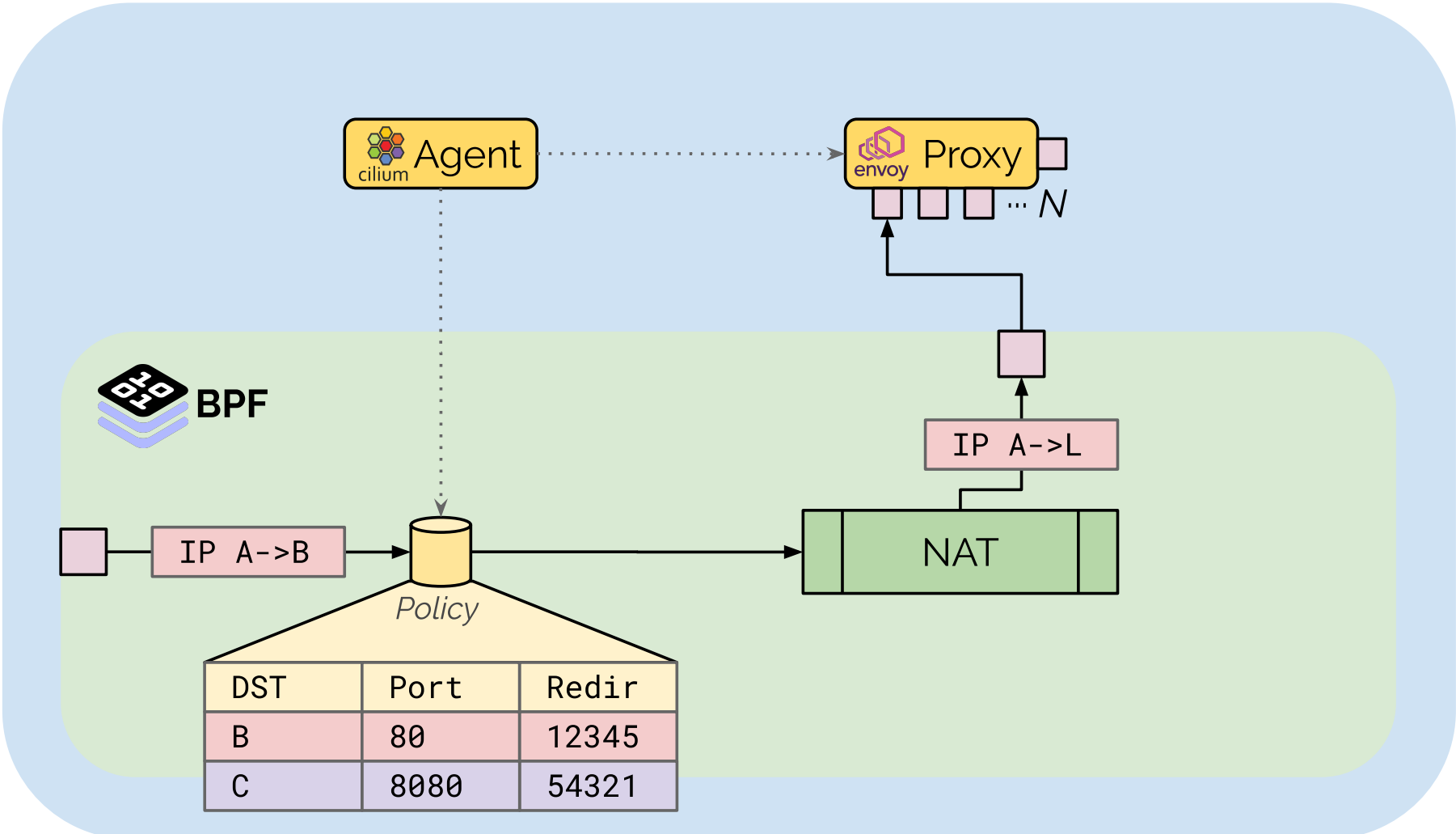
L7 Configuration: Past



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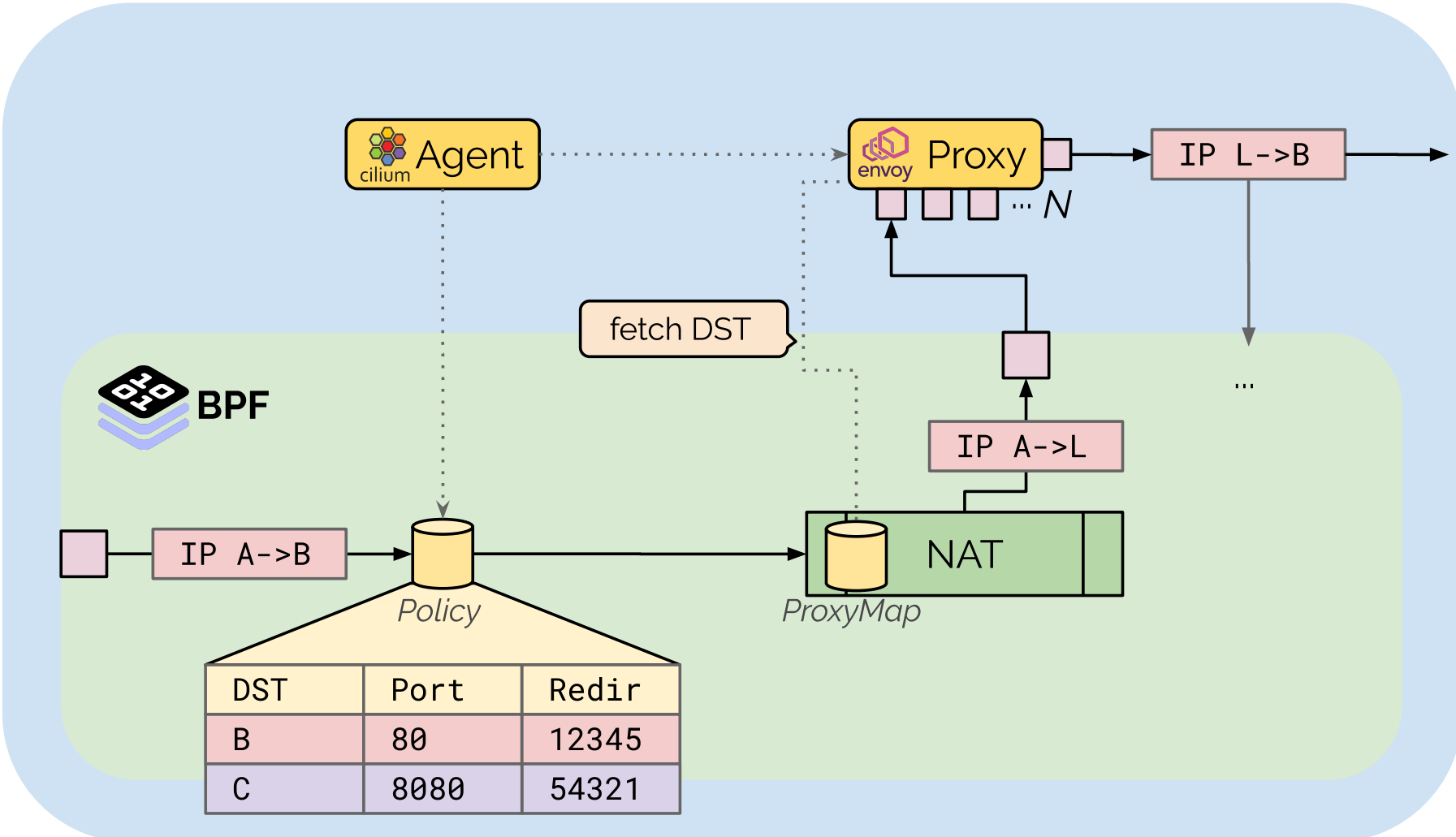
L7 Configuration: Past



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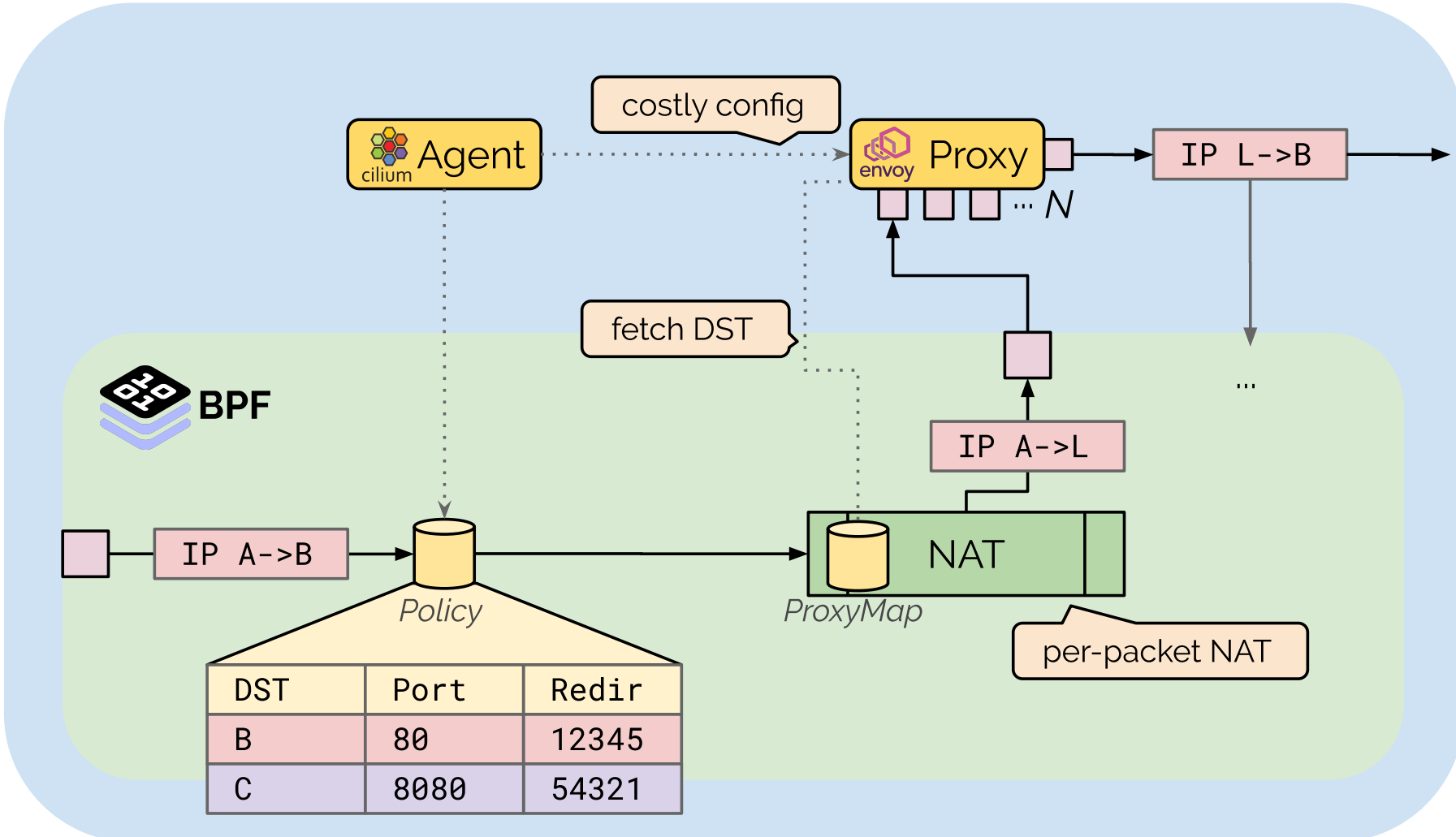
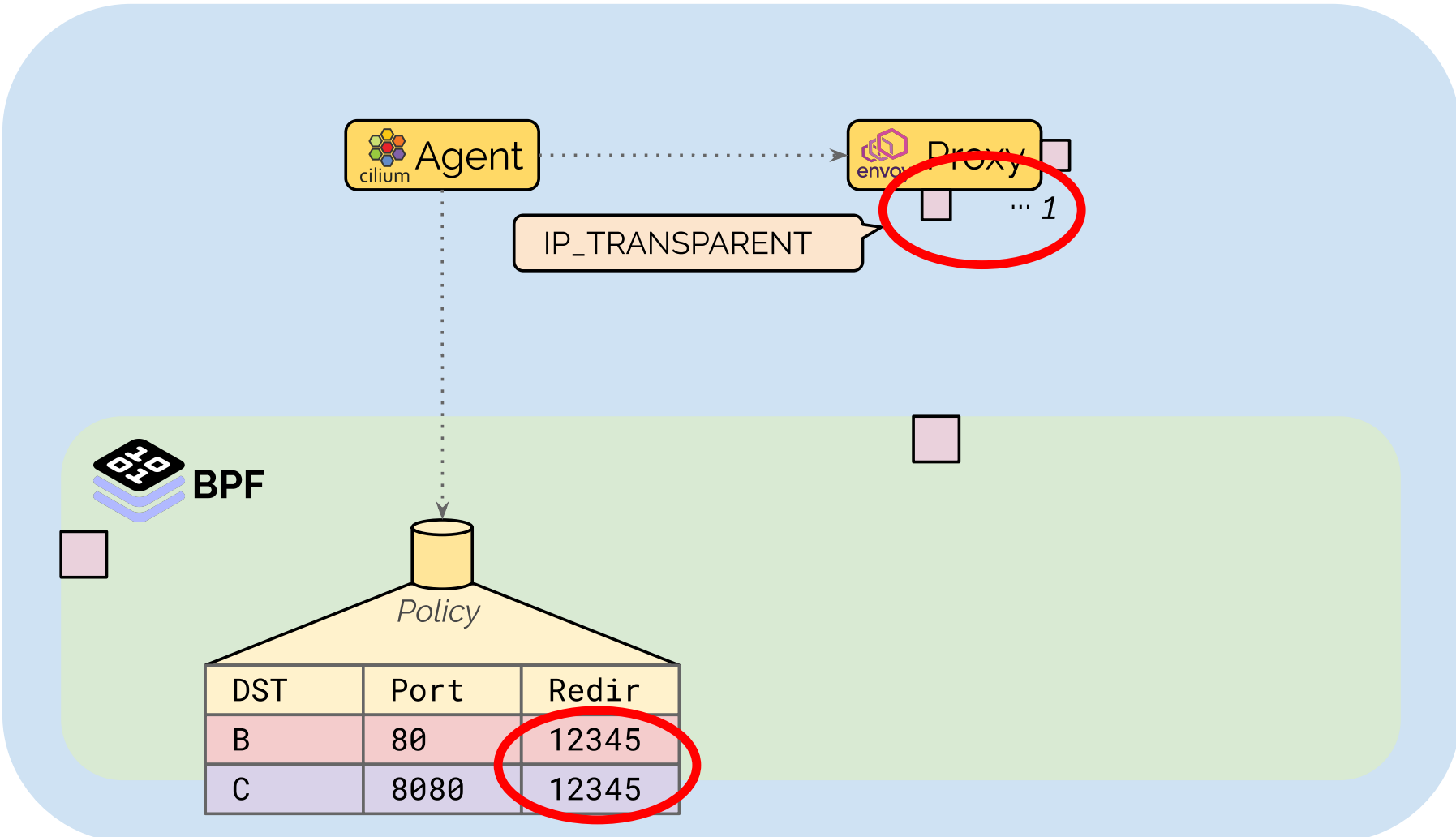
L7 Configuration: Past

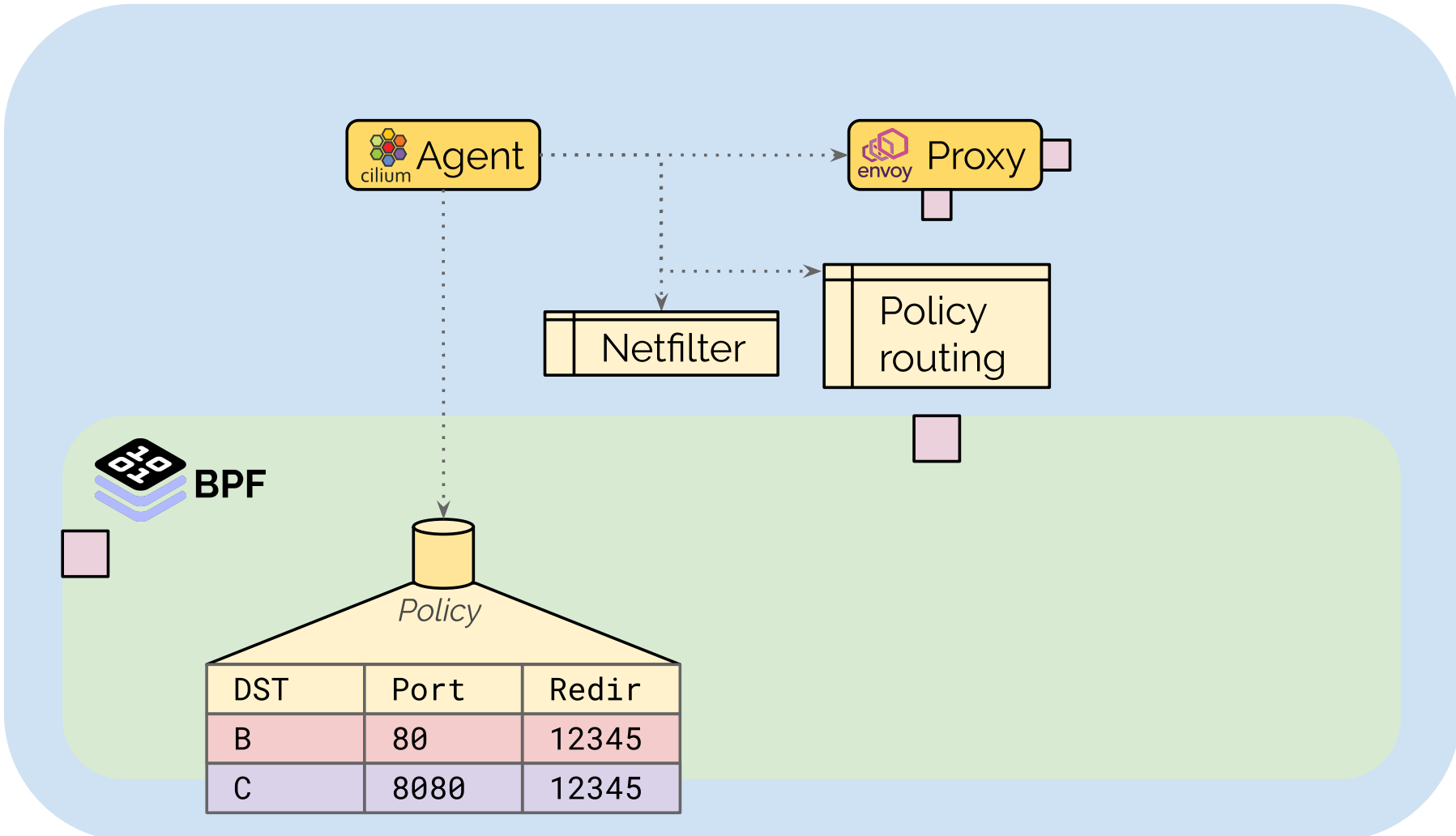


A: 192.0.2.3:33333 ; B: 192.0.2.4:80 ; L: 192.0.2.1:12345

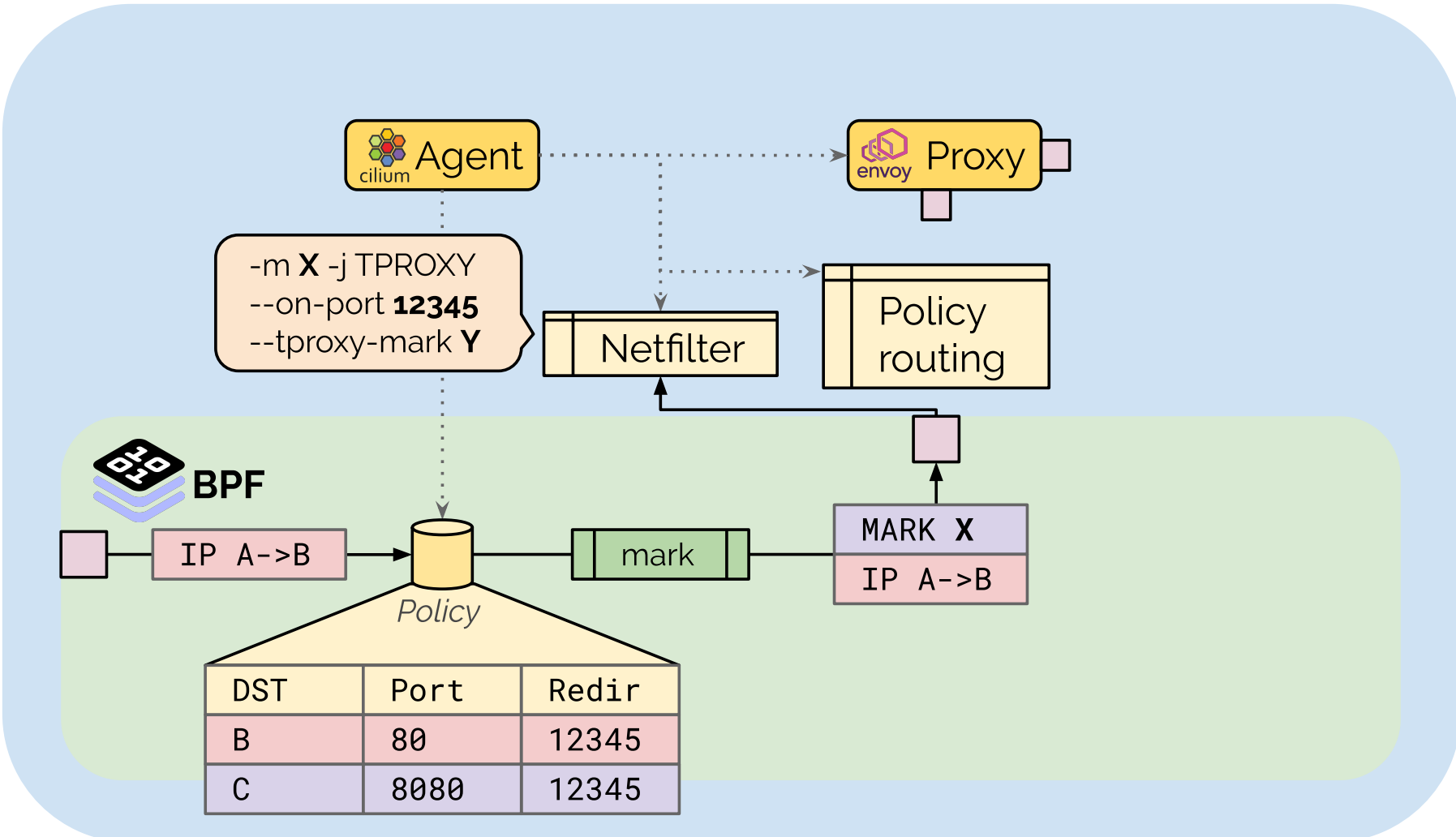
L7 Configuration: Present



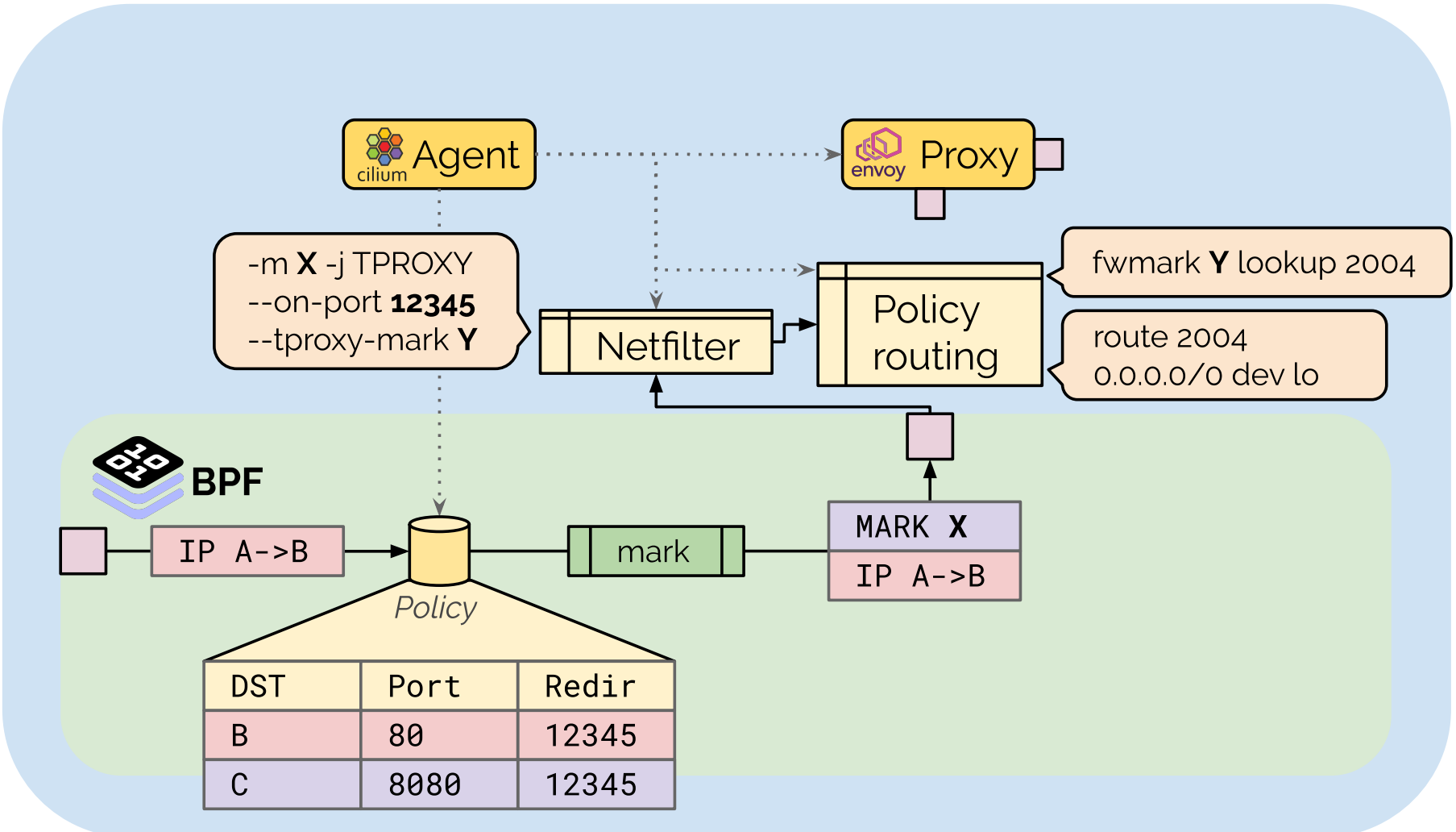
L7 Configuration: Present



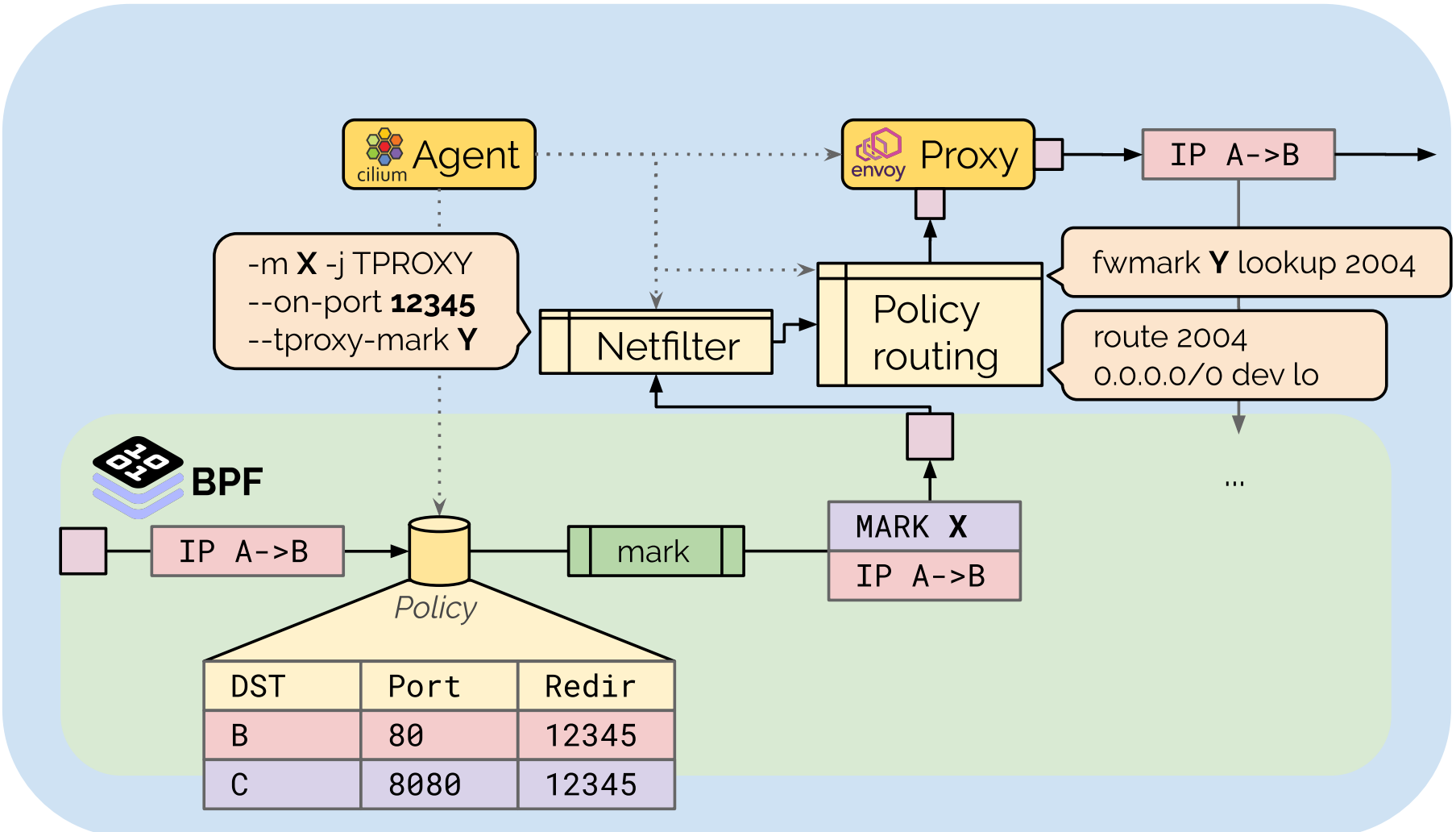
L7 Configuration: Present



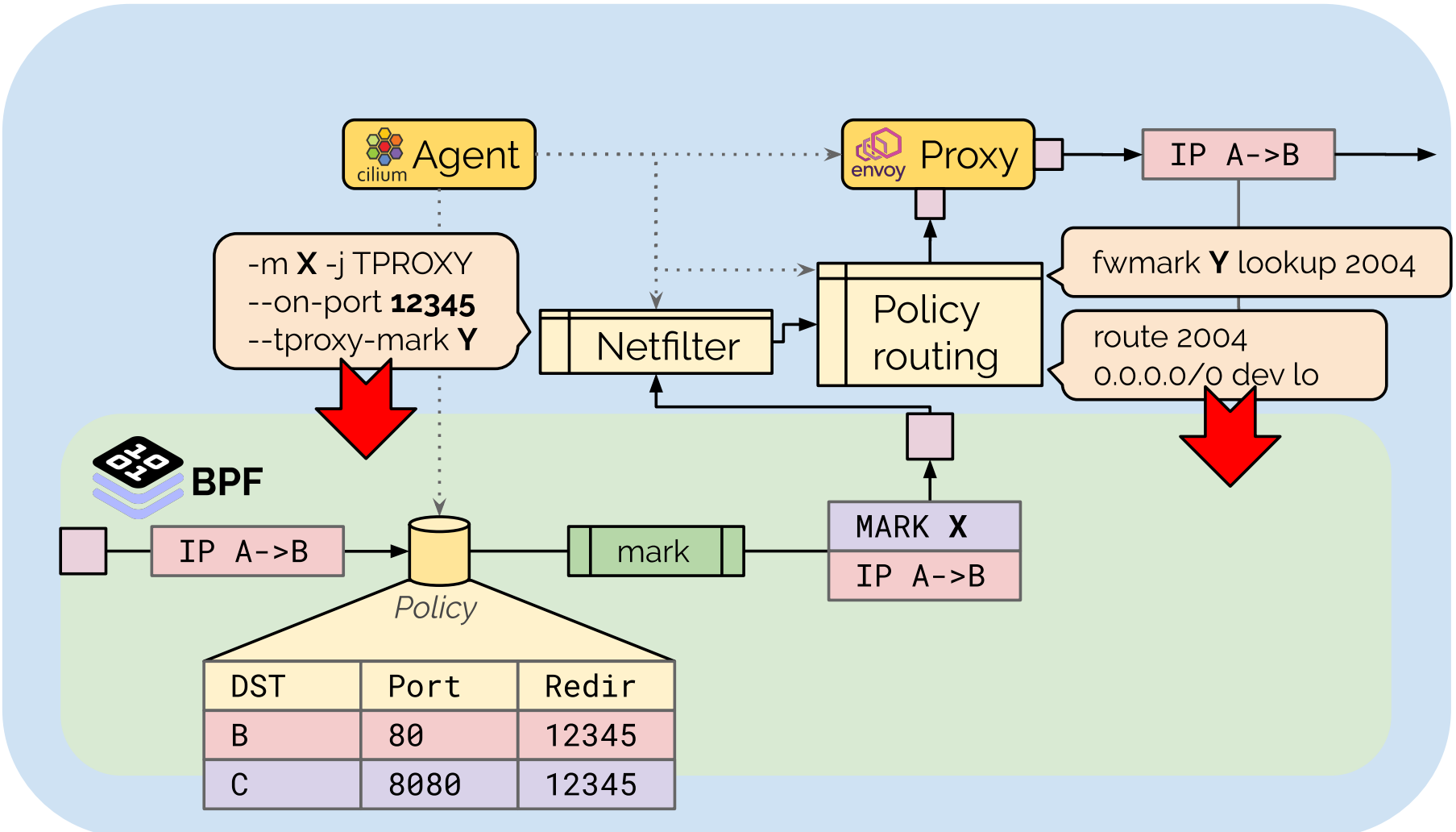
L7 Configuration: Present



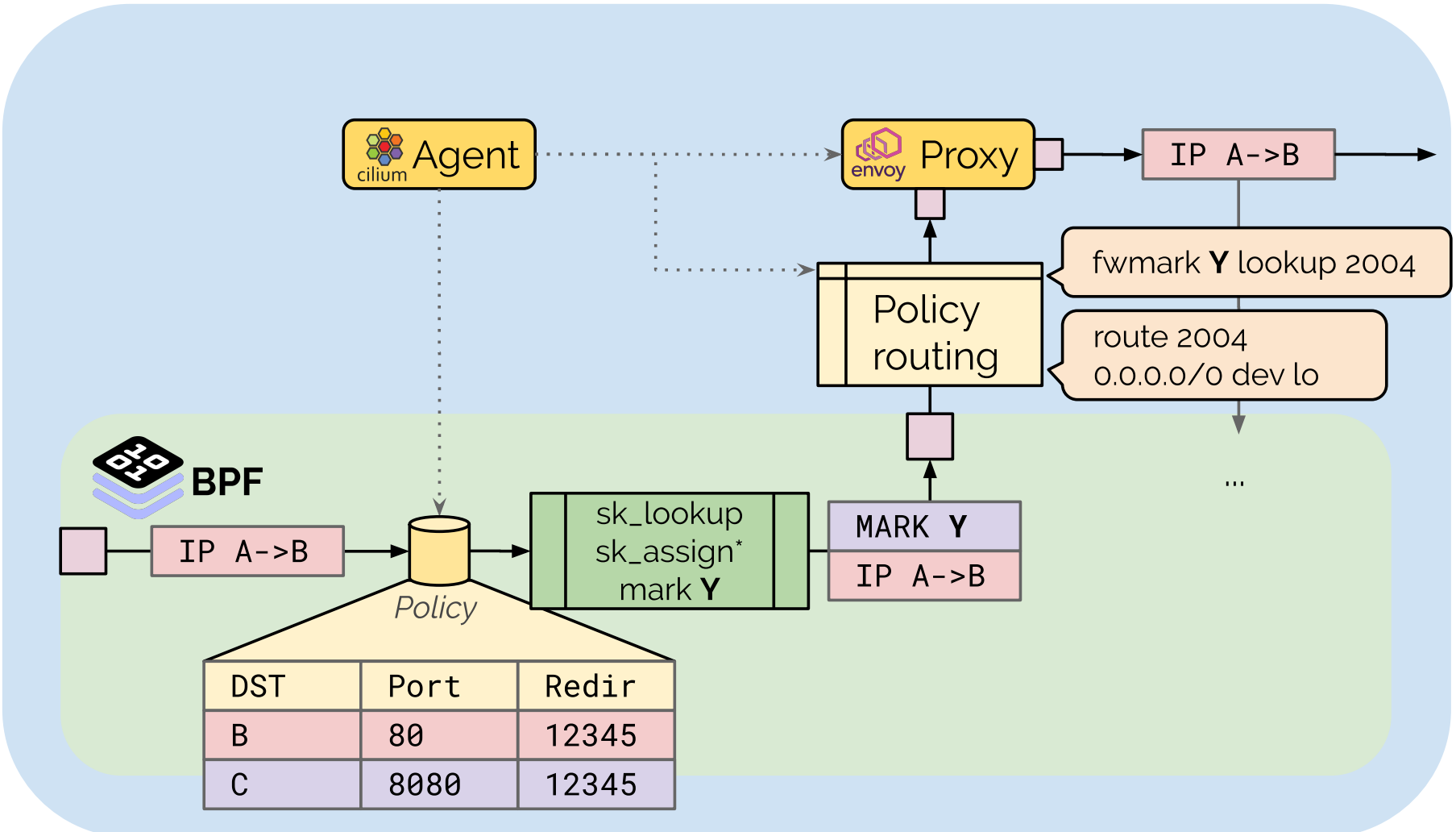
L7 Configuration: Present



L7 Configuration: Proposal



L7 Configuration: Proposal



Socket assign: RFC

```
/* int bpf_sk_assign(struct sk_buff *skb, struct bpf_sock *sk,
 *                   u64 flags)
 *  Description
 *    Assign the *sk* to the *skb*.
 *
 *    This operation is only valid from TC ingress path.
 *
 *    The *flags* argument must be zero.
 *  Return
 *    0 on success, or a negative errno in case of failure.
 *
 *    * **-EINVAL**       Unsupported flags specified.
 *    * **-EOPNOTSUPP**: Unsupported operation, for example
 *                       a call from outside of TC ingress.
 *    * **-ENOENT**:      The socket cannot be assigned.
 */
```

Socket assign: Hiccup

- BPF progs are attached at TC ingress
- `skb_orphan()` invoked directly before `PREROUTING`

[1] https://www.mail-archive.com/netdev@vger.kernel.org/msg303851.html
[2] https://www.mail-archive.com/netdev@vger.kernel.org/msg304057.html

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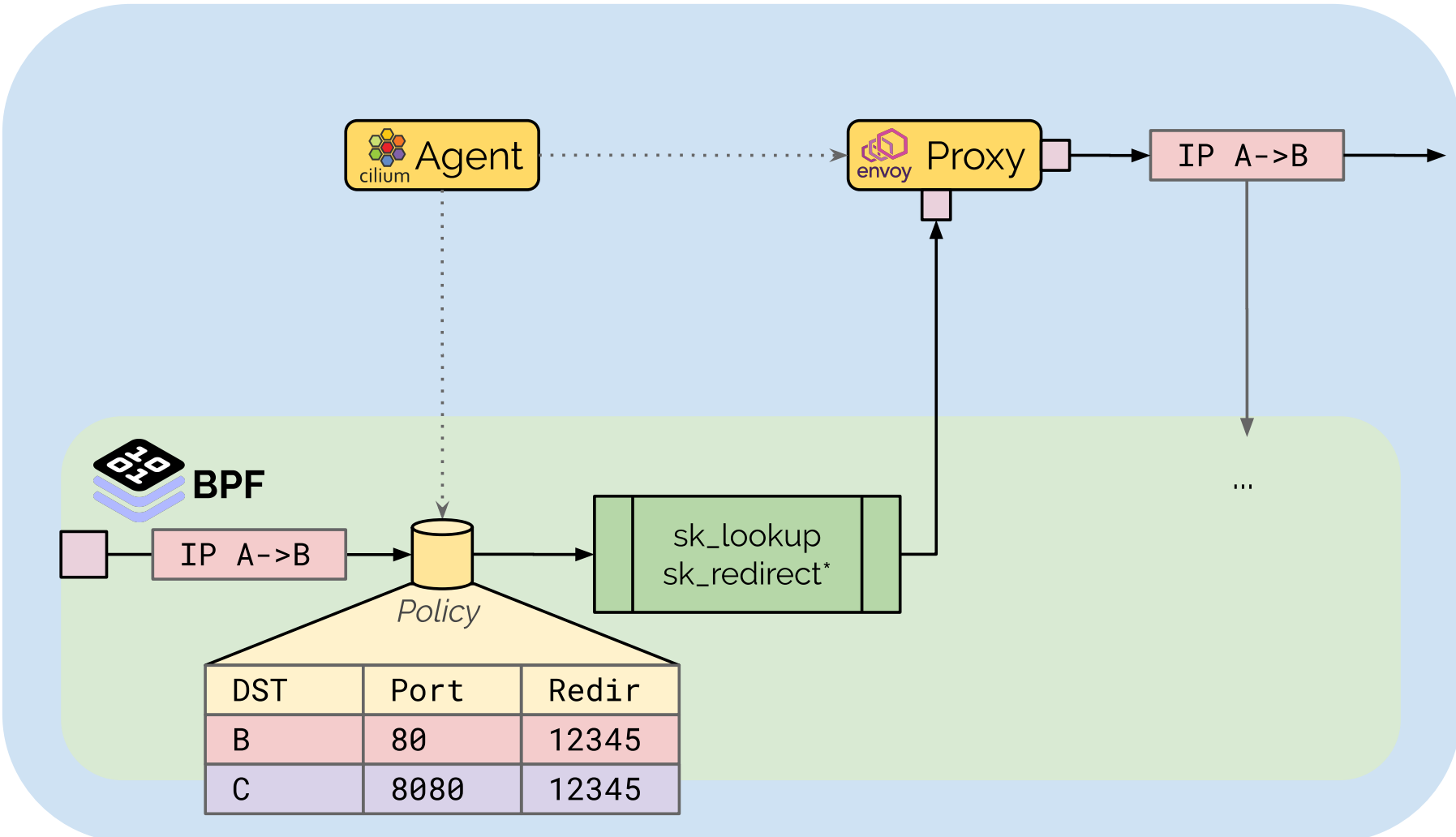
Socket assign: Hiccup

- BPF progs are attached at TC ingress
- `skb_orphan()` invoked directly before `PREROUTING`
- TC folks are already carrying hacks for this[1]
- Just move to `____dev_forward_skb()`[2]?

[1] https://www.mail-archive.com/netdev@vger.kernel.org/msg303851.html
[2] https://www.mail-archive.com/netdev@vger.kernel.org/msg304057.html

L7 Configuration: Socket redirect



Summary

- Minimize processing cost
  - Number of events
  - Cost for each event
- Separate concerns: Policy vs addressing
- Frontload expensive operations
- ... while keeping runtime costs low

Thank you

More information

- https://cilium.io
- https://cilium.io/slack
- https://github.com/cilium/cilium
- https://twitter.com/ciliumproject

Thank you

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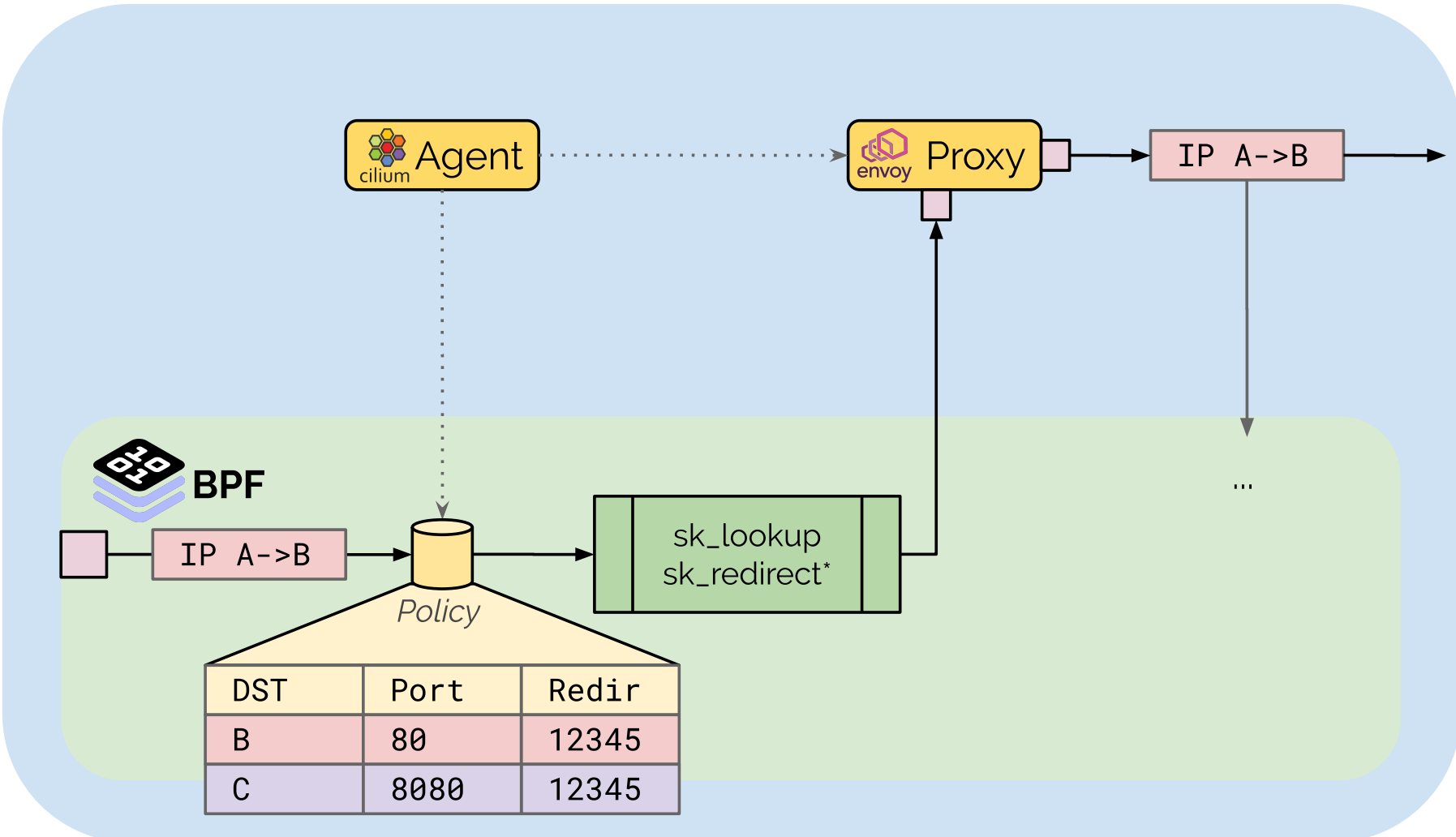
Socket redirect



Socket assign: API quirks

- Nit: Need to use `sock_common` socket lookups
- Add `bpf_skc_lookup_udp()`
- Optimization: Add lookup flags to `bpf_sk*_lookup_*()`