Broker

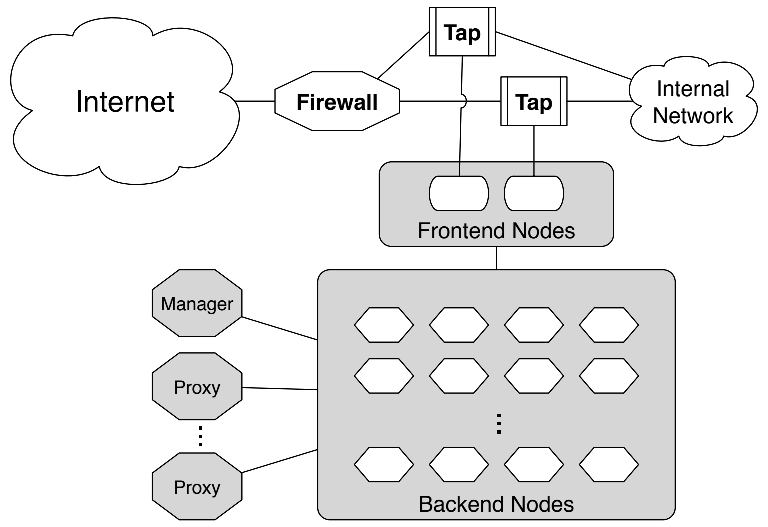
Matthias Vallentin
UC Berkeley
International Computer Science Institute (ICSI)

BroCon '16

Communication in Bro

Broccoli, Independent State

2005



Bro Cluster

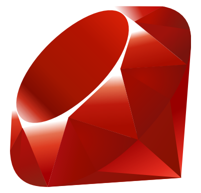
2007

 +

Python Bindings

Broccoli

2008

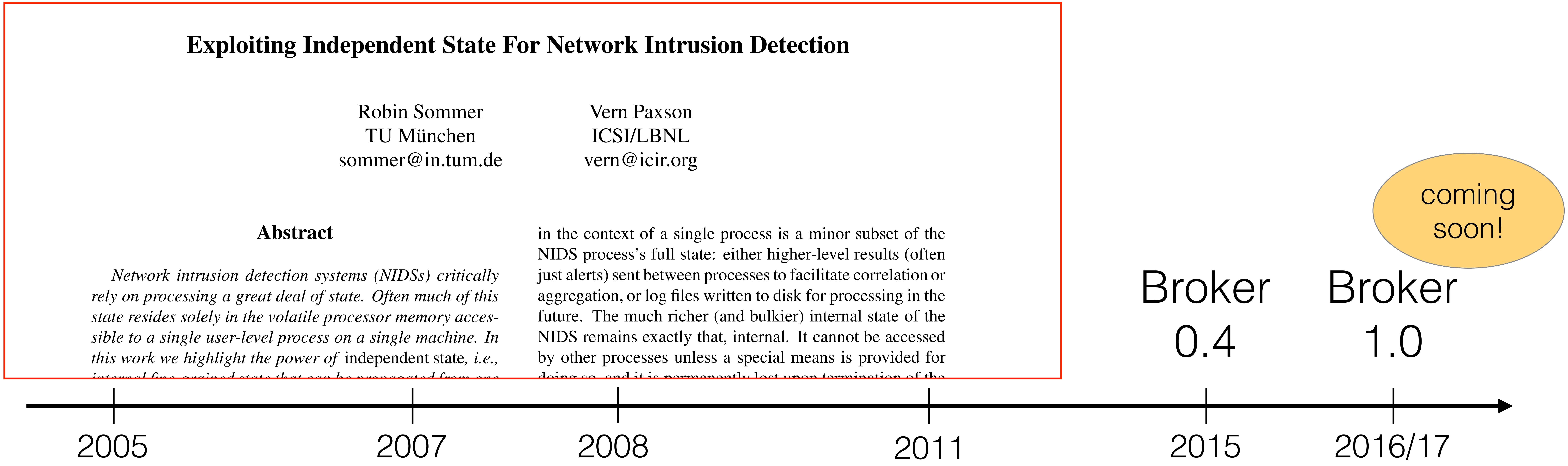
 +  

Ruby & Perl Bindings

Broccoli

2011

Communication in Bro



Exploiting Independent State For Network Intrusion Detection

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Abstract

Network intrusion detection systems (NIDSs) critically rely on processing a great deal of state. Often much of this state resides solely in the volatile processor memory accessible to a single user-level process on a single machine. In this work we highlight the power of independent state, *i.e.,*

in the context of a single process is a minor subset of the NIDS process's full state: either higher-level results (often just alerts) sent between processes to facilitate correlation or aggregation, or log files written to disk for processing in the future. The much richer (and bulkier) internal state of the NIDS remains exactly that, internal. It cannot be accessed by other processes unless a special means is provided for

Outline

- Overview
- API
- Performance
- Outlook

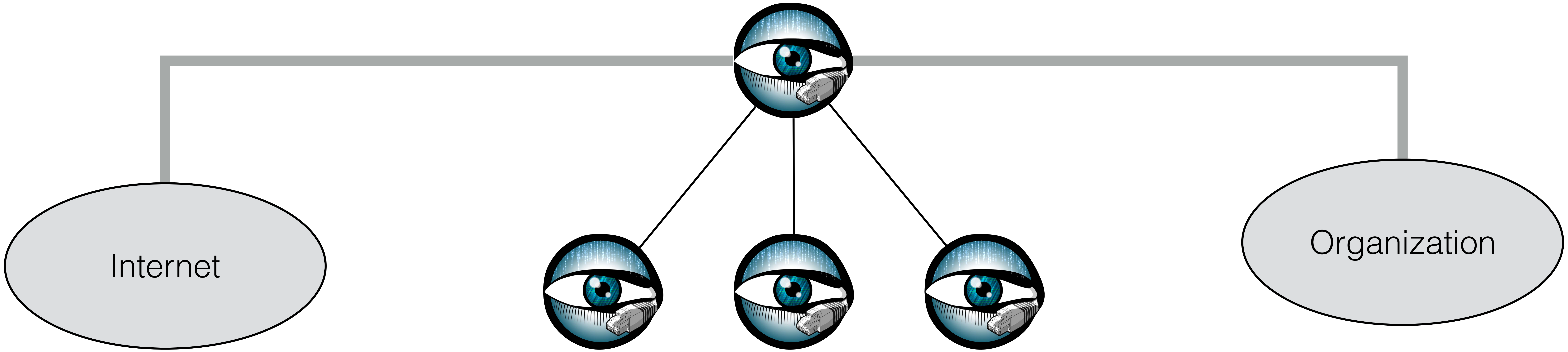
Overview

Broker = Bro'ish data model

+ publish/subscribe **communication**

+ distributed key-value **stores**

Publish/Subscribe Communication



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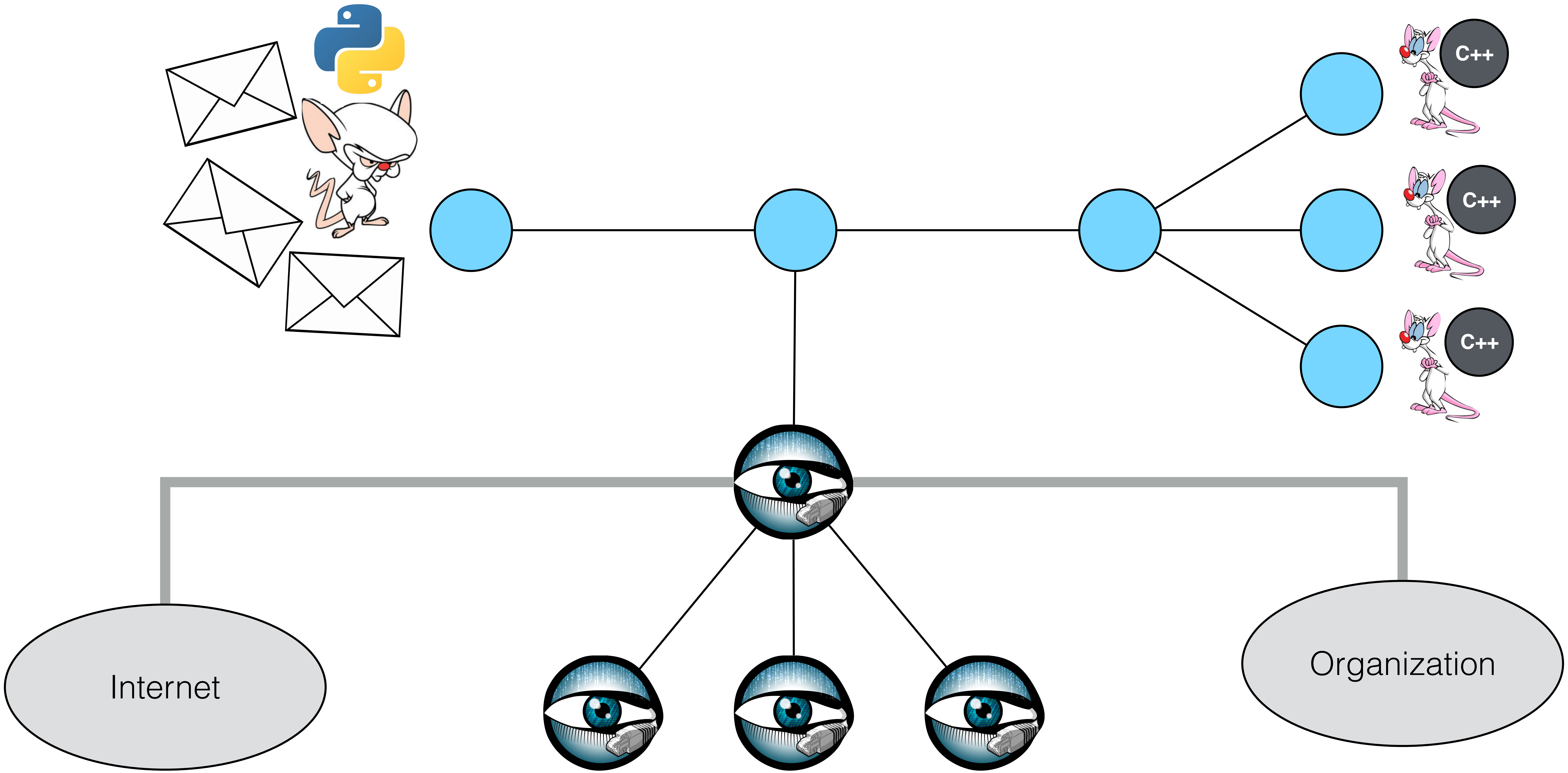

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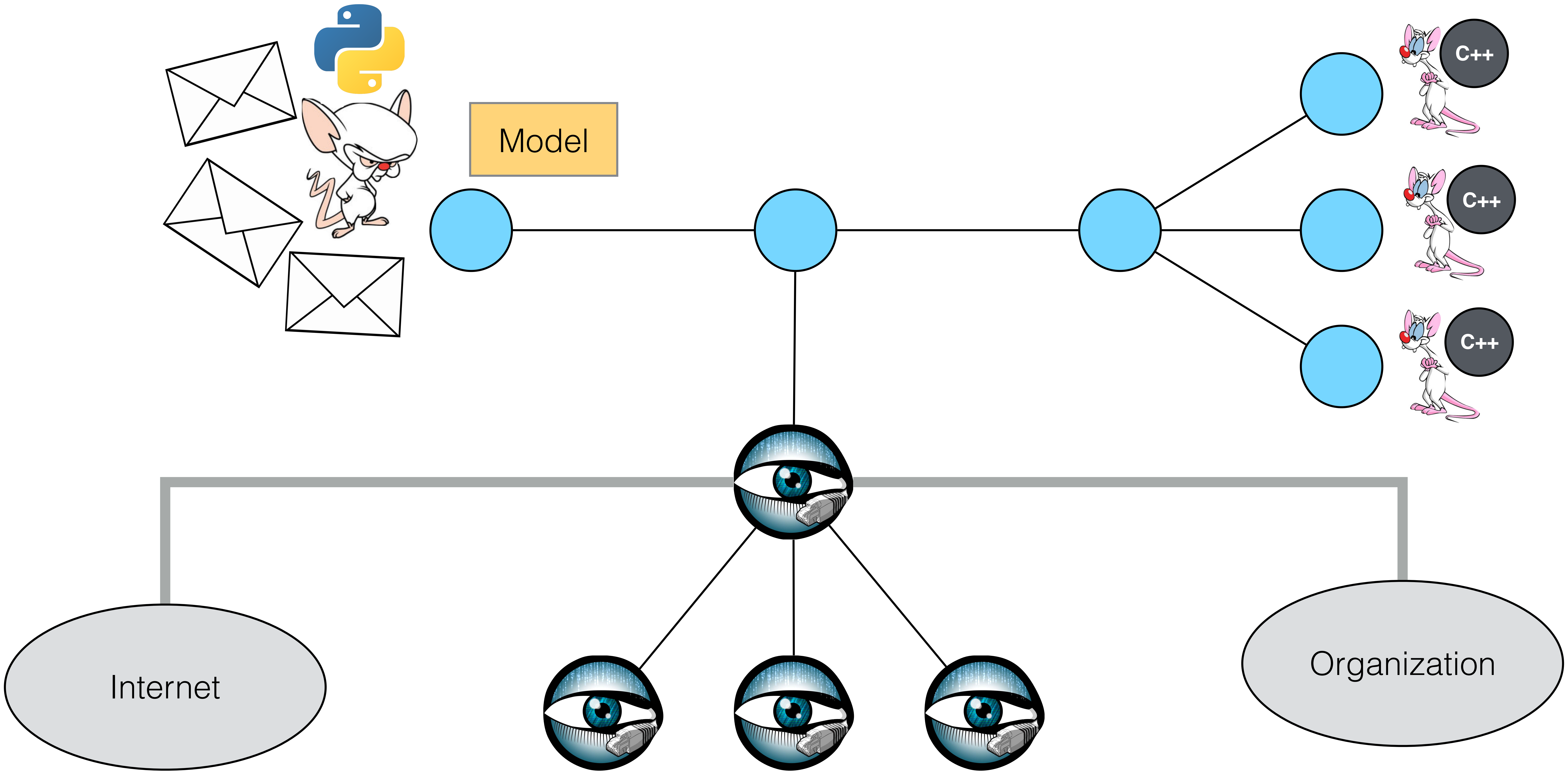

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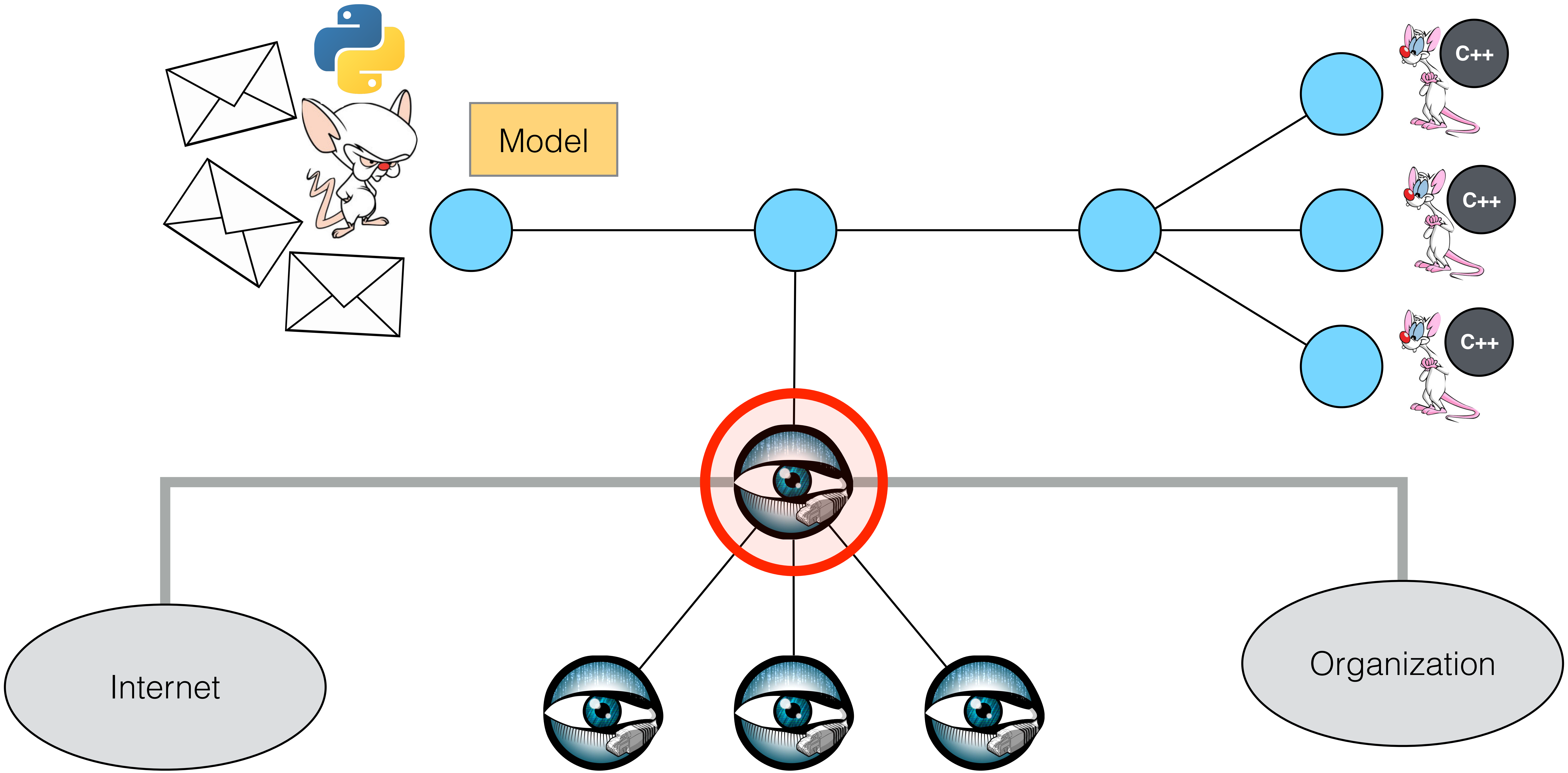

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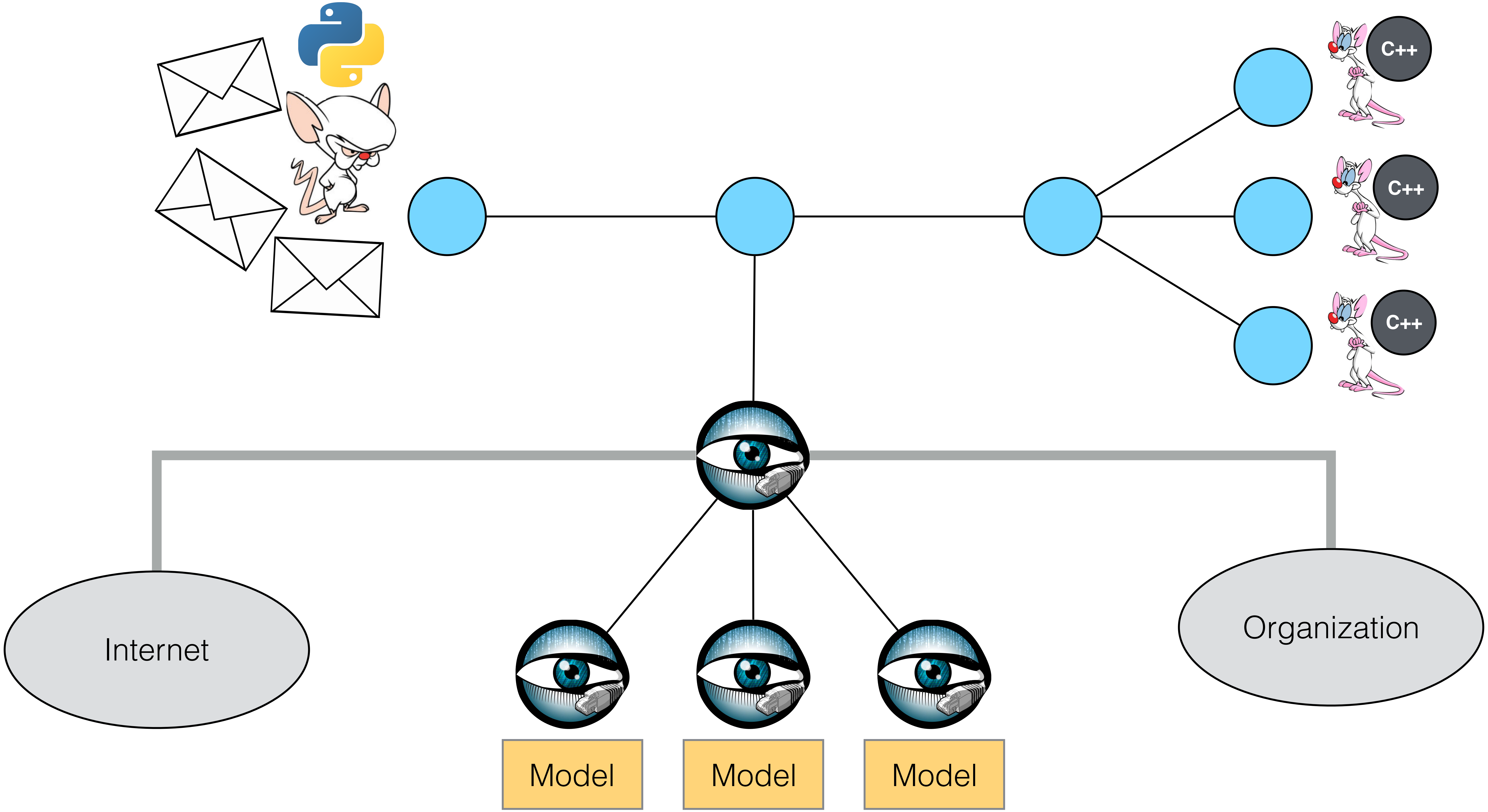

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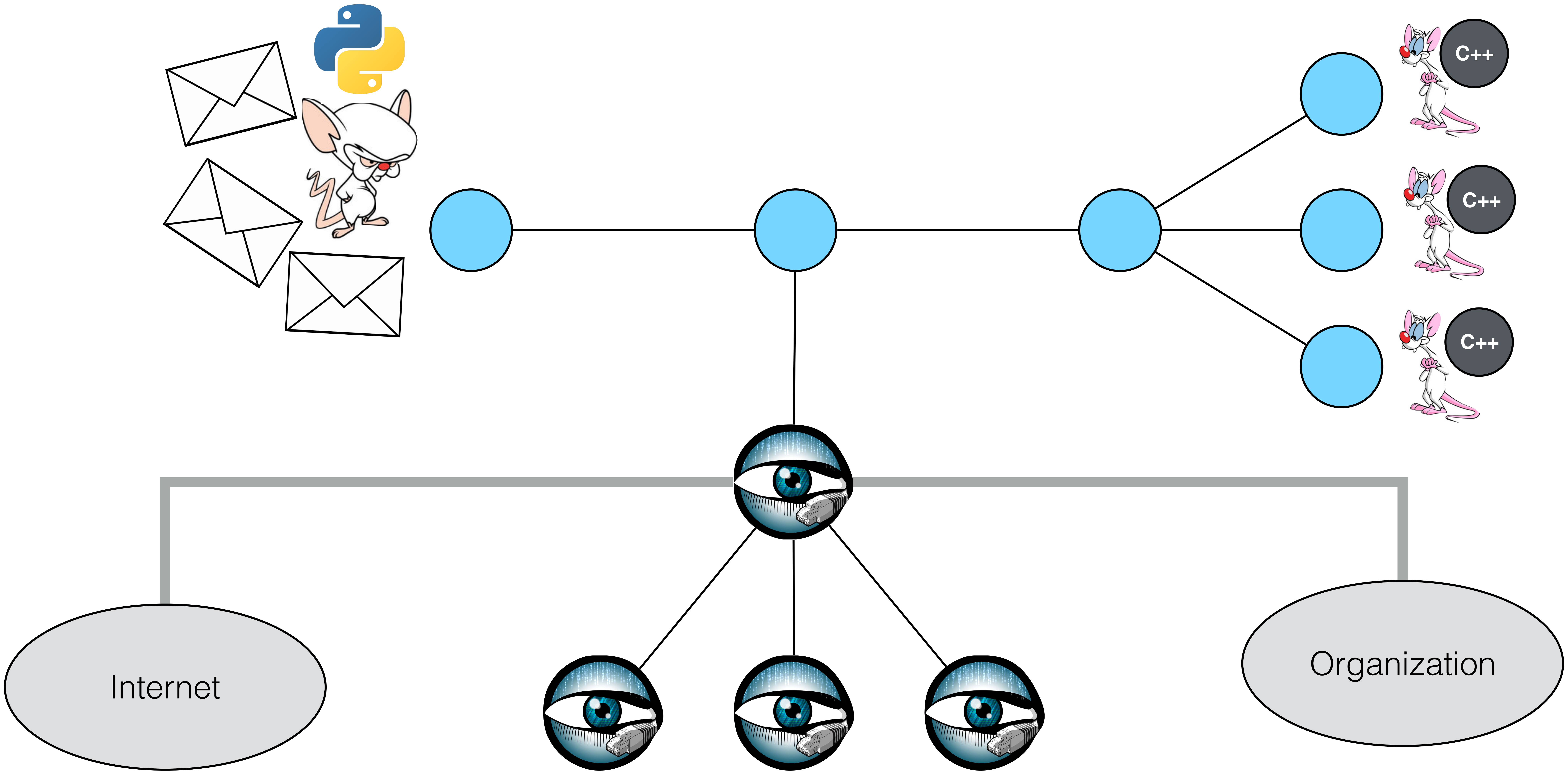

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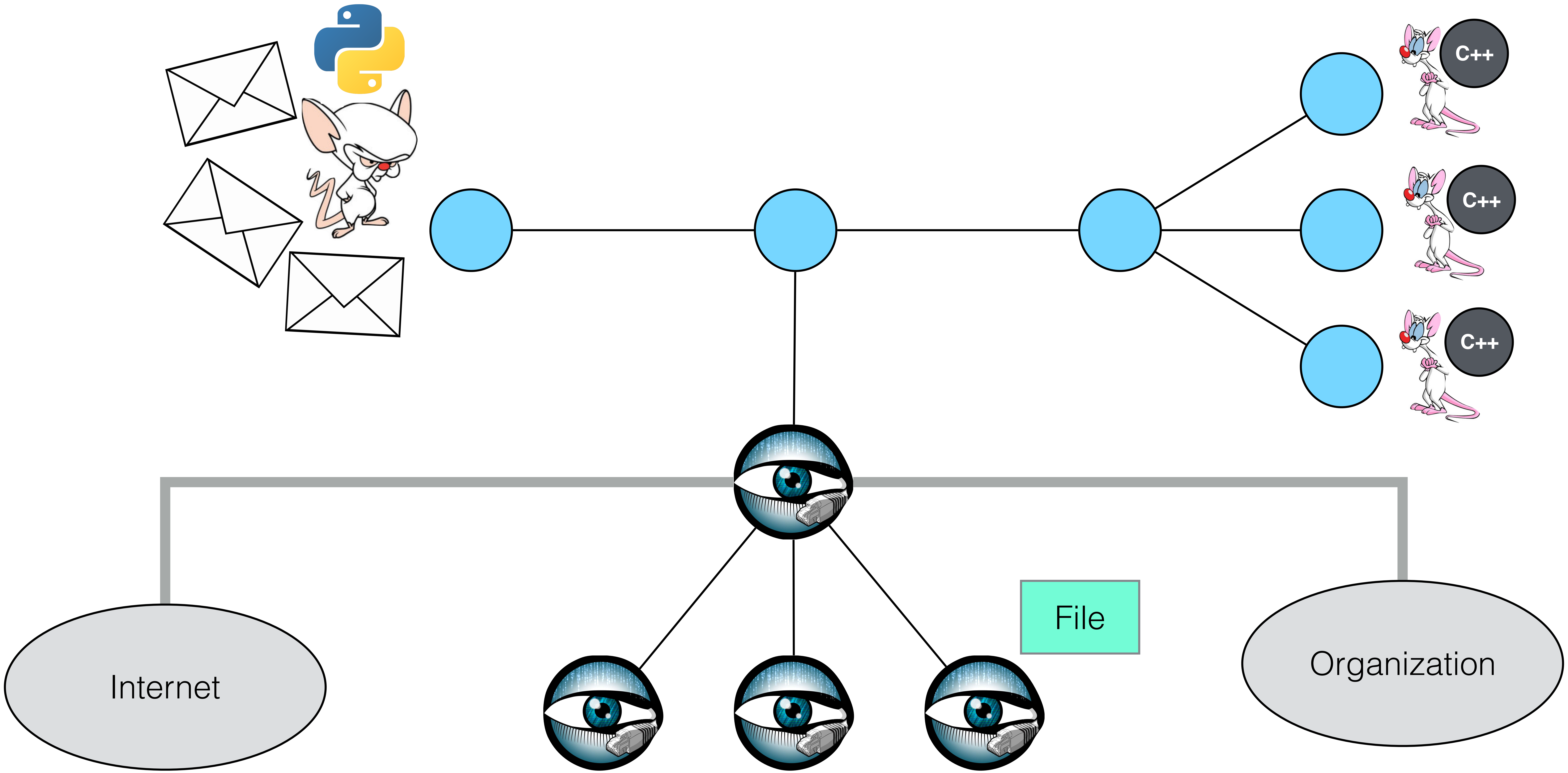

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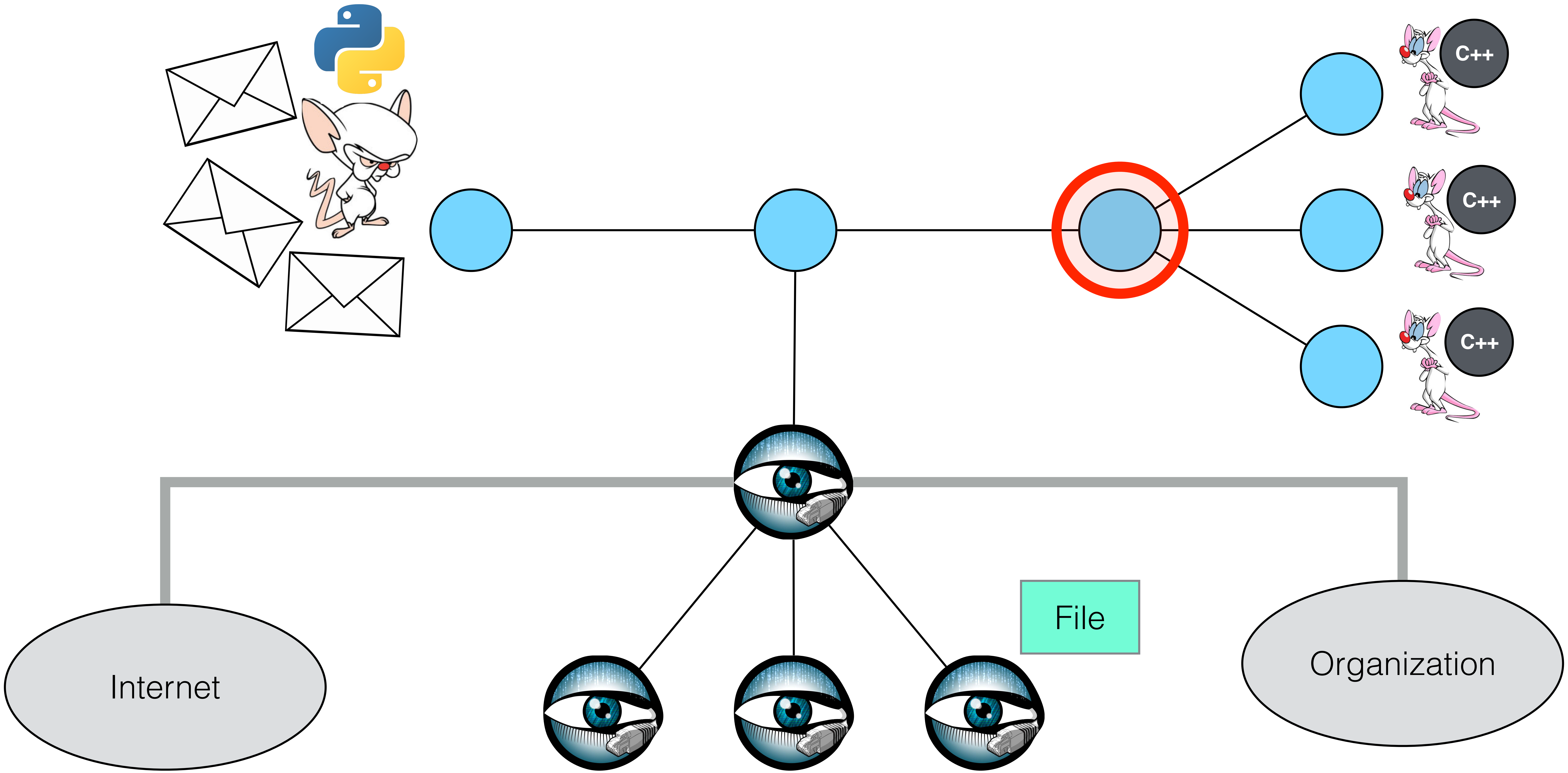

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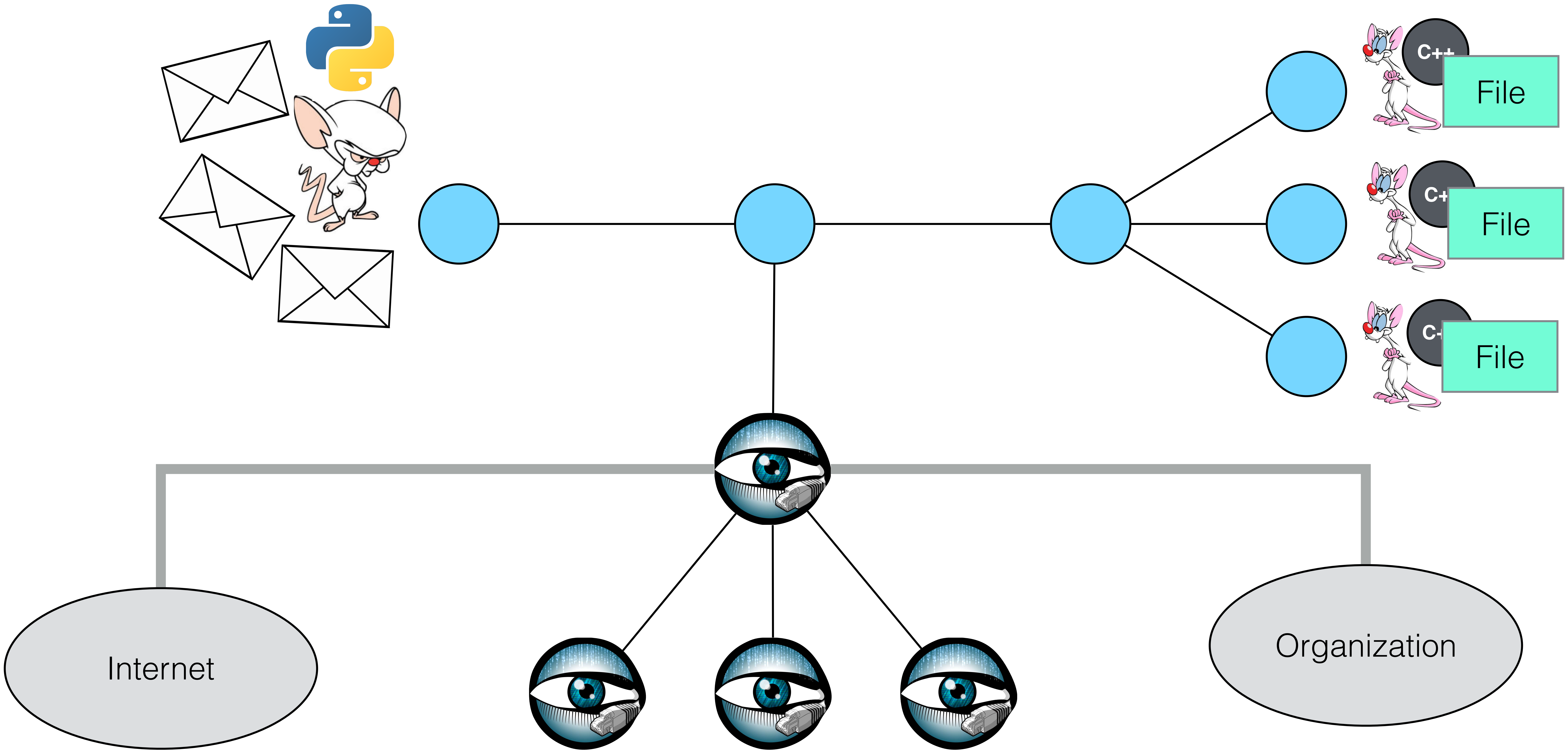

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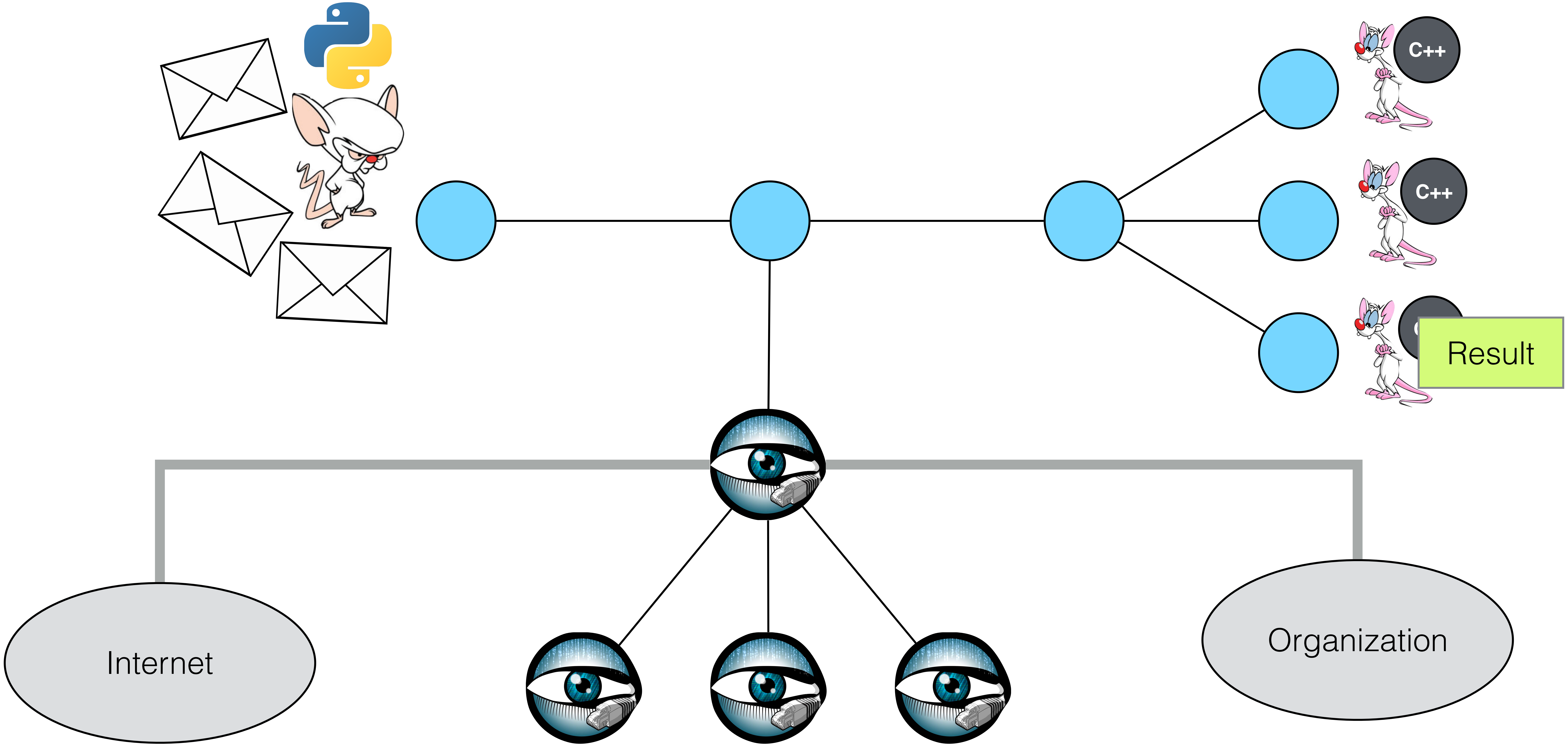

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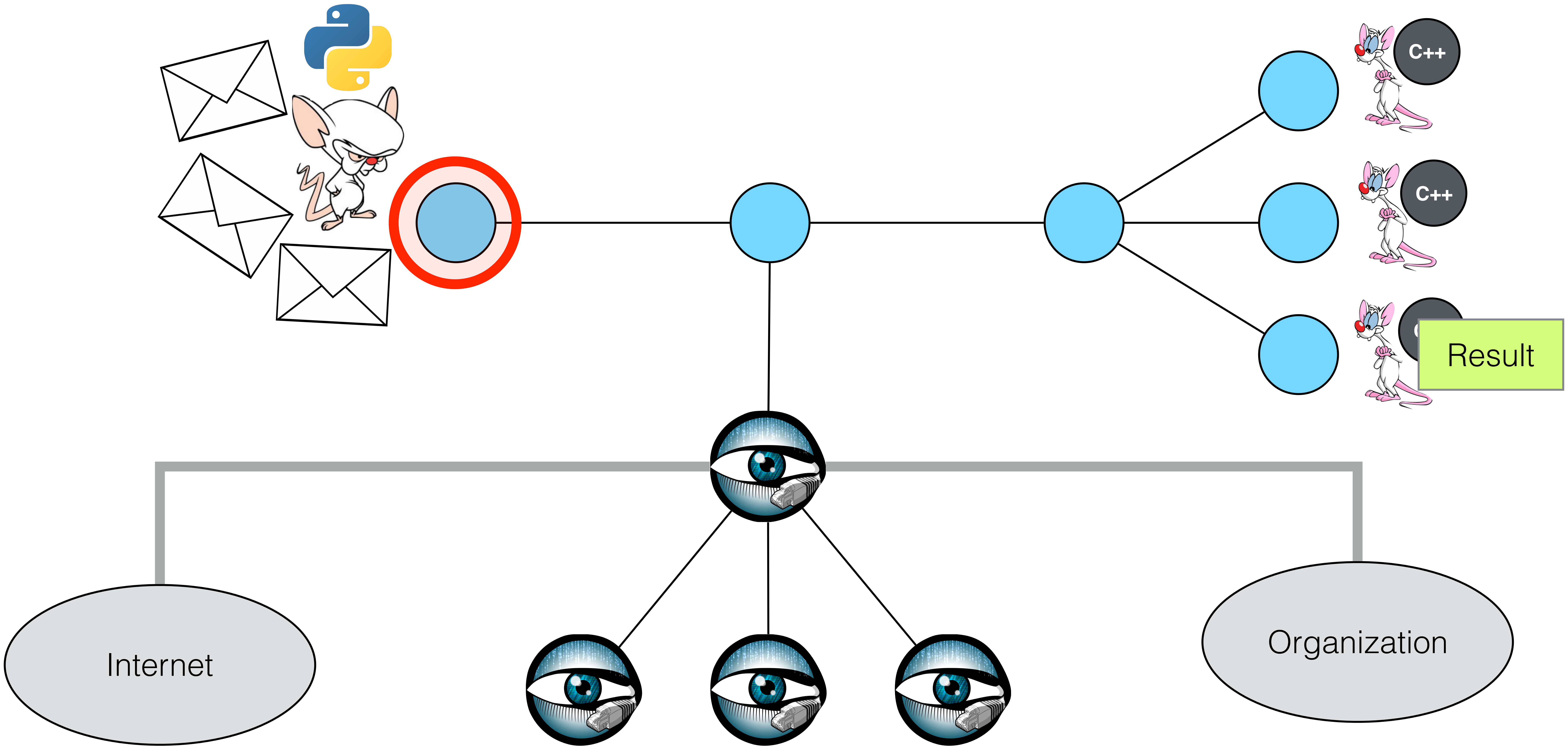

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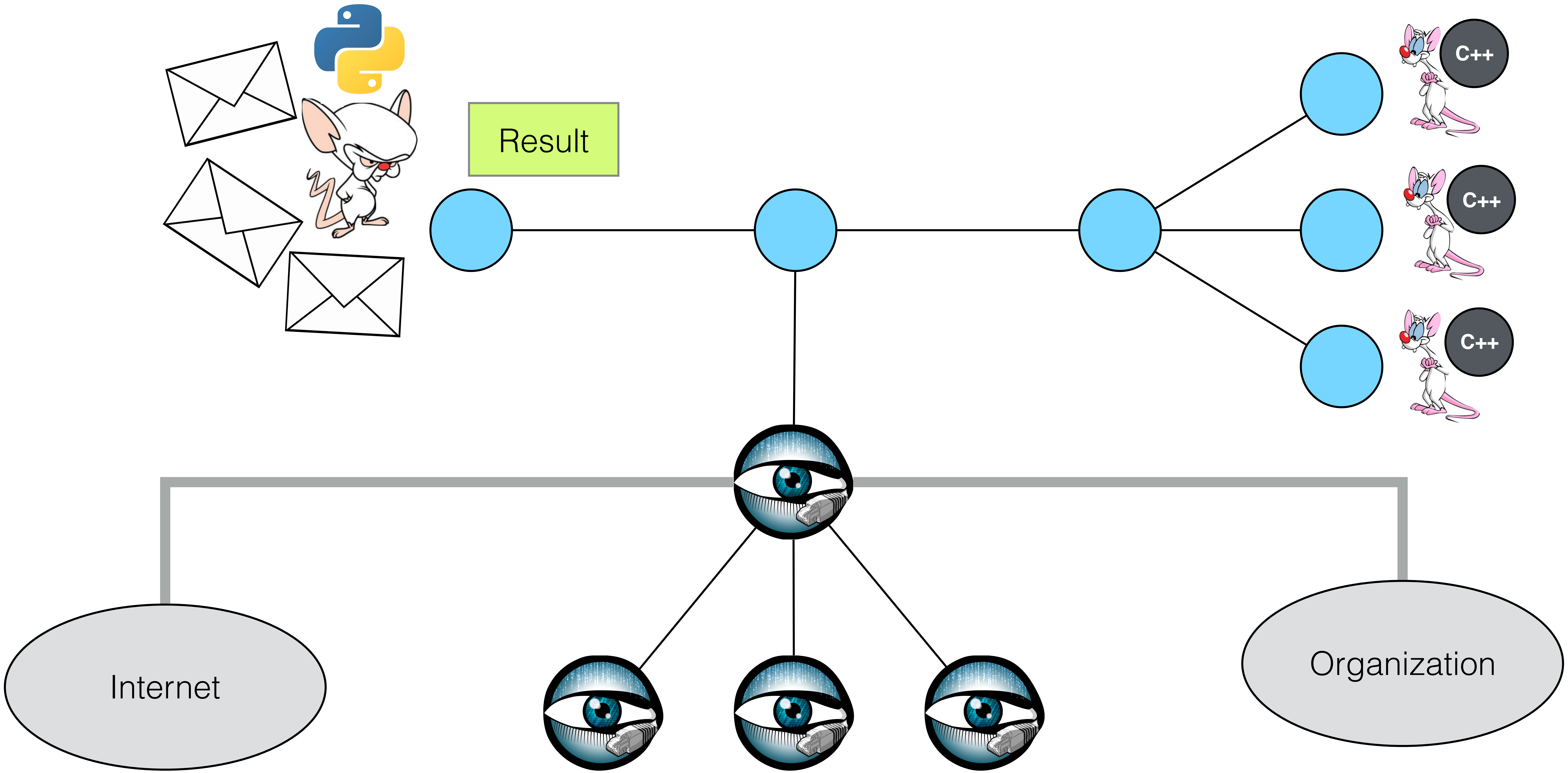
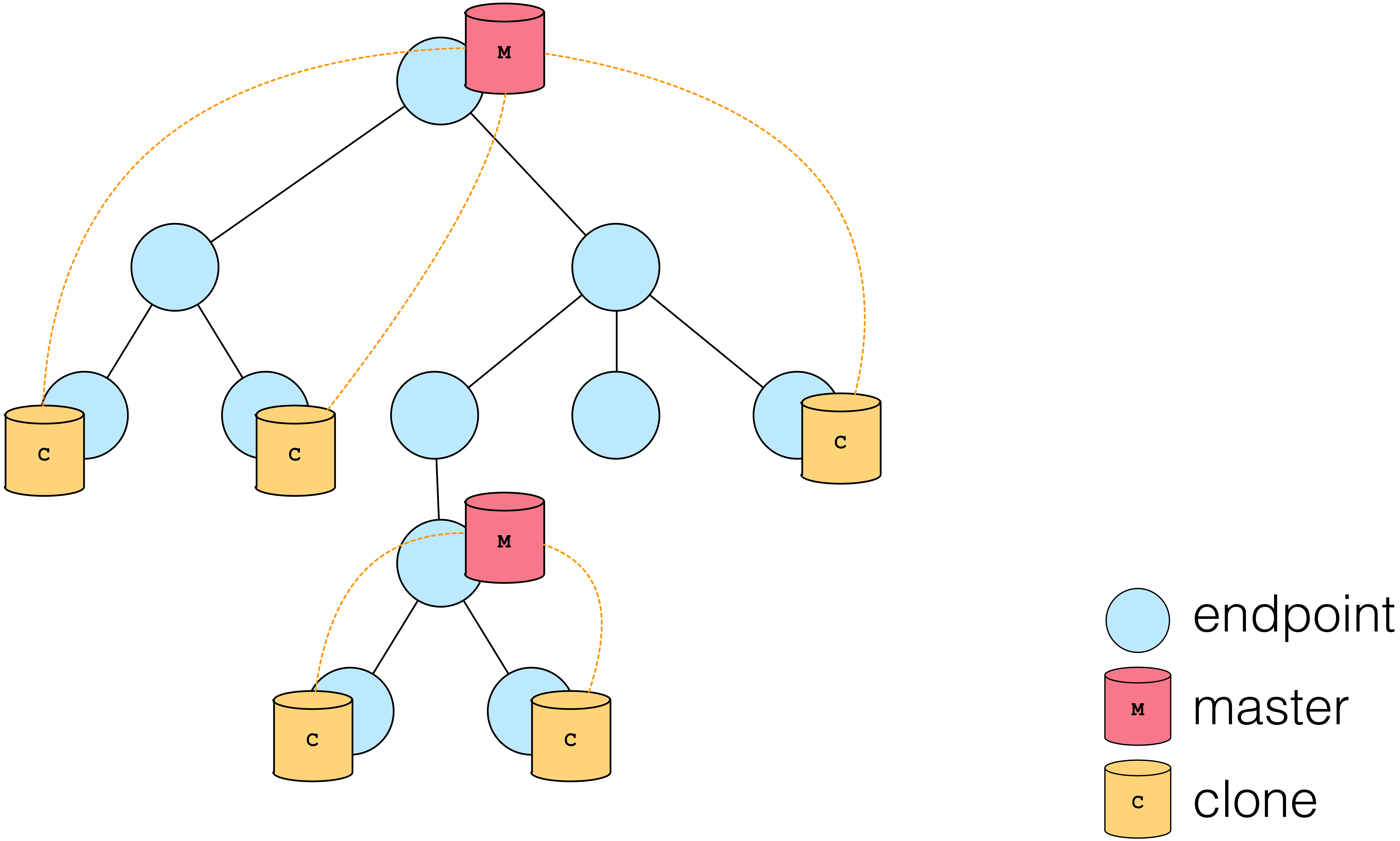


Distributed Key-Value Stores



Broker's Data Model

Arithmetic
- `boolean`
- `count`
- `integer`
- `real`

Time
- `interval`
- `timestamp`

Network
- `address`
- `port`
- `subnet`

Container
- `vector`
- `set`
- `table`

Other
- `none`
- `string`

API

Lessons Learned

- **Functionality**: It Just Works
- **Usability**: no native type support, lots of "data wrapping"
- **Semantics**: no support for nonblocking processing

Current API

```
using namespace broker;

init();

endpoint ep{"sender"};
ep.peer("127.0.0.1", 9999);

ep.outgoing_connection_status().need_pop();

auto msg = message{
  "my_event",
  "Hello C++ Broker!",
  42u
};

ep.send("bro/event", msg);

ep.outgoing_connection_status().need_pop();
```

Initialize the Broker library.
(Only one broker instance per process allowed.)

Create a local endpoint.

Block until connection status changes.

When communicating with Bro, the first argument must be a string identifying the event name. The remaining values represent the event arguments.

Publish the event under topic `bro/event`.

Block until connection status changes.

New API

```
using namespace broker;

context ctx;

auto ep = ctx.spawn<blocking>();
ep.peer("127.0.0.1", 9999);

auto v = vector{
  "my_event",
  "Hello C++ Broker!",
  42u
};

ep.publish("bro/event", v);
```

A **context** encapsulates global state for a set of endpoints (e.g., worker threads, scheduler, etc.)

Create a local endpoint with **blocking** API.

Create a vector of data.
New semantics: a **message** is a **topic** plus **data**, not a sequence of data.

Publish the event under topic `bro/event`.

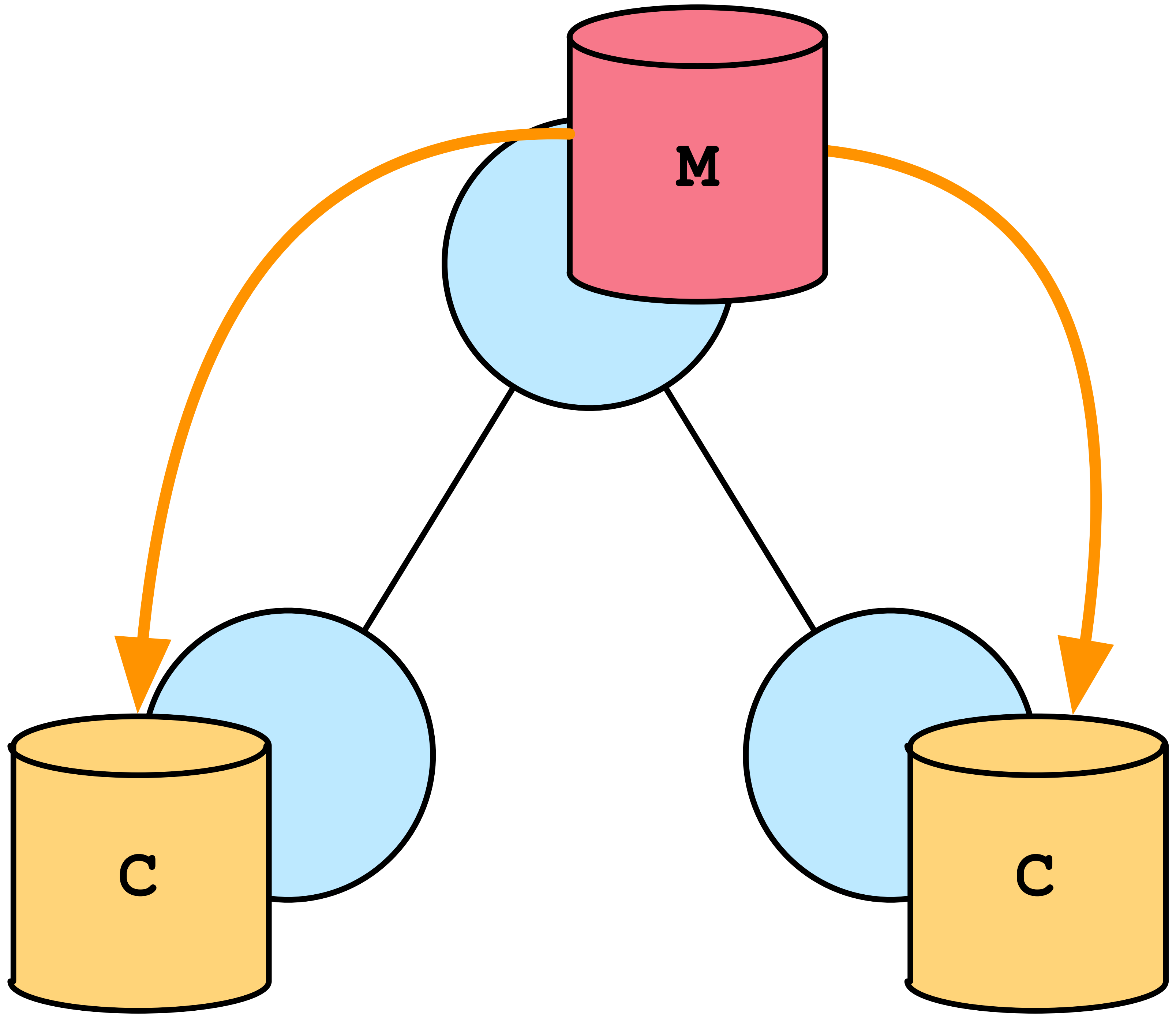
Blocking vs. Non-Blocking API

```
context ctx;
auto ep = ctx.spawn<blocking>();

ep.subscribe("foo");
ep.subscribe("bar");

// Block and wait.
auto msg = ep.receive();
cout << msg.topic()
     << " -> "
     << msg.data()
     << endl;

// Equivalent semantics; functional API.
ep.receive(
  [&](const topic& t, const data& d) {
    scout << t << " -> " << d << endl;
  }
)
```

```
context ctx;
auto ep = ctx.spawn<nonblocking>();

// Called asynchronously by the runtime.
ep.subscribe(
  "foo",
  [=](const topic& t, const data& d) {
    cout << t << " -> " << d << endl;
  }
);

// As above, just for a different topic.
ep.subscribe(
  "bar",
  [=](const topic& t, const data& d) {
    cout << t << " -> " << d << endl;
  }
);
```

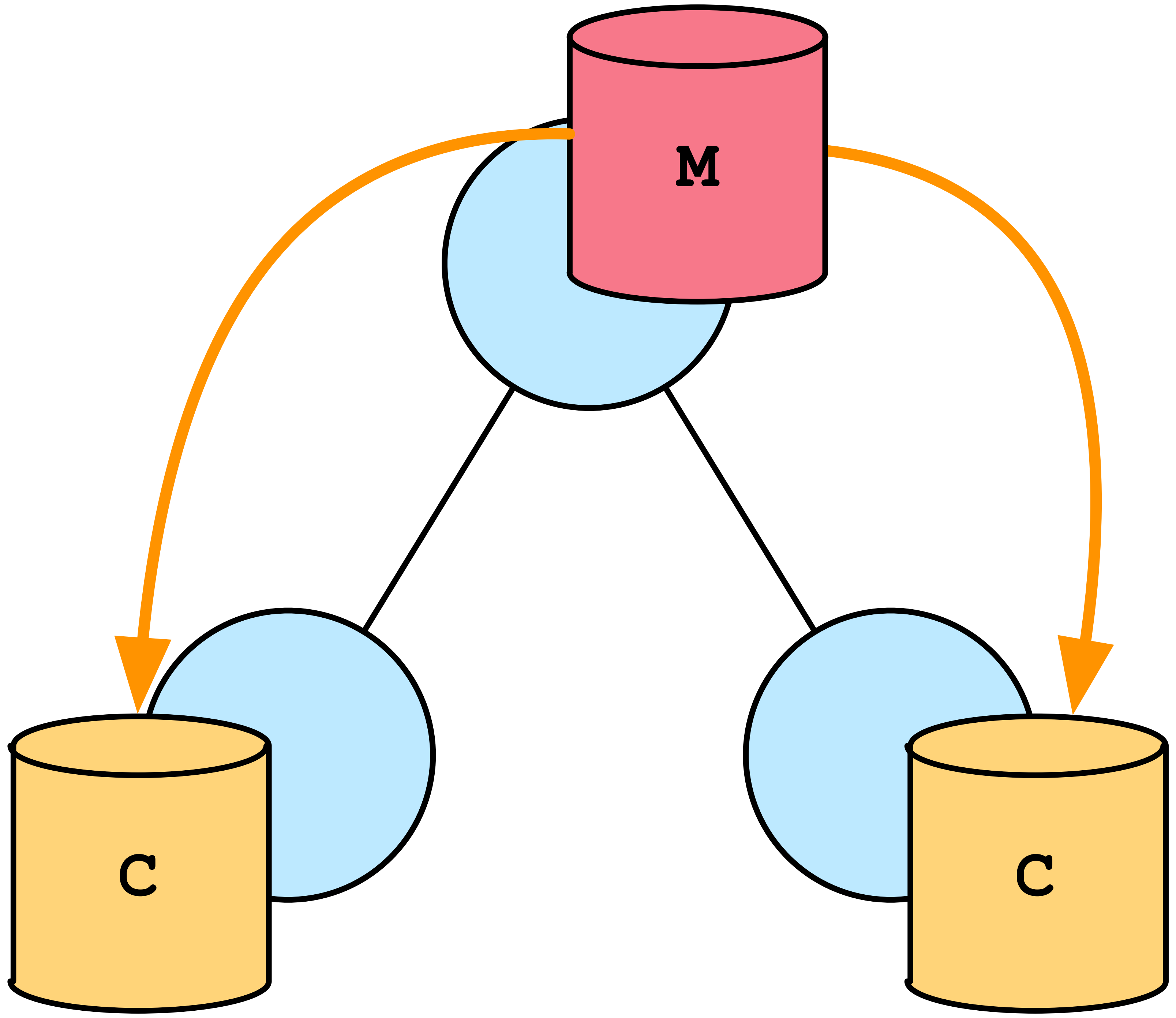
Data Store APIs

Available backends:
1. In-memory
2. SQLite
3. RocksDB




```
// Setup endpoint topology.
context ctx;
auto ep0 = ctx.spawn<blocking>();
auto ep1 = ctx.spawn<blocking>();
auto ep2 = ctx.spawn<blocking>();
ep0.peer(ep1);
ep0.peer(ep2);
// Attach stores.
auto m = ep0.attach<master, memory>("lord");
auto c0 = ep1.attach<clone>("lord");
auto c1 = ep2.attach<clone>("lord");
// Write to the master directly.
m->put("foo", 42);
m->put("bar", "baz");
// After propagation, query the clones.
sleep(propagation_delay);
auto v0 = c0->get("key");
auto v1 = c1->get("key");
assert(v0 && v1 && *v0 == *v1);
```

Data Store APIs



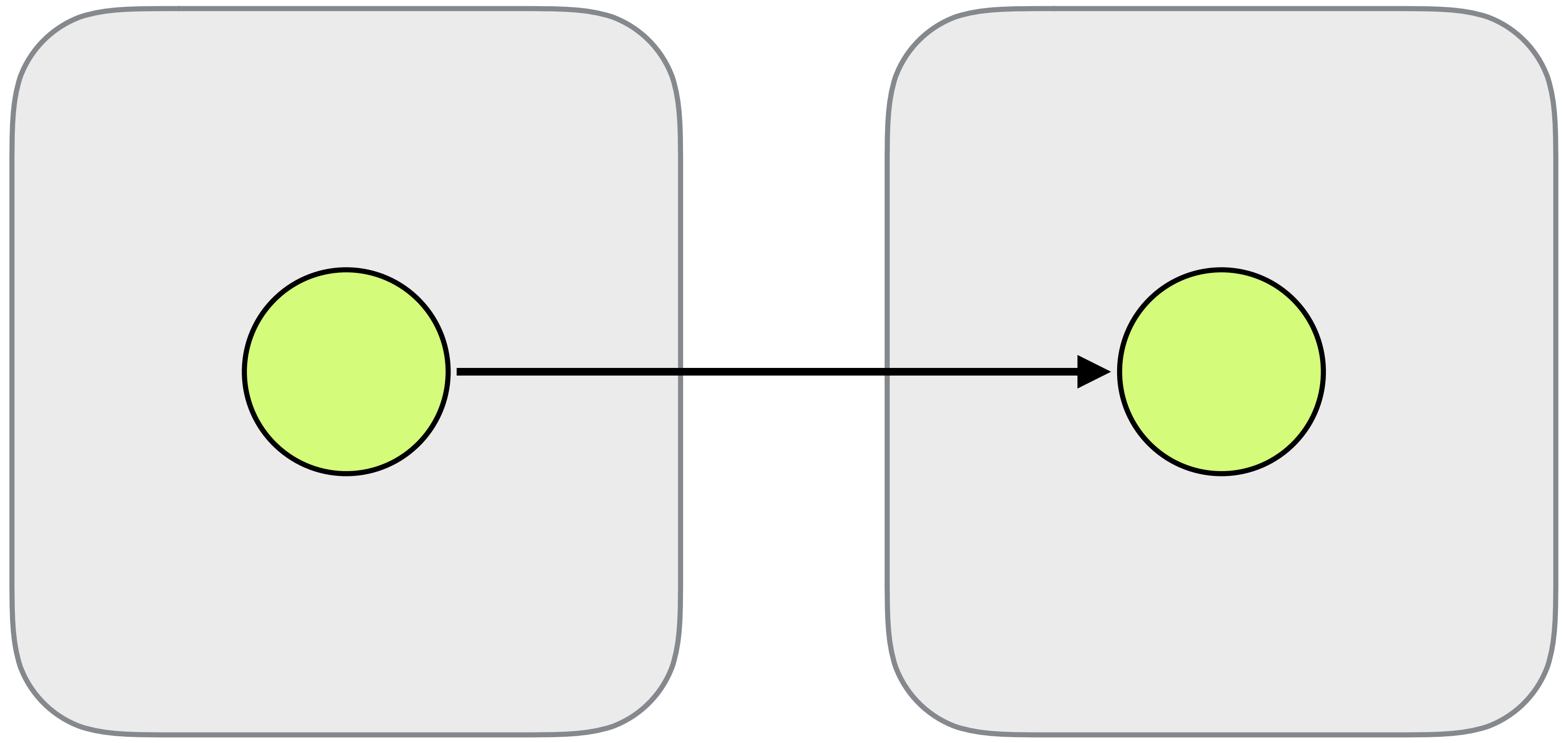

```
// Blocking API. Returns expected<data>.
auto v = c->get<blocking>("key");

// Non-blocking API.
// Runtime invokes callback.
c->get<nonblocking>("key").then(
  [=](data& d) {
    cout << "got it: " << d << endl;
  },
  [=](error& e) {
    cerr << "uh, this went wrong: "
         << e
         << endl;
  }
);
```

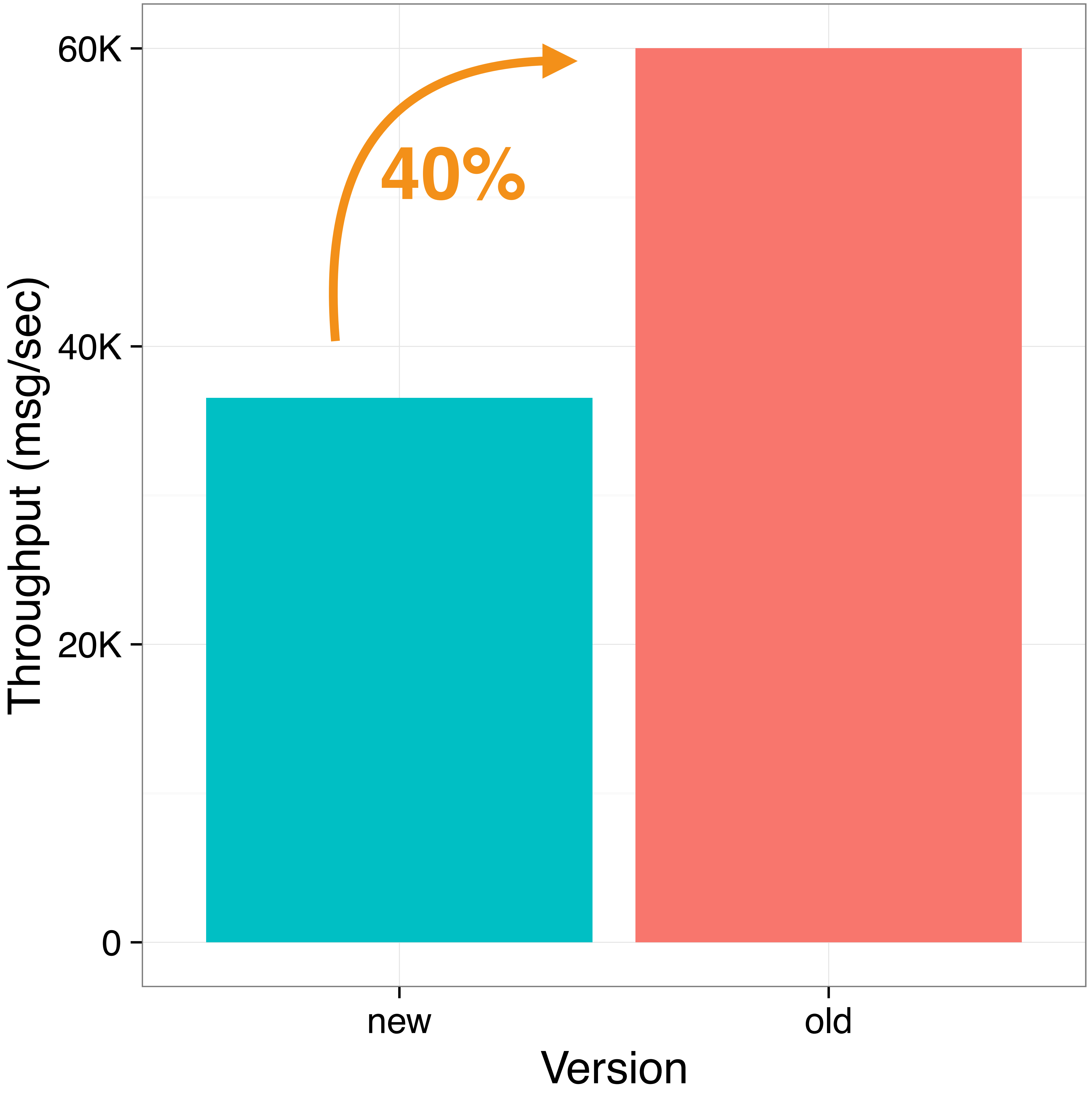
Performance

Simple Benchmark

- Throughput analysis
  - Two endpoints: sender & receiver
  - Message = conn.log entry
- System: MacBook Pro
  - 16 GB RAM
  - 4 x 2.8 GHz Core i7

Throughput





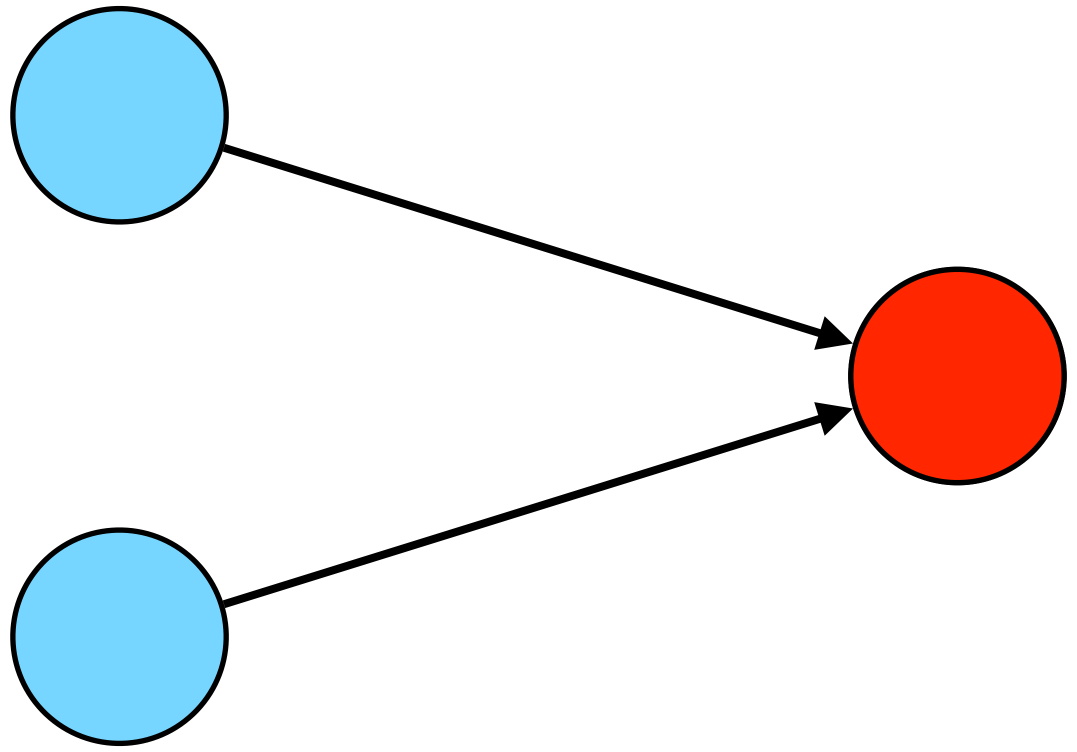
Outlook

Roadmap to 1.0

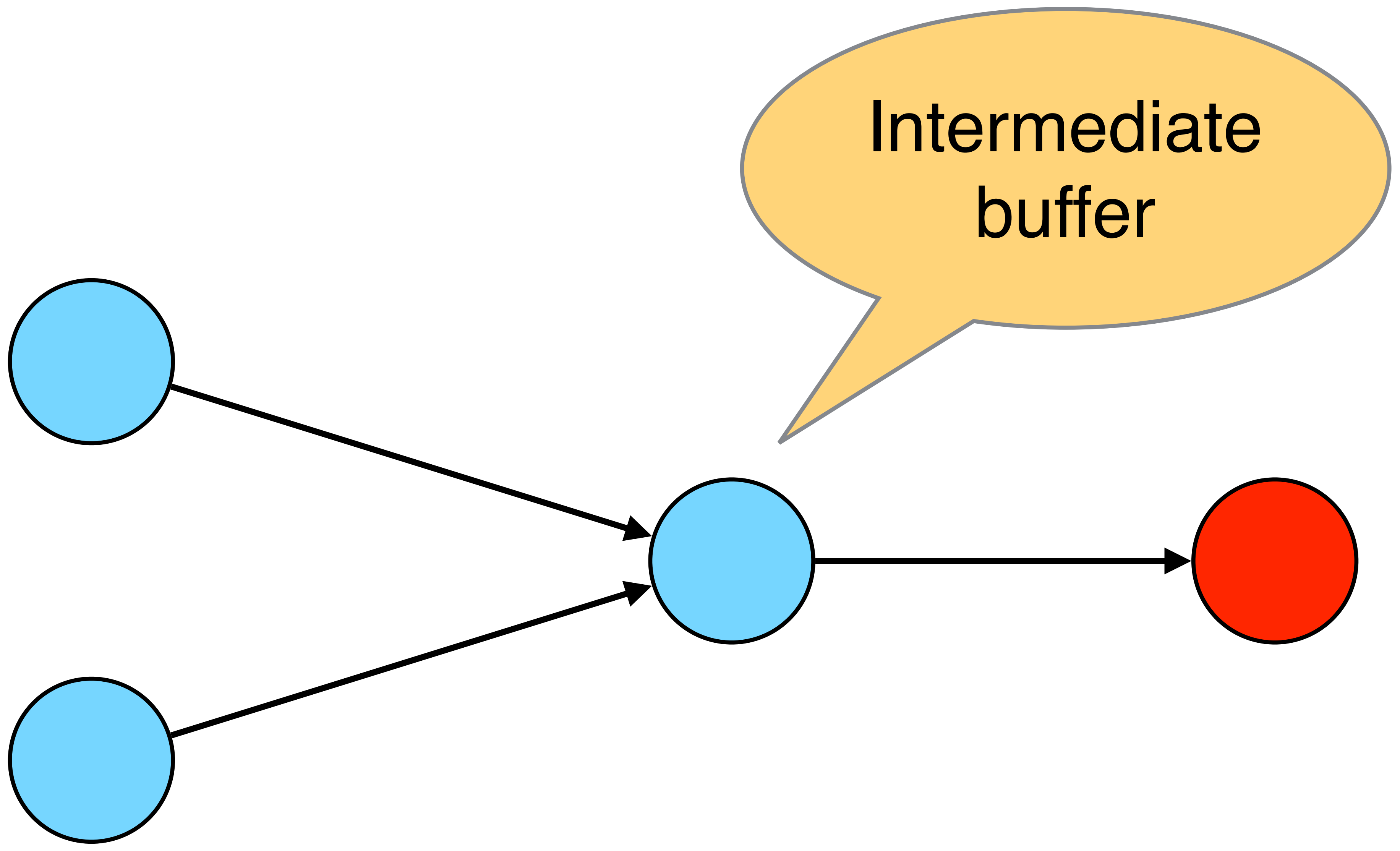
1. Finish Python bindings
2. Implement Bro endpoint
3. Pattern matching in Bro
4. Flow control

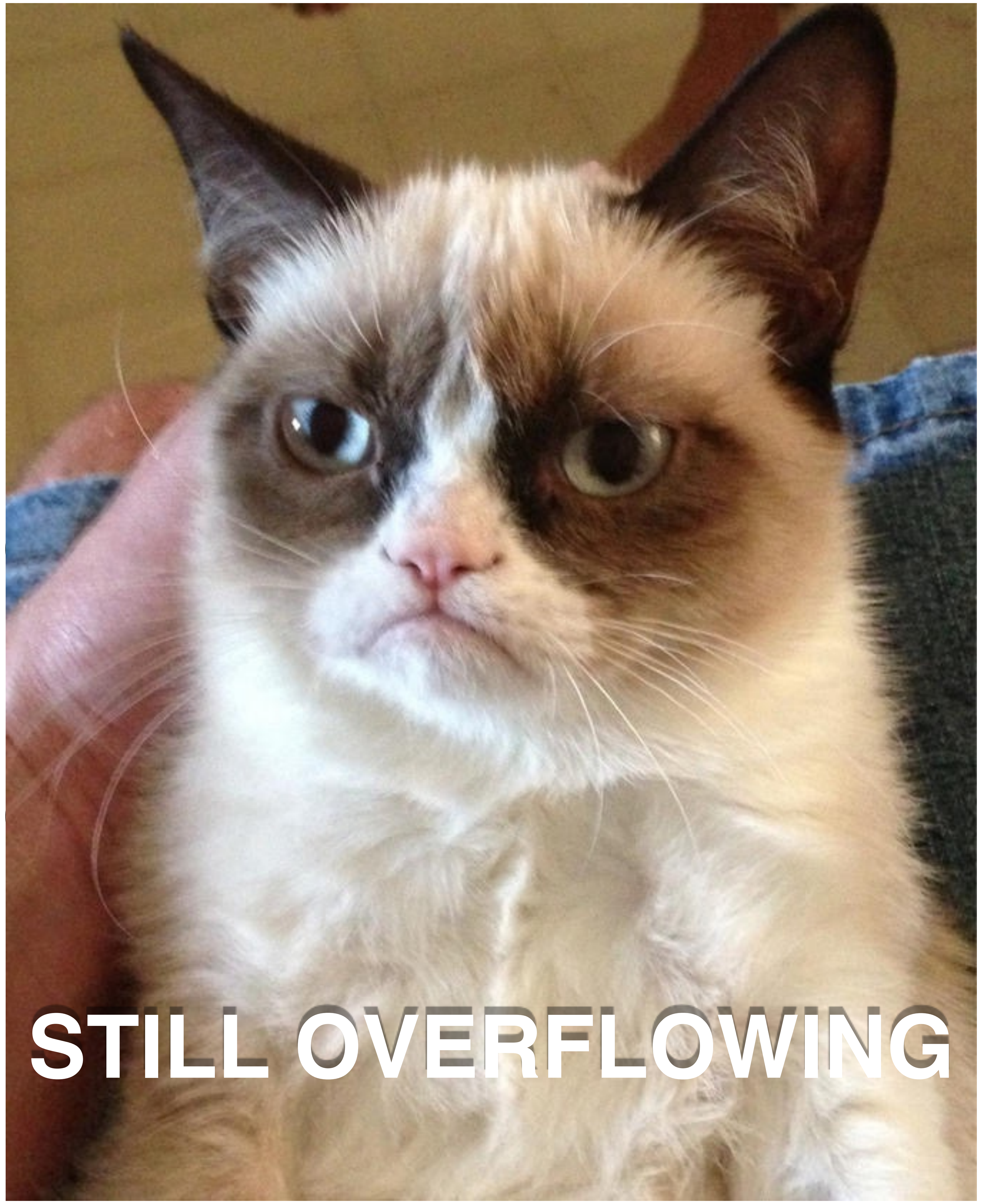
```
function lookup(key: string) : any;

when ( local x = lookup("key") )
  {
  local result = "";
  switch( x )
    {
    case addr:
      if ( x in 10.0.0.0/8 )
        result = "contained";
    case string:
      result = "error: lookup() failed: " + x;
    }
  }
```

Flow Control

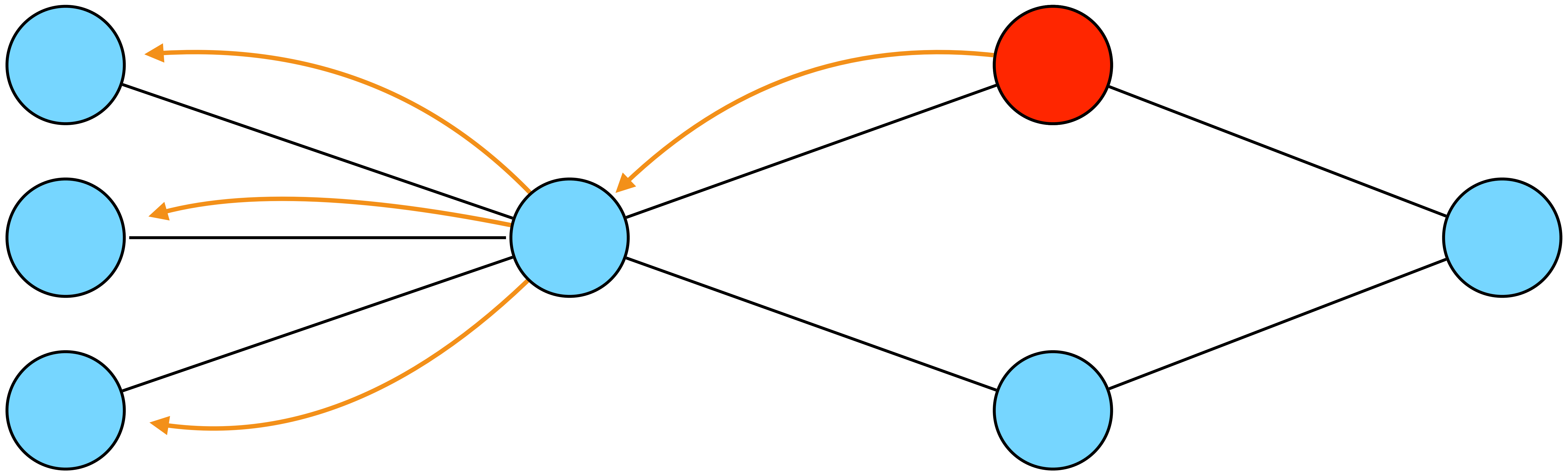


Flow Control



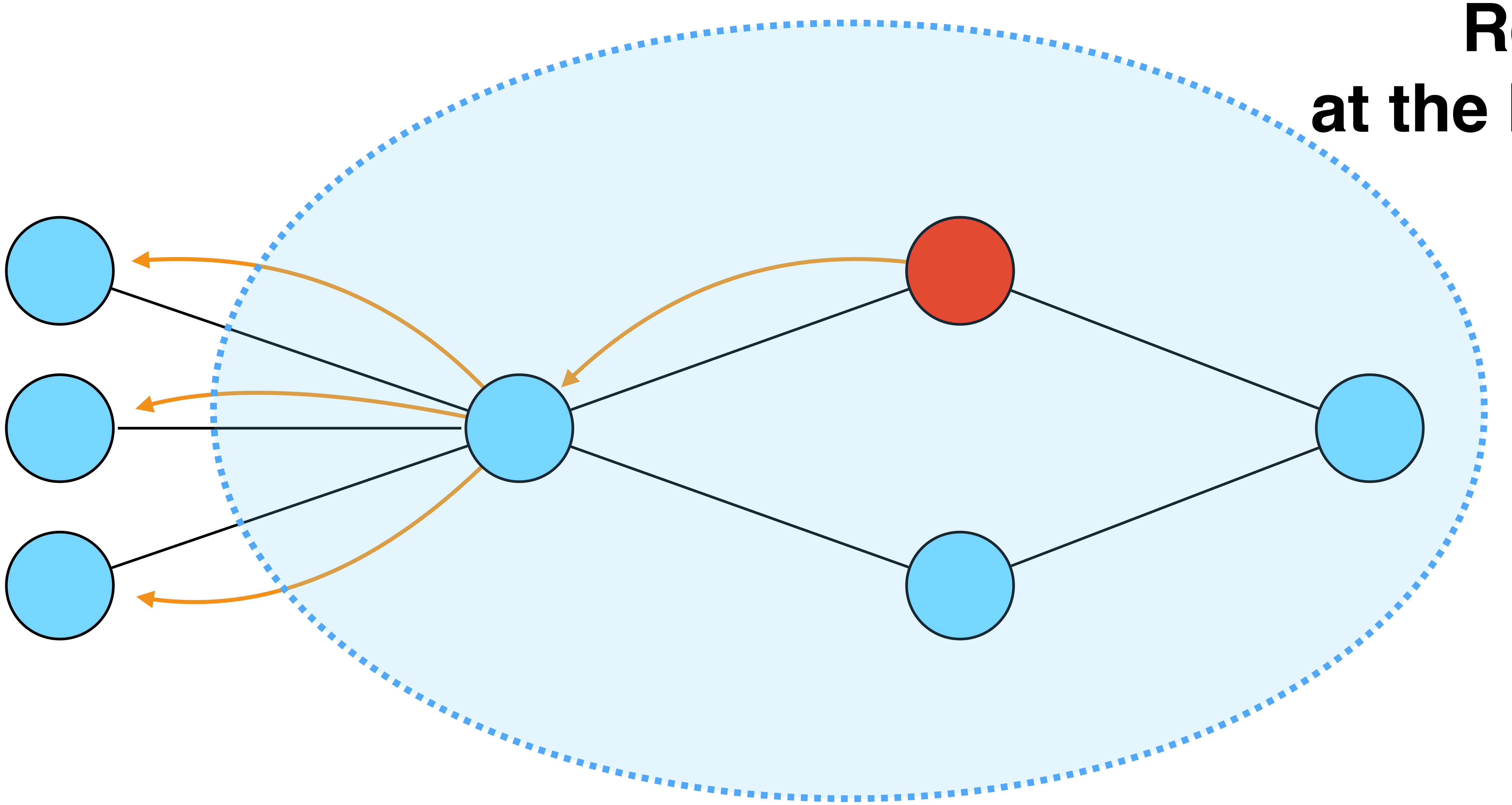

STILL OVERFLOWING

Flow Control



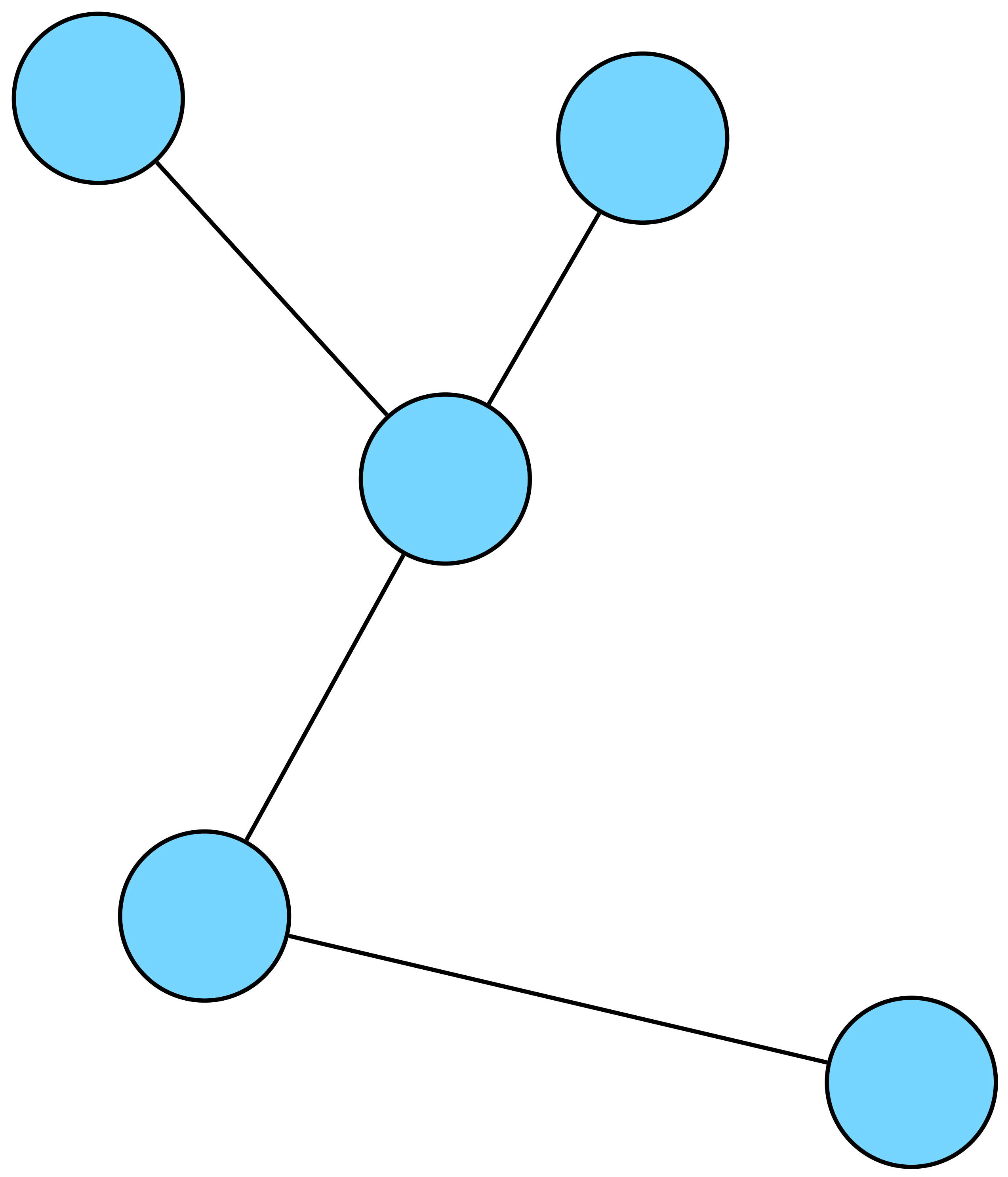
Flow Control

Reject
at the boundary

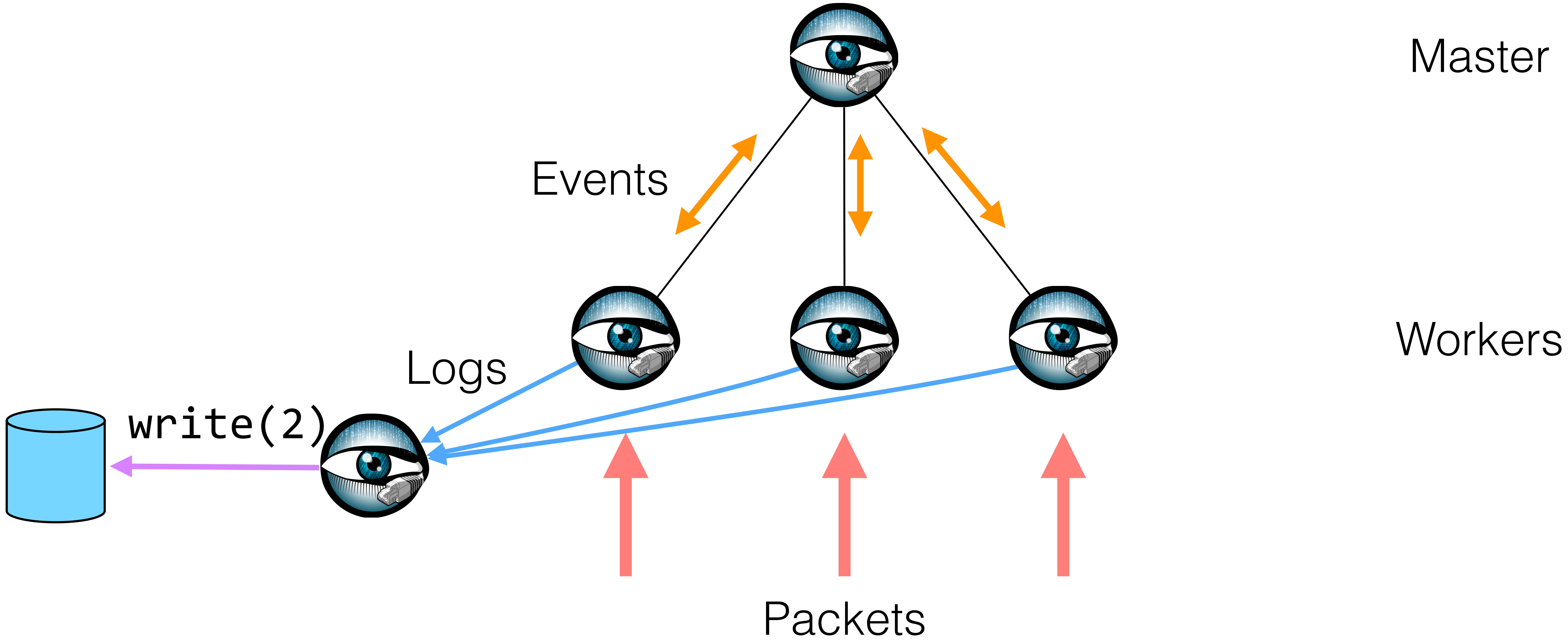


CAF: Messaging Building Block

- **CAF** = **C**++ **A**ctor **F**ramework
- Implementation of the Actor Model
- Light-weight, type-safe, scalable
- Network transparency



Bro Data Flows



Questions?

Docs: `https://bro.github.io/broker`

Chat: `https://gitter.im/bro/broker`

Code: `https://github.com/bro/broker`