A Funny Thing Happened On The Way To The Phoenix

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(Photo of the Phoenix Concert Theatre, Toronto)

Agenda

- What *is* this Phoenix thing, anyway?
- Phoenix and Plug
- Serving the Plug API
- Bandit Update
- What *is* an HTTP server, anyway?
- Scaling with processes
- Putting it all together

What’s underneath Phoenix?

What *is* this Phoenix thing, anyway?

(A gross simplification)

What *is* this Phoenix thing, anyway?

- It’s a web server. It serves web content
- Clients make requests for pages, API resources, sockets
- There is a lot more going on in Phoenix (DB, PubSub, etc)
- Today, we're looking at the HTTP part of Phoenix

HTTP in Phoenix

- Clients make requests for pages, API resources, sockets
- Requests are fundamentally isolated from one another
- The 'first point of entry' for an HTTP request into Phoenix is via the `Phoenix.Endpoint` behaviour

Phoenix.Endpoint

- "the boundary where all requests to your web application start"
- Also has a ton of 'upward facing' behaviour
- Everything 'up' from there (controllers, views, &c) is left as an exercise to the reader

Phoenix.Endpoint

- "the boundary where all requests to your web application start"
- Requests come to Phoenix via the `Plug` API
- `Phoenix.Endpoint` implements the `Plug` behaviour*

* `lib/phoenix/endpoint.ex:463` if you're curious

What is the Plug API?

Plug is an abstraction over HTTP requests & responses

Plug

```
defmodule HelloWorldPlug do
  # ...

  def call(%Plug.Conn{} = conn, _opts) do
    conn
    |> Plug.Conn.put_resp_content_type(“text/plain”)
    |> Plug.Conn.send_resp(200, "Hello World!")
  end
end
```

Phoenix is just a

(very complex)

Plug

What’s underneath Phoenix?

What’s underneath Plug?

A Plug-aware HTTP server

Cowboy is a Plug-aware* HTTP server

* when paired with `Plug.Cowboy`

Tying this back to Phoenix

- Phoenix runs an instance of Cowboy
- Hosted within Phoenix’s process tree
- Let’s take a look!

Tying this back to Phoenix

DEMO
(empex_demo + stack traces)

Bandit now supports Phoenix

Bandit is
a Plug-*native*
HTTP
server

Bandit, a pure Elixir Cowboy alternative

- Plug-native
- Written 100% in Elixir
- Robust HTTP/1.1 and HTTP/2 conformance
- Written from the ground up for correctness, performance & clarity
- Incredible performance (up to 5x Cowboy)

Bandit update

- Bandit 0.5.0 supports HTTP(S) Phoenix apps
- One-line change in Phoenix to enable
- Work entirely contained within Bandit project
- Websocket work up next

DEMO
(empex_demo + bandit adapter)

Bandit 0.5.0 drops *today*!

github.com/mtrudel/bandit

What’s underneath Phoenix?

What’s underneath Plug?

A Plug-aware HTTP server

What does an HTTP server *do*, exactly?

What does a webserver *do*, exactly?

1. Listen for connections
2. Handle each connection separately
    1. Parse the HTTP request into a `Plug.Conn` struct
    2. Pass this struct to a Plug implementation (eg: Phoenix)
    3. Provide backing support to read / write response

Problem naturally splits into two parts

1. Listen for connections (generic)
2. Handle each connection (HTTP specific)

```
# Generic
loop do
  socket = wait_for_connection()

  # HTTP Specific
  socket
  |> build_conn()
  |> plug_module.call()
end
```

Problem naturally splits into two parts

Protocol Specific

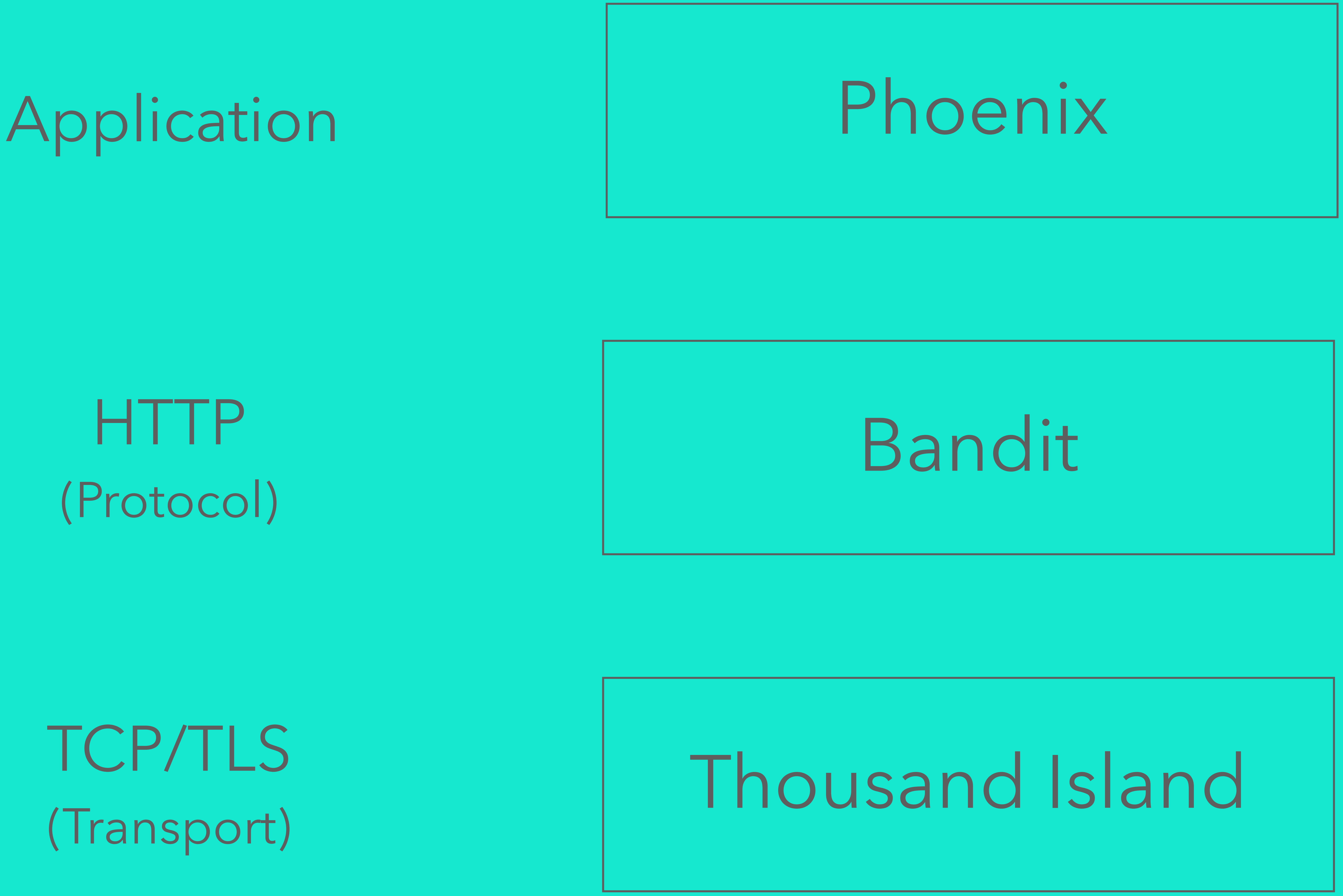
```
defmodule HTTPServer do
  def handle_connection(socket) do
    socket
    |> build_conn()
    |> plug_module.call()
  end
end
```

Generic

```
loop do
  socket = wait_for_connection()
  HTTPServer.handle_connection(socket)
end
```

Problem naturally splits into two parts

Protocol Specific	Bandit
Generic	Thousand Island


Application
Phoenix
HTTP
(Protocol)
Bandit
TCP/TLS
(Transport)
Thousand Island

Let’s talk about Thousand Island

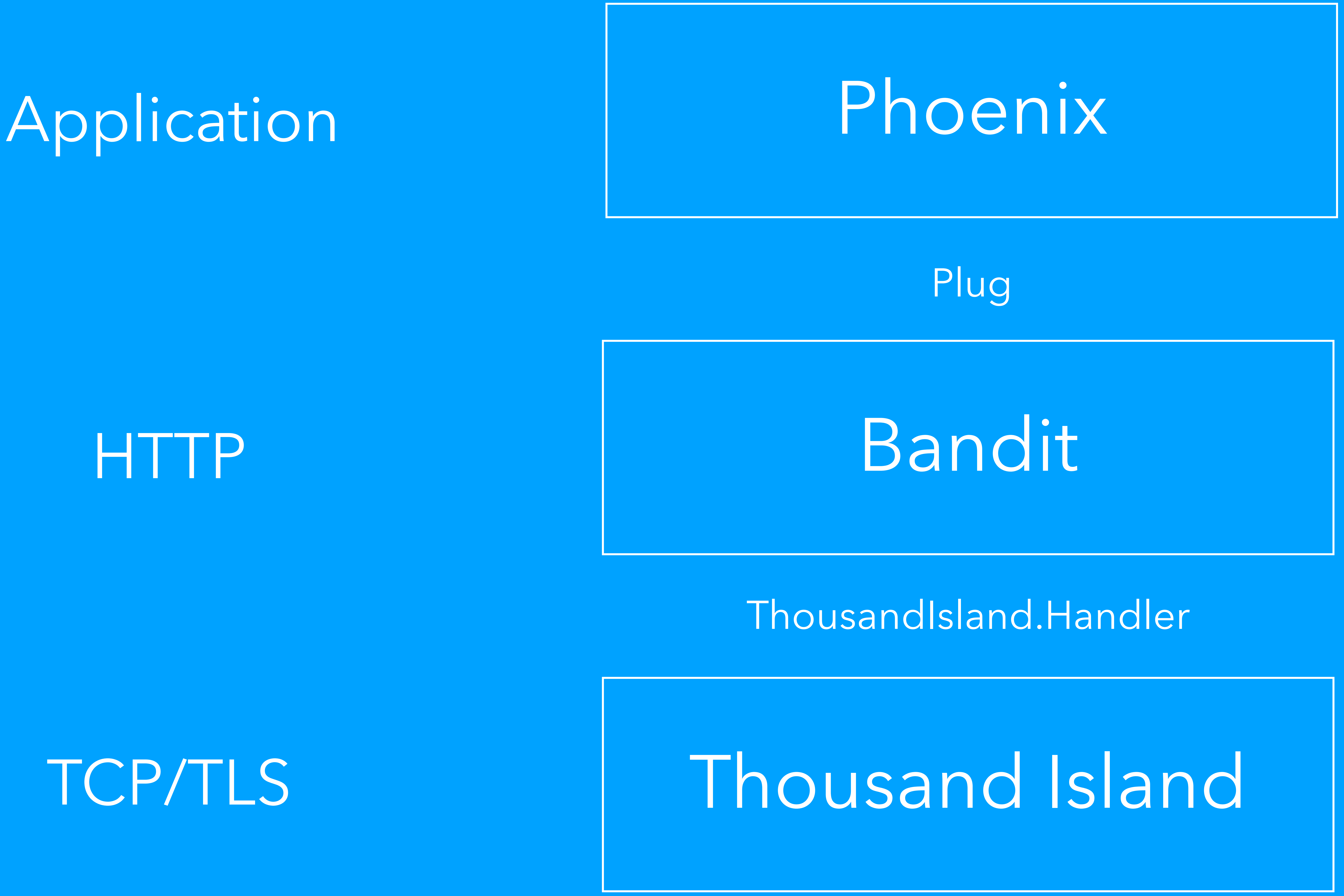
Thousand Island is a socket server

What does a socket server *do*, exactly?

- Listens for client connections over TCP/TLS
- Hands them off to an upper protocol layer (eg: an HTTP server)
- Provides send / receive / &c functionality
- Handles transport concerns (TLS, connection draining, etc)
- Does all of this efficiently and scalably

Thousand Island

- 100% Elixir socket server
- Supports TCP, TLS & Unix Domain sockets
- Fully wired for telemetry, including socket-level tracing
- Incredibly scalable, equally easy to understand (<1700 LoC)
- Extremely simple & powerful Handler behaviour for building protocols on top


Application
Phoenix
Plug
HTTP
Bandit
ThousandIsland.Handler
TCP/TLS
Thousand Island

`ThousandIsland.Handler`

'A GenServer-like API for sockets'

ThousandIsland.Handler

```elixir
defmodule ThousandIsland.Handler do
  @callback handle_connection(socket, state)
    :: {:close, state} | {:continue, state}

  @callback handle_data(data, socket, state)
    :: {:close, state} | {:continue, state}

  # …plus a few more for shutdown, errors, &c
end
```

Daytime

(RFC 867)

```elixir
defmodule Daytime do
  use ThousandIsland.Handler

  @impl ThousandIsland.Handler
  def handle_connection(socket, state) do
    time = DateTime.utc_now() |> to_string()
    ThousandIsland.Socket.send(socket, time)
    {:close, state}
  end
end

{:ok, pid} = ThousandIsland.start_link(handler_module: Daytime)
```

Echo

(RFC 862)

```
defmodule Echo do
  use ThousandIsland.Handler

  @impl ThousandIsland.Handler
  def handle_data(data, socket, state) do
    ThousandIsland.Socket.send(socket, data)
    {:continue, state}
  end
end

{:ok, pid} = ThousandIsland.start_link(handler_module: Echo)
```

Bandit

(Gross simplification)

```
defmodule Bandit.Handler do
  use ThousandIsland.Handler

  @impl ThousandIsland.Handler
  def handle_connection(socket, state) do
    Bandit.do_http(socket)
    {:close, state}
  end
end

{:ok, pid} = ThousandIsland.start_link(handler_module: Bandit.Handler)
```

Thousand Island Handler Processes

- Handlers are GenServers under the hood
- One process per client connection
- ...Bandit is implemented as a Handler
- ...Phoenix is hosted by Bandit
- ...so...

Each Phoenix request is run inside its own GenServer*

* Not entirely true (see HTTP/2)

The simplest socket server

```elixir
# Listen (this binds the port)
{:ok, listen_socket} = :gen_tcp.listen(4000, [active: false])

# Accept (this waits for a connection)
{:ok, connection_socket} = :gen_tcp.accept(listen_socket)

# Pass to Handler module to handle connection
Handler.do_connection(connection_socket)

# Close the connection
:gen_tcp.close(connection_socket)
```

Only runs once

Try #2: Run in a loop

```
def run do
  {:ok, listen_socket} = :gen_tcp.listen(4000, [active: false])
  accept(listen_socket)
end

defp accept(listen_socket) do
  {:ok, connection_socket} = :gen_tcp.accept(listen_socket)
  Handler.do_connection(connection_socket)
  :gen_tcp.close(connection_socket)
  accept(listen_socket)
end
```

Only one connection at a time

Try #3: Spin off a Task

```elixir
def run do
  {:ok, listen_socket} = :gen_tcp.listen(4000, [active: false])
  accept(listen_socket)
end

defp accept(listen_socket) do
  {:ok, connection_socket} = :gen_tcp.accept(listen_socket)
  Task.start_link(fn ->
    Handler.do_connection(connection_socket)
    :gen_tcp.close(connection_socket)
  end)
  accept(listen_socket)
end
```

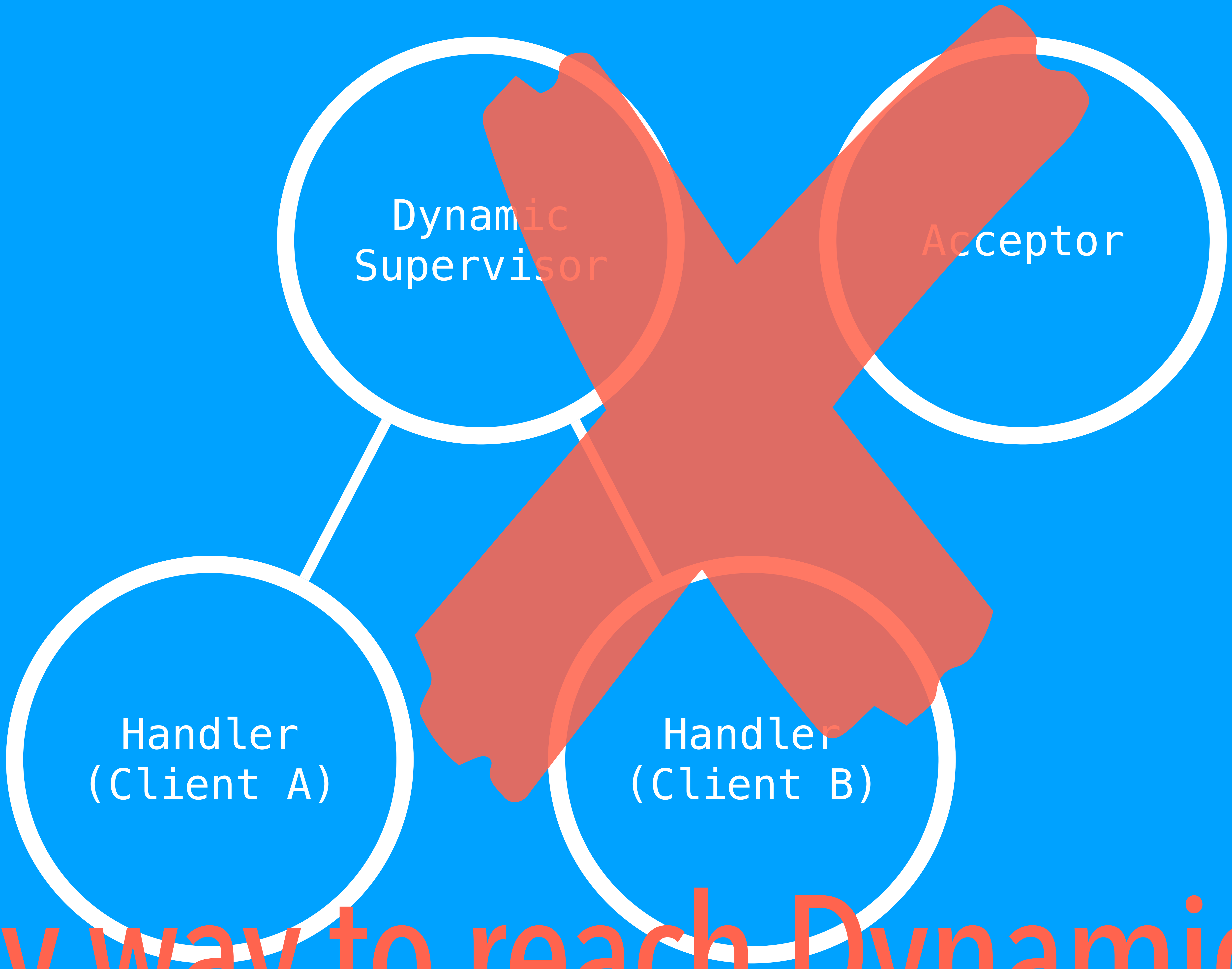
No supervision

Try #4: Use a Supervisor

```elixir
def run do
  {:ok, listen_socket} = :gen_tcp.listen(4000, [active: false])
  accept(listen_socket)
end

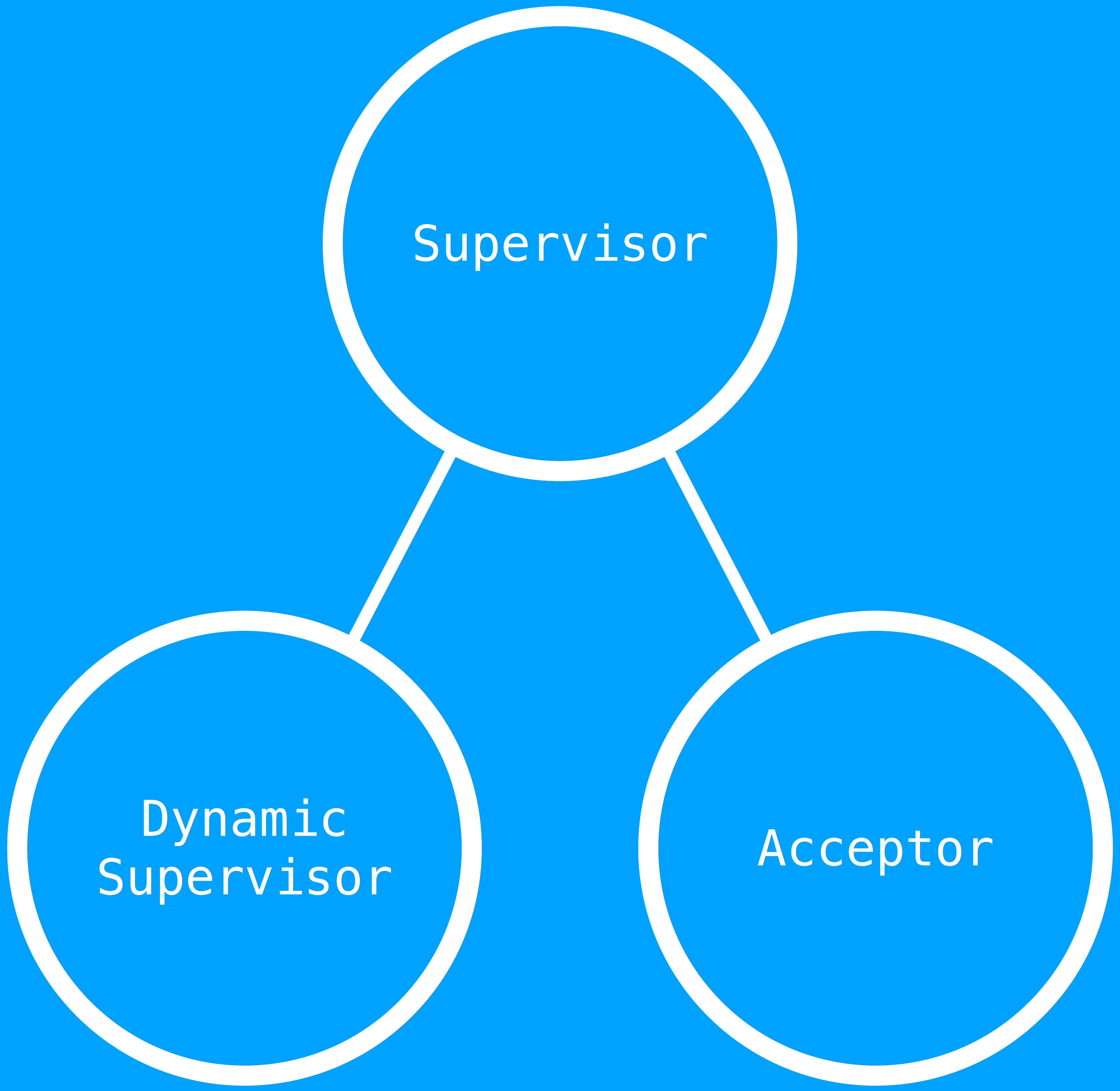
defp accept(listen_socket) do
  {:ok, connection_socket} = :gen_tcp.accept(listen_socket)
  child_spec = {Handler, connection_socket}
  DynamicSupervisor.start_child(dyn_sup_pid, child_spec)
  accept(listen_socket)
end
```

Try #4: Use a Supervisor



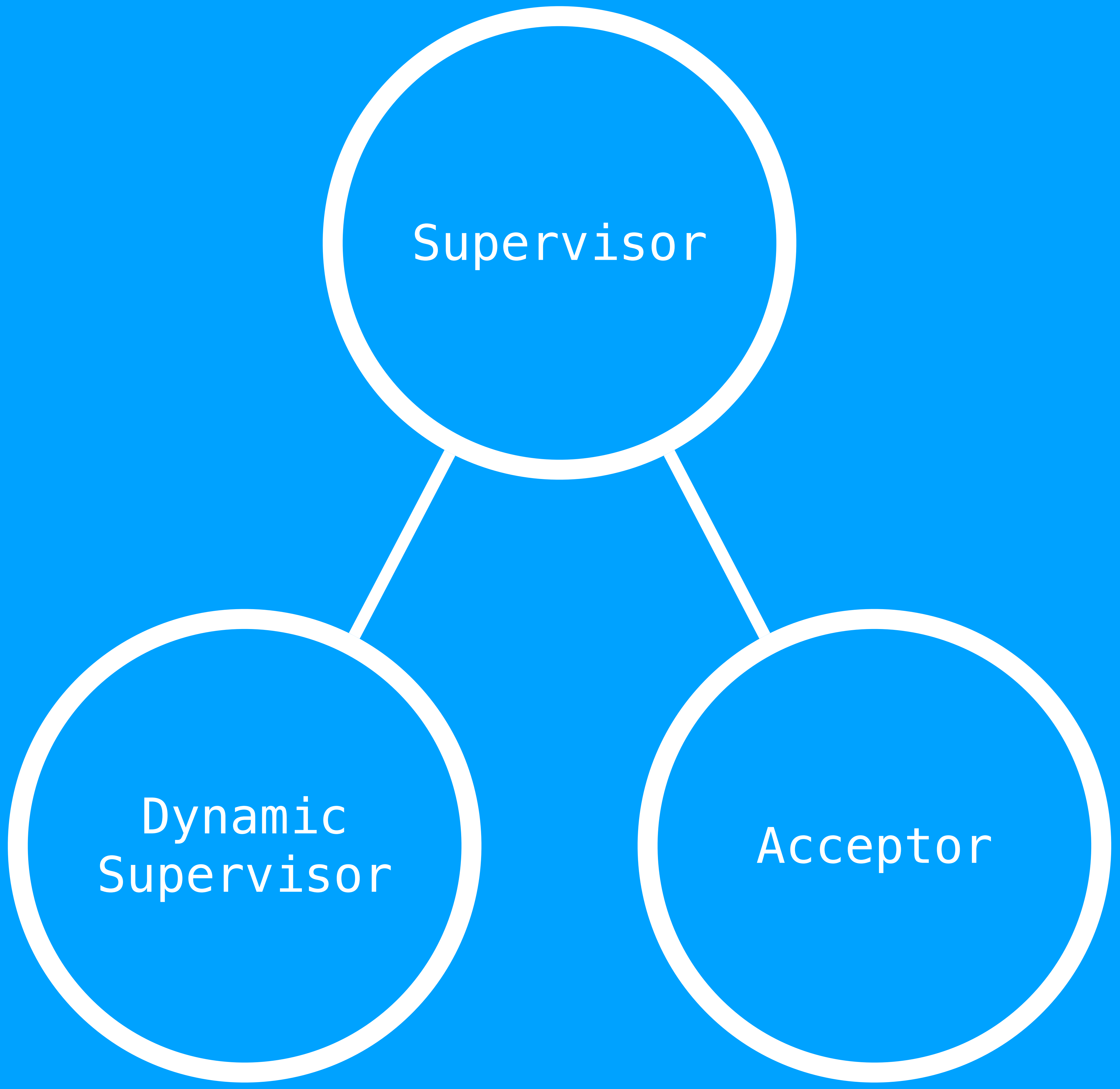
No easy way to reach Dynamic Supervisor

Try #5: Supervised Acceptor



Try #5: Supervised Acceptor

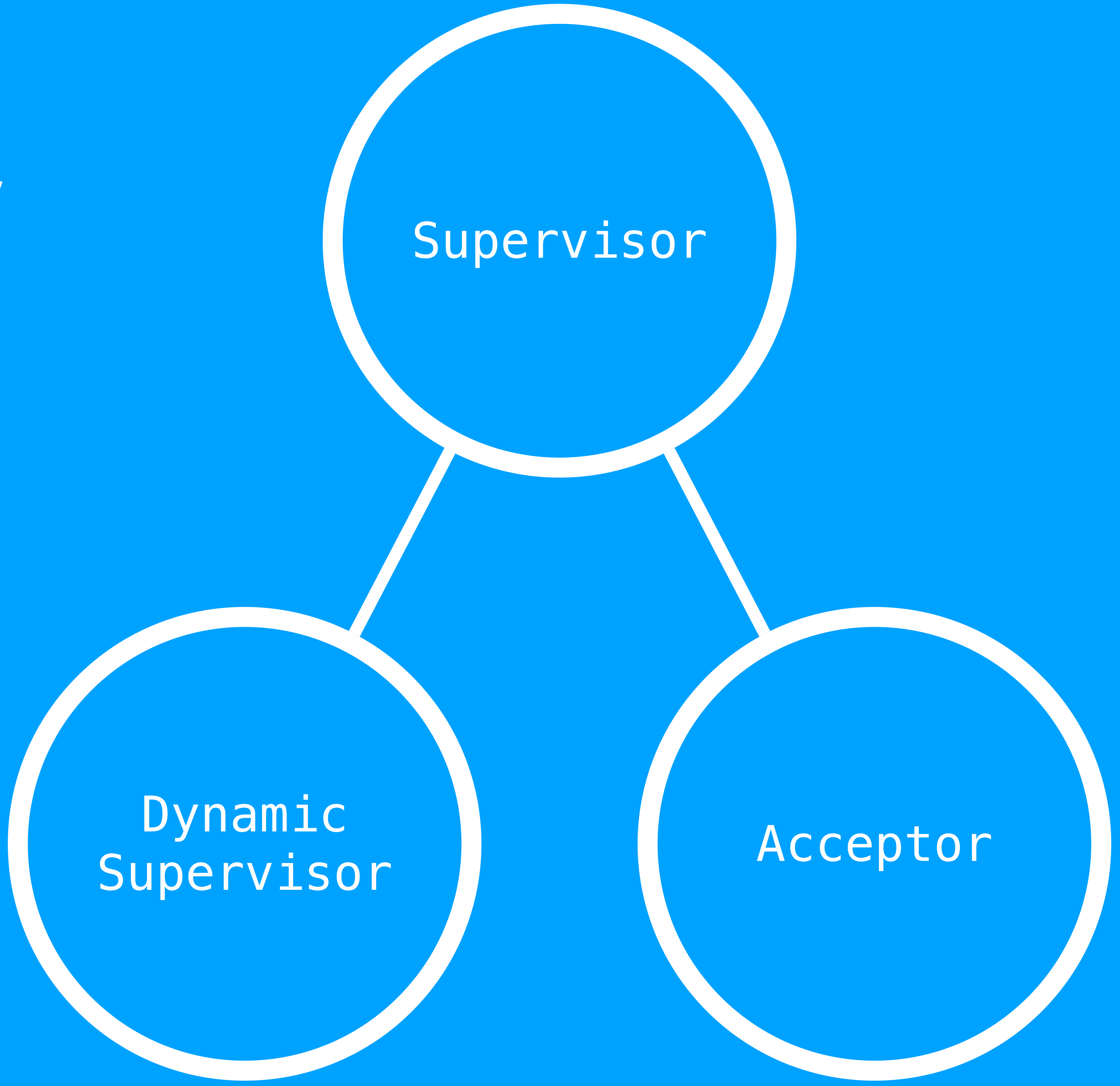
- Start Dynamic Supervisor first
- Acceptor only starts once Dynamic Supervisor is running
- The Acceptor can learn of the DynamicSupervisor's PID at startup
- This models dependencies properly



Observations

DynamicSupervisor

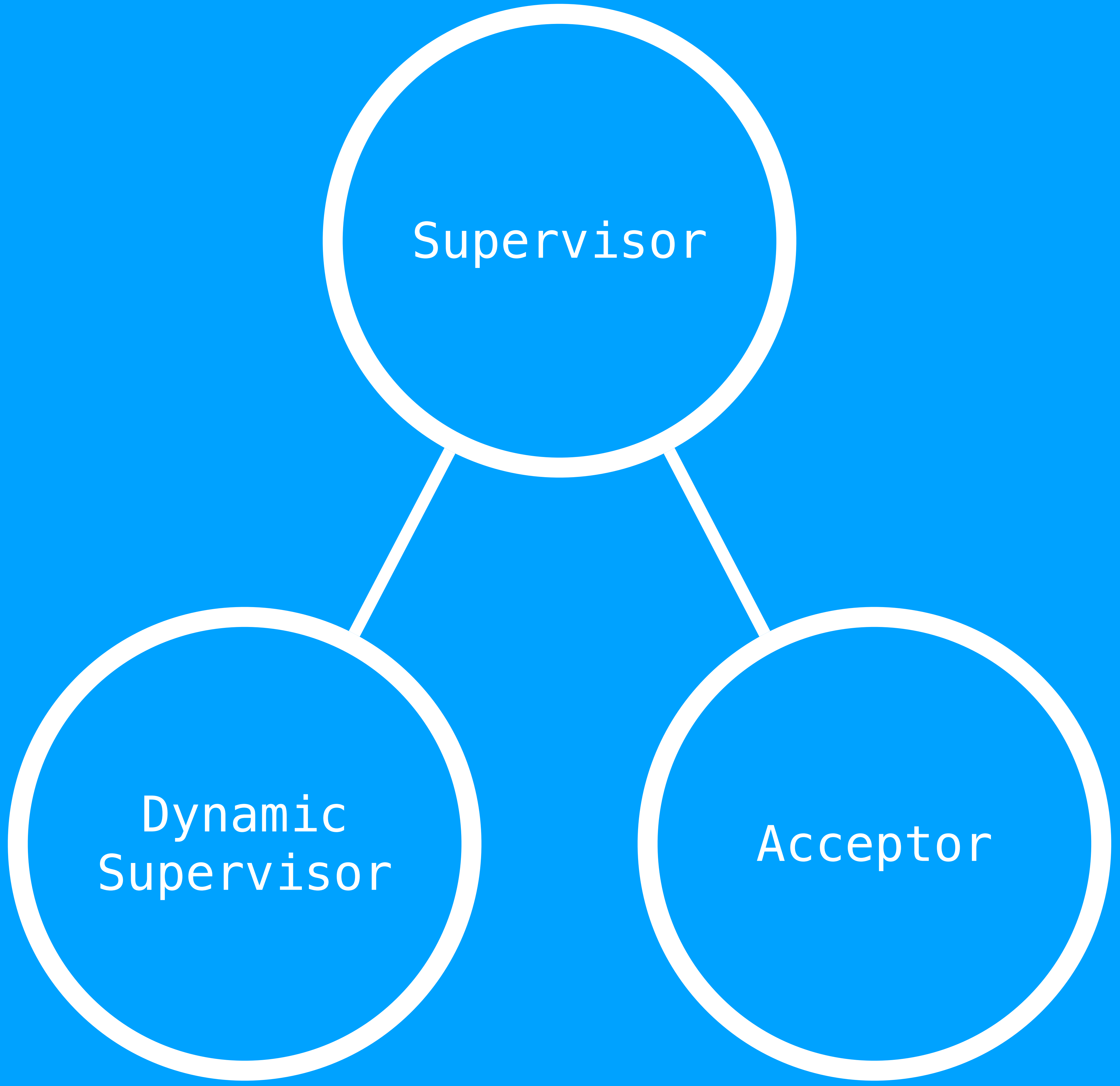
- Use when children are ‘on demand’ and independent
- Often paired with a ‘creator’ task such as an Acceptor that listens on network or queue
- Does not (and cannot) model dependencies between children



Observations

Supervisor

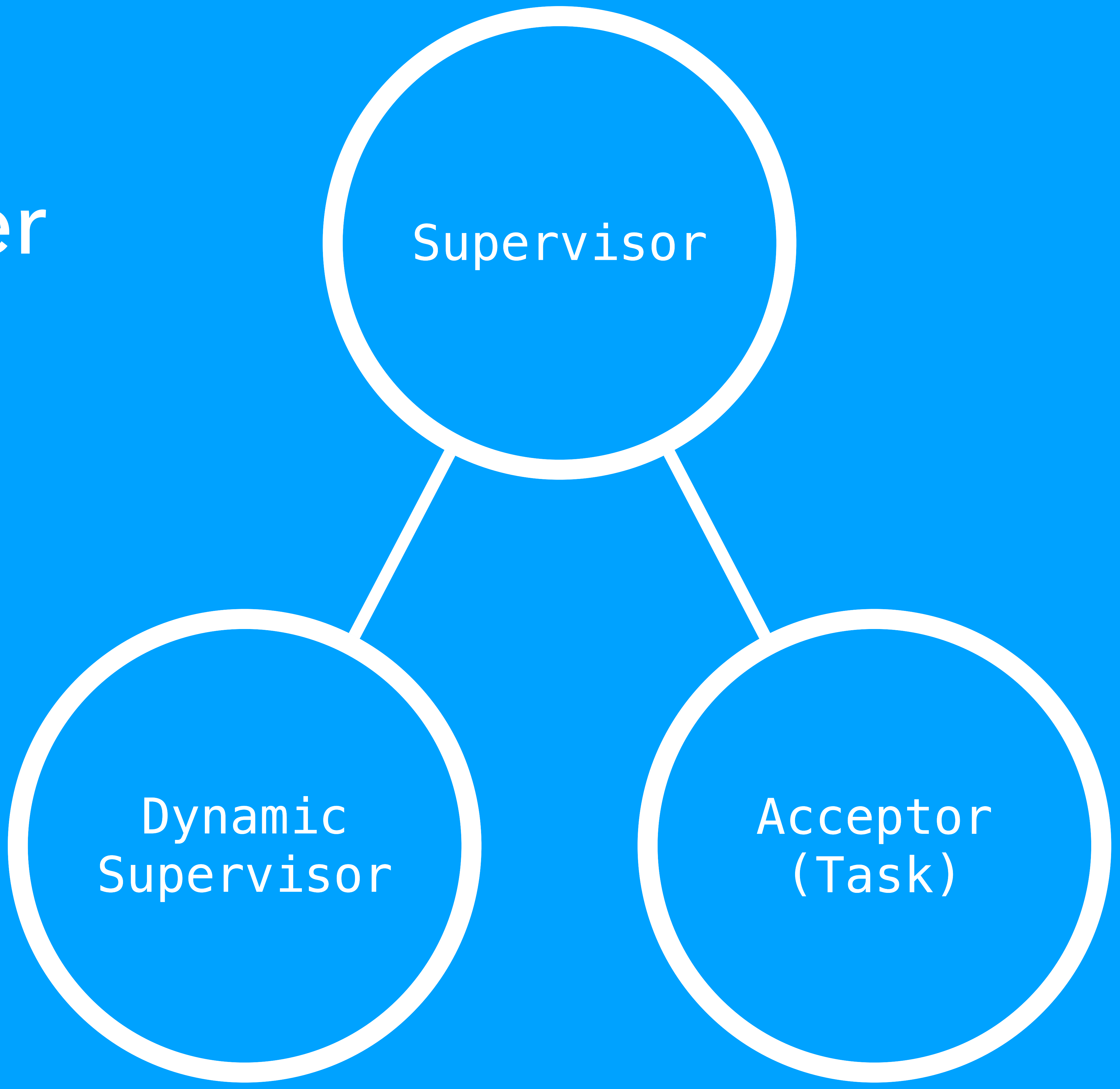
- Works best with predefined groups of processes
- Model dependencies via:
  - Start order
  - Supervision strategies (`:one_for_all`, `:rest_for_one`, &c)
- Keep domain out of Supervisors



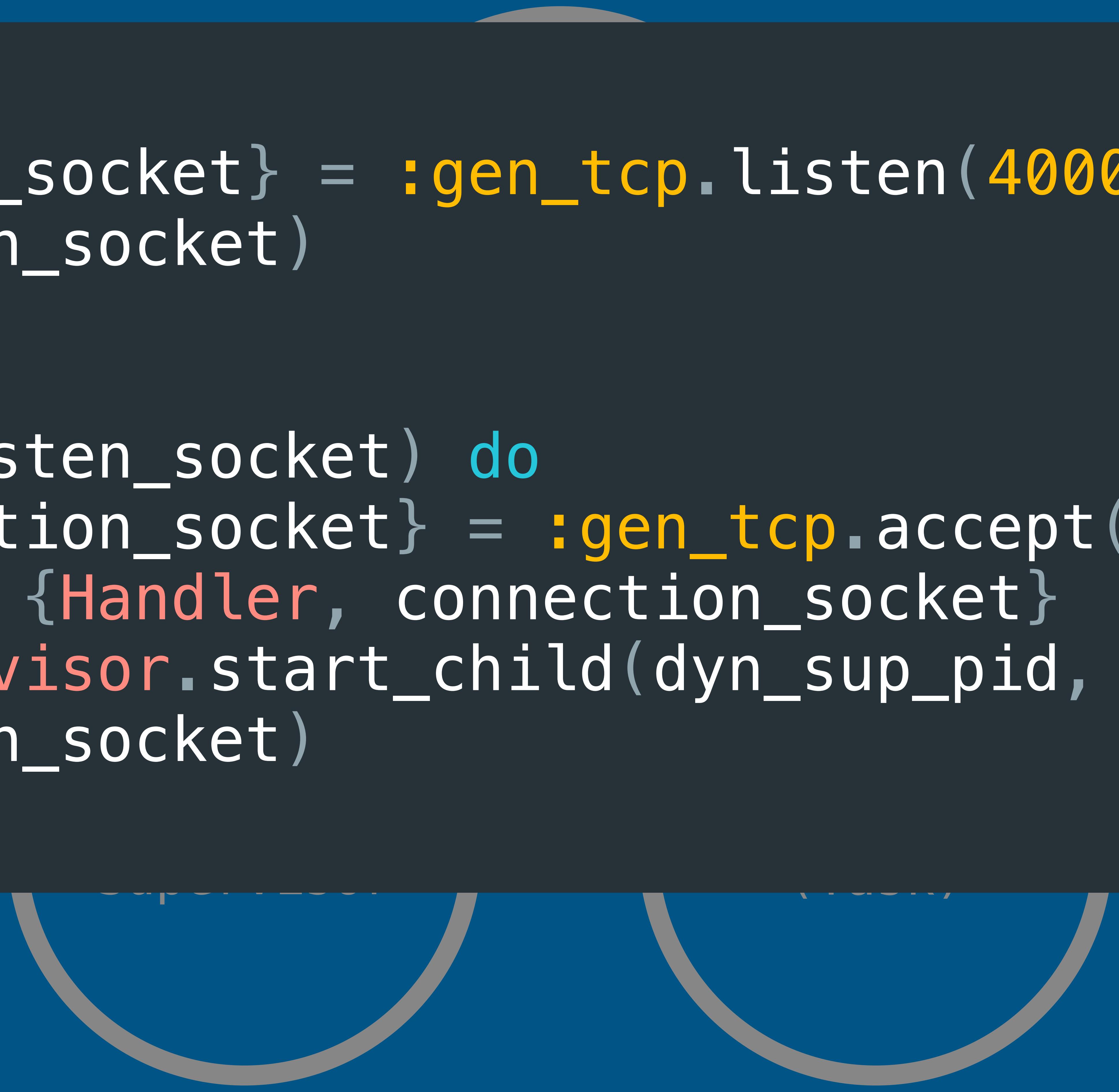
Observations

Acceptor is a Task!

- Very useful alternative to GenServer
- Doesn't need to be ephemeral
  `(use Task, restart: :permanent)`
- 'Does it need to be reachable?' is the key question to ask when deciding on Task vs. GenServer



Try #5: Supervised Acceptor



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  child_spec = {Handler, connection_socket}
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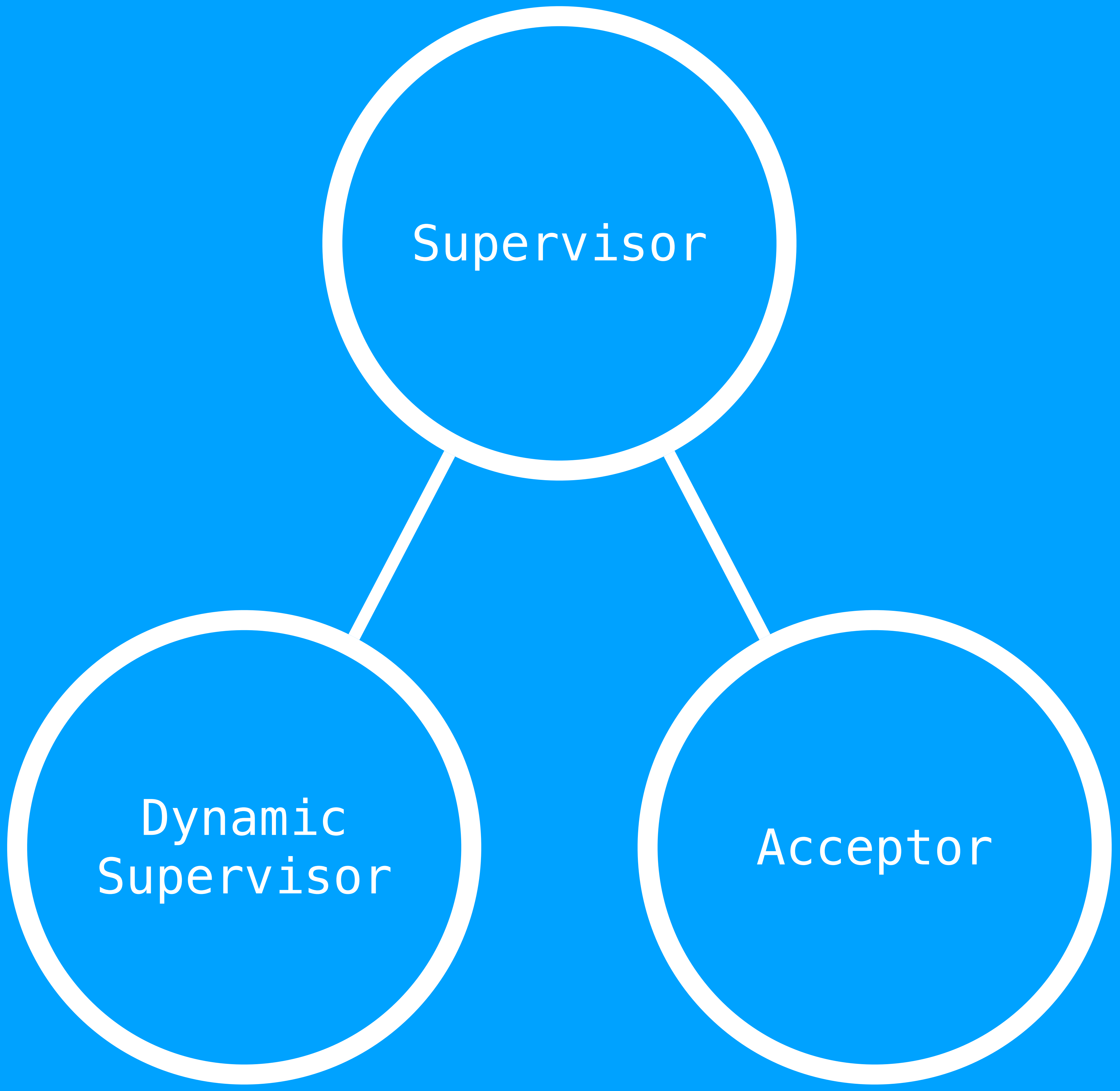
  accept(listen_socket)
end
```

Try #6: Multiple Acceptor Trees



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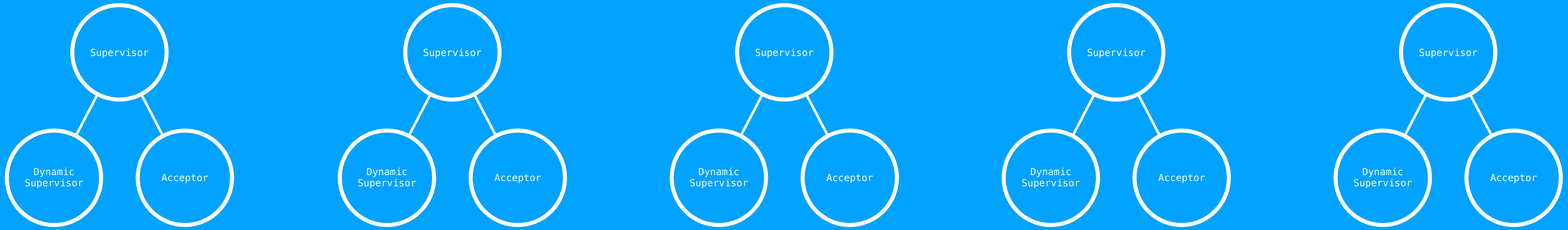

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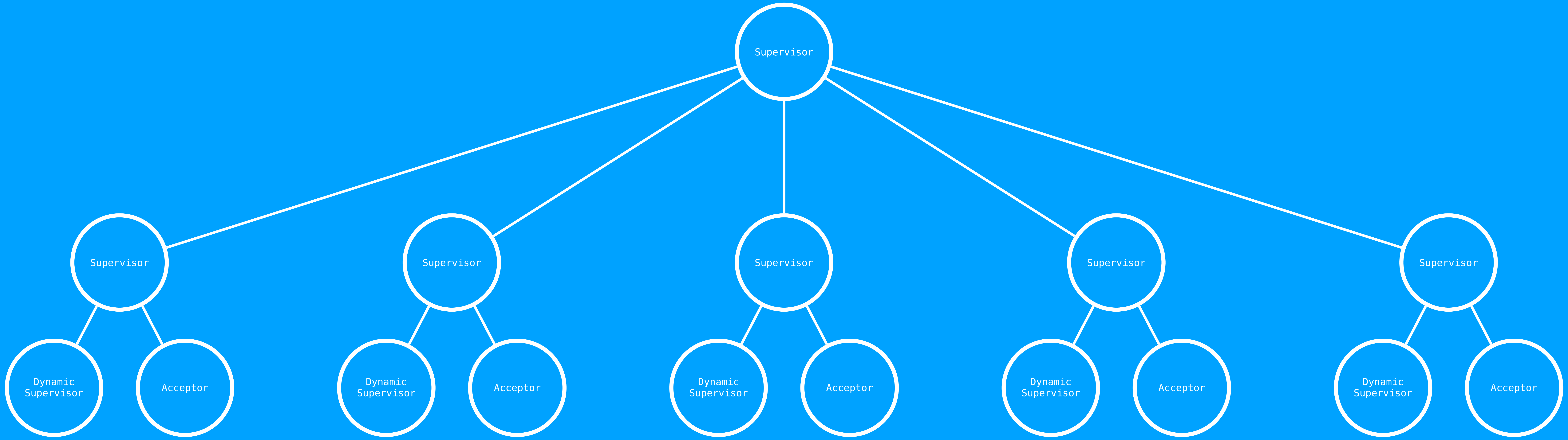
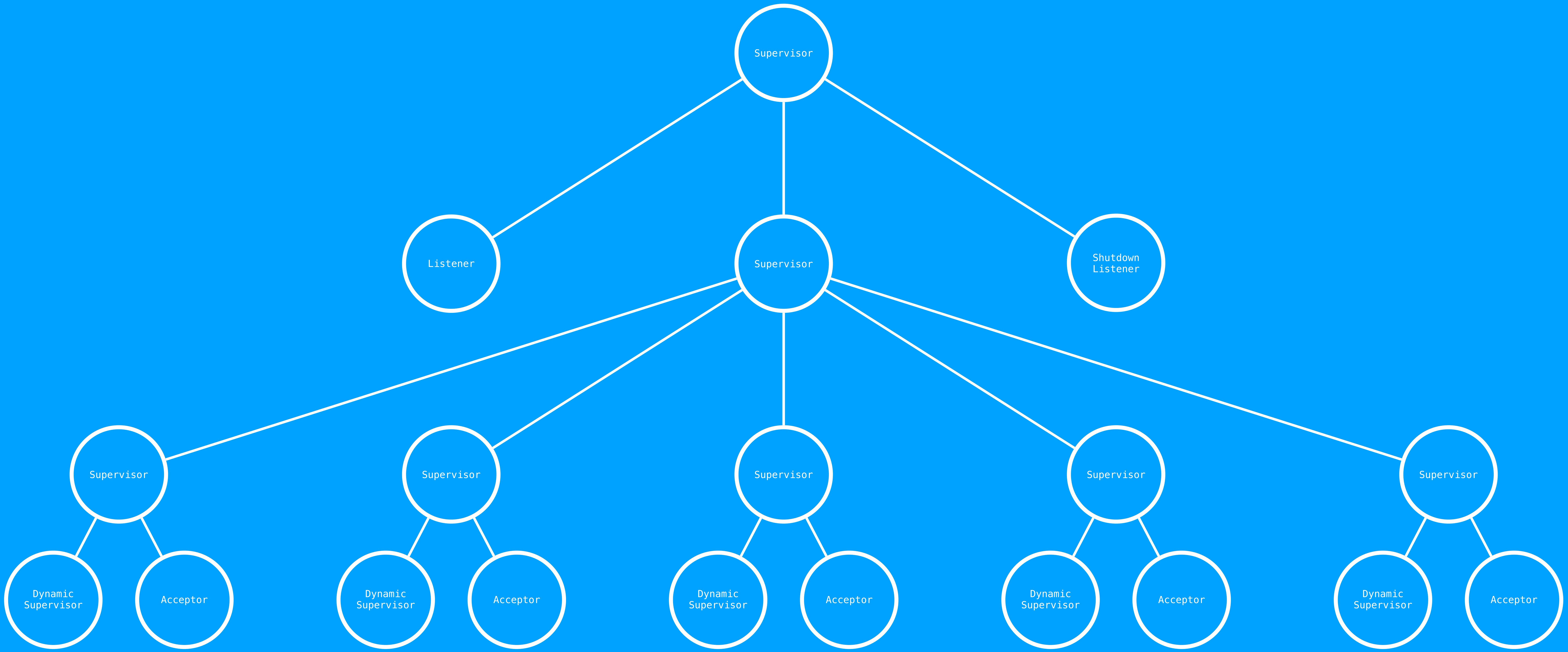
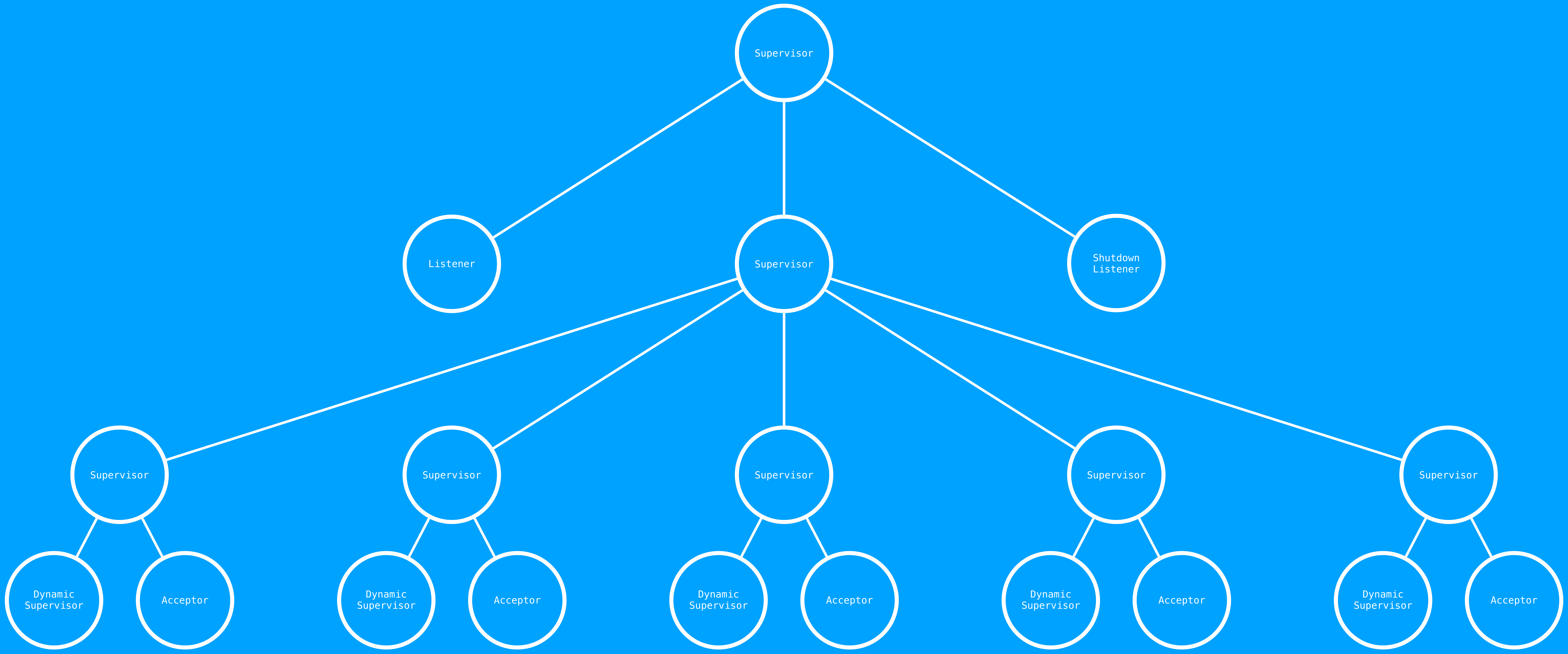


Try #6: Multiple Acceptor Trees



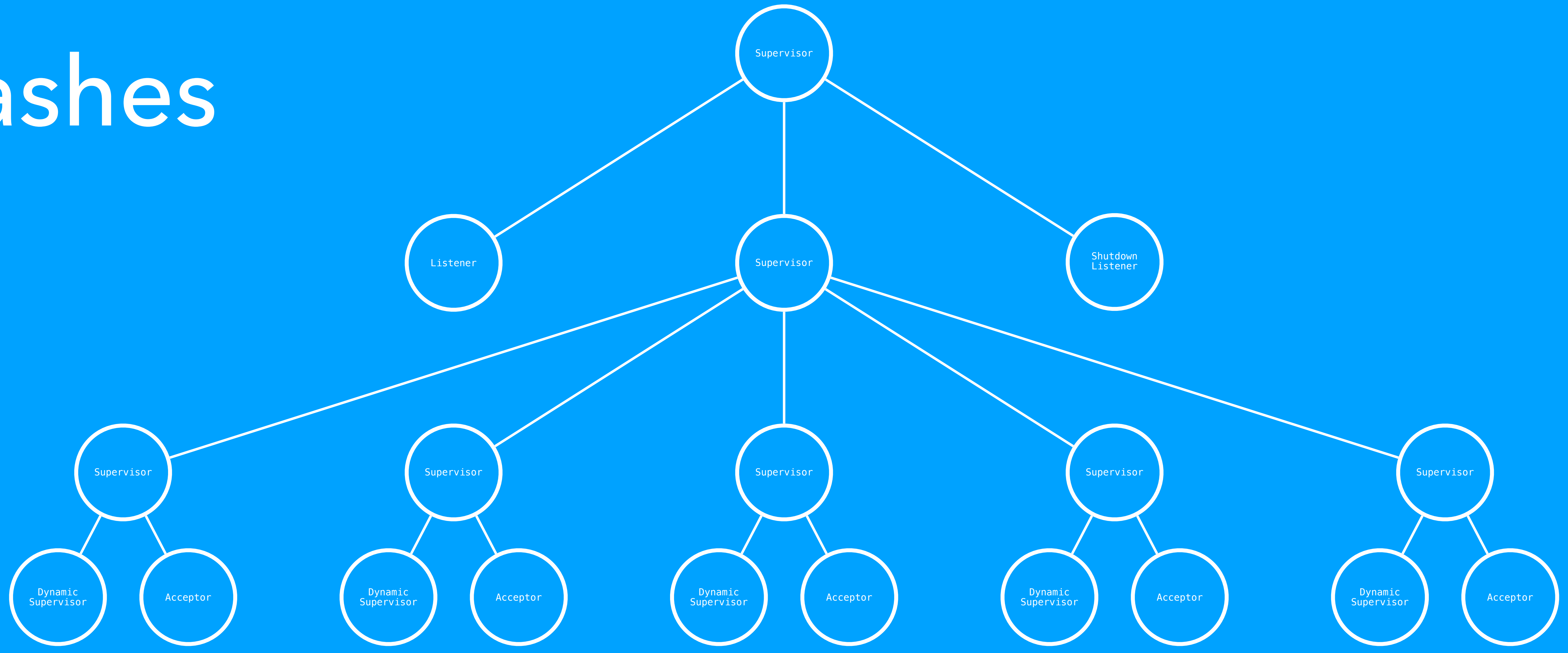
This is what Thousand Island looks like



Observations

Multiple Acceptor Trees

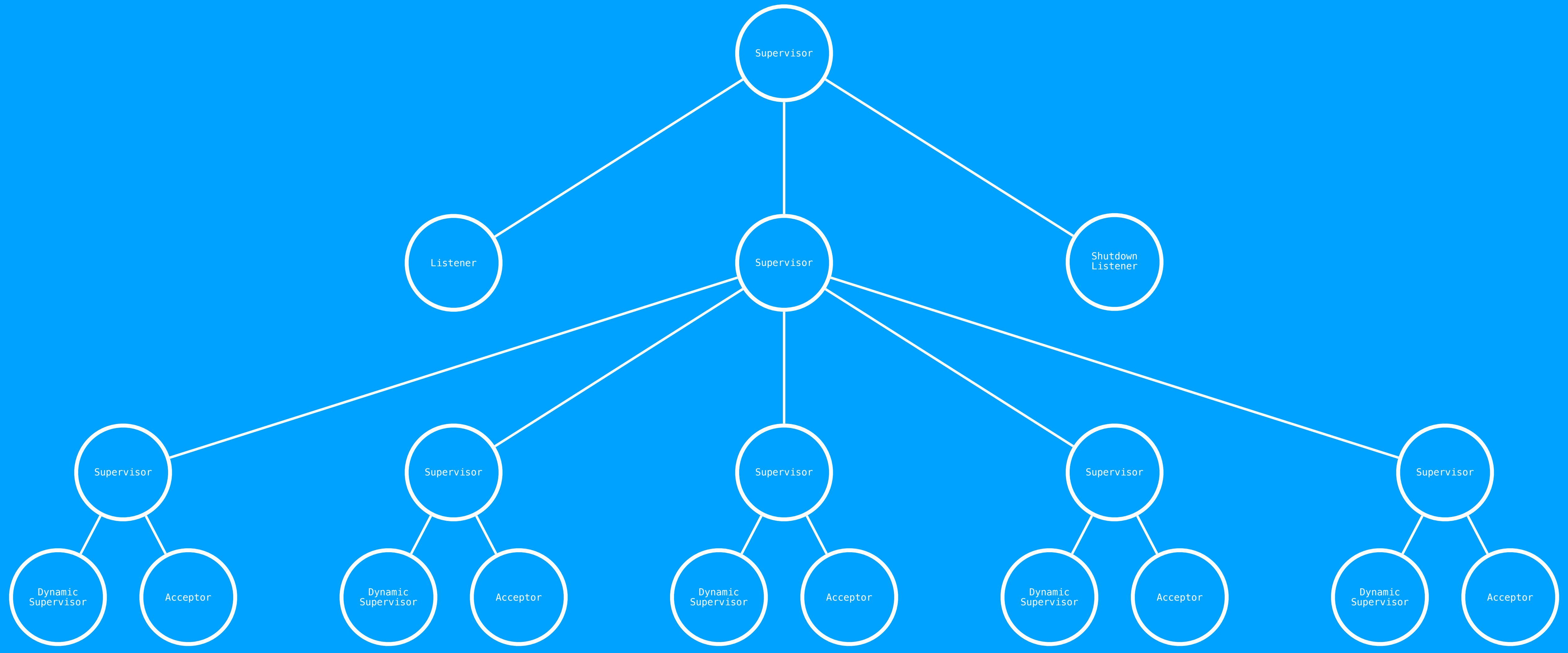
- Each acceptor tree is isolated
- Minimizes ‘blast radius’ of crashes
- Reduces contention for shared resources



Observations

Prefer Composition

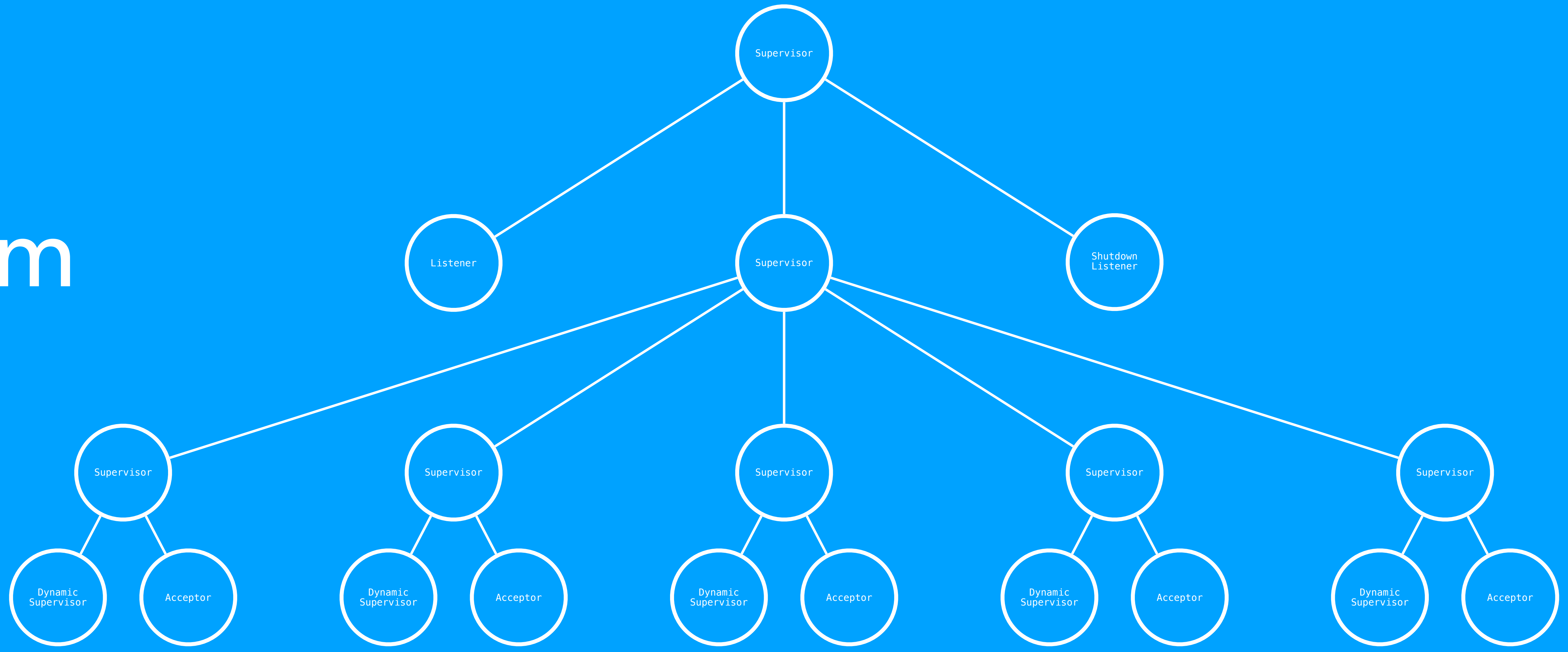
- Lots of simple supervisors is better than fewer complex ones
- Supervisors are just processes themselves
- Supervisors supervising supervisors is fine!



Observations

Prefer To Expose Process Trees

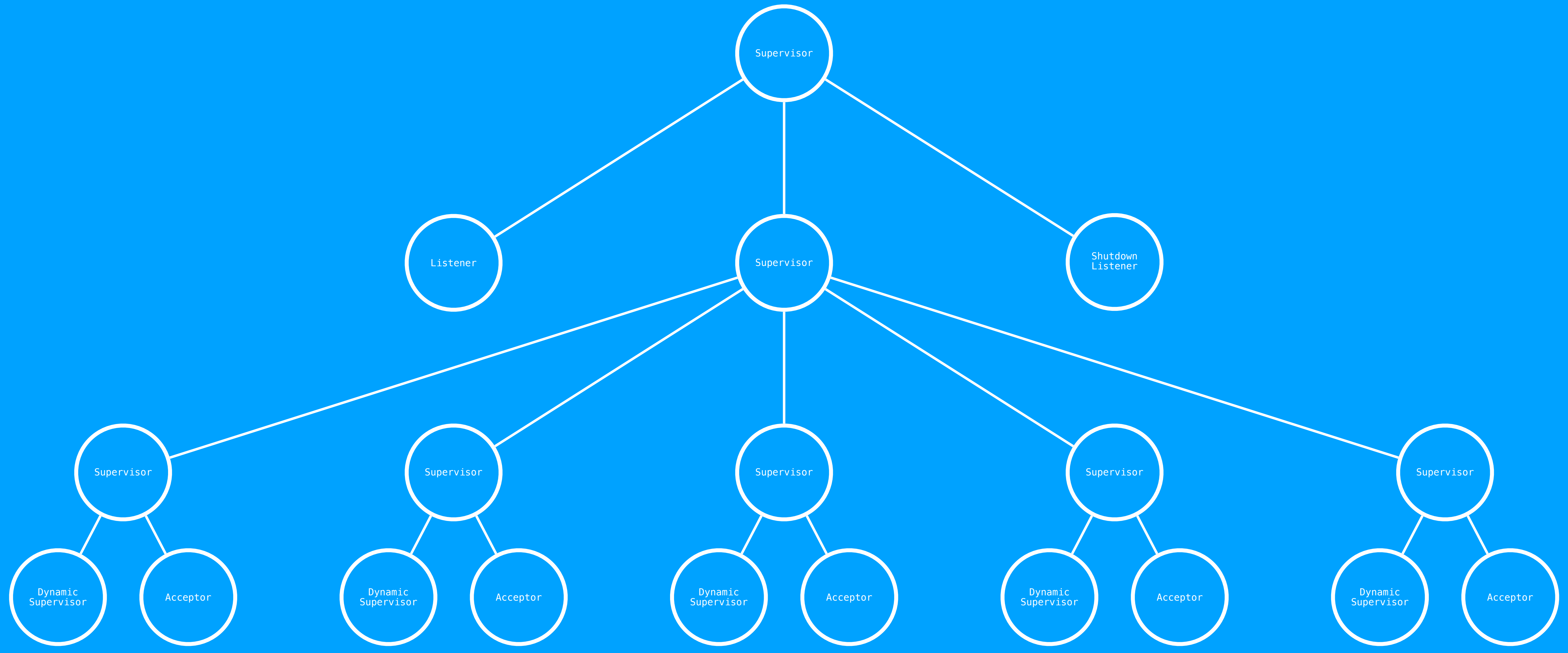
- Let users compose with their existing application
- Express dependencies to/from your existing application
- More flexible
  - eg: multiple Thousand Island servers on different ports



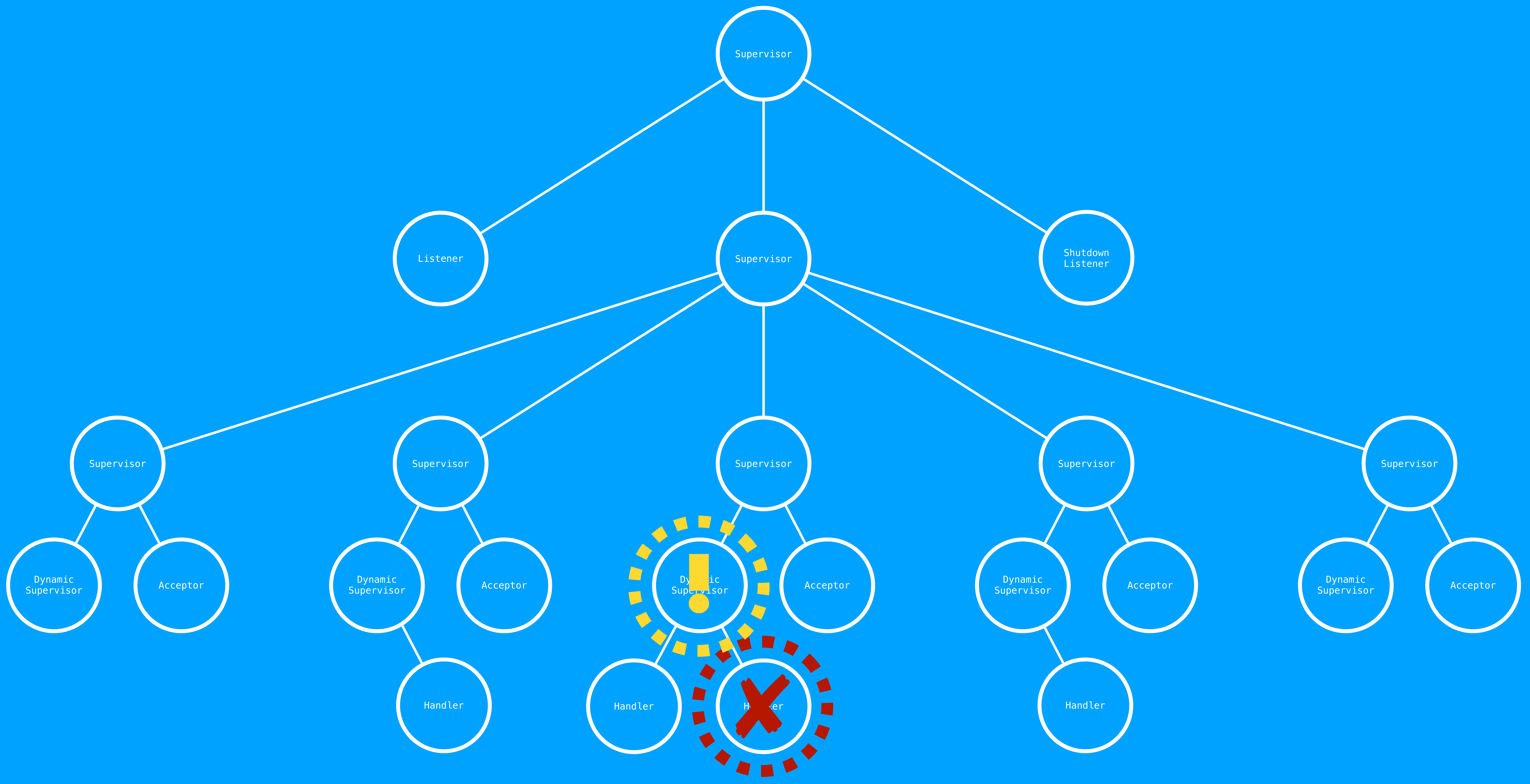
Observations

Supervisors are 'Restart Machines'

- Supervision helps contain the 'blast radius' of crashes
- Examples!



Supervisors are 'Restart Machines'



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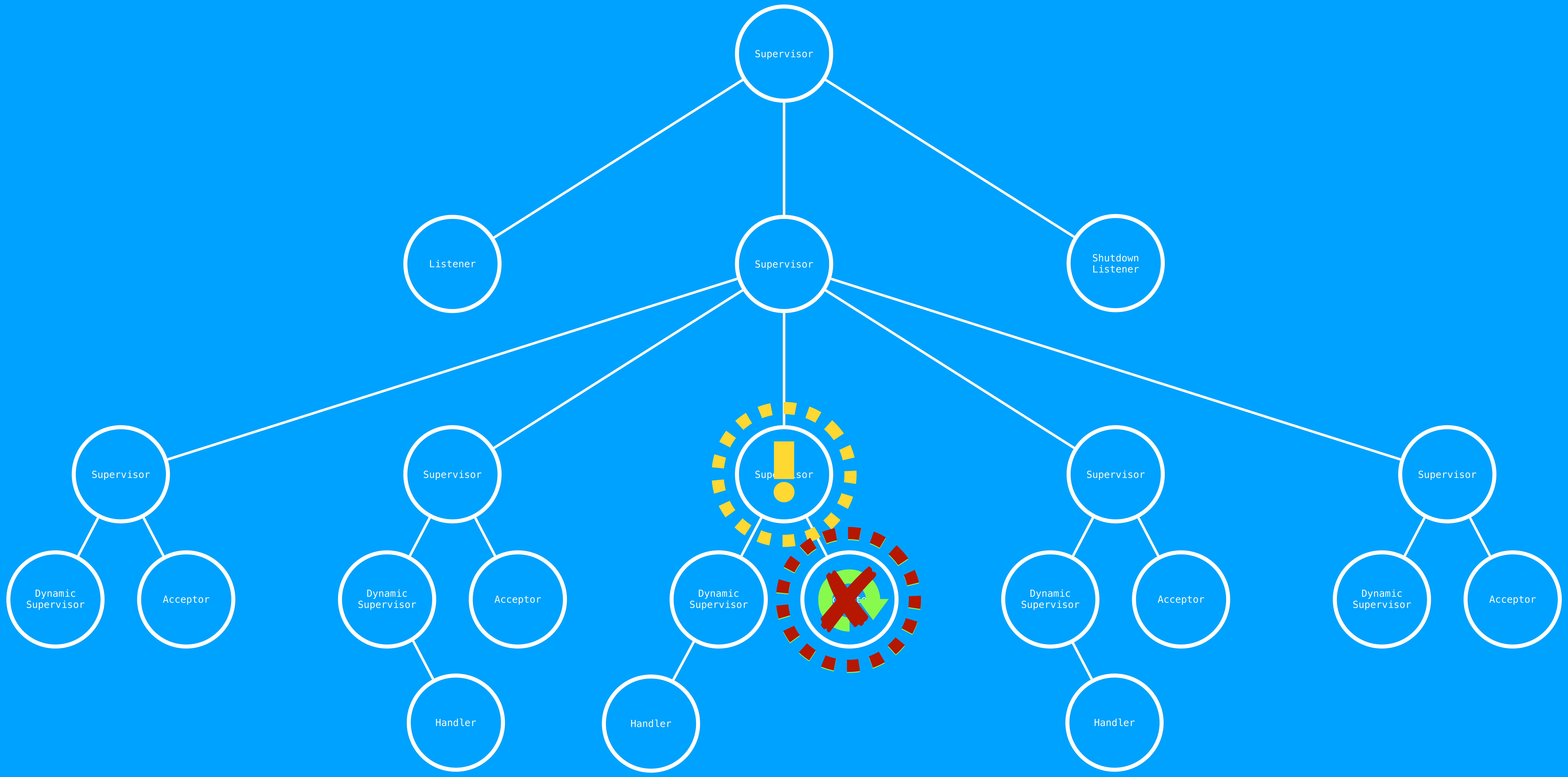

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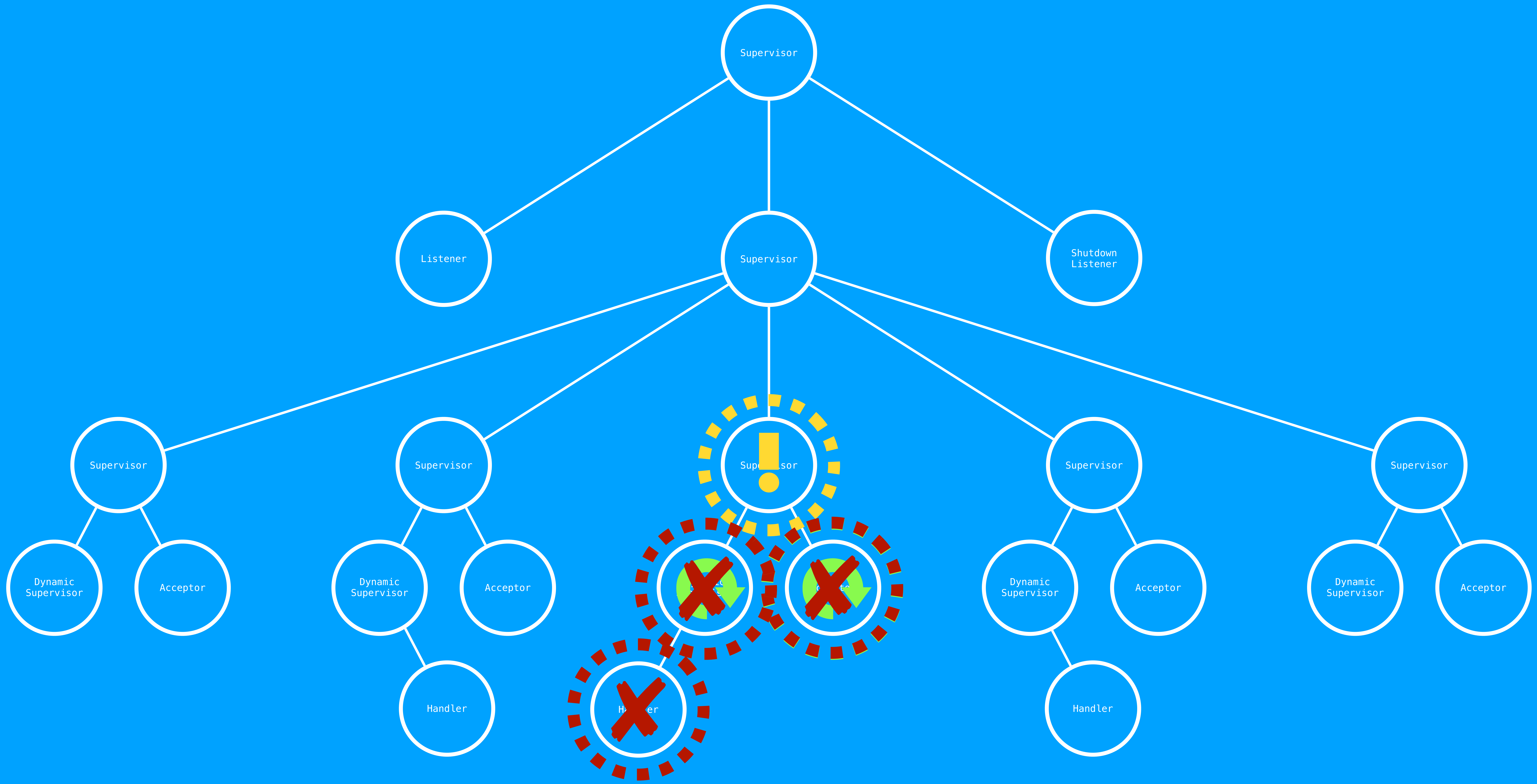
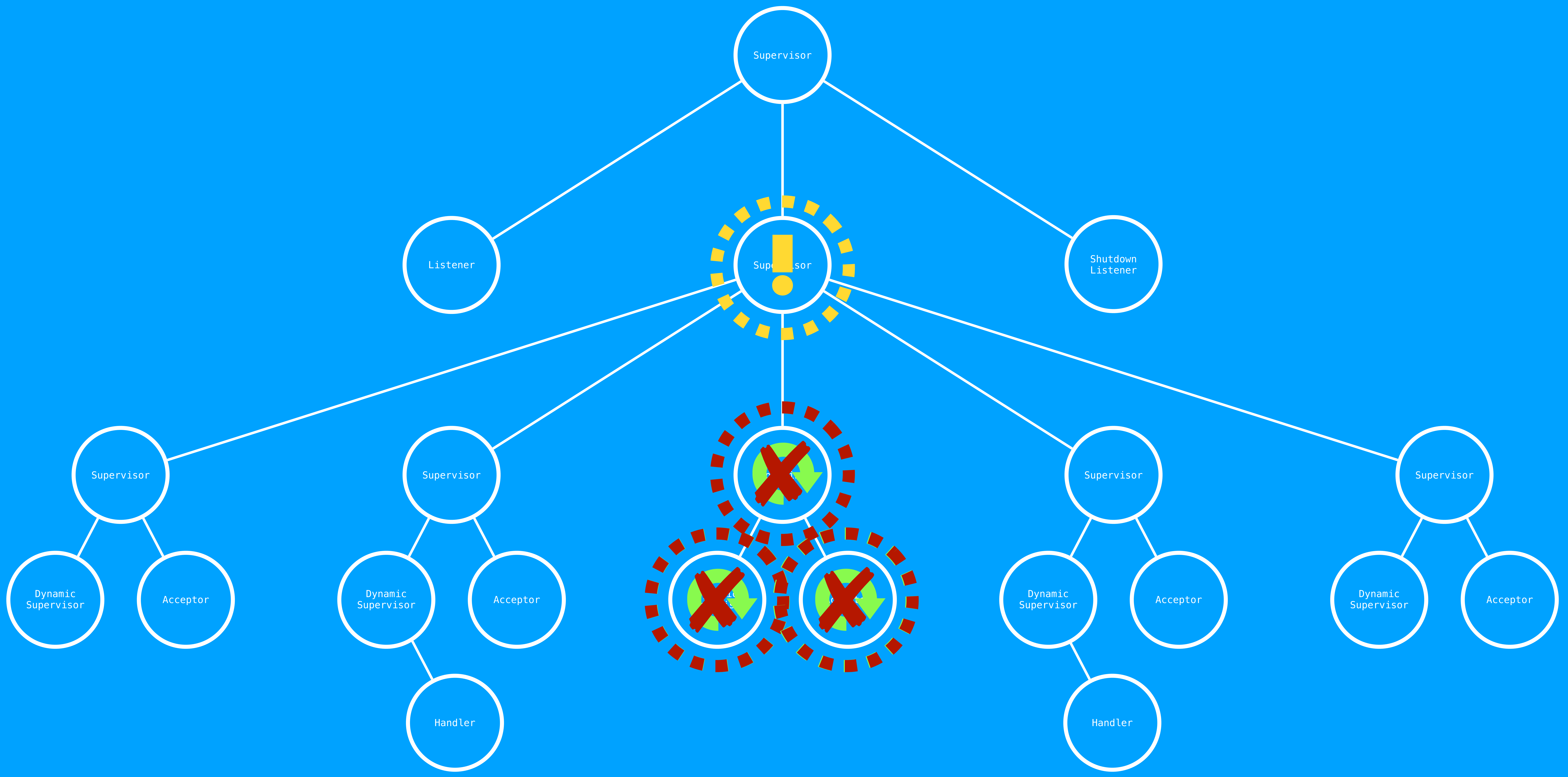


Supervisors are 'Restart Machines'



You can't

'Let It Crash'

without also knowing

How To Restart It

Putting It All Together

What's underneath Phoenix?

What's Underneath Phoenix?

Phoenix exposes itself as a Plug via `Phoenix.Endpoint`

… which is called via an HTTP server such as Bandit

… which is implemented as a Thousand Island Handler

… which is run inside a fresh GenServer process for each connection

… which is created by an acceptor task & supervised by a supervisor

… of which there are multiple instances

… all managed by a tree of Supervisors

… rooted at a PID returned by `ThousandIsland.start_link`

… that is wired into your Phoenix instance's process tree

What’s underneath Phoenix?

Very little magic

Not *too* many surprises

All things we’ve seen before

Careful fault containment

A textbook example of OTP

NOTHING TO BE SCARED OF

Agenda

- github.com/mtrudel/bandit
- github.com/mtrudel/thousand_island
- github.com/mtrudel/talks
- mat.geeky.net
- mat@geeky.net
- @mattrudel
- Thanks!

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