Akka:

Simpler Concurrency, Scalability & Fault-tolerance through Actors

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The problem

It is way too hard to build:

1. correct highly concurrent systems
2. truly scalable systems
3. fault-tolerant systems that self-heals

...using "state-of-the-art" tools

Vision

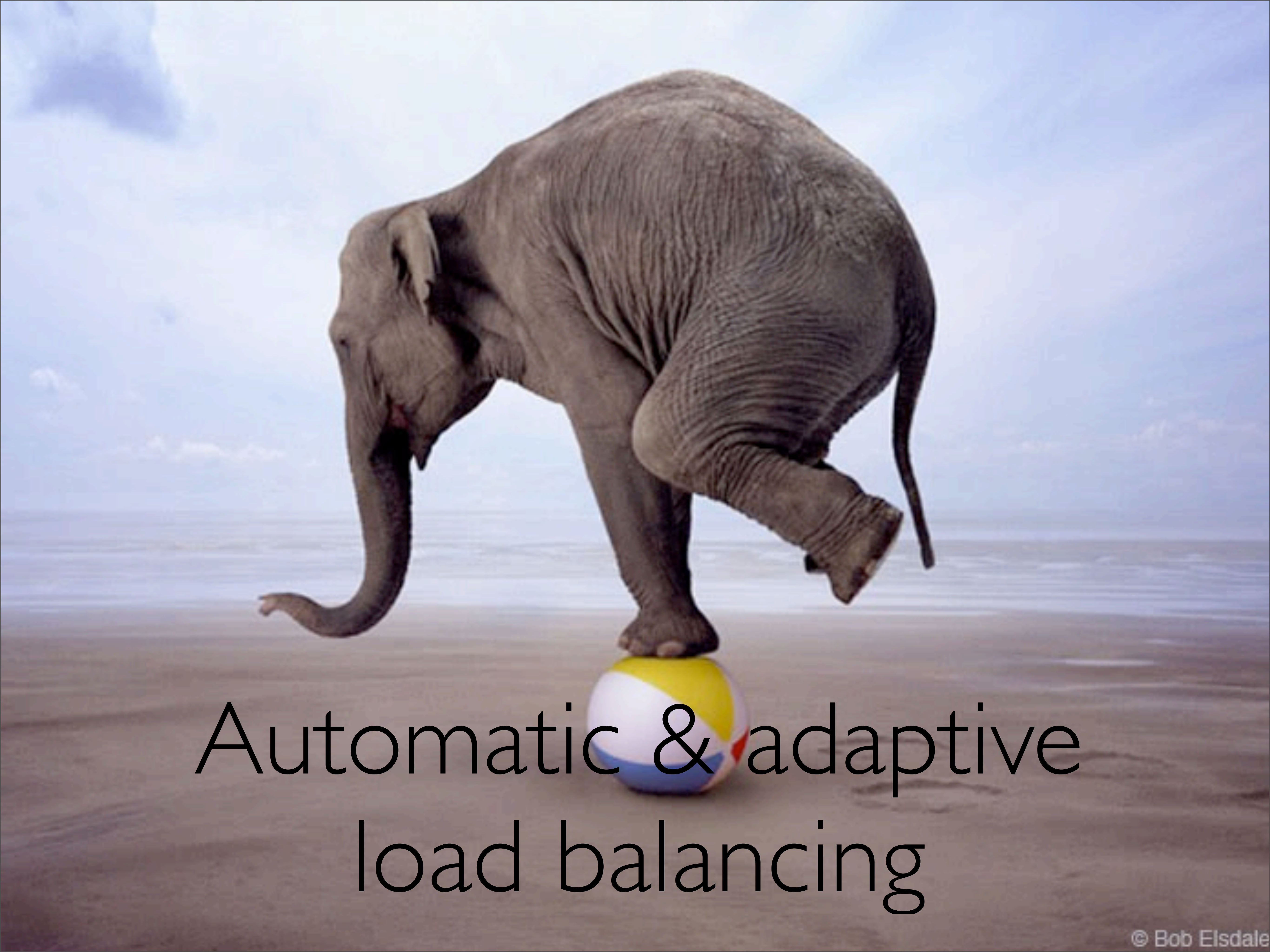
- Simpler
  - Concurrency
  - Scalability
  - Fault-tolerance
- Through one single unified
  - Programming model
  - Runtime service

Manage system overload

Scale up & Scale out

Replicate and distribute for fault-tolerance

Automatic & adaptive load balancing



Introducing

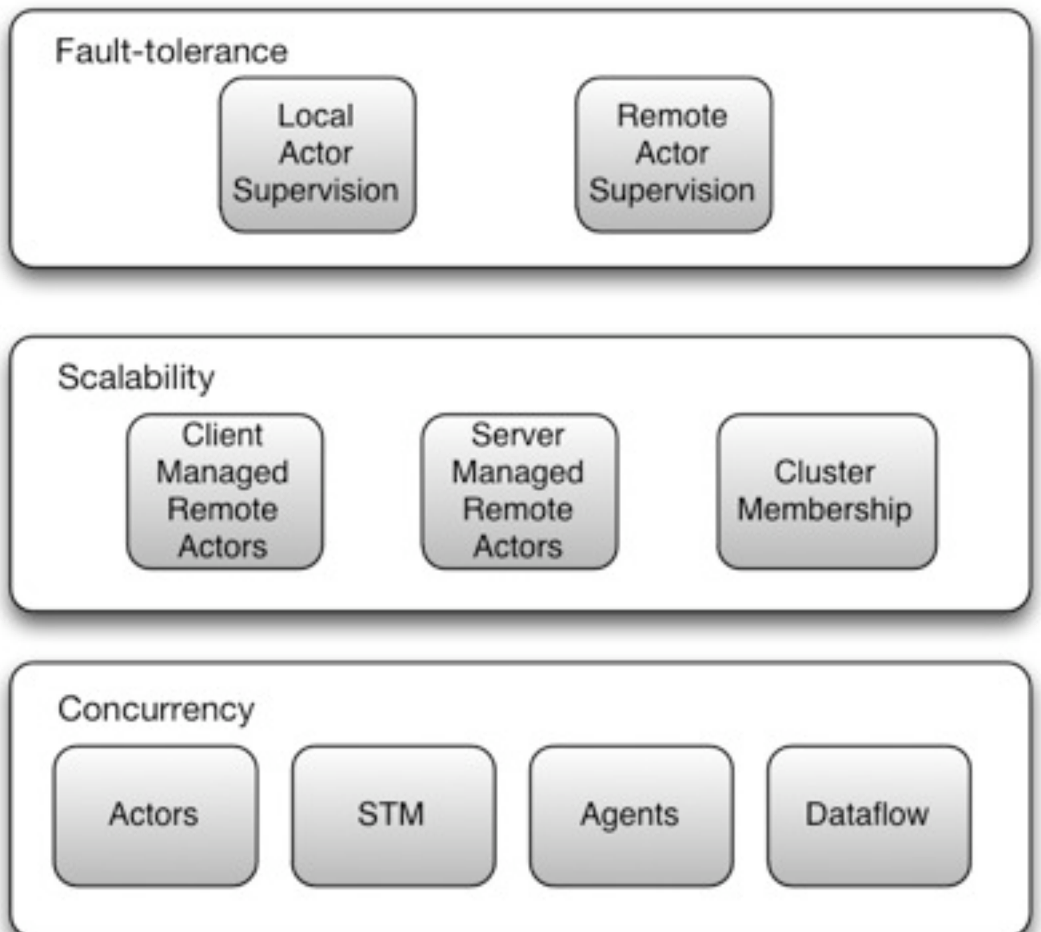
akka

Concurrency   Scalability   Fault-tolerance

Actors   STM   Agents   Dataflow

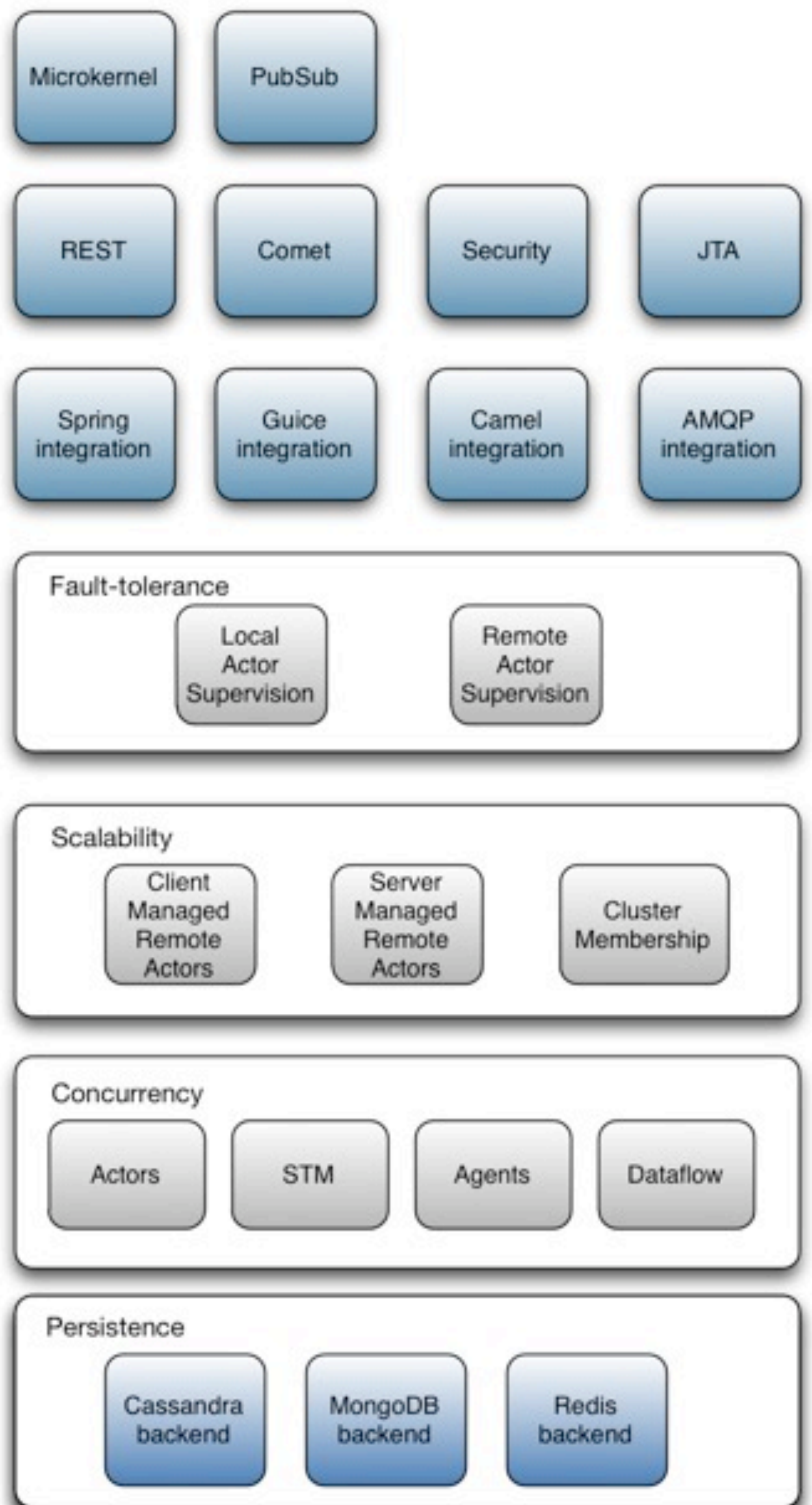
Distributed   Secure   Persistent   Open Source   Clustered

Architecture



Core Modules

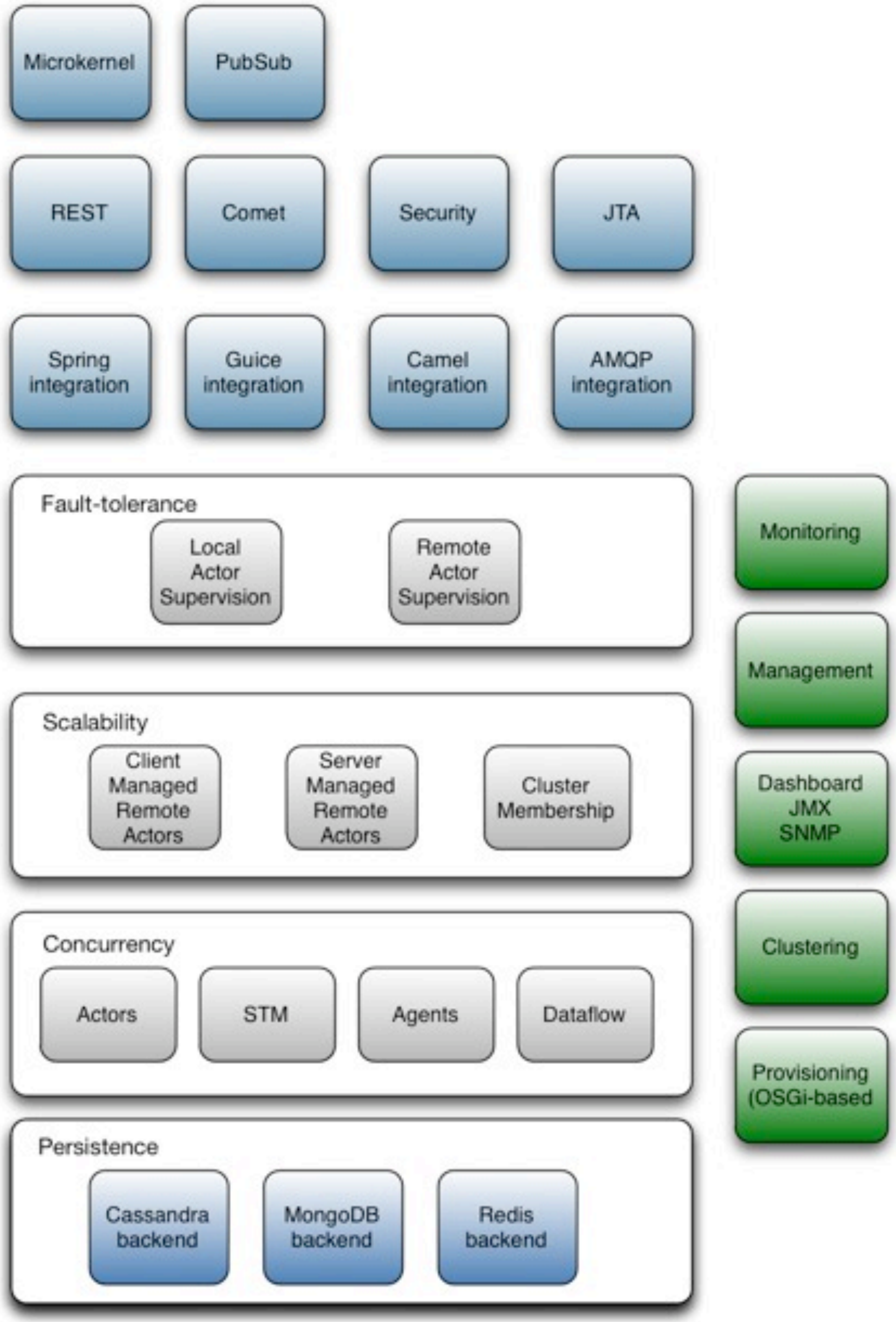
Architecture



Add-on Modules

Add-on Modules

Architecture



Enterprise Modules

Actors

one tool in the toolbox

Akka Actors

Actor Model of Concurrency

- Implements Message-Passing Concurrency
- Share NOTHING
- Isolated lightweight processes
- Communicates through messages
- Asynchronous and non-blocking
- Each actor has a mailbox (message queue)

Actor Model of Concurrency

- Easier to reason about
- Raised abstraction level
- Easier to avoid
  - Race conditions
  - Deadlocks
  - Starvation
  - Live locks

Two different models

- Thread-based
- Event-based
  - Very lightweight (600 bytes per actor)
  - Can easily create millions on a single workstation (13 million on 8 G RAM)
  - Does not consume a thread

Actors

```scala
case object Tick

class Counter extends Actor {
  private var counter = 0

  def receive = {
    case Tick =>
      counter += 1
      println(counter)
  }
}
```

Create Actors

```
import Actor._

val counter = actorOf[Counter]
```

`counter` is an `ActorRef`

Create Actors

```
val actor = actorOf(new MyActor(..))
```

create actor with constructor arguments

Start actors

```
val counter = actorOf[Counter]
counter.start
```

Start actors

```
val counter = actorOf[Counter].start
```

Stop actors

```
val counter = actorOf[Counter].start
counter.stop
```

init & shutdown callbacks

```
class MyActor extends Actor {

  override def preStart = {
    ... // called after 'start'
  }

  override def postStop = {
    ... // called before 'stop'
  }
}
```

the self reference

```
class RecursiveActor extends Actor {
  private var counter = 0
  self.id = “service:recursive”

  def receive = {
    case Tick =>
      counter += 1
      self ! Tick
  }
}
```

Actors

anonymous

```
val worker = actor {
  case Work(fn) => fn()
}
```

Send: !

```
counter ! Tick
```

fire-forget

Send: !

```
counter.sendOneWay(Tick)
```

fire-forget

Send: !!

```
val result = (actor !! Message).as[String]
```

uses Future under the hood (with time-out)

Send: !!

```
val result = counter.sendRequestReply(Tick)
```

uses Future under the hood (with time-out)

Send: !!!

```
// returns a future
val future = actor !!! Message
future.await
val result = future.get

...
Futures.awaitOne(List(fut1, fut2, ...))
Futures.awaitAll(List(fut1, fut2, ...))
```

returns the Future directly

Send: !!!

```
val result = counter.sendRequestReplyFuture(Tick)
```

returns the Future directly

Reply

```
class SomeActor extends Actor {
  def receive = {
    case User(name) =>
      // use reply
      self.reply("Hi " + name)
  }
}
```

Reply

```
class SomeActor extends Actor {
  def receive = {
    case User(name) =>
      // store away the sender
      // to use later or
      // somewhere else
      ... = self.sender
  }
}
```

Reply

```
class SomeActor extends Actor {
  def receive = {
    case User(name) =>
      // store away the sender future
      // to resolve later or
      // somewhere else
      ... = self.senderFuture
  }
}
```

Immutable messages

```
// define the case class
case class Register(user: User)

// create and send a new case class message
actor ! Register(user)

// tuples
actor ! (username, password)

// lists
actor ! List(“bill”, “bob”, “alice”)
```

ActorRegistry

```
val actors = ActorRegistry.actors
val actors = ActorRegistry.actorsFor[TYPE]
val actors = ActorRegistry.actorsFor(id)
val actor = ActorRegistry.actorFor(uuid)
ActorRegistry.foreach(fn)
ActorRegistry.shutdownAll
```

TypedActor

Typed Actors

```
class CounterImpl
  extends TypedActor with Counter {

  private var counter = 0;

  def count = {
    counter += 1
    println(counter)
  }
}
```

Create Typed Actor

```
val counter = TypedActor.newInstance(
    classOf[Counter], classof[CounterImpl])
```

Send message

```
counter.count
```

fire-forget

Request Reply

```
val hits = counter.getNrOfHits
```

uses Future under the hood (with time-out)

the context reference

```
class PingImpl extends TypedActor
  with Ping {
  def hit(count: Int) = {
    val pong = getContext
      .getSender.asInstanceOf[Pong]
    pong.hit(count += 1)
  }
}
```

Actors: config

```
akka {
  version = "0.10"
  time-unit = "seconds"
  actor {
    timeout = 5
    throughput = 5
  }
}
```

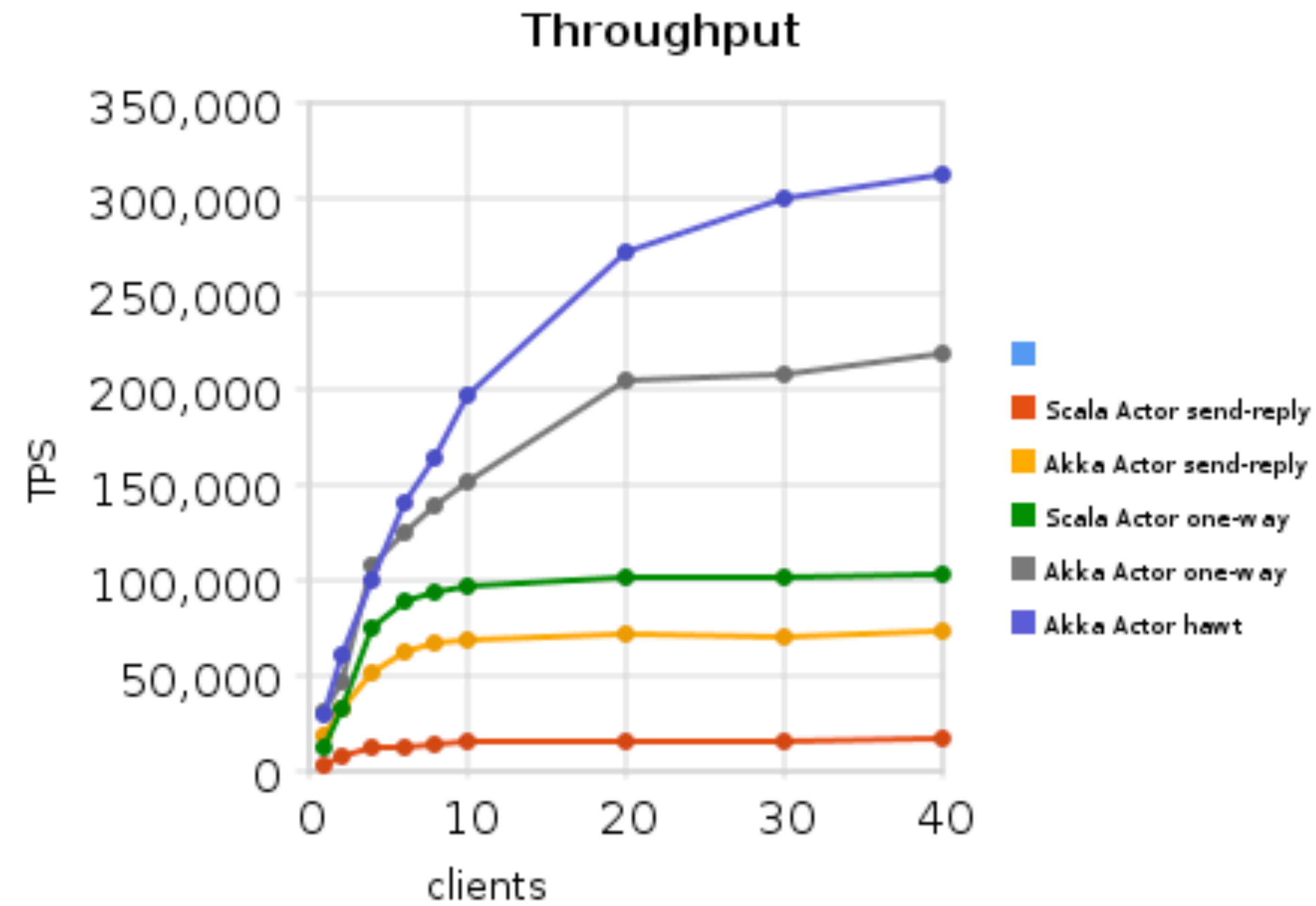
Scalability Benchmark

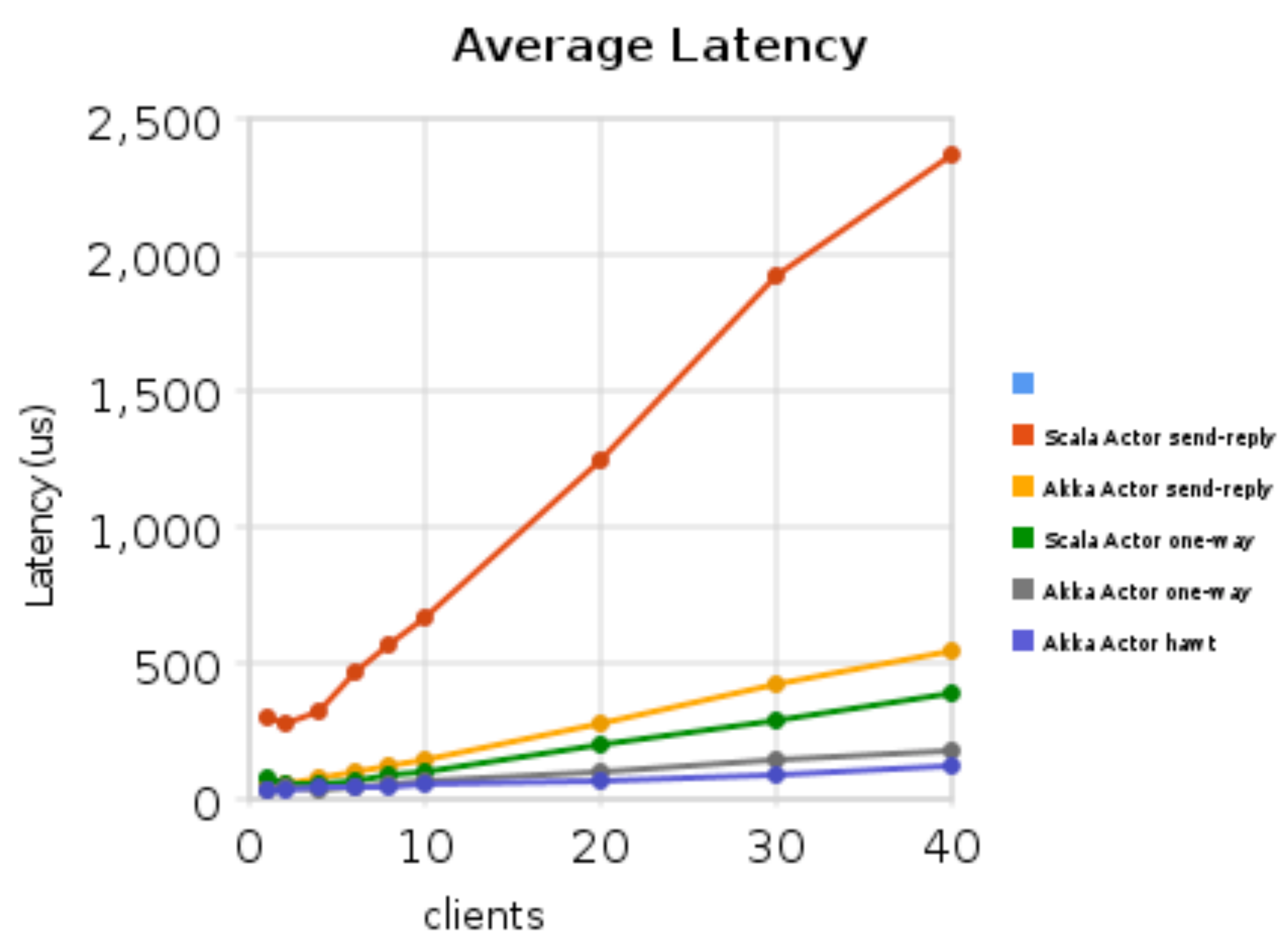
Simple Trading system

- Synchronous Scala version
- Scala Library Actors 2.8.0
  - Fire-forget
  - Request-reply (Futures)
- Akka
  - Fire-forget (Hawt dispatcher)
  - Fire-forget (default dispatcher)
  - Request-reply

Run it yourself:

http://github.com/patriknw/akka-sample-trading





Agents

yet another tool in the toolbox

Agents

```
val agent = Agent(5)

// send function asynchronously
agent send (_ + 1)

val result = agent() // deref
... // use result

agent.close
```

Cooperates with STM

Akka Dispatchers

Dispatchers

Executor-based Dispatcher
Executor-based Work-stealing Dispatcher
Hawt Dispatcher
Thread-based Dispatcher

Dispatchers

```
object Dispatchers {
  object globalHawtDispatcher extends HawtDispatcher
  ...

  def newExecutorBasedEventDrivenDispatcher(name: String)

  def newExecutorBasedEventDrivenWorkStealingDispatcher(name: String)

  def newHawtDispatcher(aggregate: Boolean)

  ...
}
```

Set dispatcher

```
class MyActor extends Actor {
  self.dispatcher = Dispatchers
    .newThreadBasedDispatcher(self)

  ...
}

actor.dispatcher = dispatcher // before started
```

Let it crash

fault-tolerance

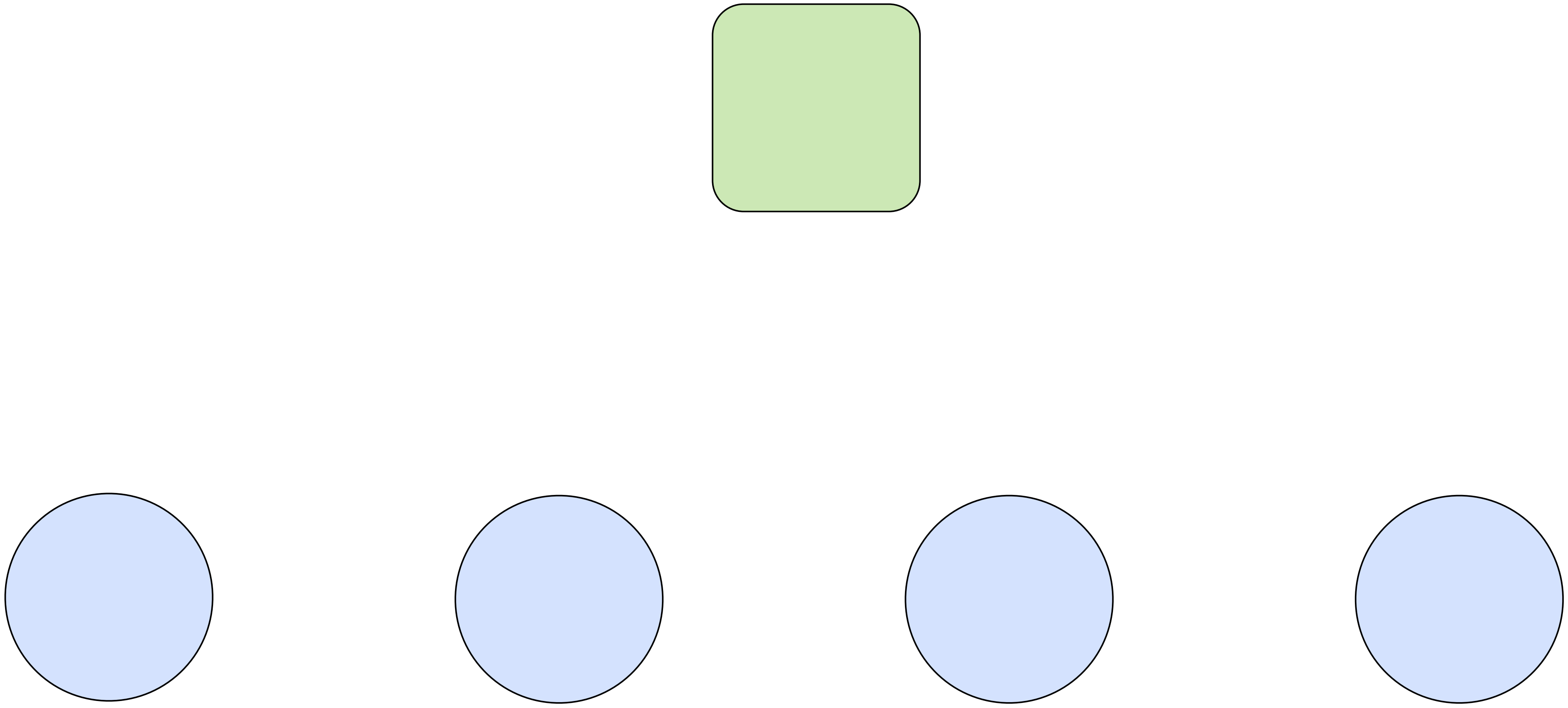
Influenced by

Erlang

9 nines

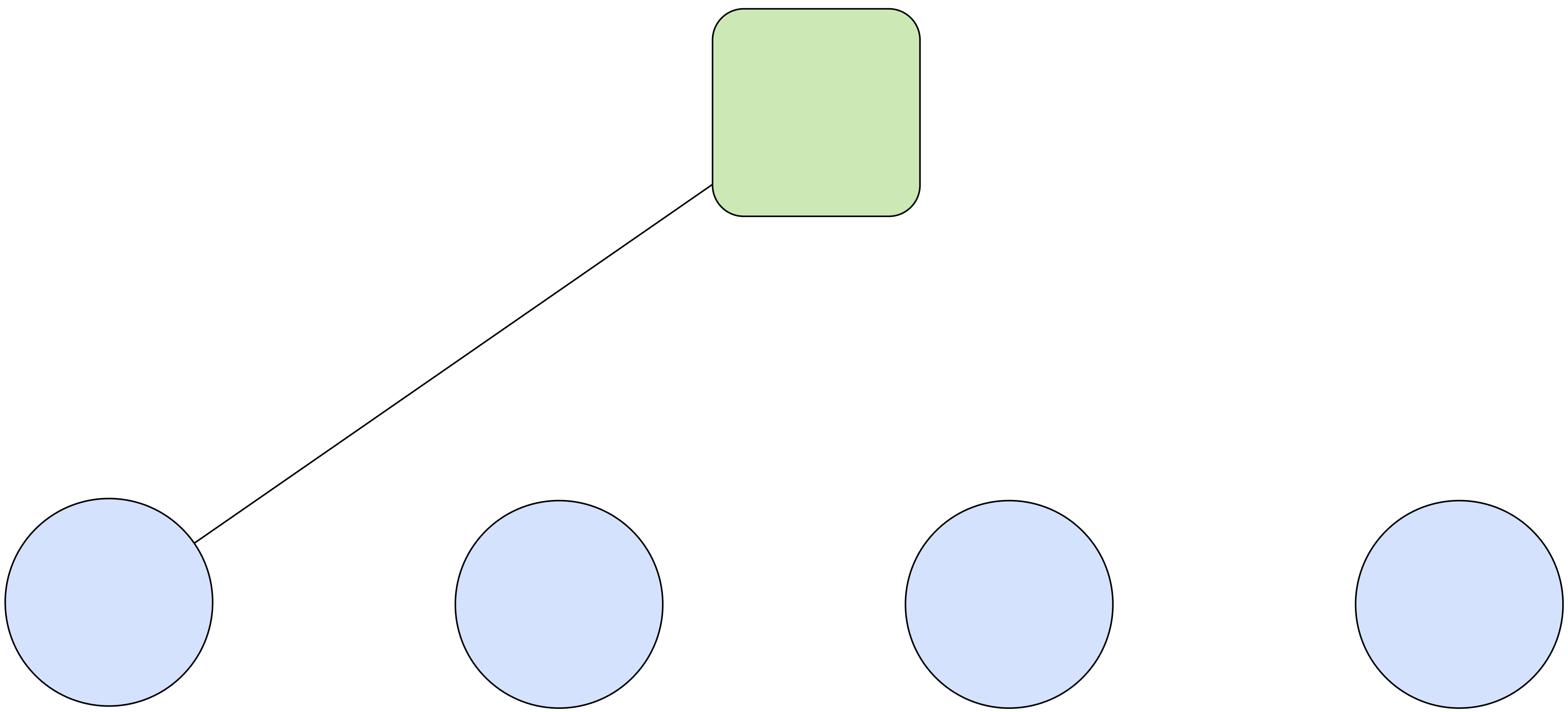
OneForOne

fault handling strategy



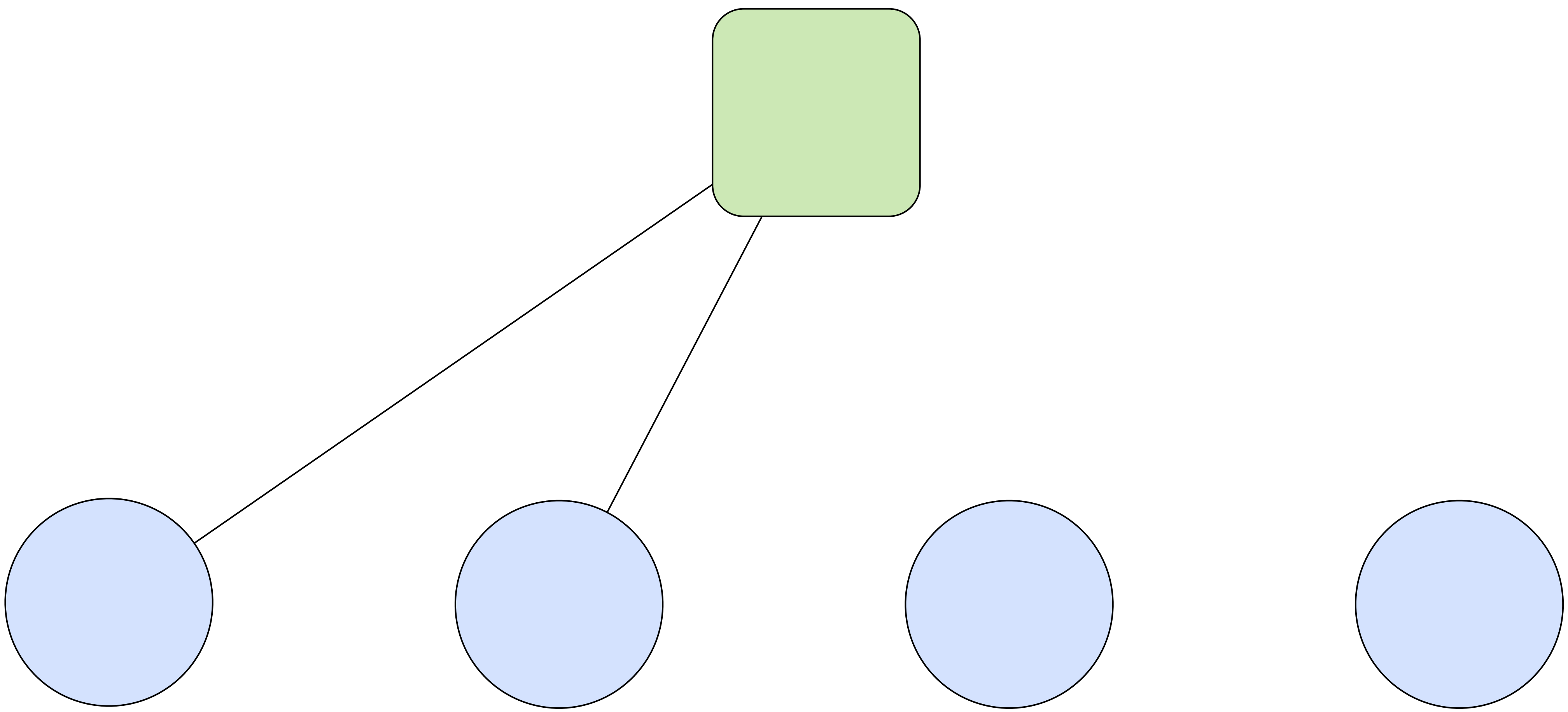
OneForOne

fault handling strategy

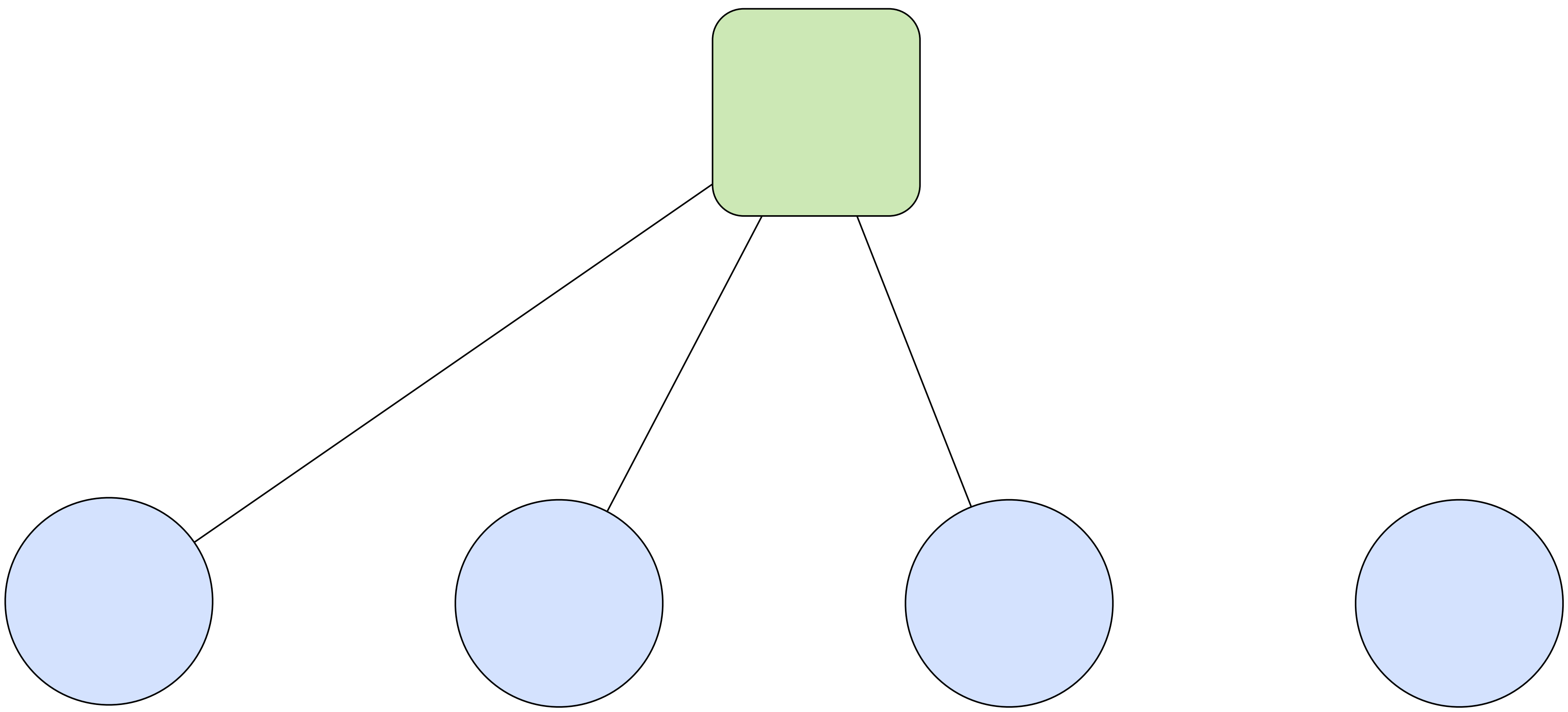


OneForOne

fault handling strategy



OneForOne
fault handling strategy



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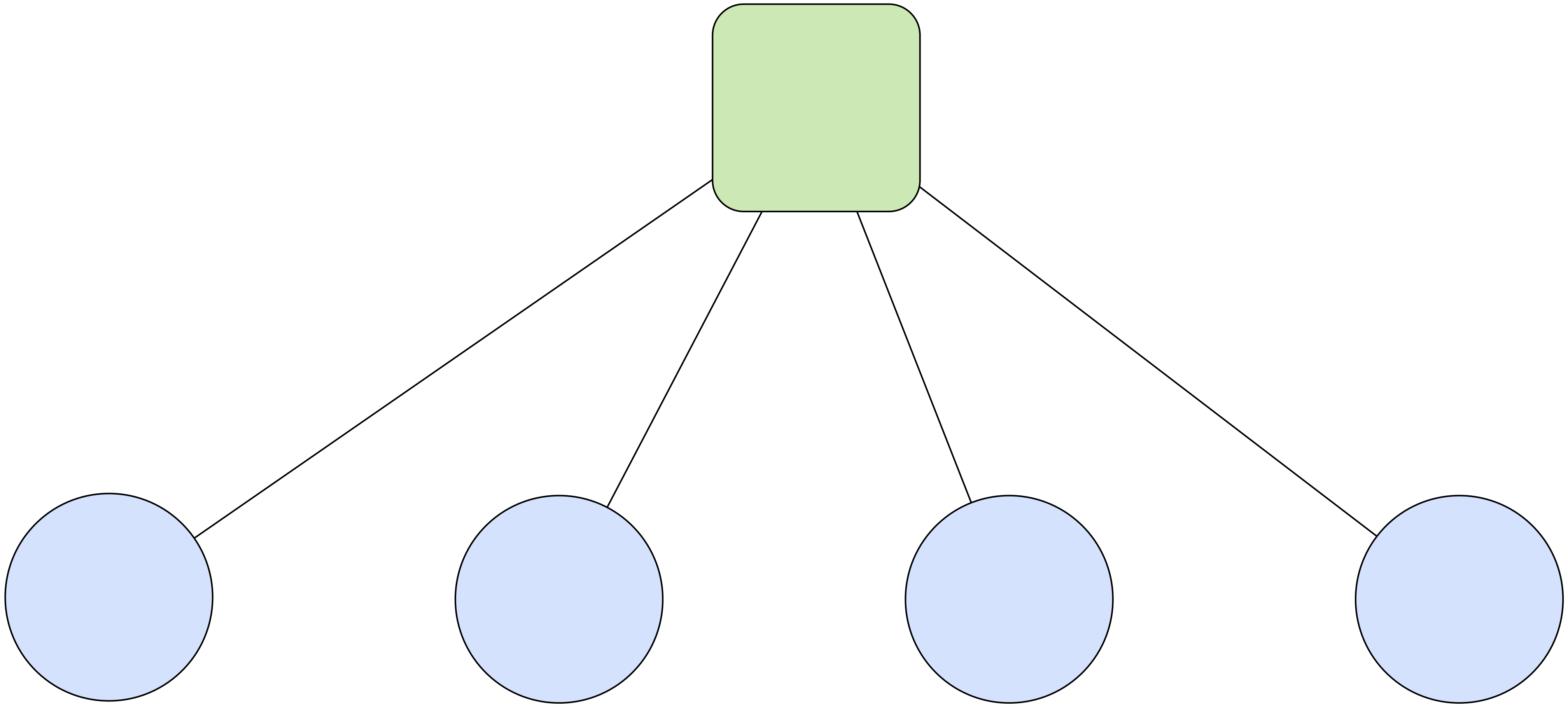

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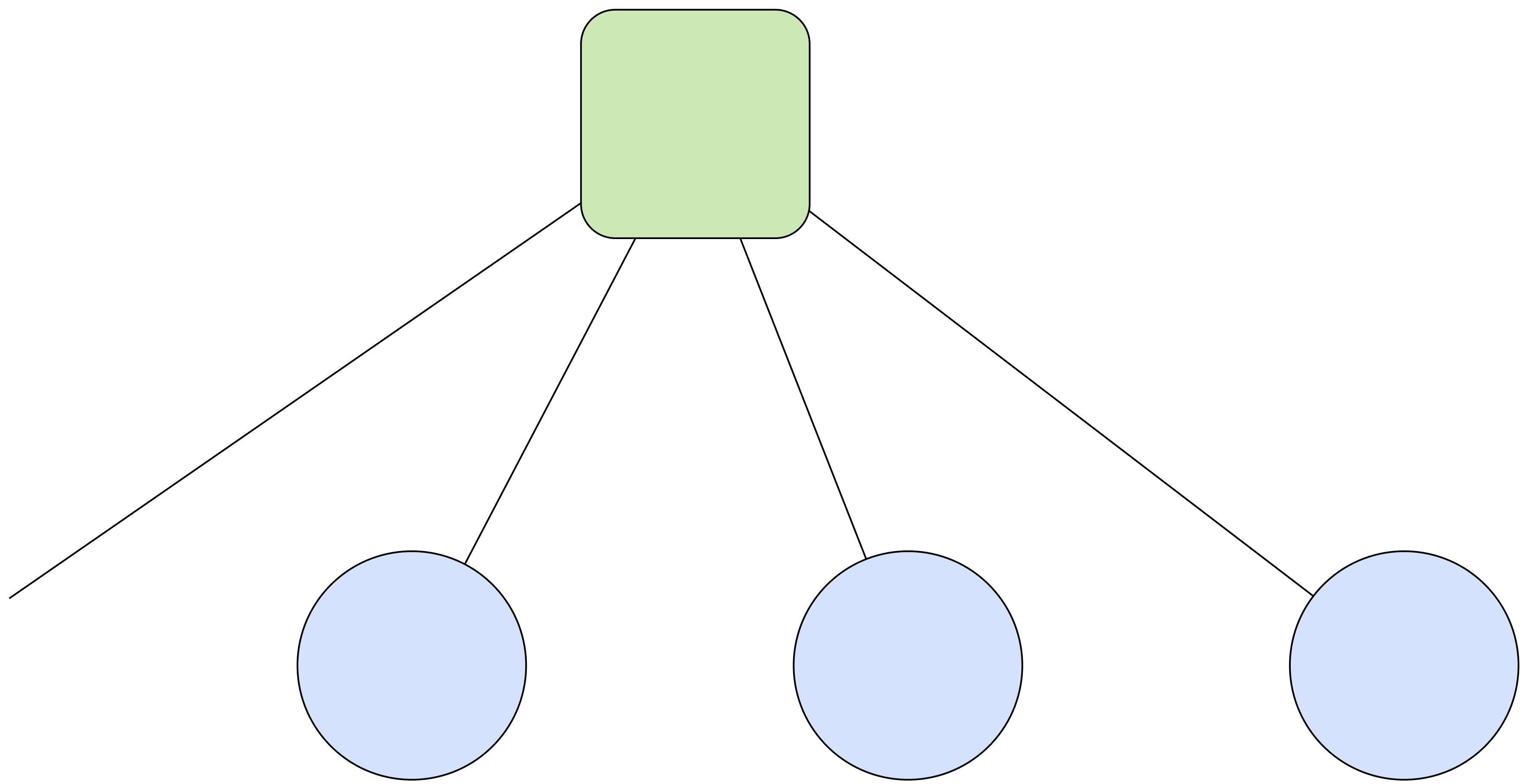
fault handling strategy



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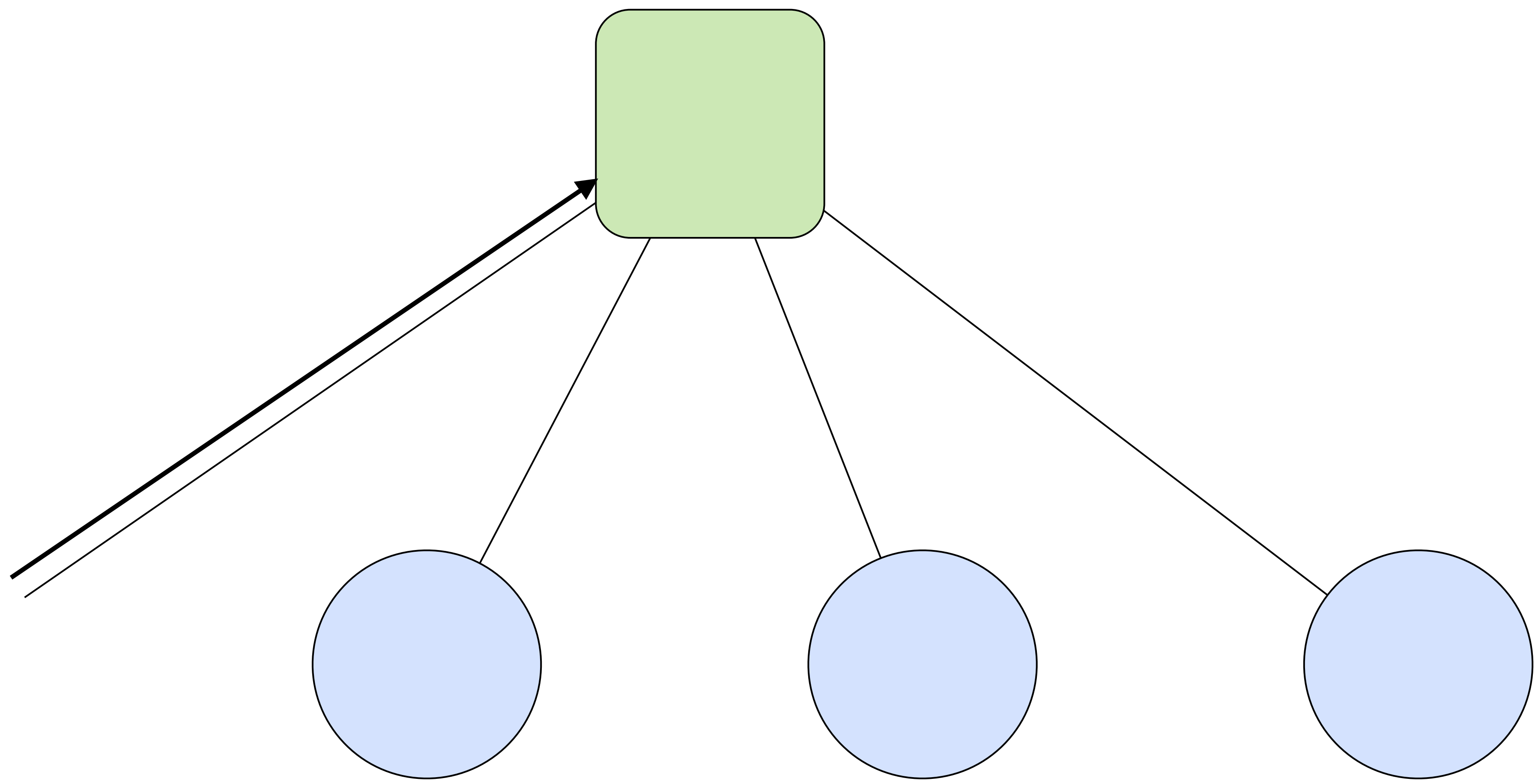

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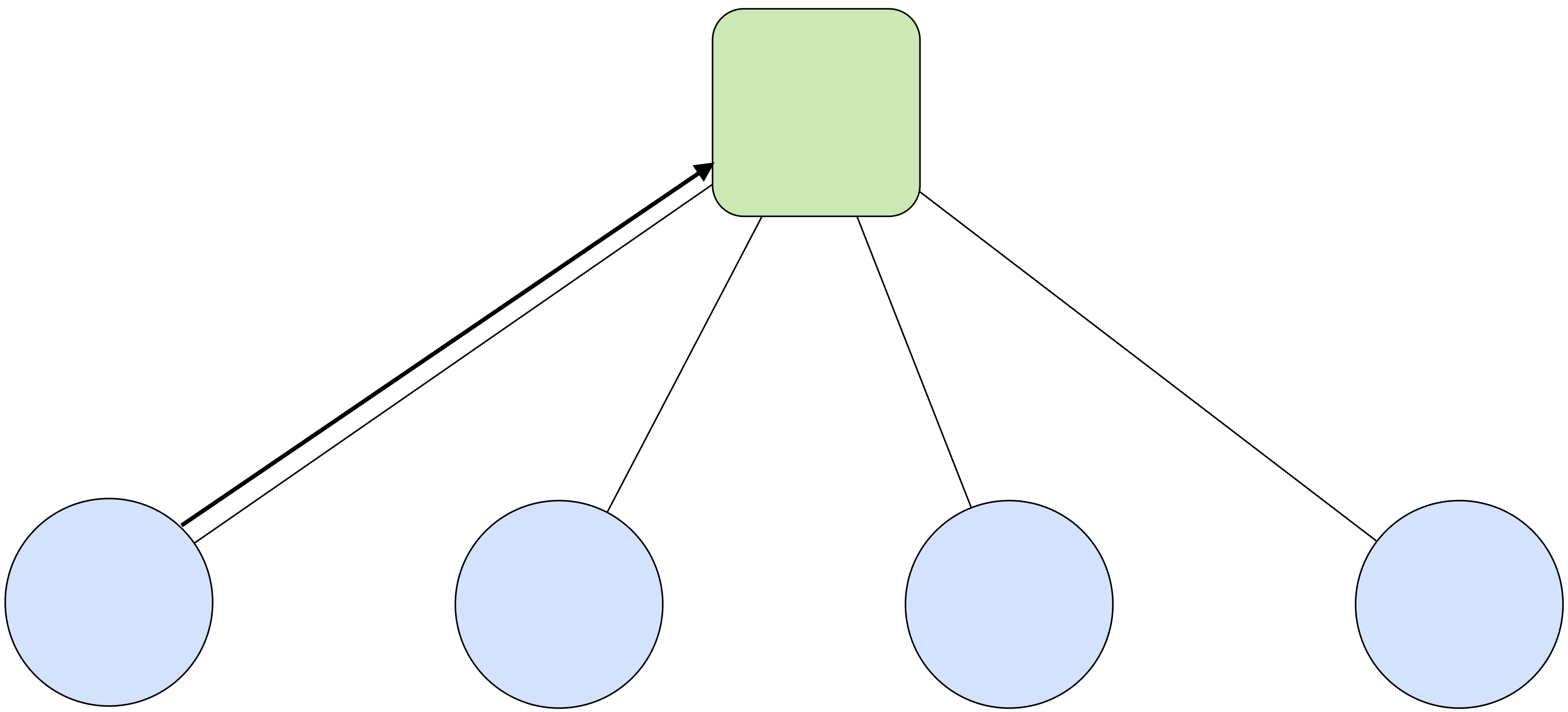
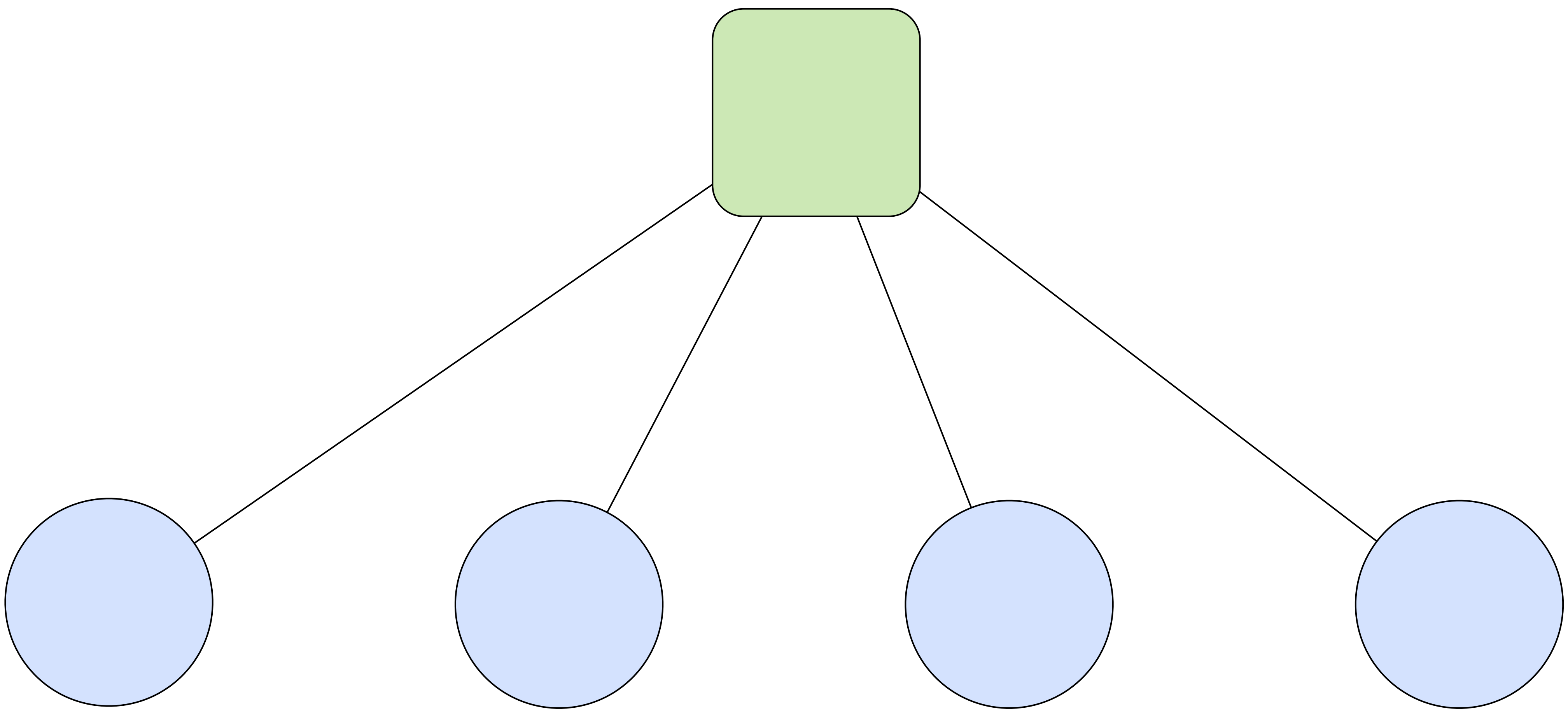


AllForOne
fault handling strategy



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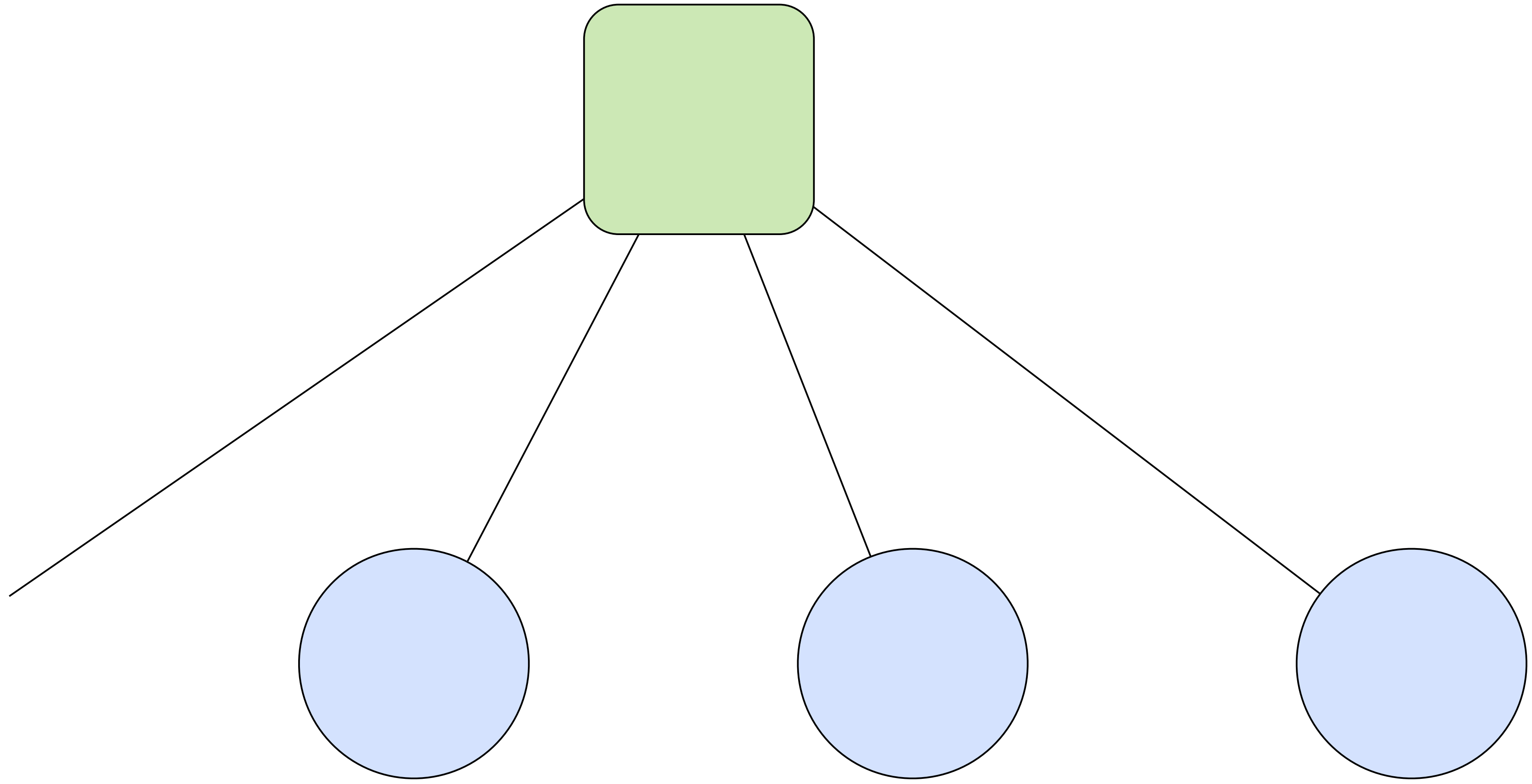

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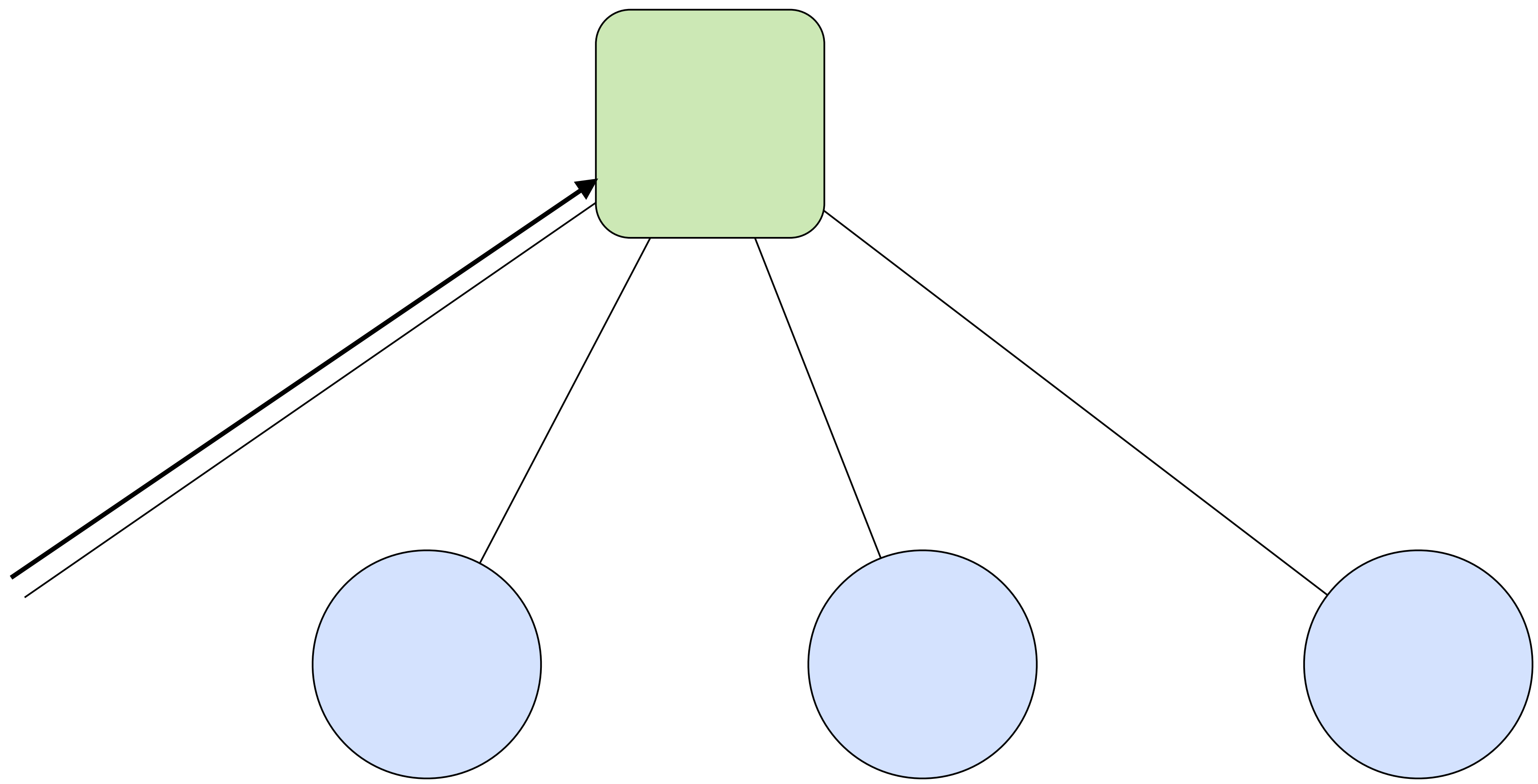

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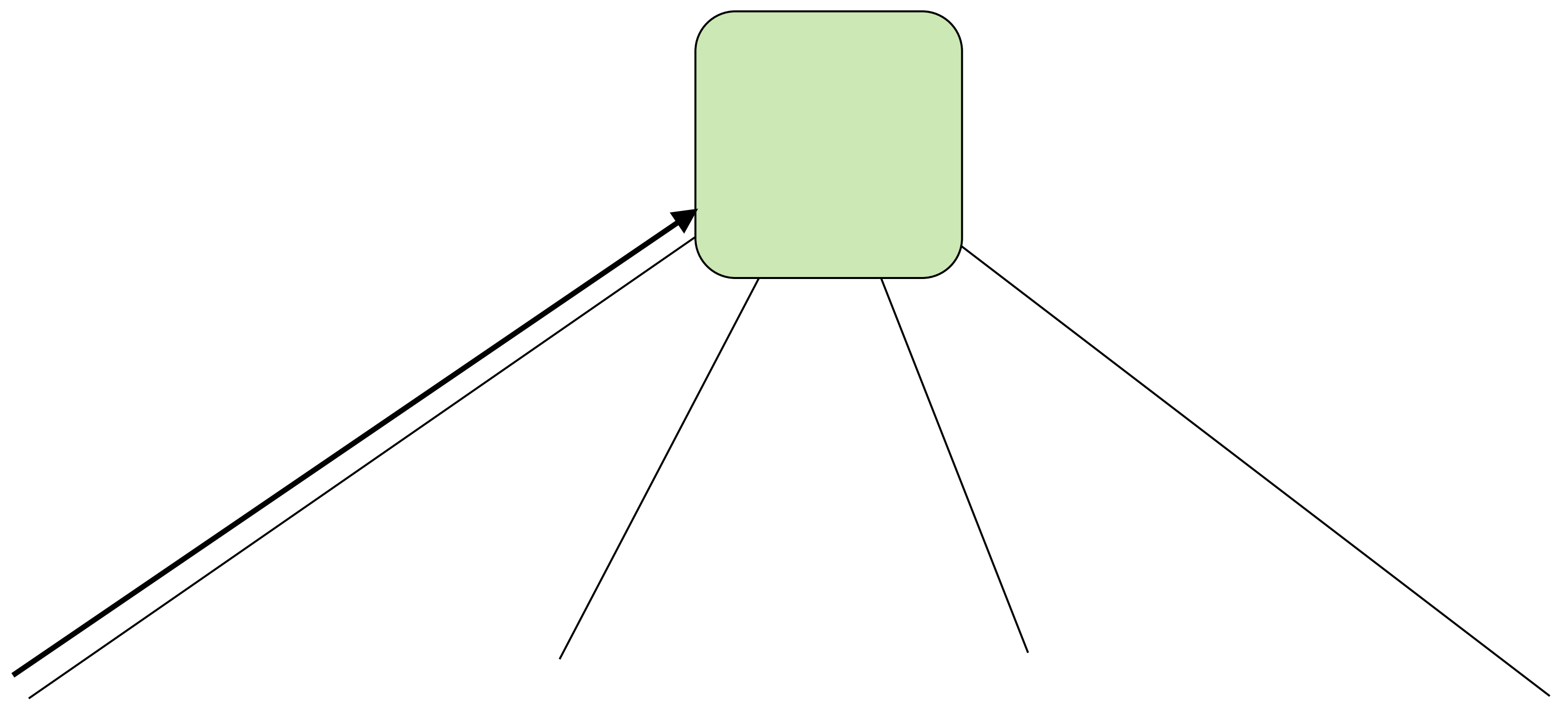

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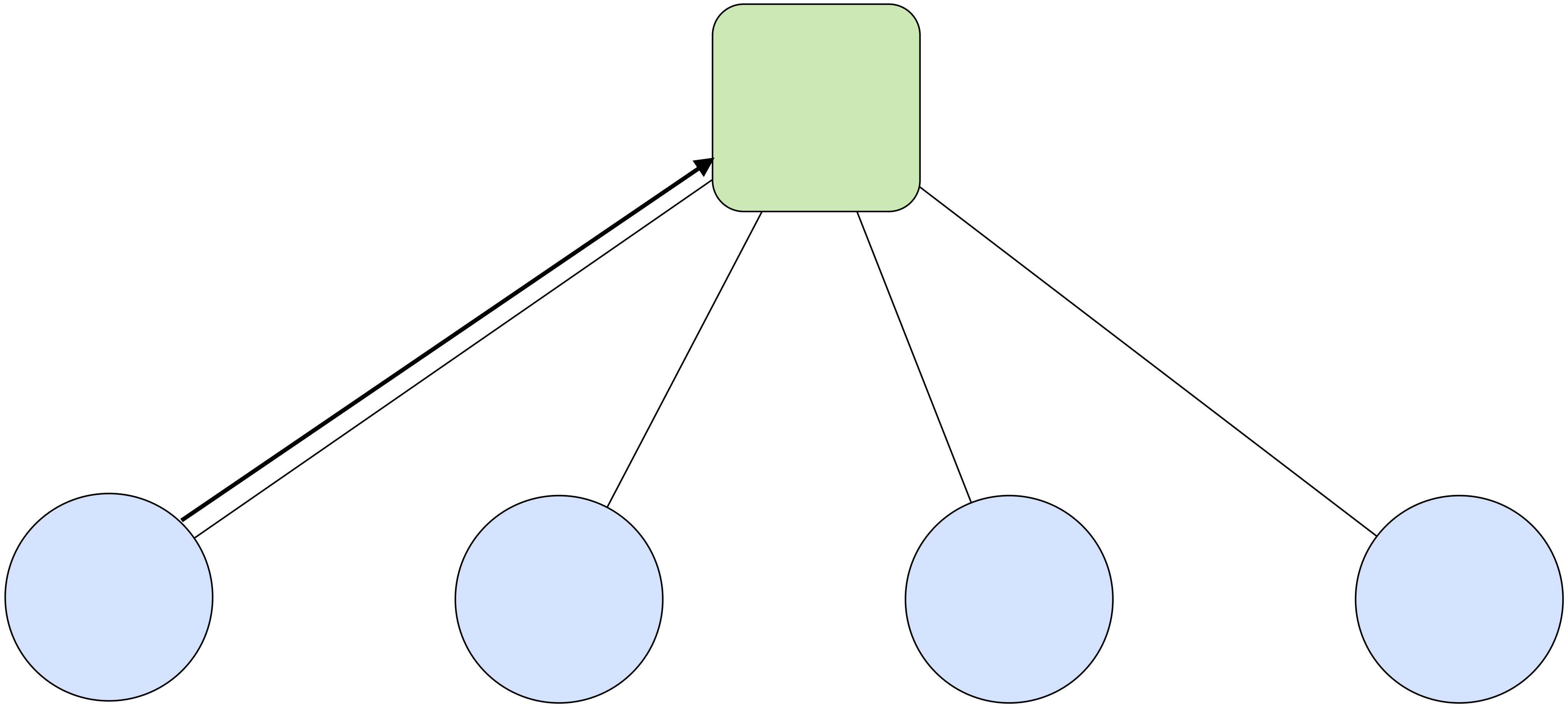
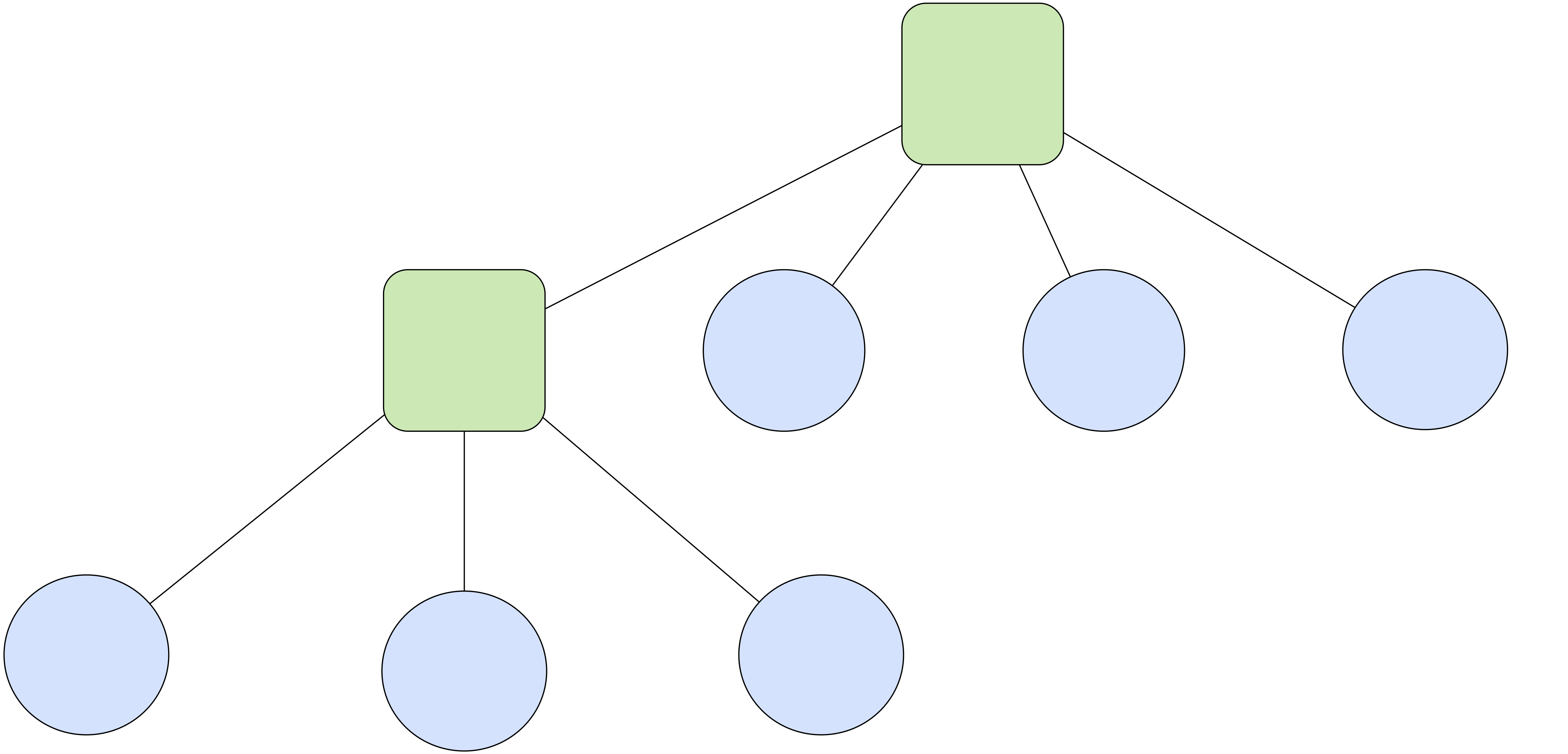


Supervisor hierarchies



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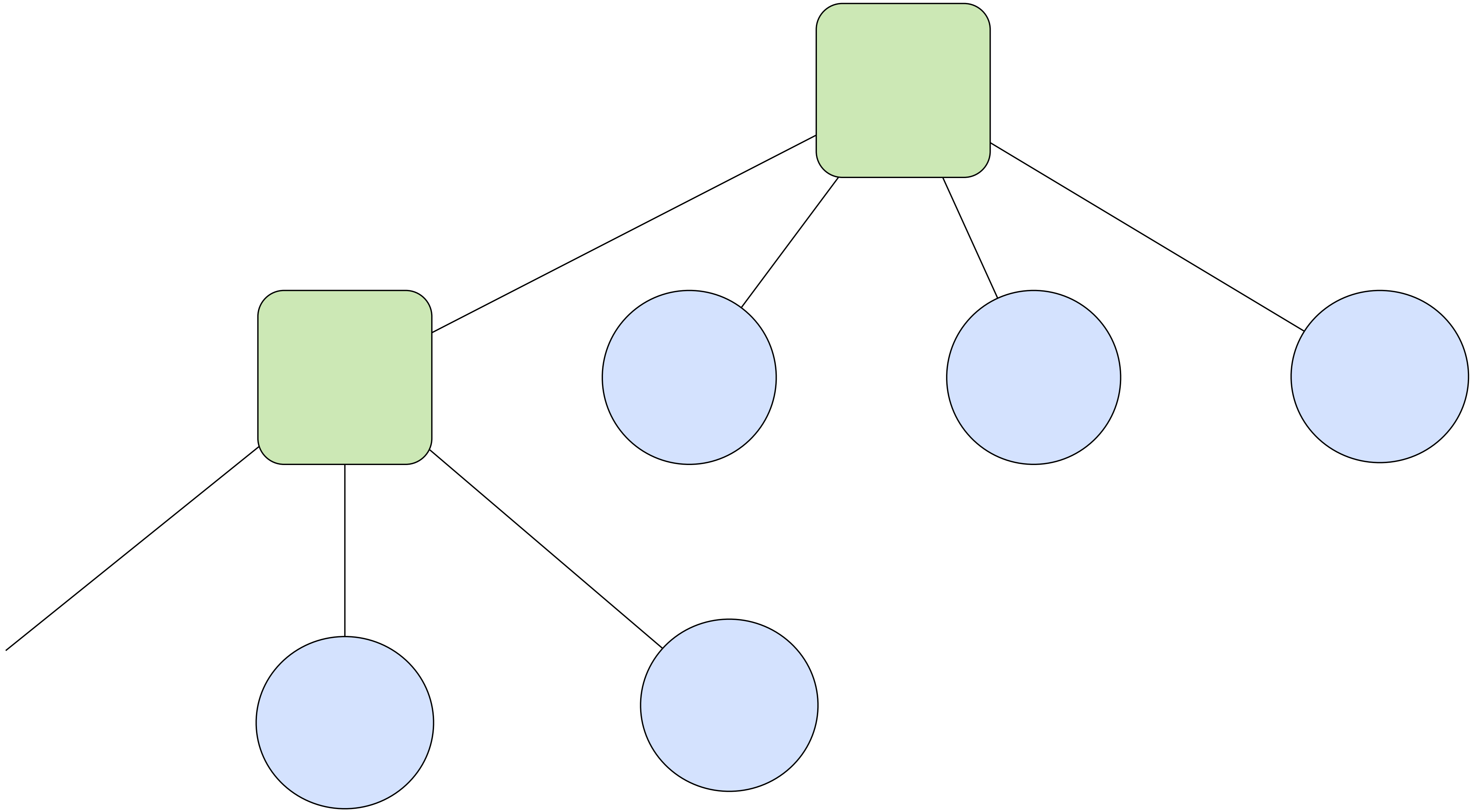

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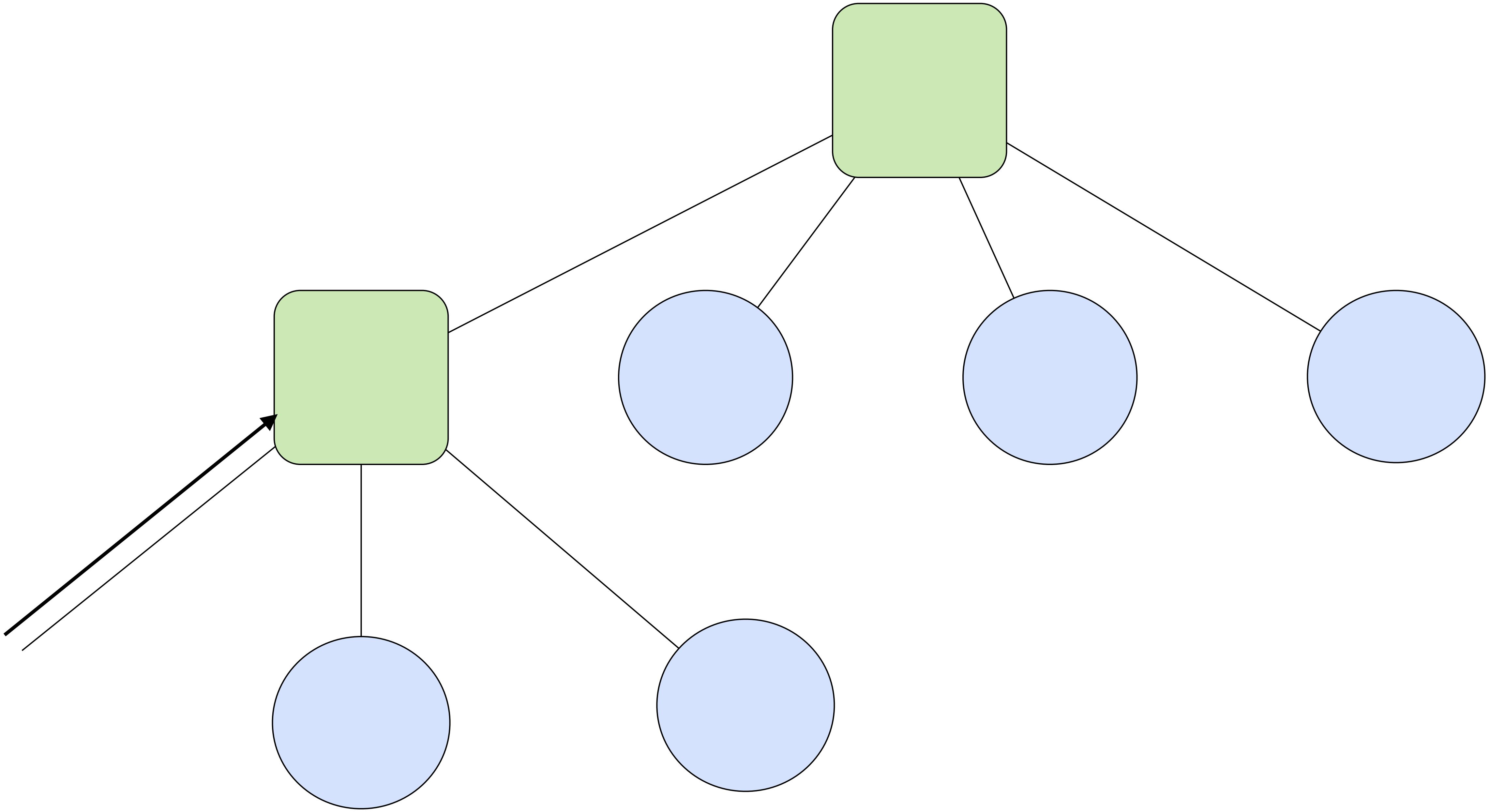

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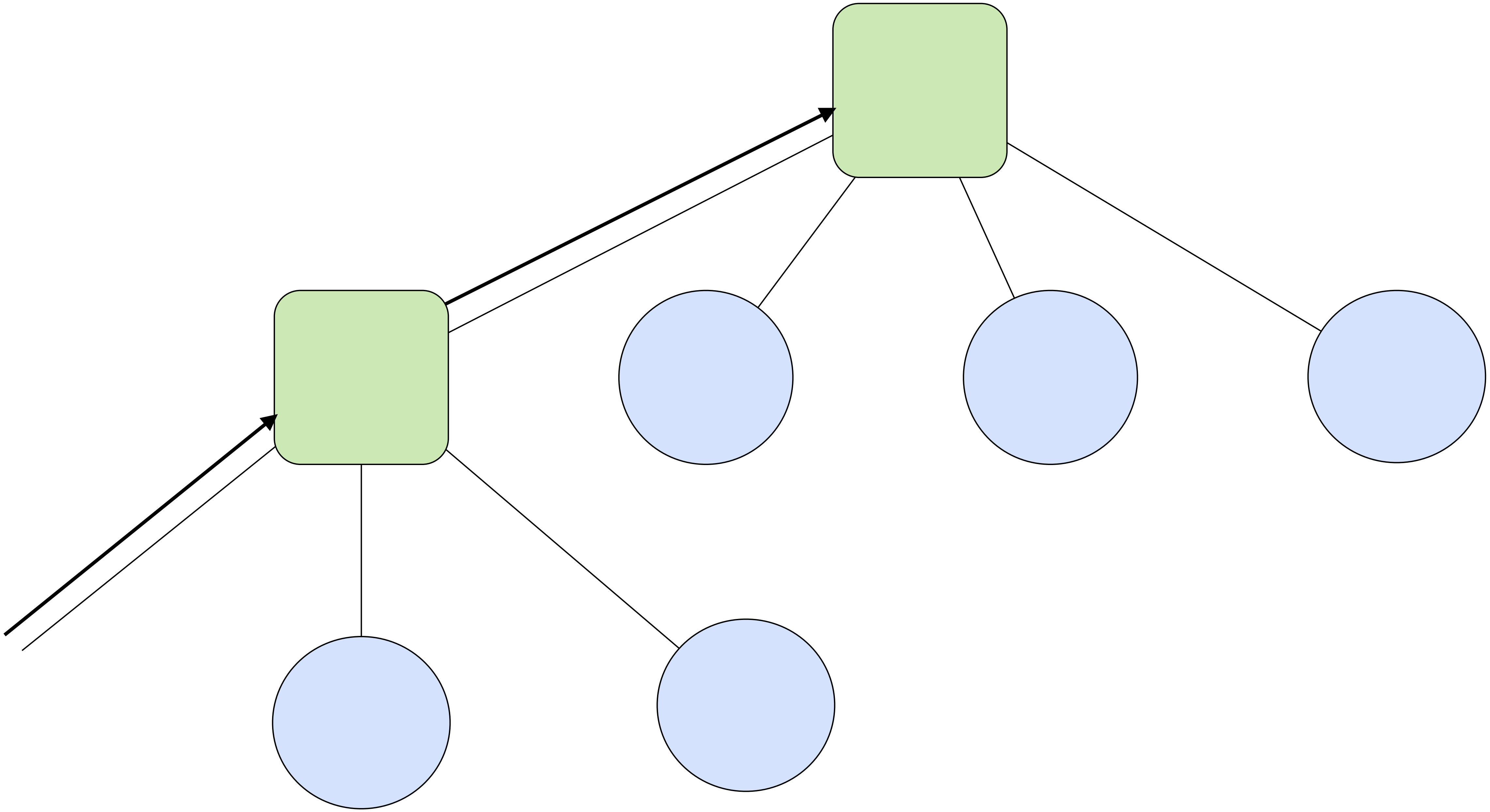

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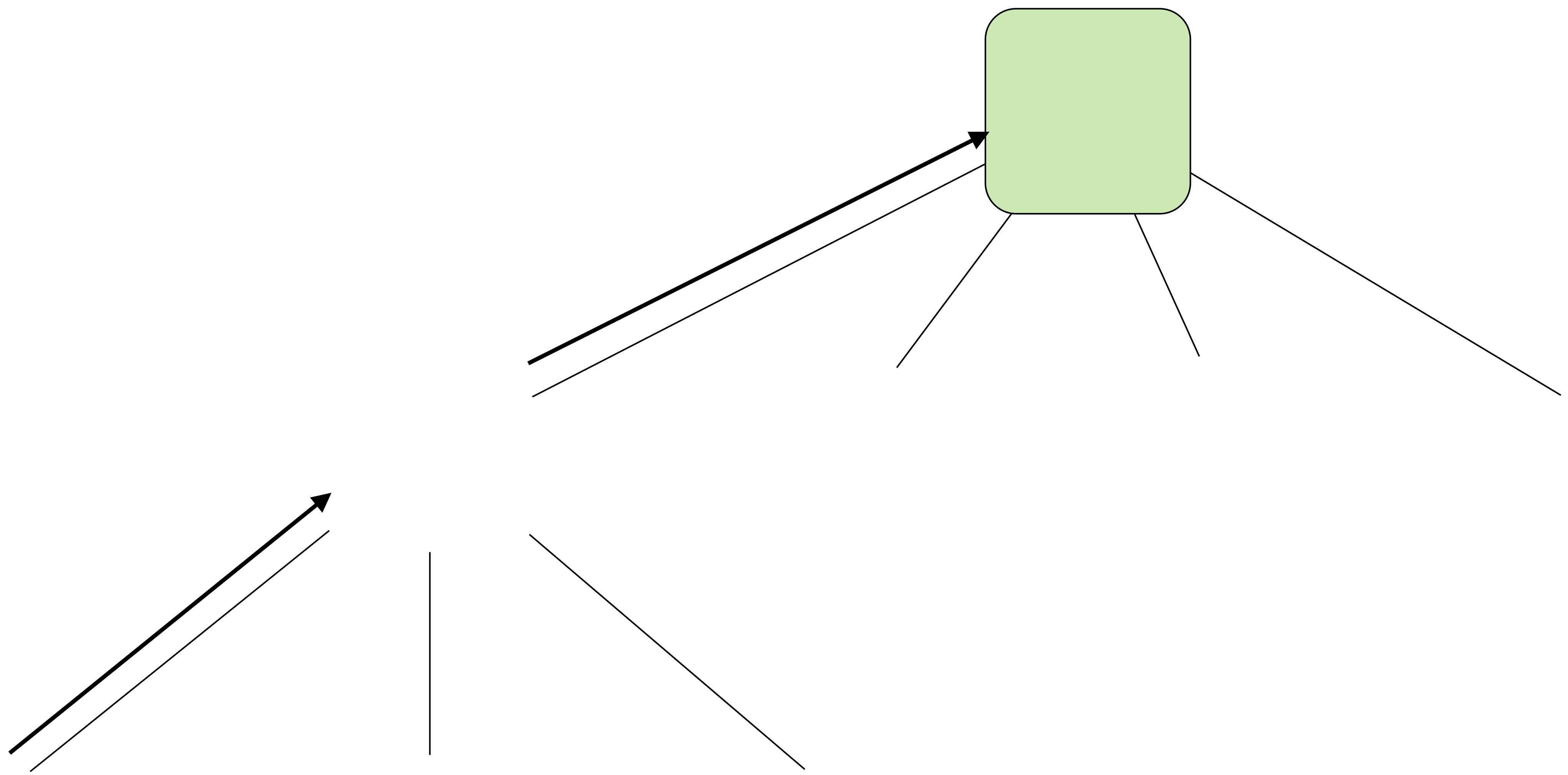

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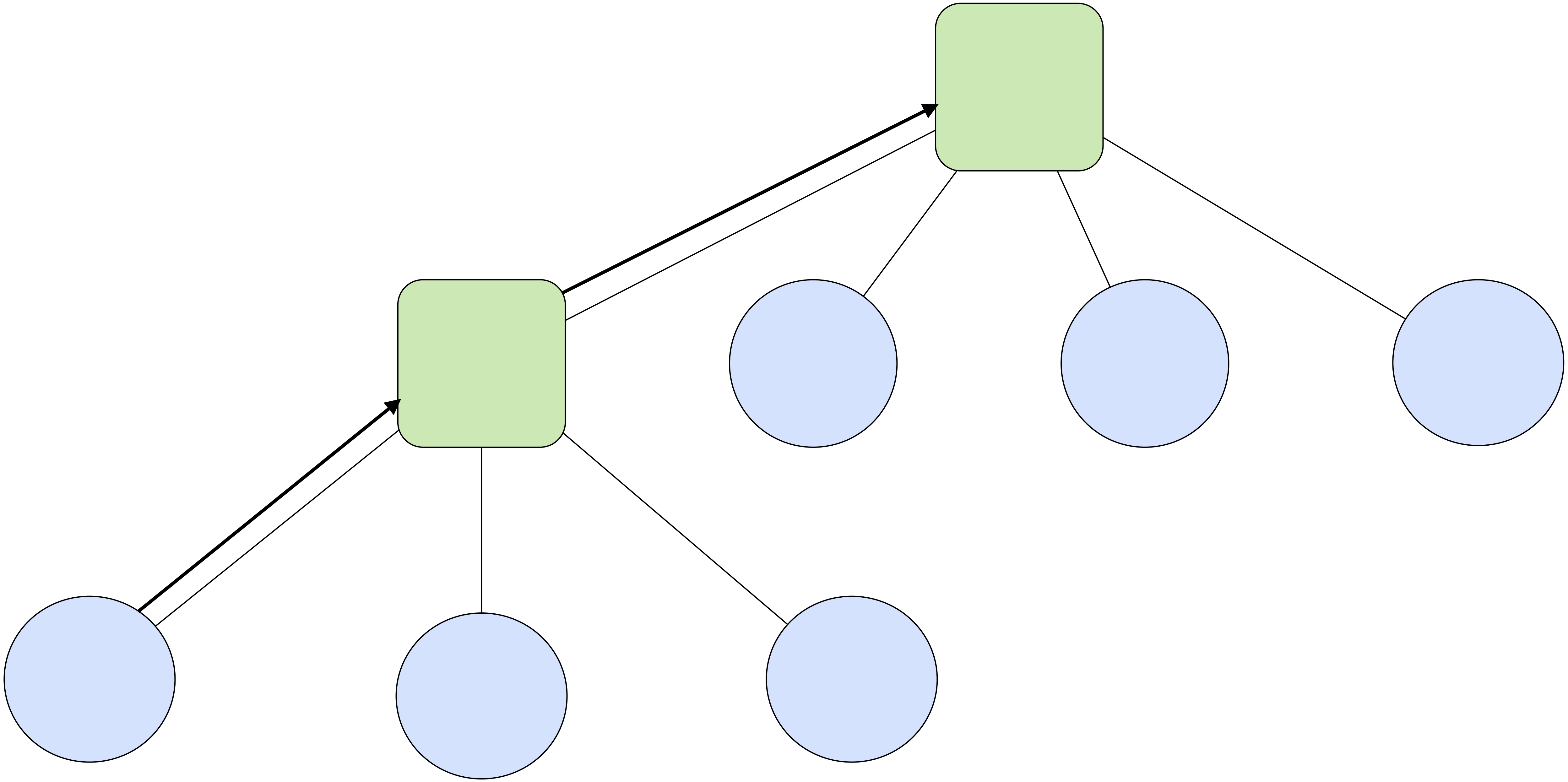


Fault handlers

```
AllForOneStrategy(
  maxNrOfRetries,
  withinTimeRange)

OneForOneStrategy(
  maxNrOfRetries,
  withinTimeRange)
```

Linking

```
link(actor)
unlink(actor)

startLink(actor)
spawnLink[MyActor]
```

trapExit

```
trapExit = List(
  classOf[ServiceException],
  classOf[PersistenceException])
```

Supervision

```
class Supervisor extends Actor {
  trapExit = List(classOf[Throwable])
  faultHandler =
    Some(OneForOneStrategy(5, 5000))

  def receive = {
    case Register(actor) =>
      link(actor)
  }
}
```

Manage failure

```
class FaultTolerantService extends Actor {
  ...
  override def preRestart(reason: Throwable) = {
    ... // clean up before restart
  }
  override def postRestart(reason: Throwable) = {
    ... // init after restart
  }
}
```

Remote Actors

Remote Server

```
// use host & port in config
RemoteNode.start

RemoteNode.start("localhost", 9999)
```

Scalable implementation based on NIO (Netty) & Protobuf

Two types of
remote actors

- Client managed
- Server managed

Client-managed

supervision works across nodes

```
// methods in Actor class

spawnRemote[MyActor](host, port)

spawnLinkRemote[MyActor](host, port)

startLinkRemote(actor, host, port)
```

Client-managed

moves actor to server
client manages through proxy

```
val actorProxy = spawnLinkRemote[MyActor](
  “darkstar”,
  9999)

actorProxy ! message
```

Server-managed

register and manage actor on server

client gets "dumb" proxy handle

```
RemoteNode.register("service:id", actorOf[MyService])
```

server part

Server-managed

```
val handle = RemoteClient.actorFor(
  “service:id”,
  “darkstar”,
  9999)

handle ! message
```

client part

Cluster Membership

```
Cluster.relayMessage(
  classOf[TypeOfActor], message)

for (endpoint <- Cluster)
  spawnRemote[TypeOfActor](
                  endpoint.host,
                  endpoint.port)
```

STM

yet another tool in the toolbox

What is STM?

STM: overview

- See the memory (heap and stack) as a transactional dataset
- Similar to a database
  - begin
  - commit
  - abort/rollback
- Transactions are retried automatically upon collision
- Rolls back the memory on abort

Managed References

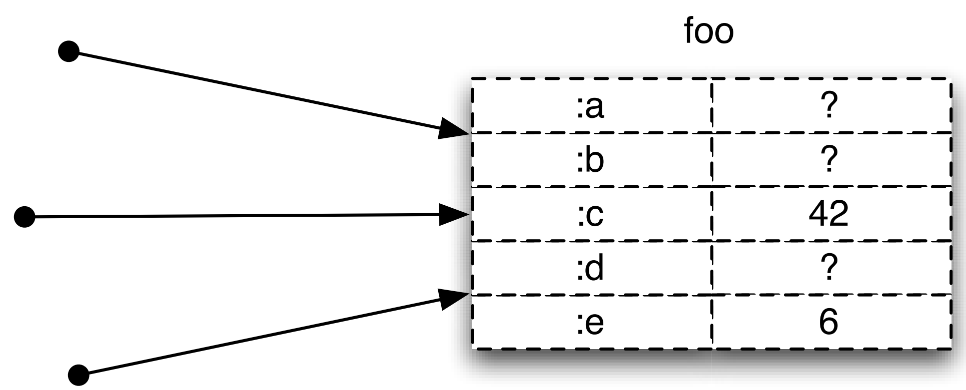
- Separates Identity from Value
  - Values are immutable
  - Identity (Ref) holds Values
- Change is a function
- Compare-and-swap (CAS)
- Abstraction of time
- Must be used within a transaction

atomic

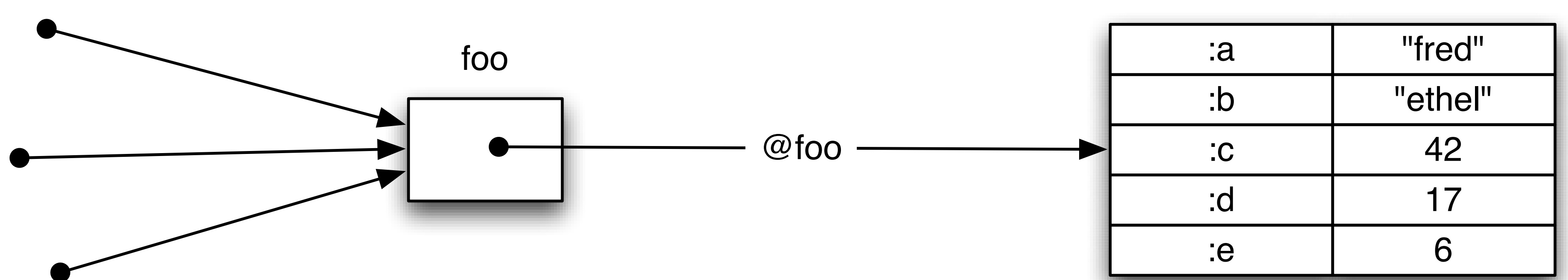
```scala
import se.scalablesolutions.akka.stm.local._

atomic {
  ...

  atomic {
    ... // transactions compose!!!
  }
}
```

Managed References

Typical OO: direct access to mutable objects



Managed Reference: separates Identity & Value



Managed References

- Separates Identity from Value
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- Change is a function
- Compare-and-swap (CAS)
- Abstraction of time
- Must be used within a transaction

Managed References

```scala
import se.scalablesolutions.akka.stm.local._

// giving an initial value
val ref = Ref(0)

// specifying a type but no initial value
val ref = Ref[Int]
```

Managed References

```
val ref = Ref(0)

atomic {
  ref.set(5)
}
// -> 0

atomic {
  ref.get
}
// -> 5
```

Managed References

```scala
val ref = Ref(0)

atomic {
  ref alter (_ + 5)
}
// -> 5

val inc = (i: Int) => i + 1

atomic {
  ref alter inc
}
// -> 6
```

Managed References

```
val ref = Ref(1)
val anotherRef = Ref(3)

atomic {
  for {
    value1 <- ref
    value2 <- anotherRef
  } yield (value1 + value2)
}
// -> Ref(4)

val emptyRef = Ref[Int]

atomic {
  for {
    value1 <- ref
    value2 <- emptyRef
  } yield (value1 + value2)
}
// -> Ref[Int]
```

Transactional datastructures

```scala
// using initial values
val map    = TransactionalMap("bill" -> User("bill"))
val vector = TransactionalVector(Address("somewhere"))

// specifying types
val map    = TransactionalMap[String, User]
val vector = TransactionalVector[Address]
```

life-cycle listeners

```
atomic {
  deferred {
    // executes when transaction commits
  }
  compensating {
    // executes when transaction aborts
  }
}
```

Actors + STM =

Transactors

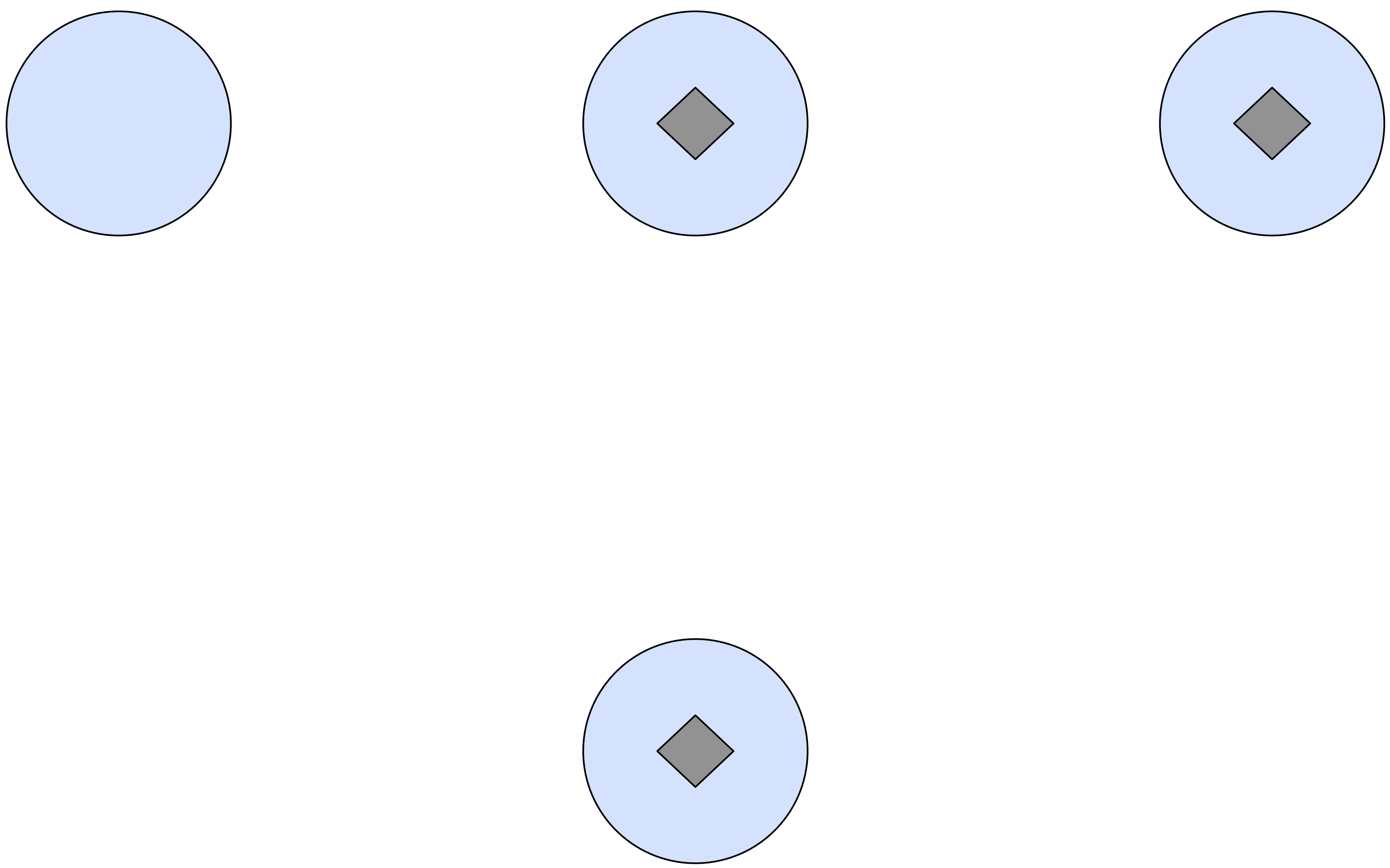
Transactors

```scala
class UserRegistry extends Transactor {

  private lazy val storage =
    TransactionalMap[String, User]()

  def receive = {
    case NewUser(user) =>
      storage + (user.name -> user)
    ...
  }
}
```

Transactors



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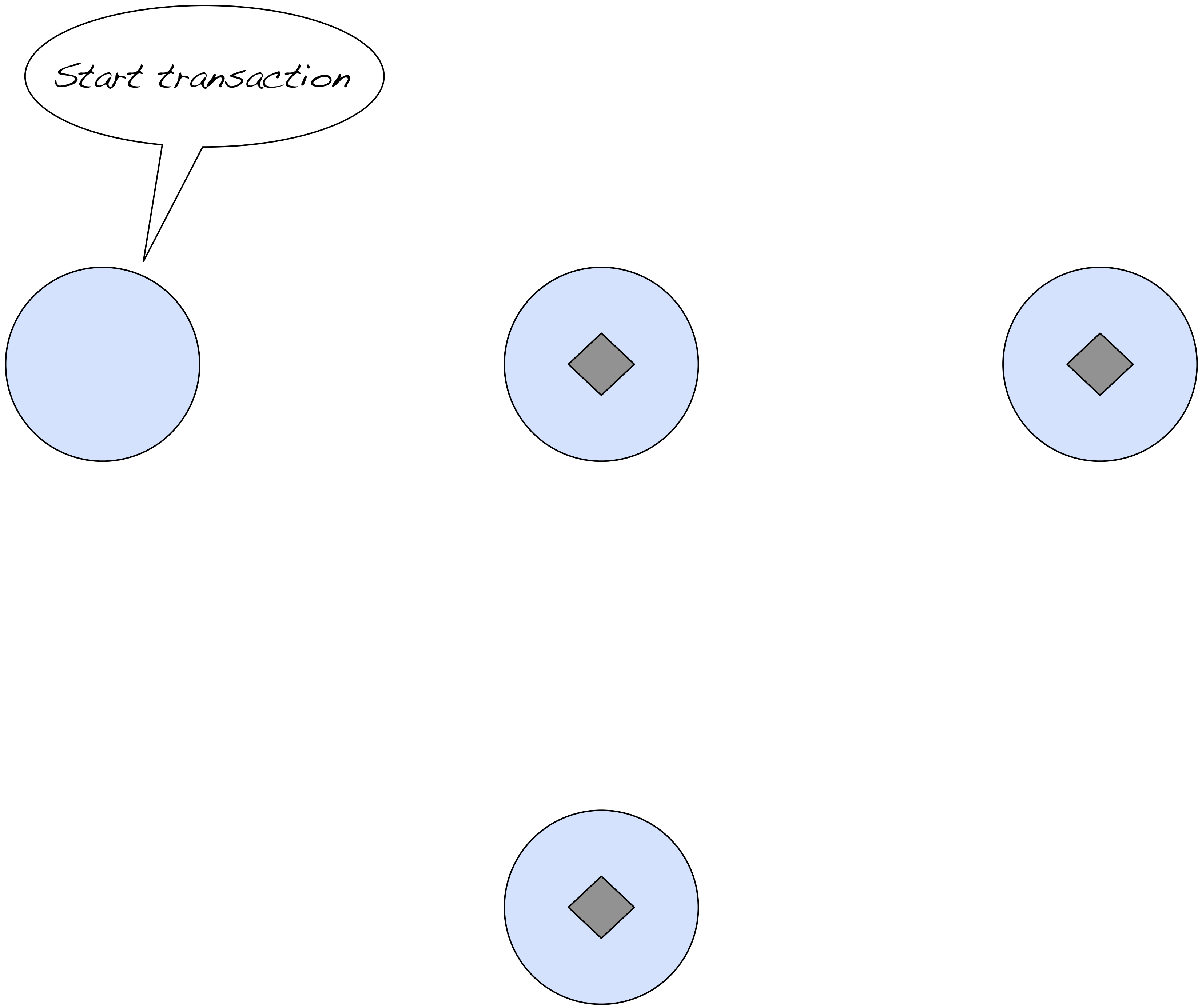

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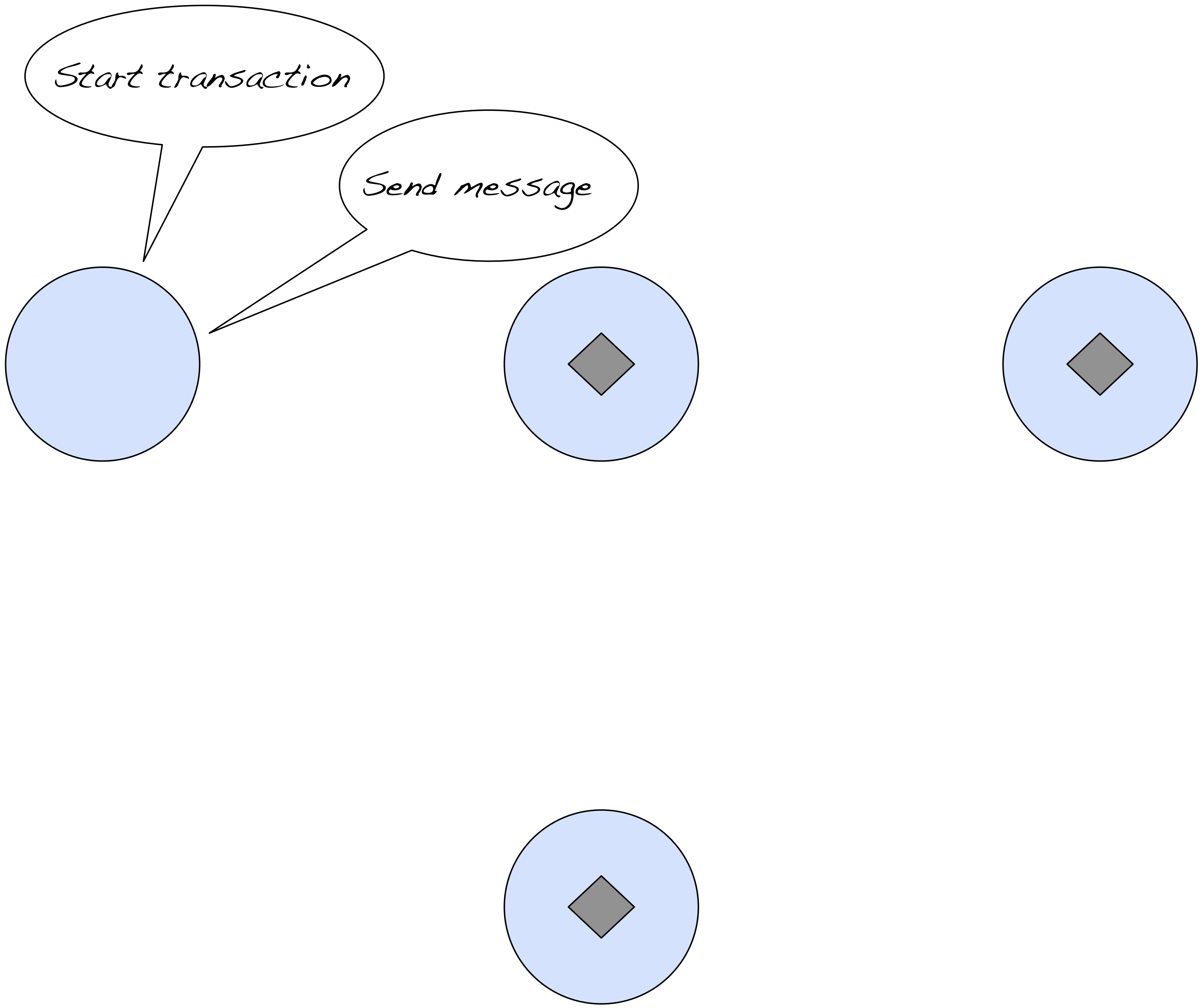

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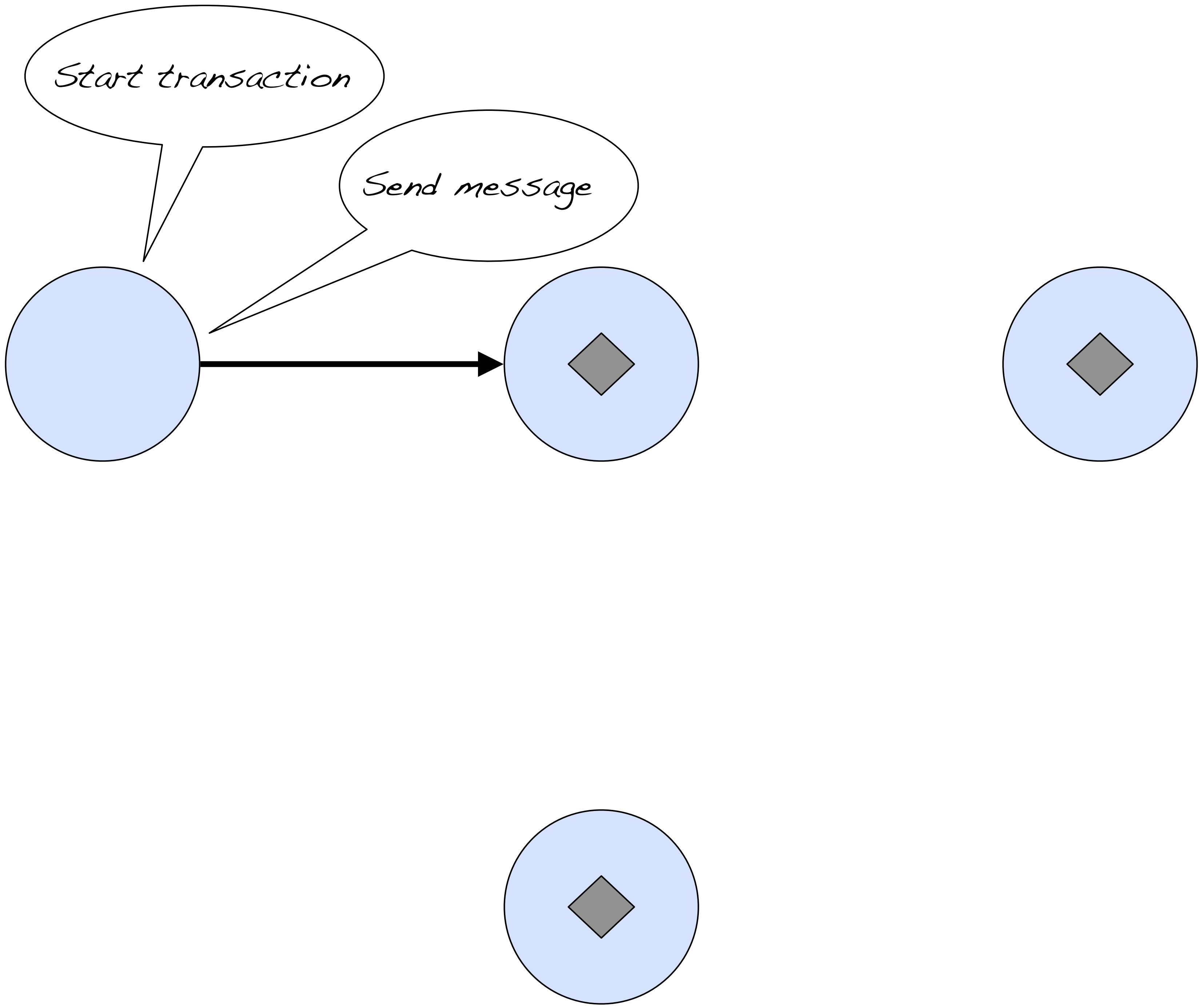

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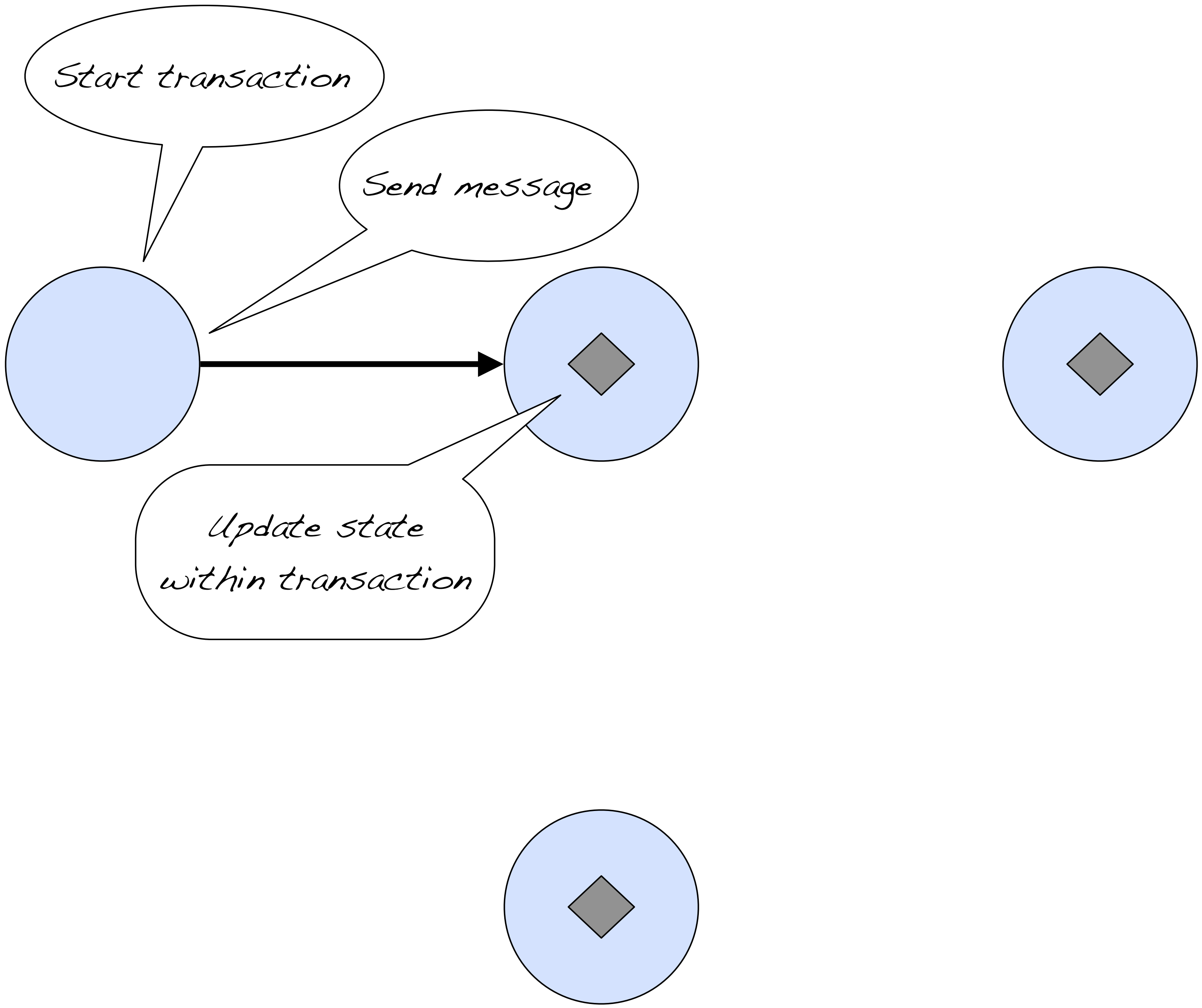

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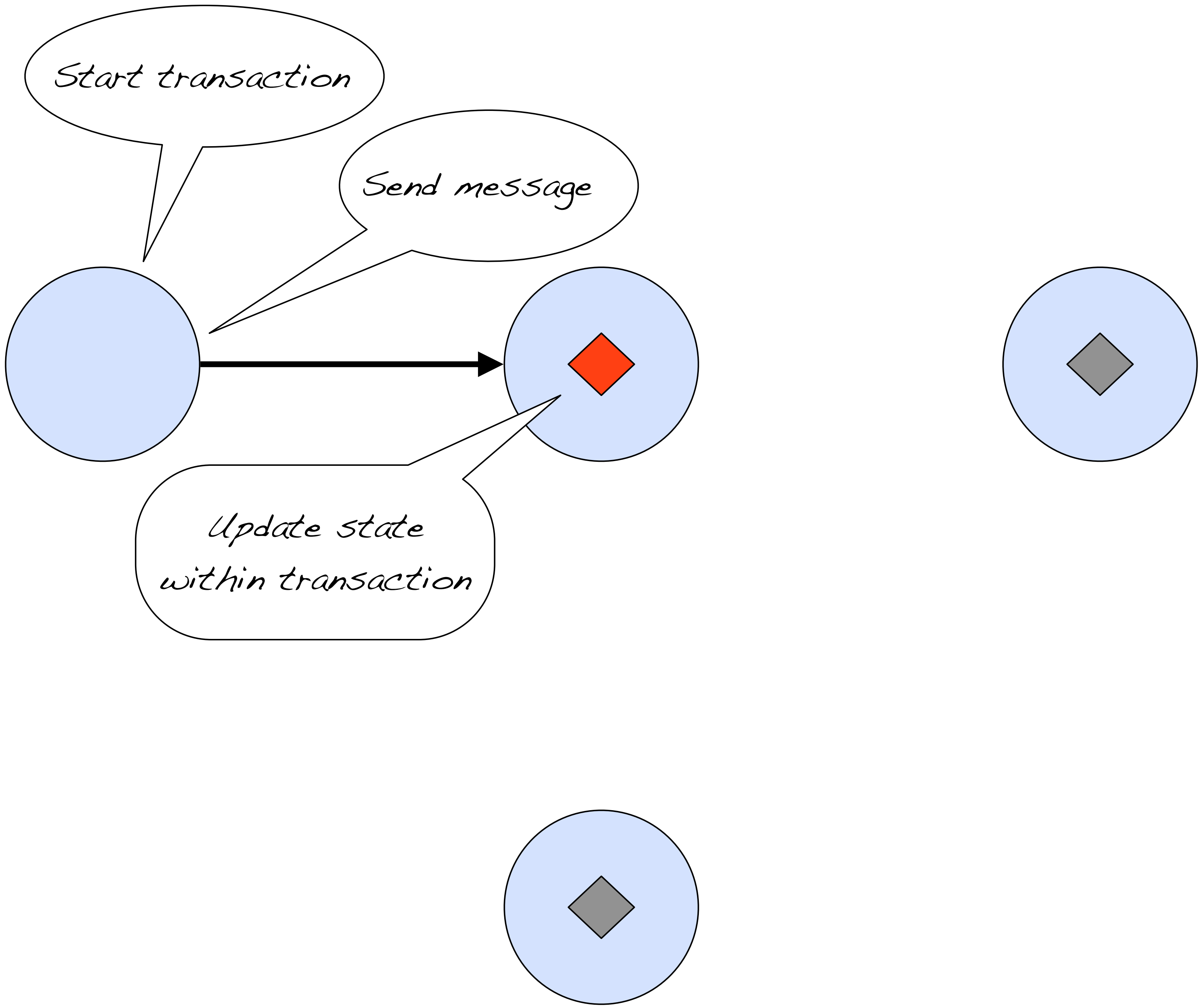

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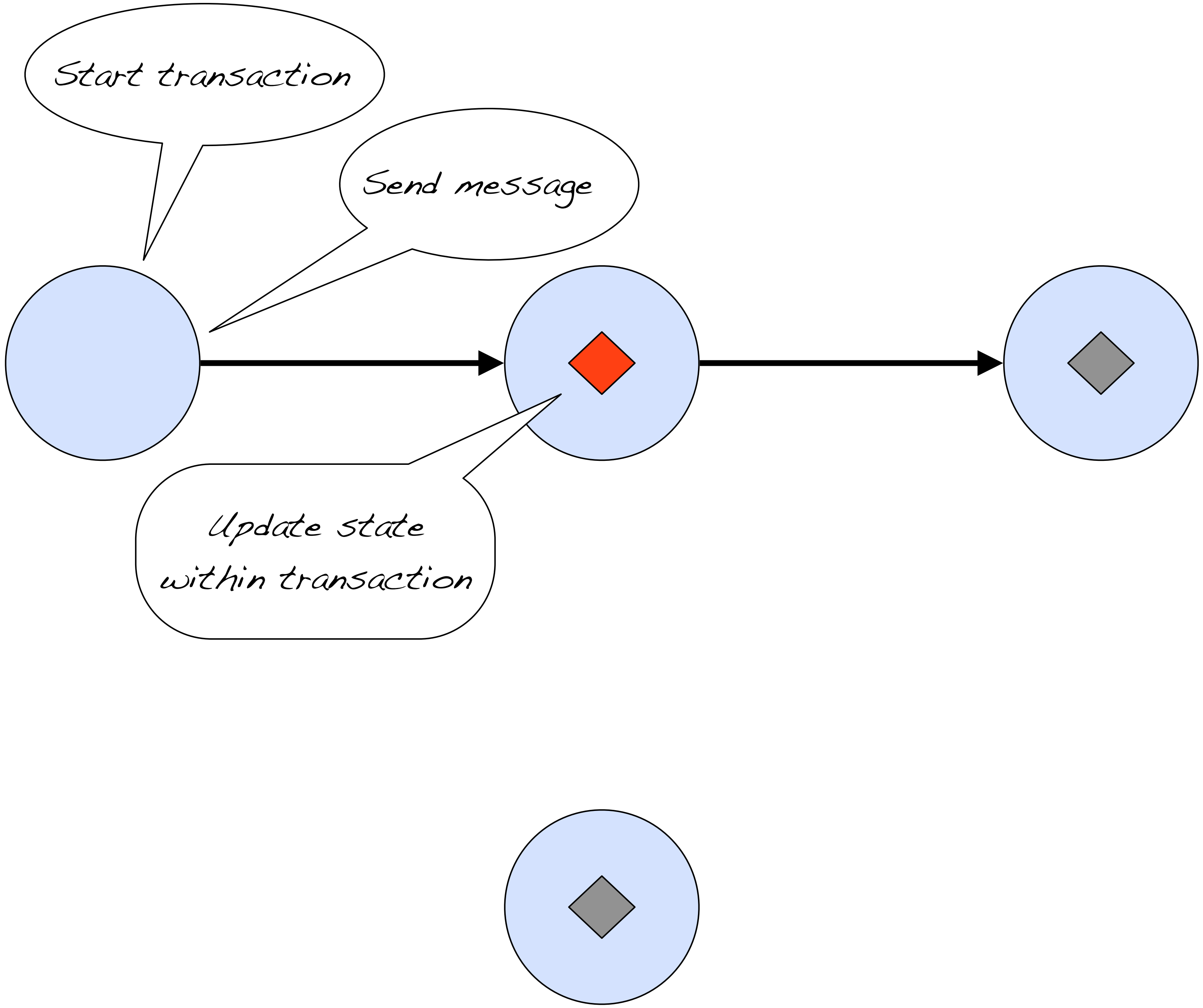

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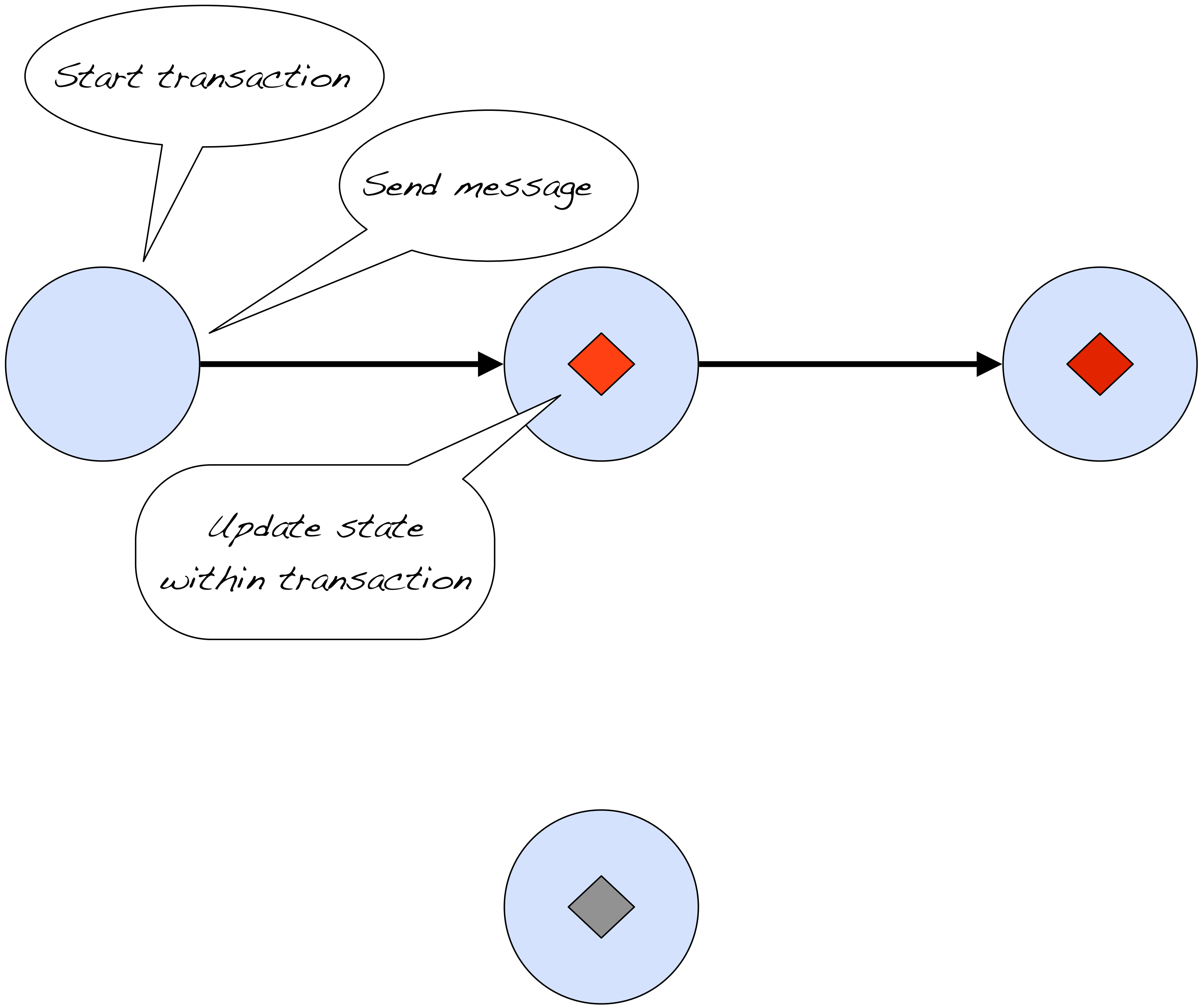

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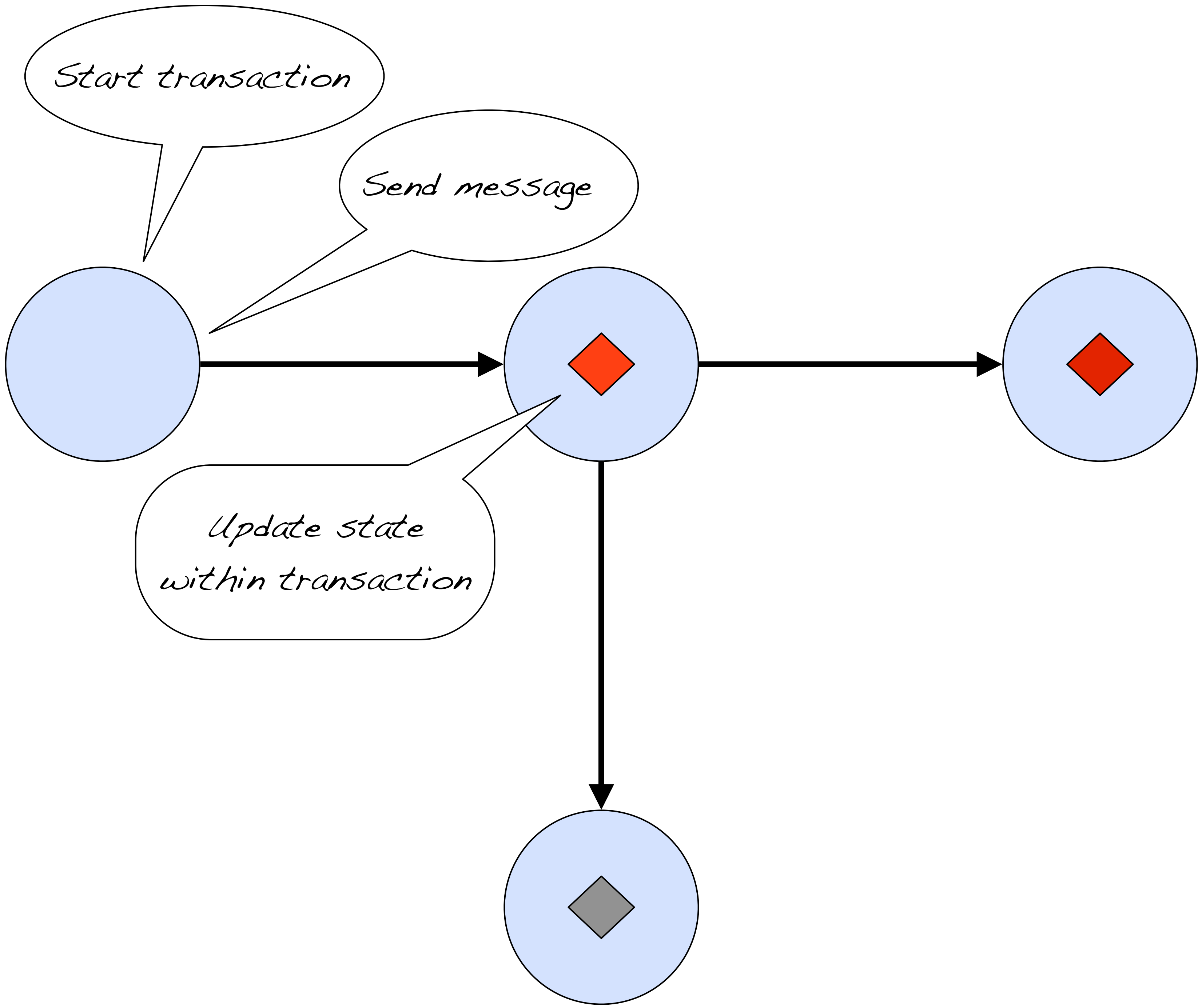

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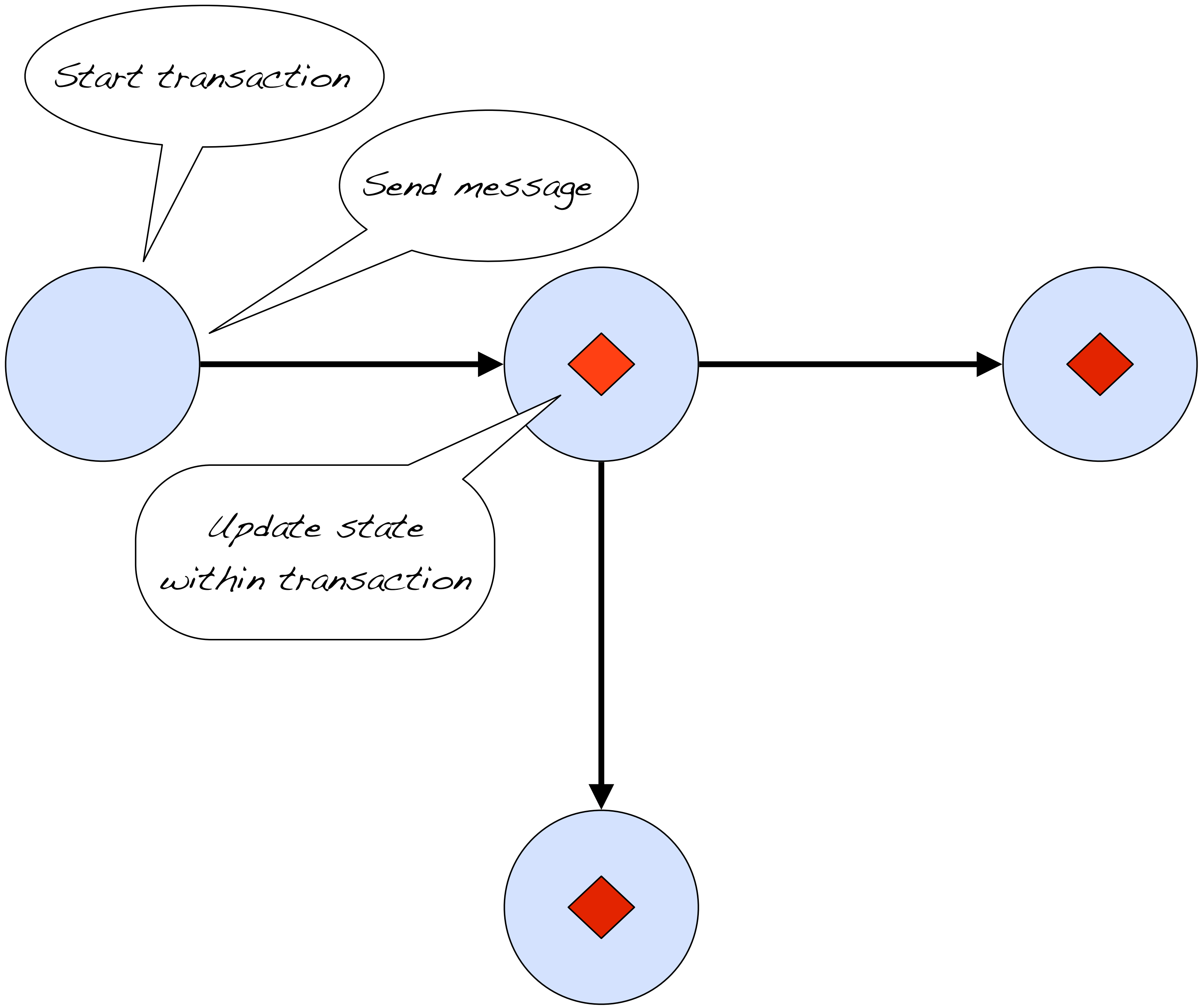

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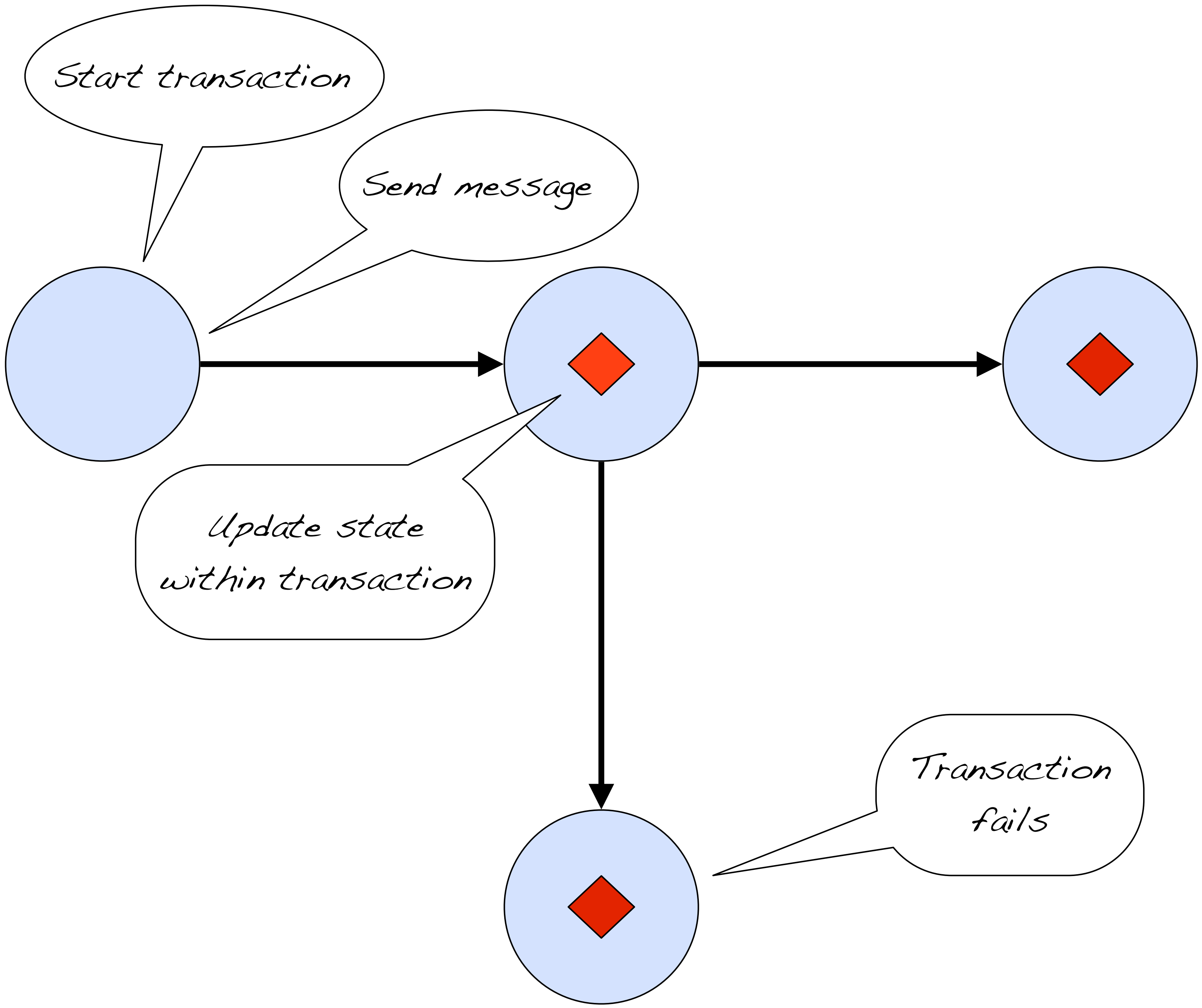

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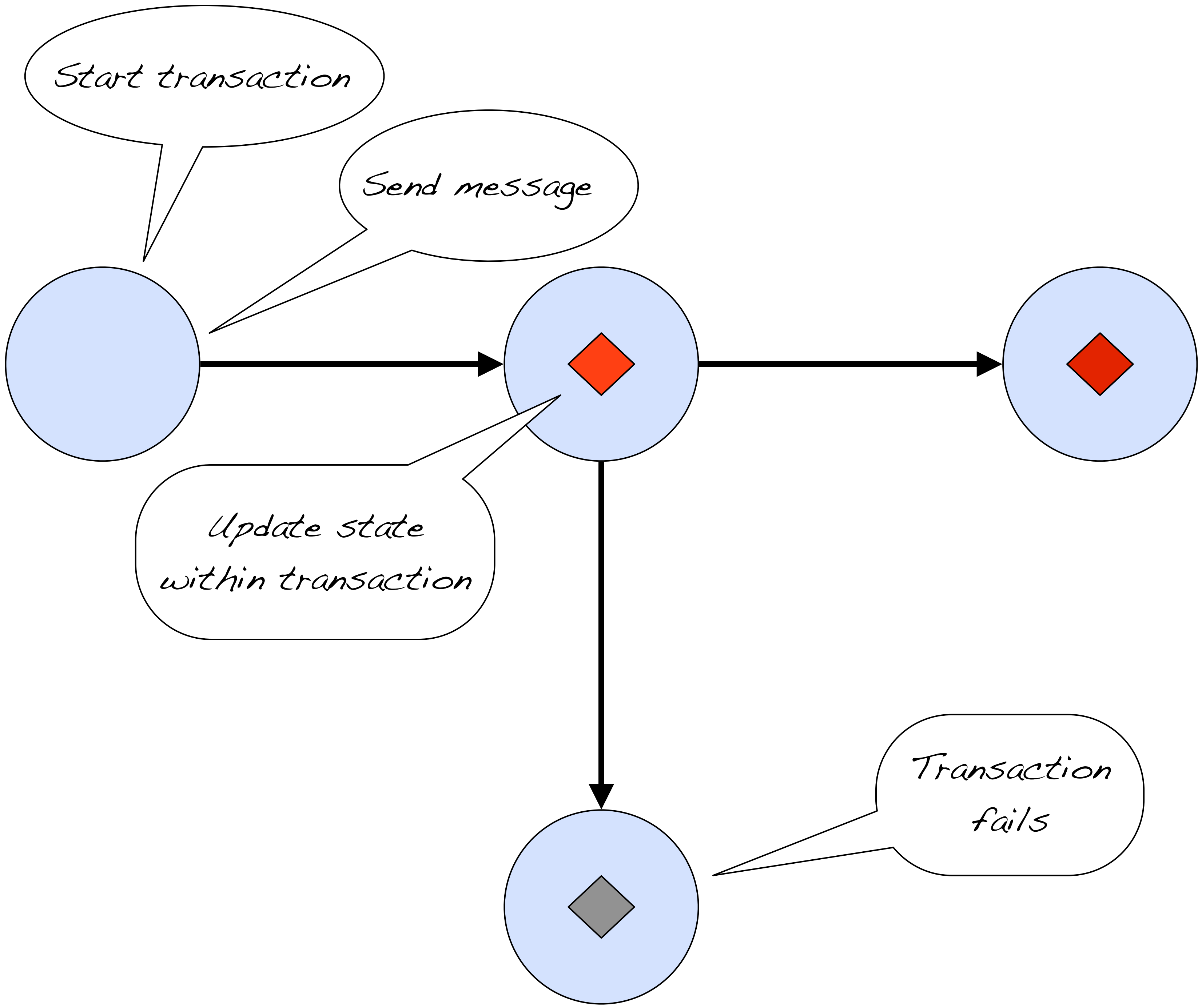

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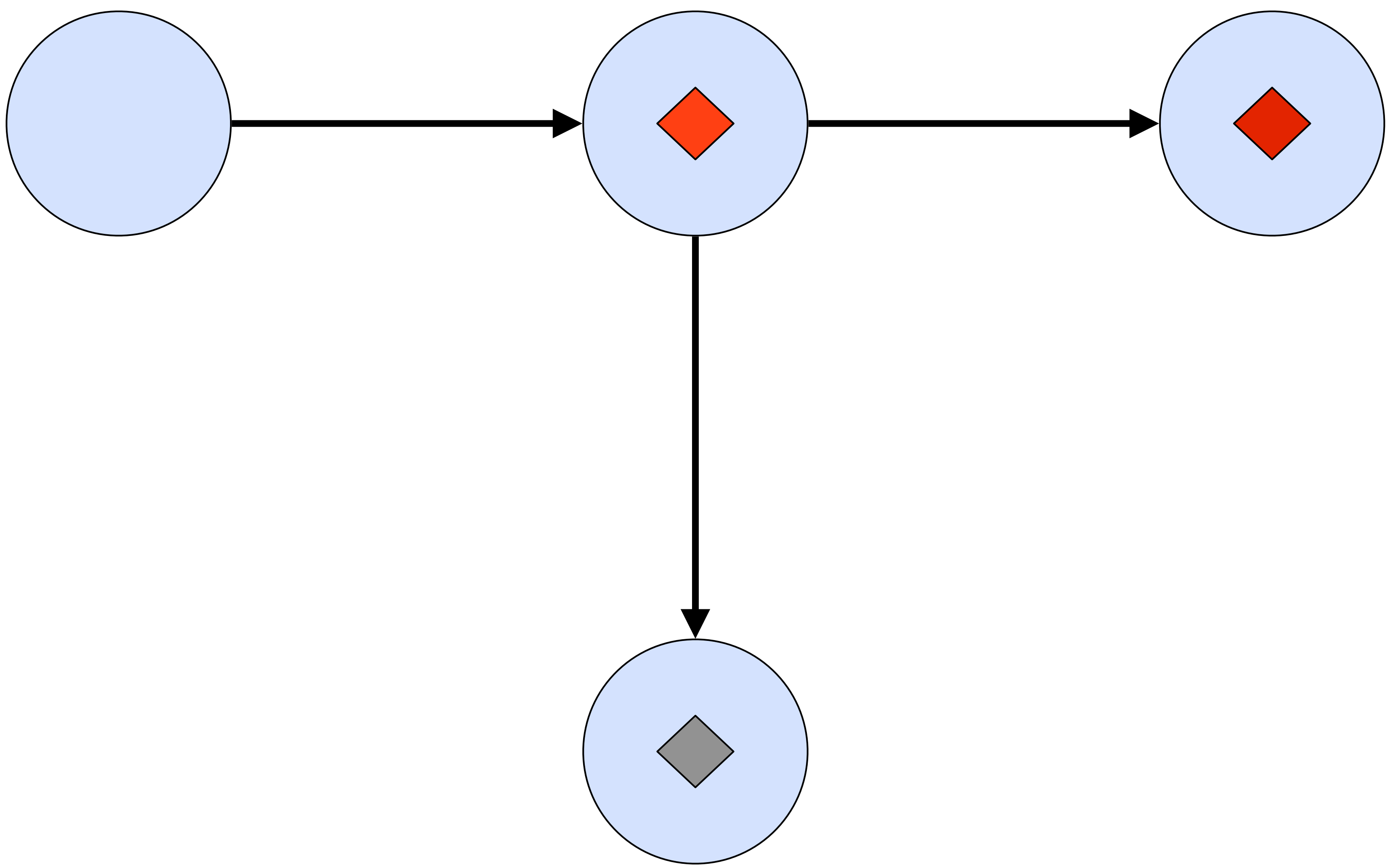
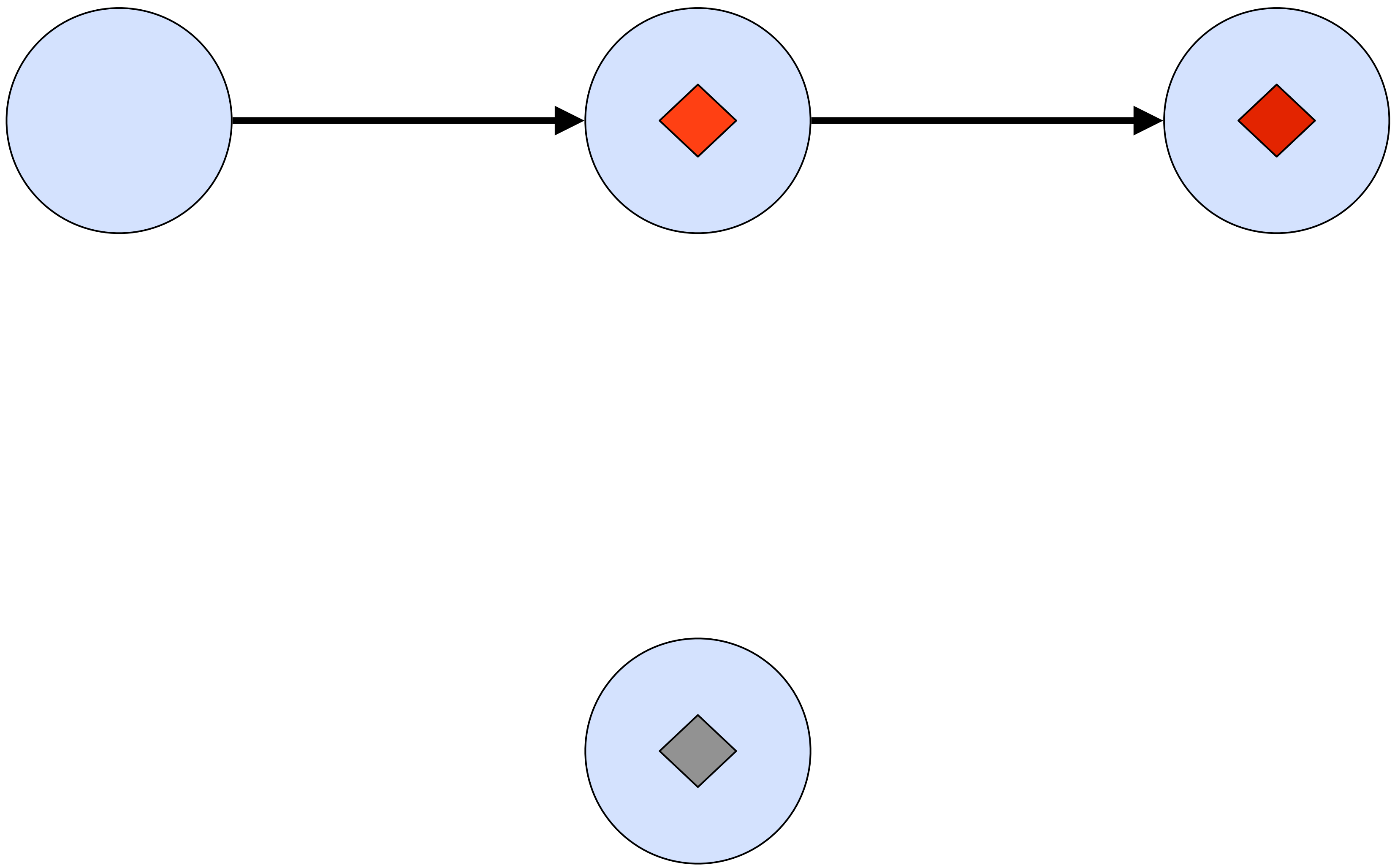
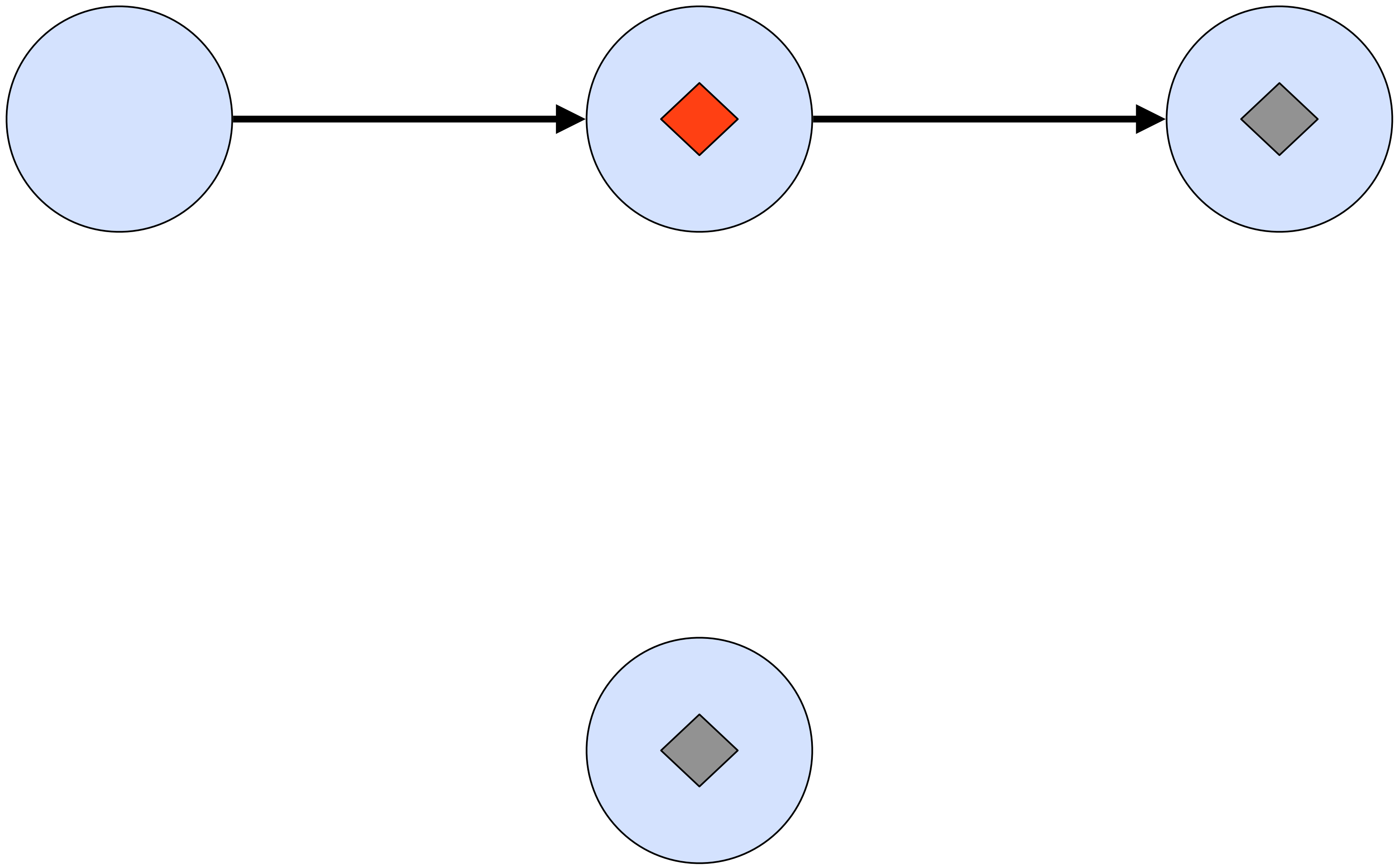


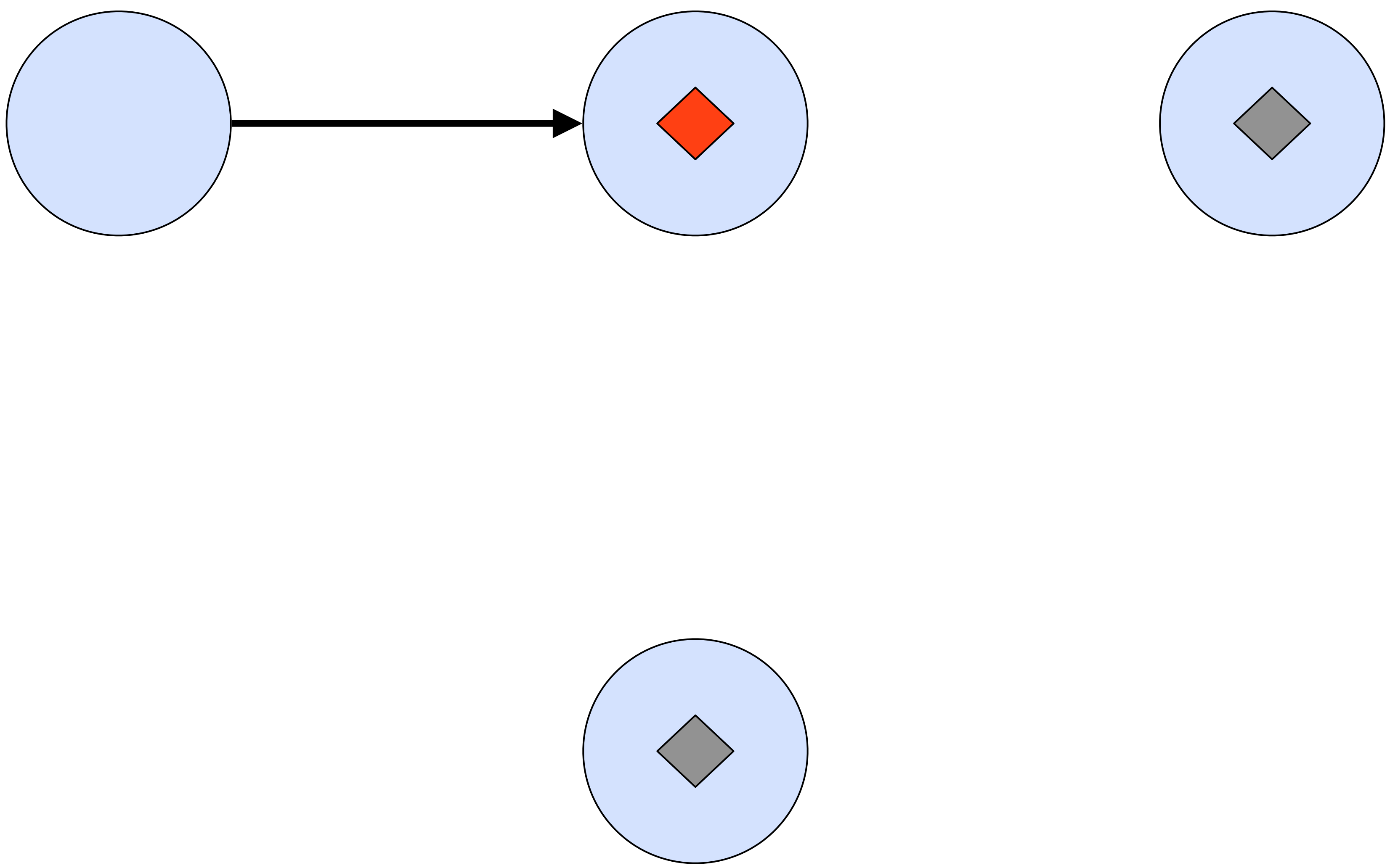
Transactors



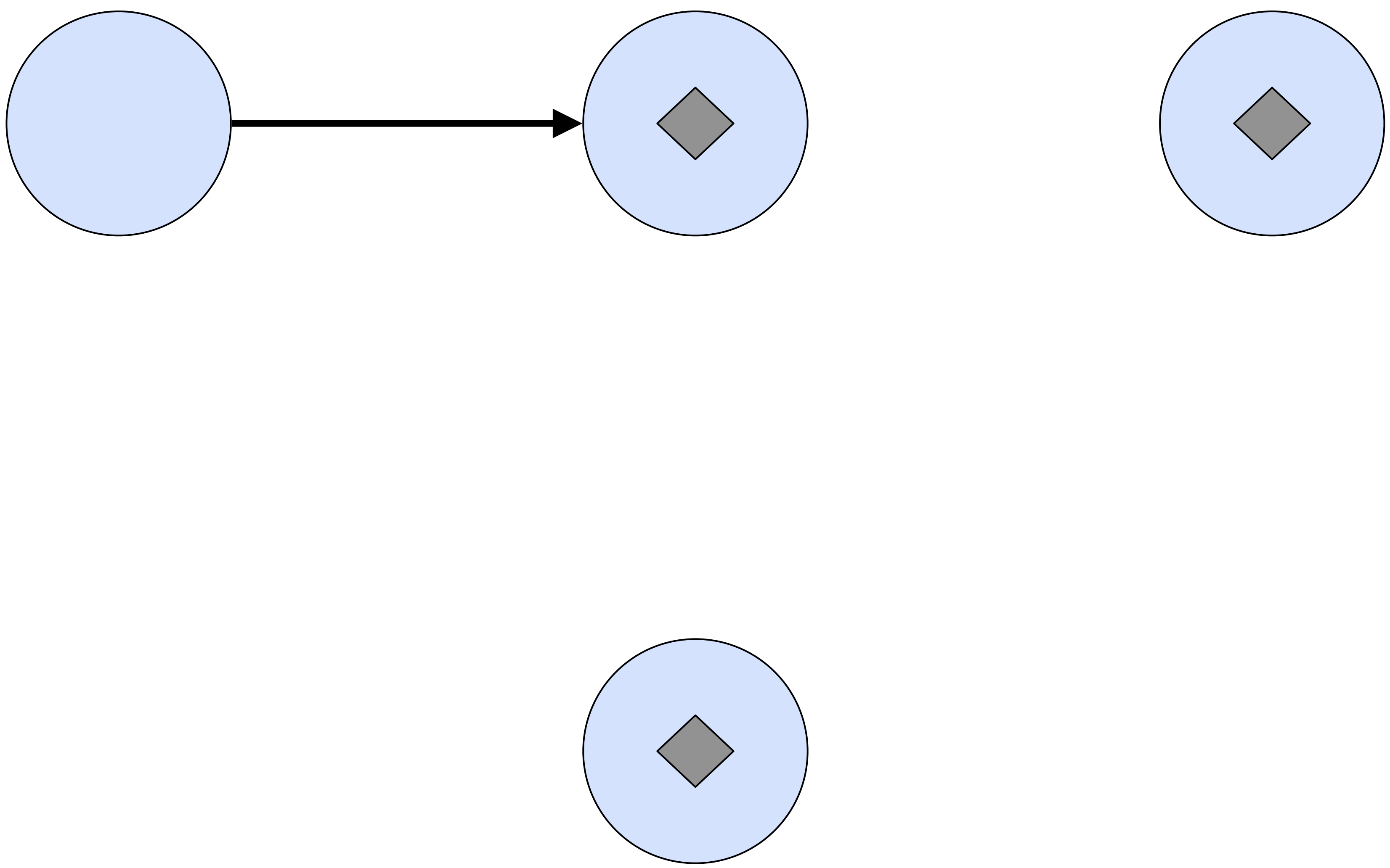
Transactors



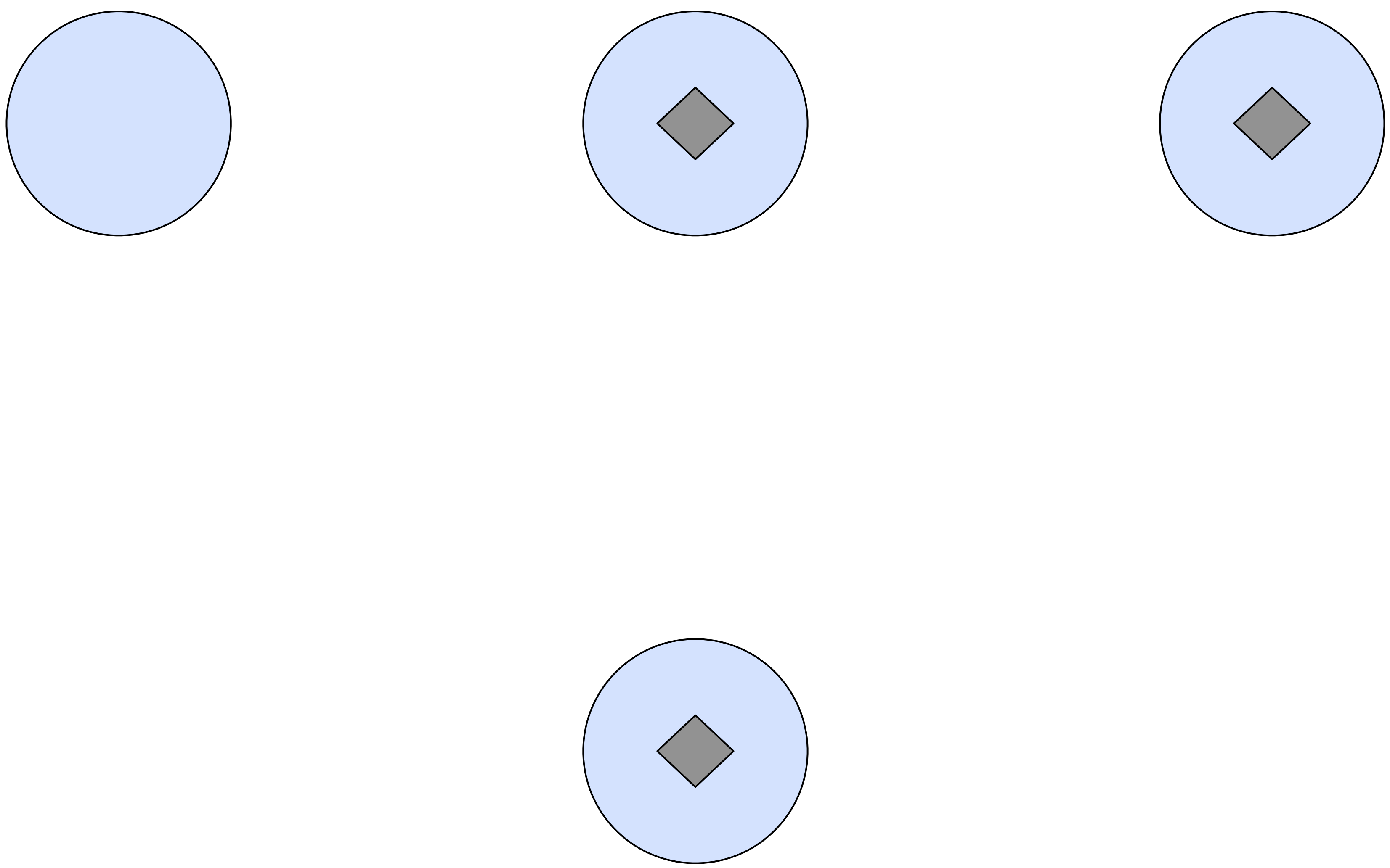
Transactors



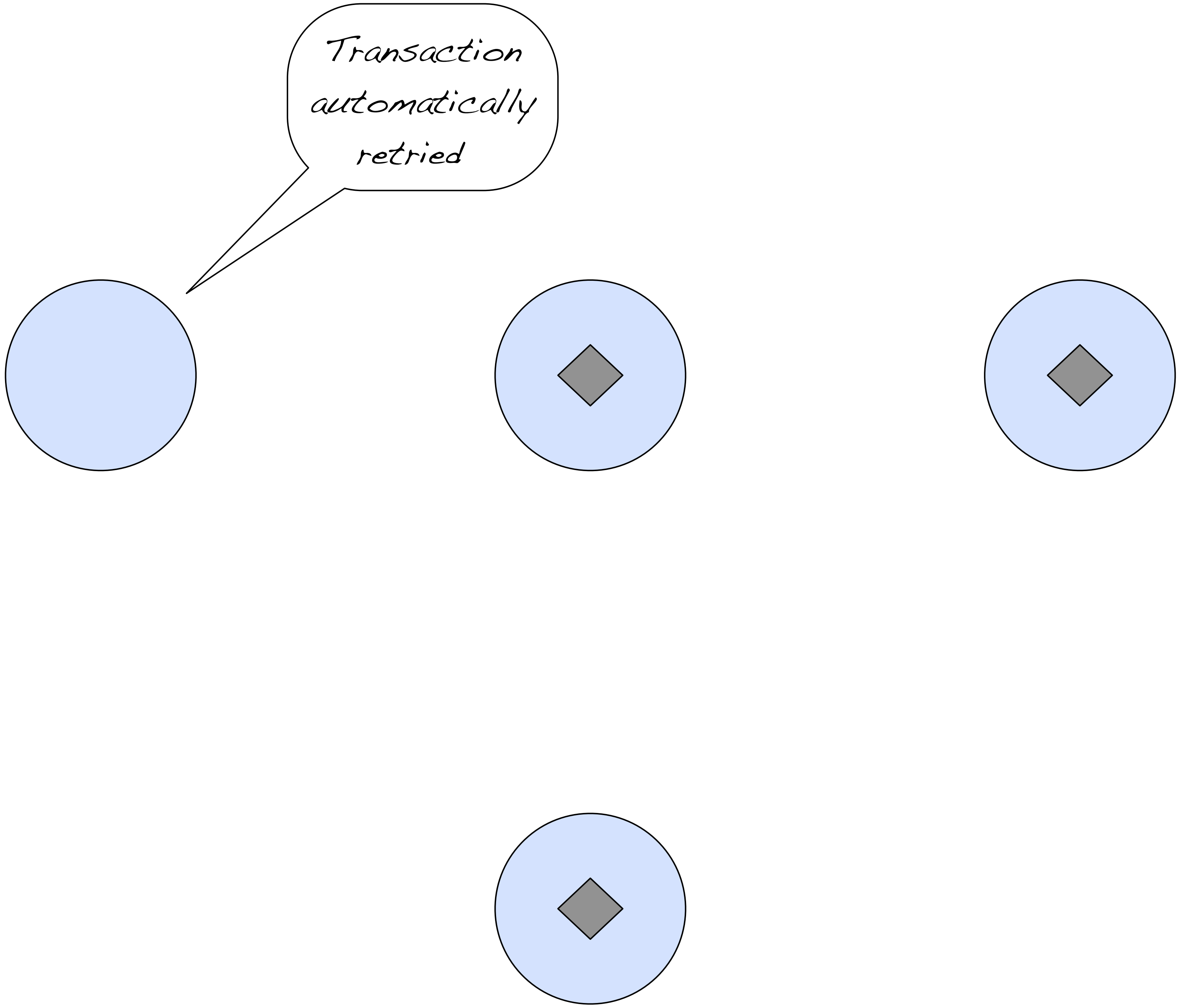
Transactors



Transactors



Transactors



blocking transactions

```scala
class Transferer extends Actor {
  implicit val txFactory = TransactionFactory(
    blockingAllowed = true, trackReads = true, timeout = 60 seconds)

  def receive = {
    case Transfer(from, to, amount) =>
      atomic {
        if (from.get < amount) {
          log.info("not enough money - retrying")
          retry
        }
        log.info("transferring")
        from alter (_ - amount)
        to alter (_ + amount)
      }
  }
}
```

either-orElse

```
atomic {
  either {
    if (left.get < amount) {
      log.info("not enough on left - retrying")
      retry
    }
    log.info("going left")
  } orElse {
    if (right.get < amount) {
      log.info("not enough on right - retrying")
      retry
    }
    log.info("going right")
  }
}
```

STM: config

```
akka {
  stm {
    max-retries = 1000
    timeout = 10
    write-skew = true
    blocking-allowed = false
    interruptible = false
    speculative = true
    quick-release = true
    propagation = requires
    trace-level = none
    hooks = true
    jta-aware = off
  }
}
```

Modules

Akka Persistence

STM gives us

Atomic

Consistent

Isolated

Persistence module turns STM into

- Atomic
- Consistent
- Isolated
- Durable

Akka Persistence API

```
// transactional Cassandra-backed Map
val map = CassandraStorage.newMap

// transactional Redis-backed Vector
val vector = RedisStorage.newVector

// transactional Mongo-backed Ref
val ref = MongoStorage.newRef
```

For Redis only (so far)

```
val queue: PersistentQueue[ElementType] =
  RedisStorage.newQueue

val set: PersistentSortedSet[ElementType] =
  RedisStorage.newSortedSet
```

Akka Spring

Spring integration

```
<beans>
  <akka:typed-actor
    id="myActiveObject"
    interface="com.biz.MyPOJO"
    implementation="com.biz.MyPOJO"
    transactional="true"
    timeout="1000" />
  ...
</beans>
```

Spring integration

```xml
<akka:supervision id="my-supervisor">

  <akka:restart-strategy failover="AllForOne"
                         retries="3"
                         timerange="1000">
    <akka:trap-exits>
      <akka:trap-exit>java.io.IOException</akka:trap-exit>
    </akka:trap-exits>
  </akka:restart-strategy>

  <akka:typed-actors>
    <akka:typed-actor interface="com.biz.MyPOJO"
                      implementation="com.biz.MyPOJOImpl"
                      lifecycle="permanent"
                      timeout="1000">
    </akka:typed-actor>
  </akka:typed-actors>
</akka:supervision>
```

Akka Camel

Camel: consumer

```
class MyConsumer extends Actor with Consumer {
  def endpointUri = "file:data/input"

  def receive = {
    case msg: Message =>
      log.info("received %s" format
      msg.bodyAs(classOf[String]))
  }
}
```

Camel: consumer

```
class MyConsumer extends Actor with Consumer {
  def endpointUri =
    "jetty:http://0.0.0.0:8877/camel/test"

  def receive = {
    case msg: Message =>
      reply("Hello %s" format
              msg.bodyAs(classOf[String]))
  }
}
```

Camel: producer

```
class CometProducer
  extends Actor with Producer {

  def endpointUri =
    "cometd://localhost:8111/test"

  def receive = produce // use default impl
}
```

Camel: producer

```
val producer = actorOf[CometProducer].start

val time = "Current time: " + new Date
producer ! time
```

Akka HotSwap

HotSwap

```
actor ! HotSwap({
  // new body
  case Ping =>
    ...
  case Pong =>
    ...
})
```

HotSwap

```
self.become({
  // new body
  case Ping =>
    ...
  case Pong =>
    ...
})
```

How to run it?

- ☑ Deploy as dependency JAR in WEB-INF/lib etc.
- ☑ Run as stand-alone microkernel
- ☑ OSGi-enabled; drop in any OSGi container (Spring DM server, Karaf etc.)

Akka Kernel

Start Kernel

```
java -jar akka-1.0-SNAPSHOT.jar \
  -Dakka.config=<path>/akka.conf
```

...and much much more

PubSub

REST

Security

FSM

Comet

Web

OSGi

Guice

Learn more

http://akkasource.org

EOF