Akka:

Simpler Concurrency, Scalability & Fault-tolerance through Actors

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We believe that...

- Writing correct concurrent applications is **too hard**

- Scaling out applications is **too hard**

- Writing highly fault-tolerant applications is **too hard**

It doesn't have to be like this

We need to raise the abstraction level

Locks & Threads

are...

...sometimes

plain evil

...but always the

wrong default

"Threads are to Concurrency as Witchcraft is to Physics"

"Hanging by a thread is the punishment for Shared State Concurrency"

- Gilad Bracha

Introducing

STM Actors Agents

Dataflow Distributed Open Source

RESTful Secure Persistent

OVERVIEW

Akka is the platform for the next generation event-driven, scalable and fault-tolerant architectures on the JVM

Simpler Concurrency

Write simpler concurrent (yet correct) applications using Actors, STM & Transactors.

Event-driven Architecture

The perfect platform for asynchronous event-driven architectures. Never block.

True Scalability

Scale out on multi-core or multiple nodes using asynchronous message passing.

Fault-tolerance

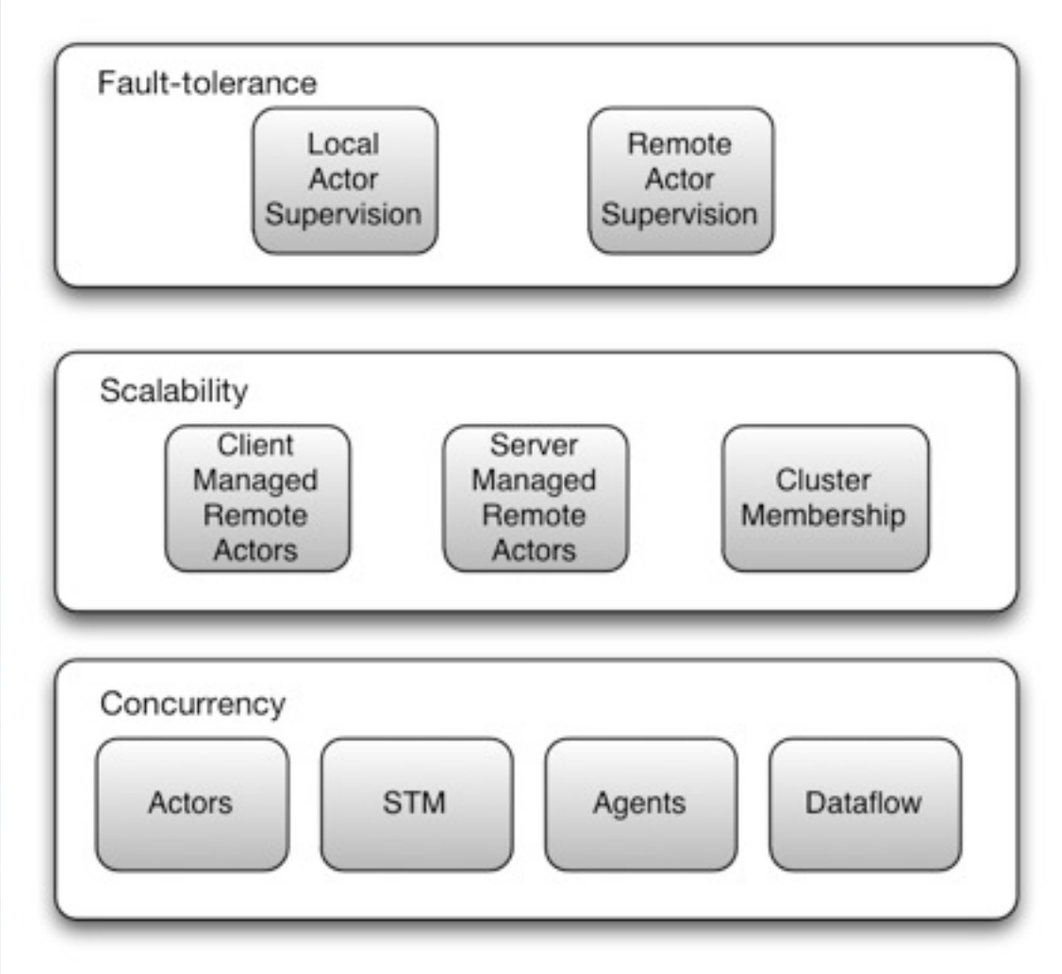
Embrace failure. Write applications that self-heal using Erlang-style Actor supervisor hierarchies.

Transparent Remoting

Remote Actors gives you a high-performance transparent distributed programming model.

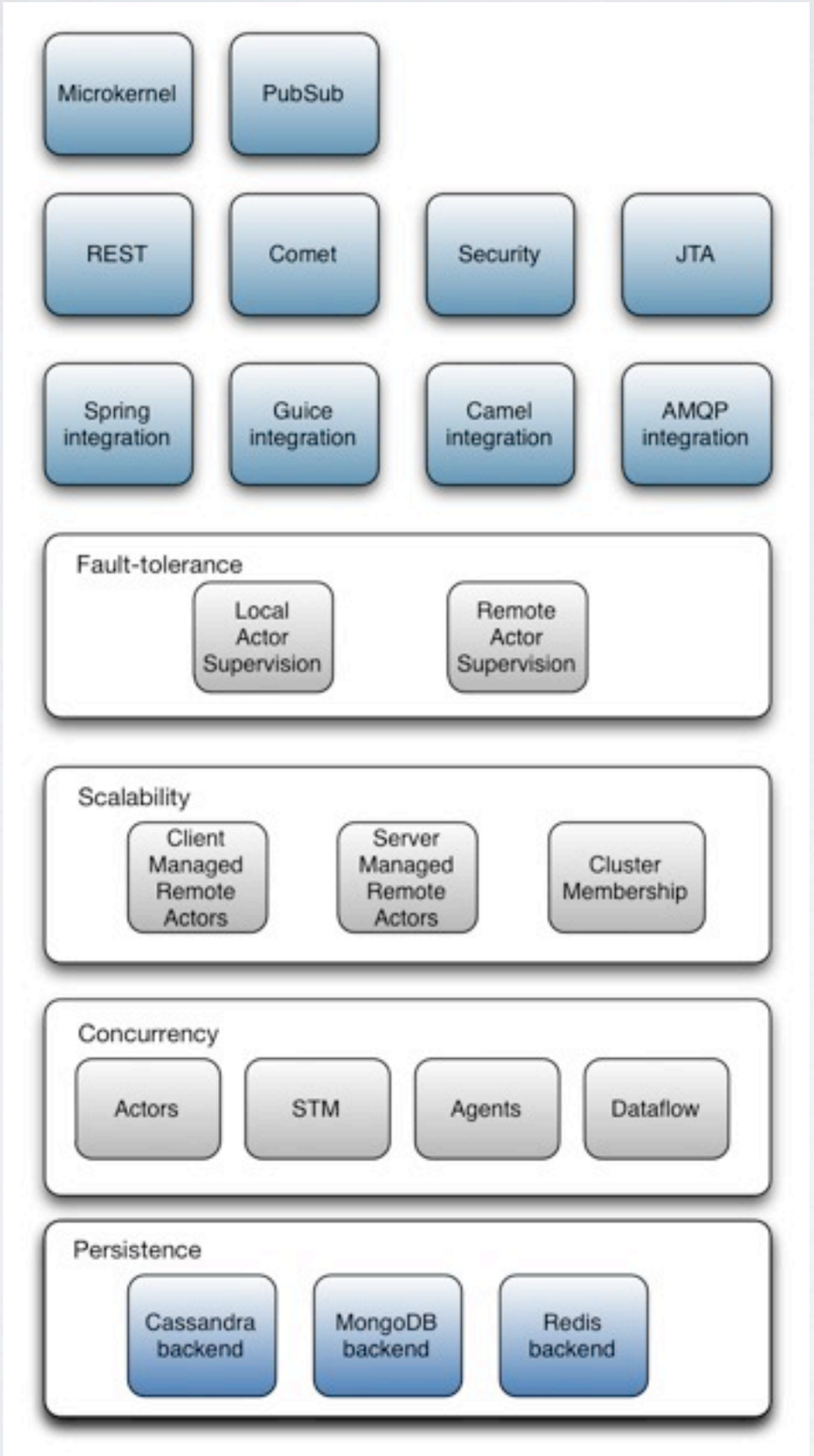
Java & Scala API

ARCHITECTURE



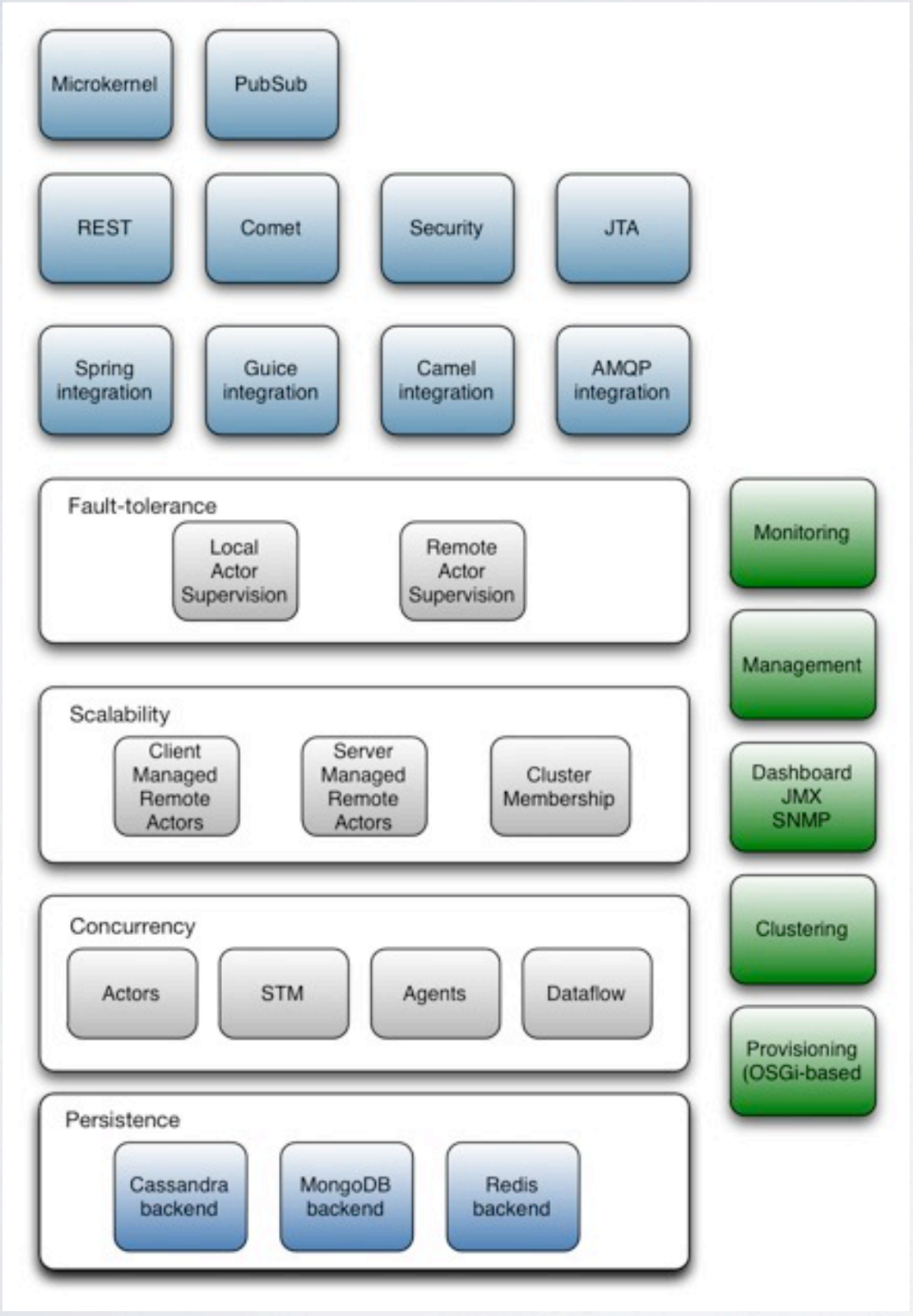
CORE SERVICES

ARCHITECTURE



ADD-ON MODULES

ARCHITECTURE



ENTERPRISE MODULES

Actors

one tool in the toolbox

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

Akka Actors

Two different models

- Thread-based
- Event-based
  - Very lightweight (600 bytes per actor)
  - Can easily create millions on a single workstation (6.5 million on 4 G RAM)
  - Does not consume a thread

Actor

Actors

```
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 init = {
    ... // called after ‘start’
  }

  override def shutdown = {
    ... // 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: !!

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

uses Future under the hood (with time-out)

Send: !!

```
val resultOption = actor !! Message

val result = resultOption
               .getOrElse(defaultResult)

val result = resultOption.getOrElse(
    throw new Exception("Timed out")))
```

returns an Option[ResultType] directly

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

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
  }
}
```

UntypedActor

Untyped Actors

```
public class MyUntypedActor
  extends UntypedActor {

  public void onReceive(Object message)
    throws Exception {
    if (message instanceof String) {
      String msg = (String)message;
      System.out.println(
        "Received message: " + msg);
    }
  }
}
```

Create UntypedActor

```
UntypedActorRef actor =
  UntypedActor.actorOf(MyUntypedActor.class);

actor.start();
```

the context reference

```
class RecursiveActor
  extends UntypedActor {
  getContext().setId(“service:recursive”);

  public void onReceive(Object message)
    throws Exception {
    if (message instanceof Tick)
      getContext().sendOneWay(Tick);
  }
}
```

sendOneWay

```
actor.sendOneWay(msg);
```

fire-forget

sendRequestReply

```
Object res = actor.sendRequestReply(msg);
```

uses Future under the hood (with time-out)

sendRequestReplyFuture

```
// returns a future
Future future =
    actor.sendRequestReplyFuture(msg);

future.await();
Object result = future.get();
```

returns the Future directly

reply

```
public class HelloUntypedActor
  extends UntypedActor {

  public void onReceive(Object message)
    throws Exception {
    if (message instanceof String) {
      String name = (String)message;
      // use reply
      getContext().reply("Hi " + name);
    }
  }
}
```

TypedActor

Typed Actors

```
public class CounterImpl
   extends TypedActor implements Counter {

   private int counter = 0;

   public void count() {
      counter++;
      System.out.println(counter);
   }
}
```

Create Typed Actor

```
Counter counter =
  (Counter)TypedActor.newInstance(
    Counter.class, CounterImpl.class, 1000);
```

Send message

```
counter.count();
```

fire-forget

Request Reply

```
int hits = counter.getNrOfHits();
```

uses Future under the hood (with time-out)

the context reference

```
class PingImpl extends TypedActor
   implements Ping {
   public void hit(int count) {
      Pong pong =
         (Pong)getContext().getSender();
      pong.hit(count++);
   }
}
```

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”)
```

Actors: config

```
akka {
  version = "0.9.1"
  time-unit = "seconds"
  actor {
    timeout = 5
    throughput = 5
  }
}
```

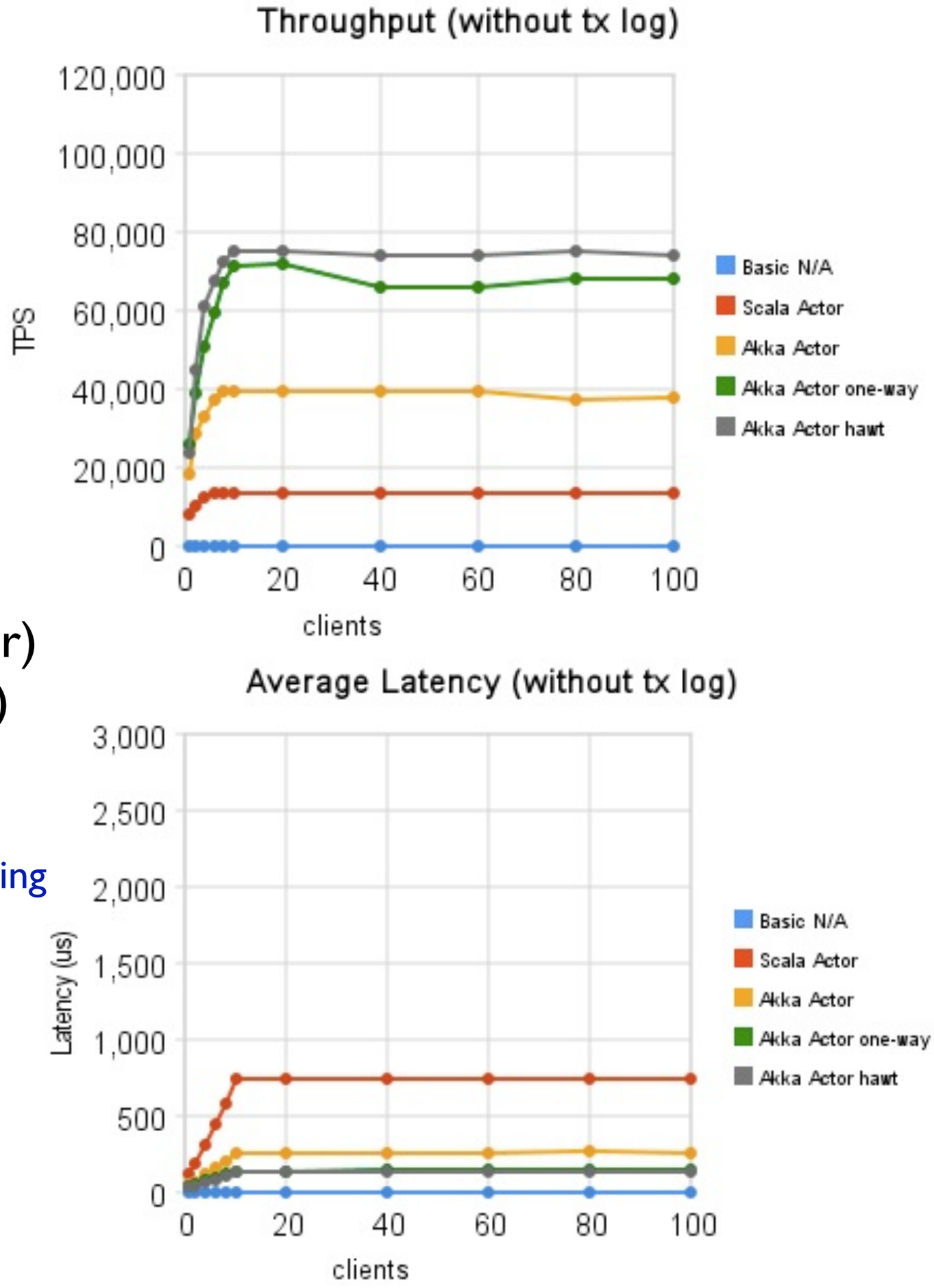
Scalability Benchmark

Simple Trading system

- Synchronous Scala version
- Scala Library Actors 2.8.0
- Akka request-reply
- Akka fire-forget (default dispatcher)
- Akka fire-forget (Hawt dispatcher)

Run it yourself:

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



Performance Microbenchmark

- Chameneos benchmark
  - http://shootout.alioth.debian.org/

Akka 0.8.1	**3815**
Scala Actors 2.8.0 (react)	**16086**

- +4 times faster
- Run it yourself (3 different benchmarks):
  - http://github.com/jboner/akka-bench

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
Reactor-based Dispatcher
Reactor-based Single-thread 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
```

EventBasedDispatcher

Fluent DSL

```
val dispatcher =
  Dispatchers.newExecutorBasedEventDrivenDispatcher
dispatcher
    .withNewThreadPoolWithBoundedBlockingQueue(100)
    .setCorePoolSize(16)
    .setMaxPoolSize(128)
    .setKeepAliveTimeInMillis(60000)
    .setRejectionPolicy(new CallerRunsPolicy)
    .buildThreadPool
```

MessageQueues

Unbounded LinkedBlockingQueue

Bounded LinkedBlockingQueue

Bounded ArrayBlockingQueue

Bounded SynchronousQueue

Plus different options per queue

Let it crash

fault-tolerance

Stolen from

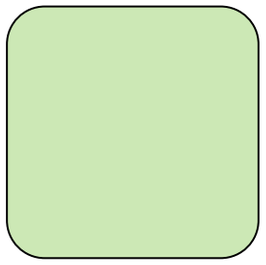
Erlang

9

nines

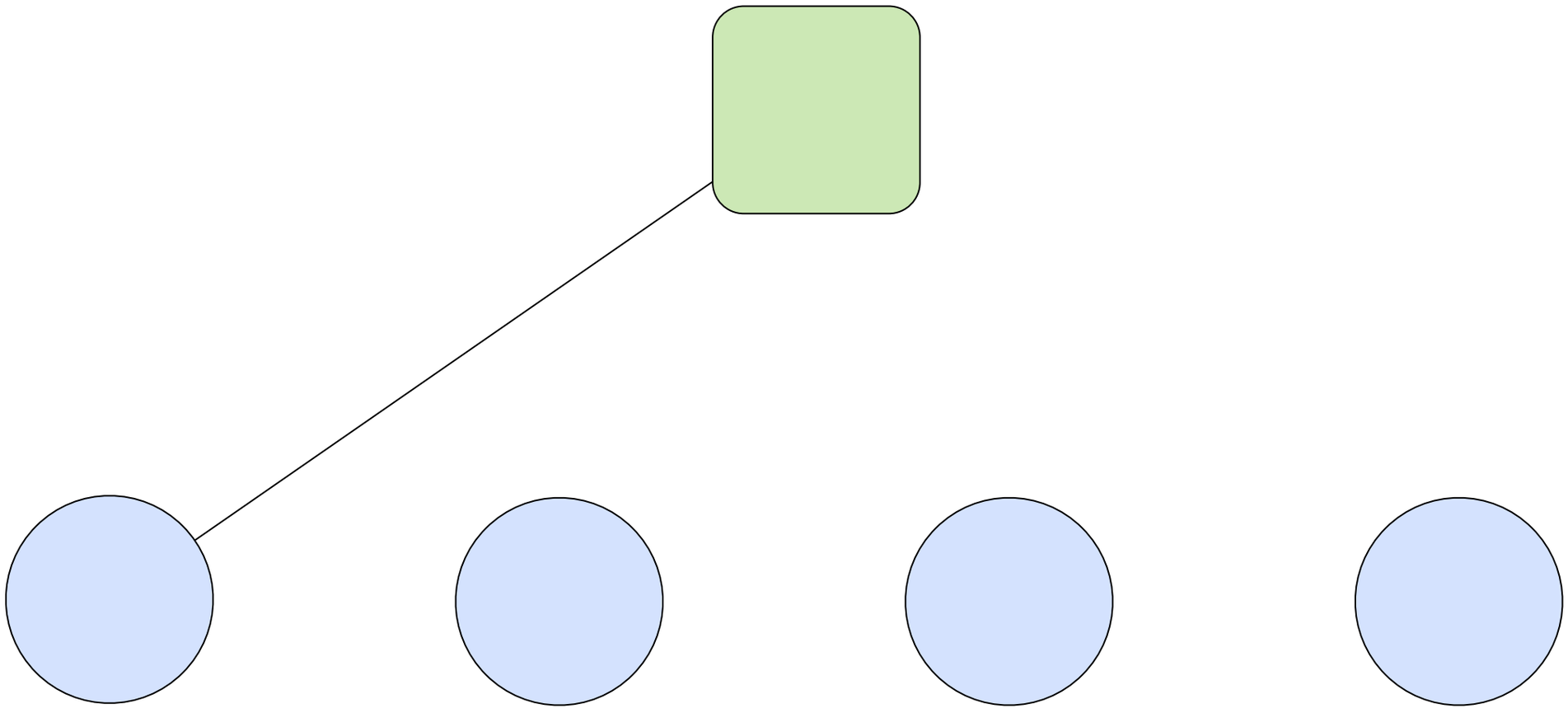
OneForOne

fault handling strategy



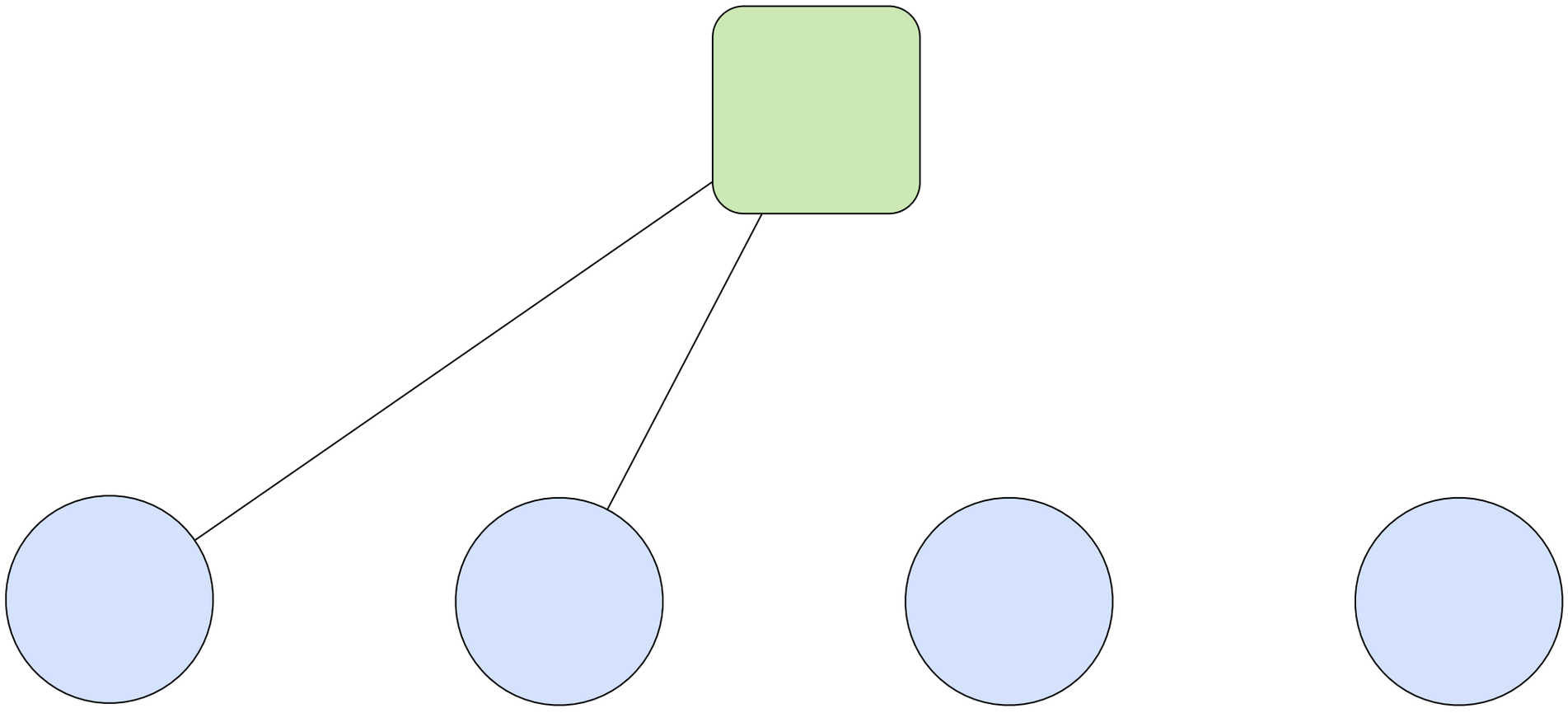
OneForOne

fault handling strategy



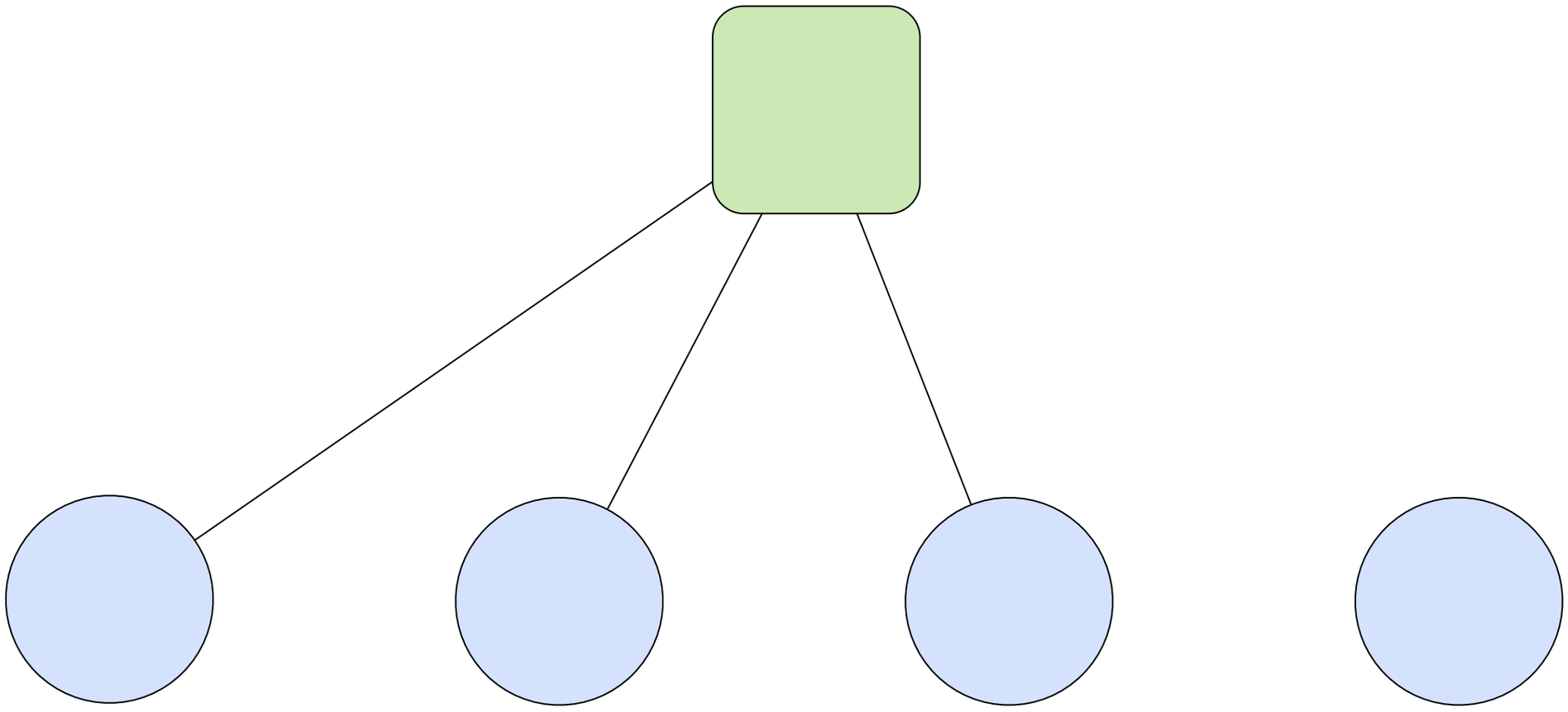
OneForOne

fault handling strategy



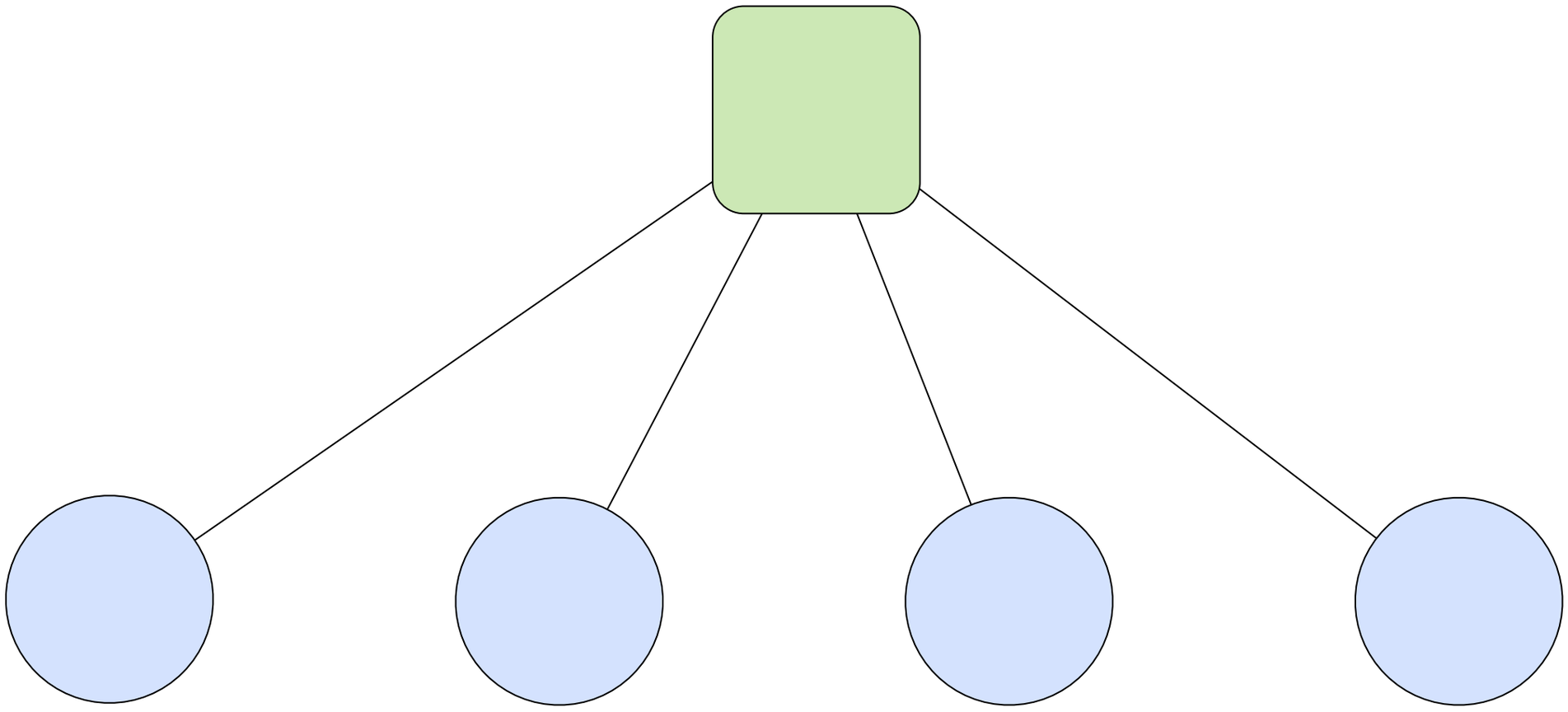
OneForOne

fault handling strategy



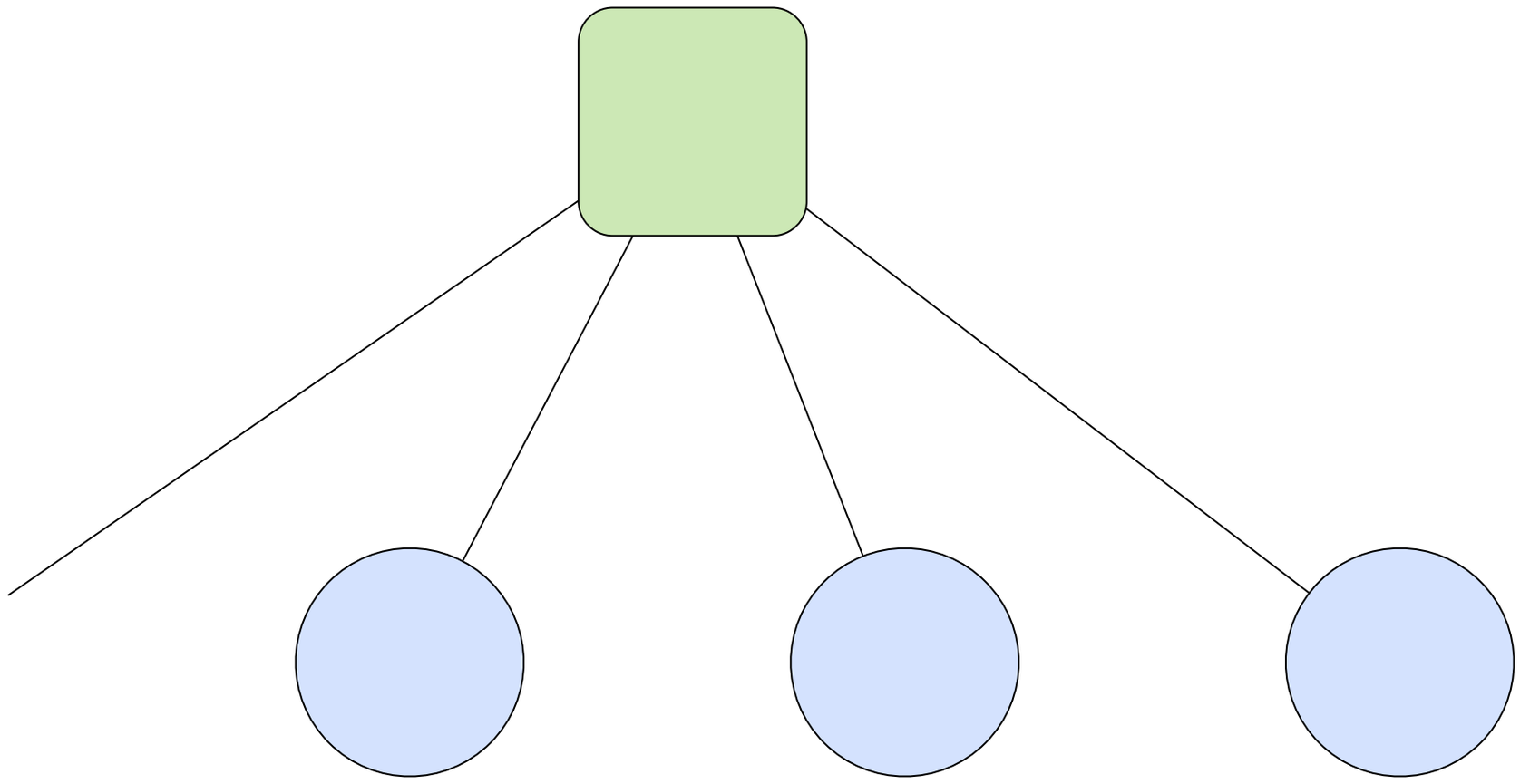
OneForOne

fault handling strategy



OneForOne

fault handling strategy



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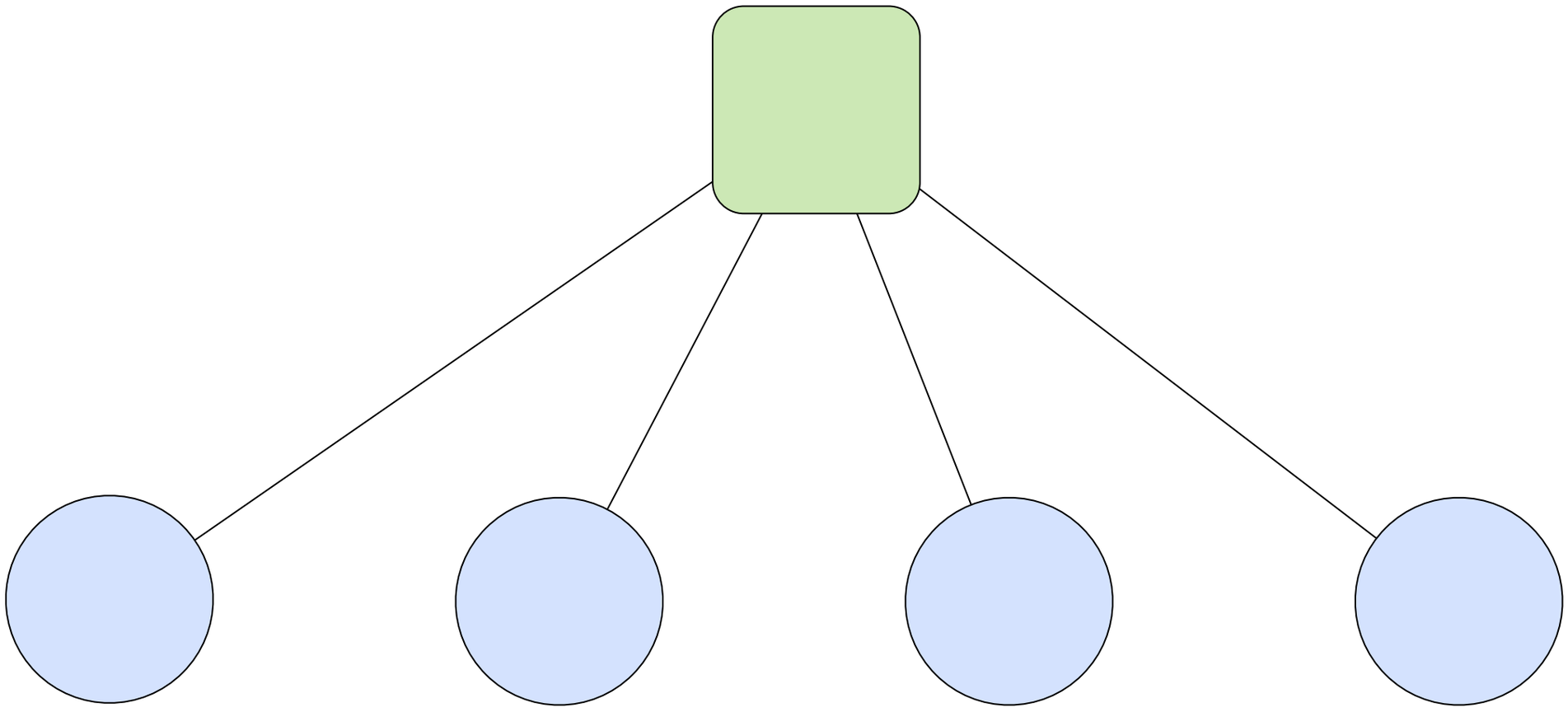
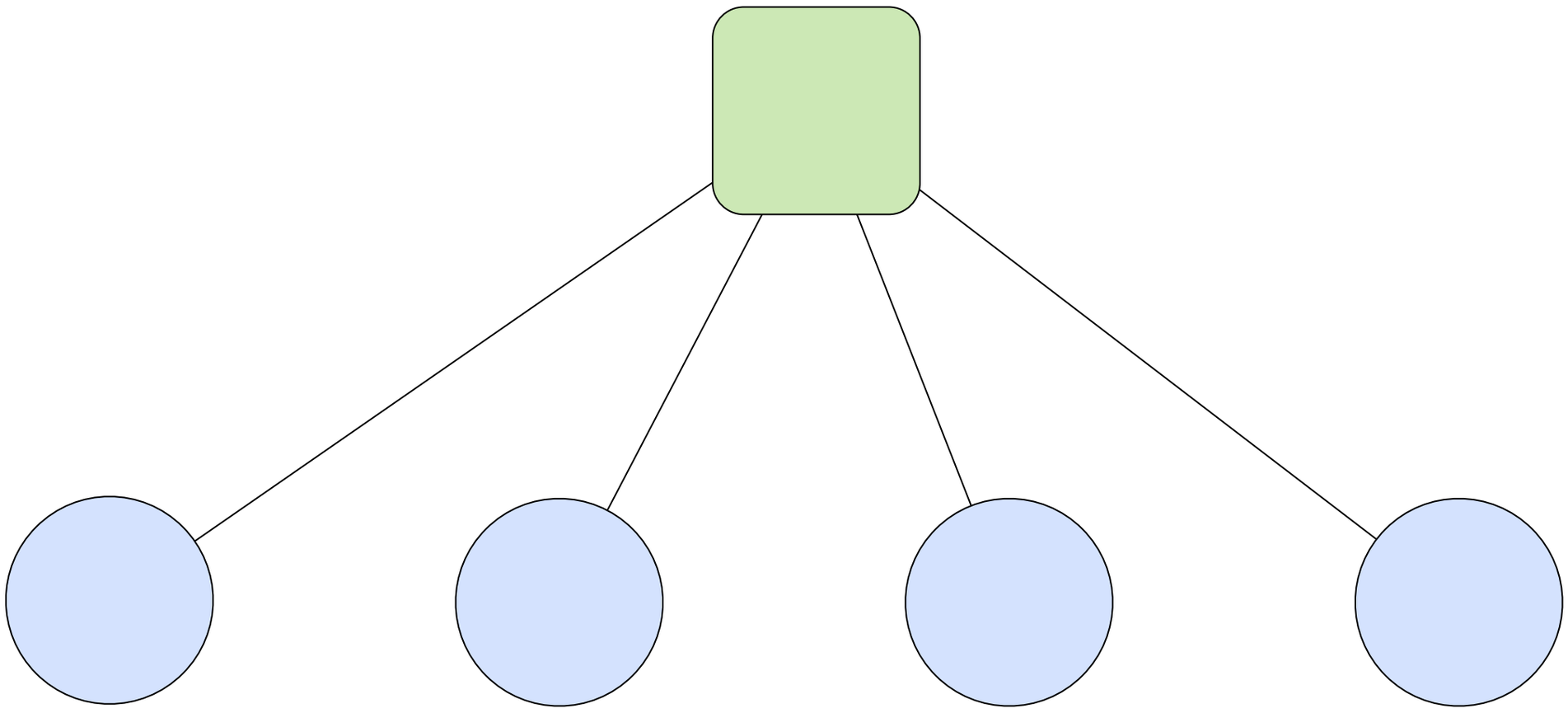
fault handling strategy



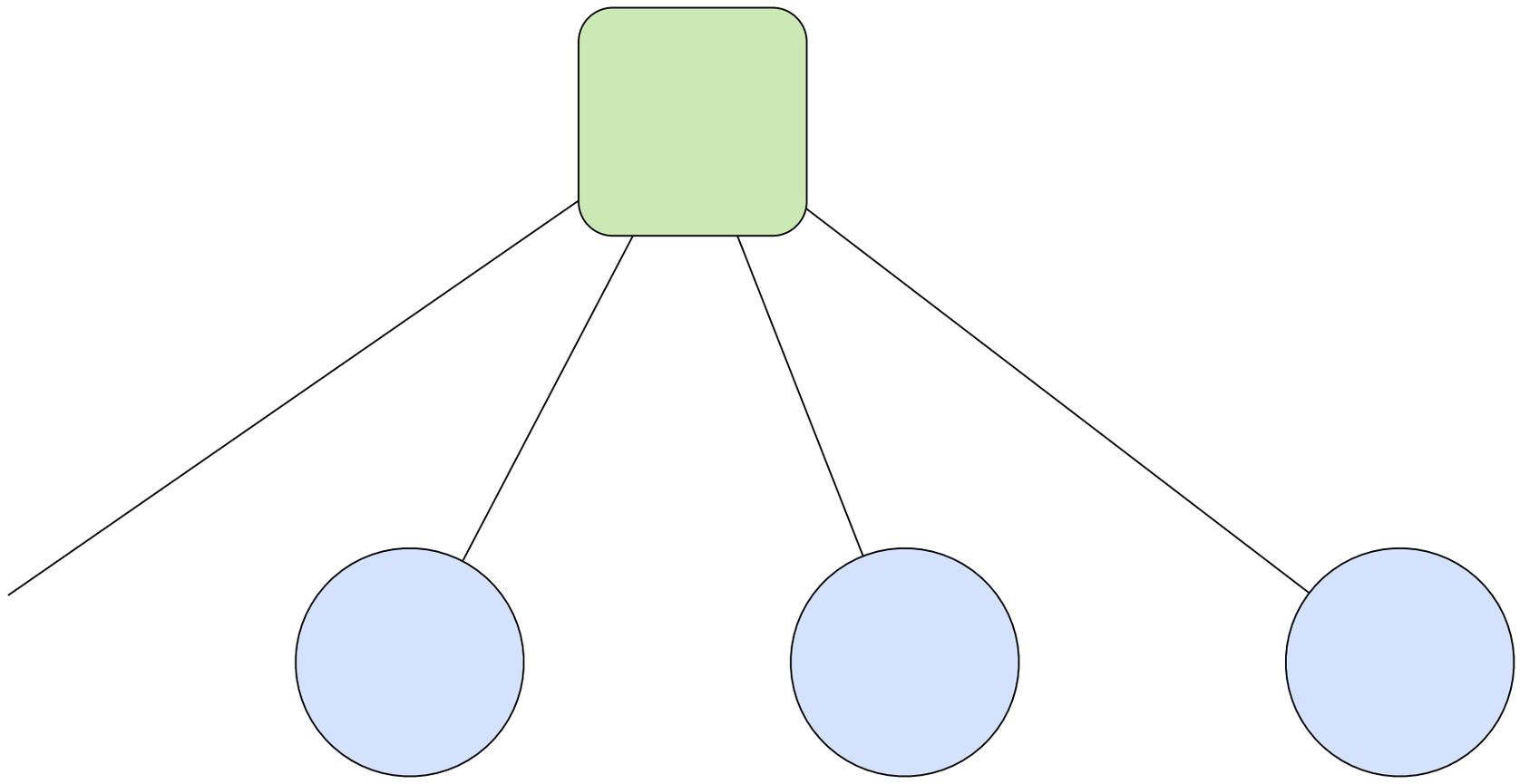
AllForOne

fault handling strategy



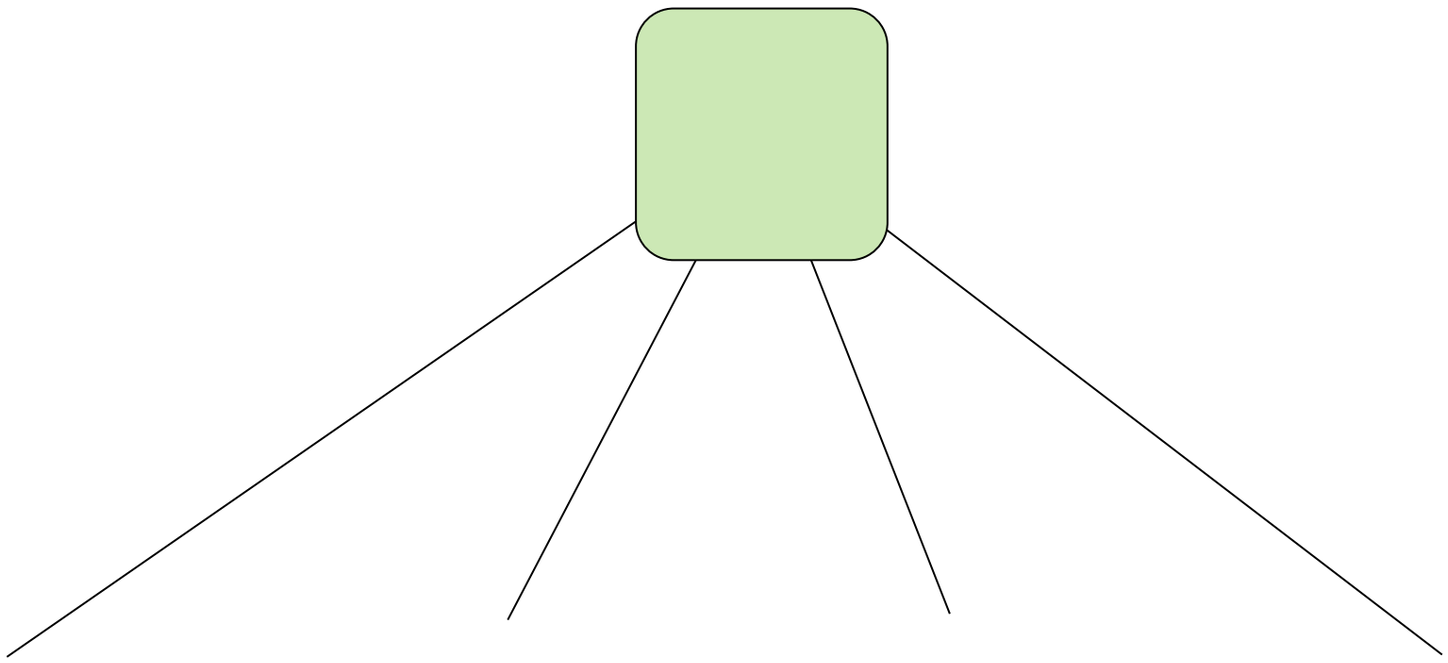
AllForOne

fault handling strategy



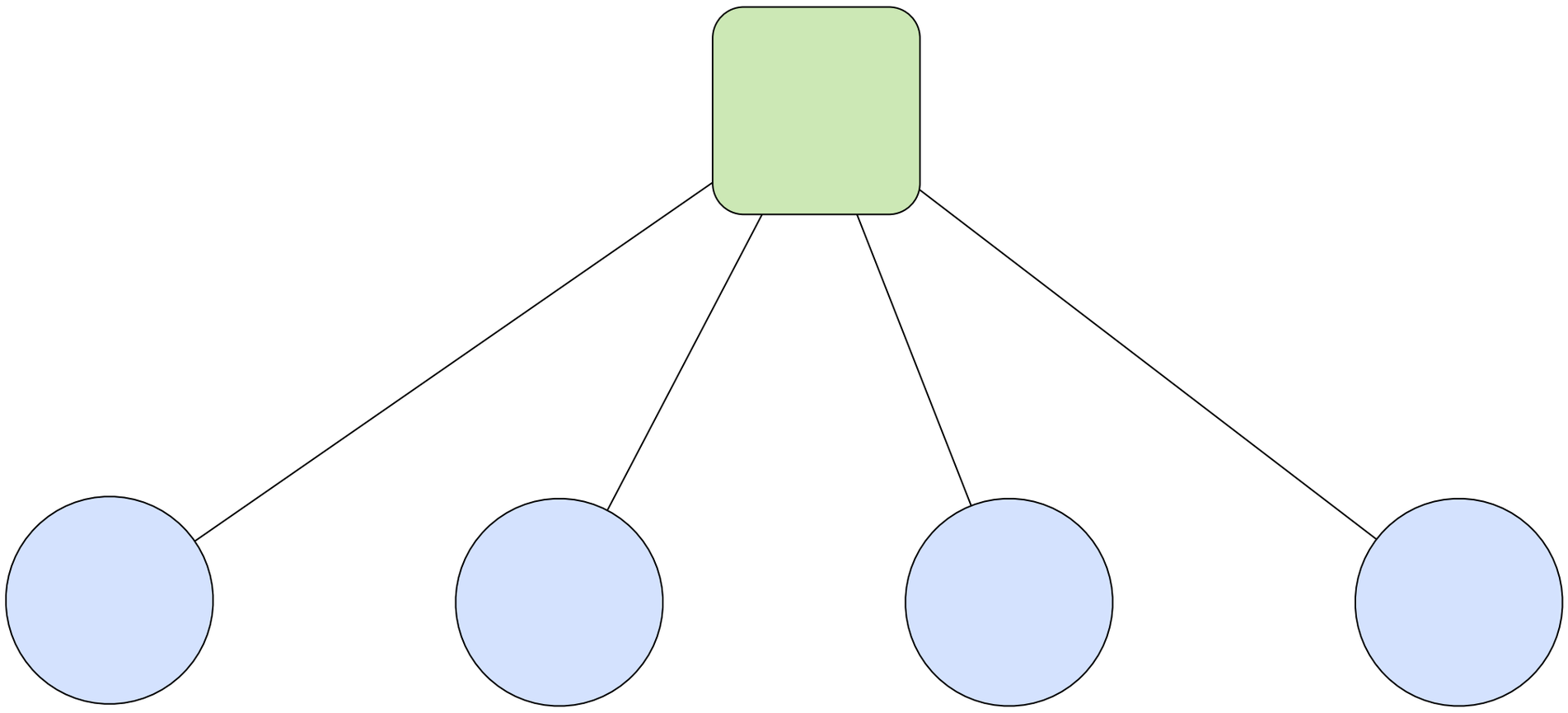
AllForOne

fault handling strategy

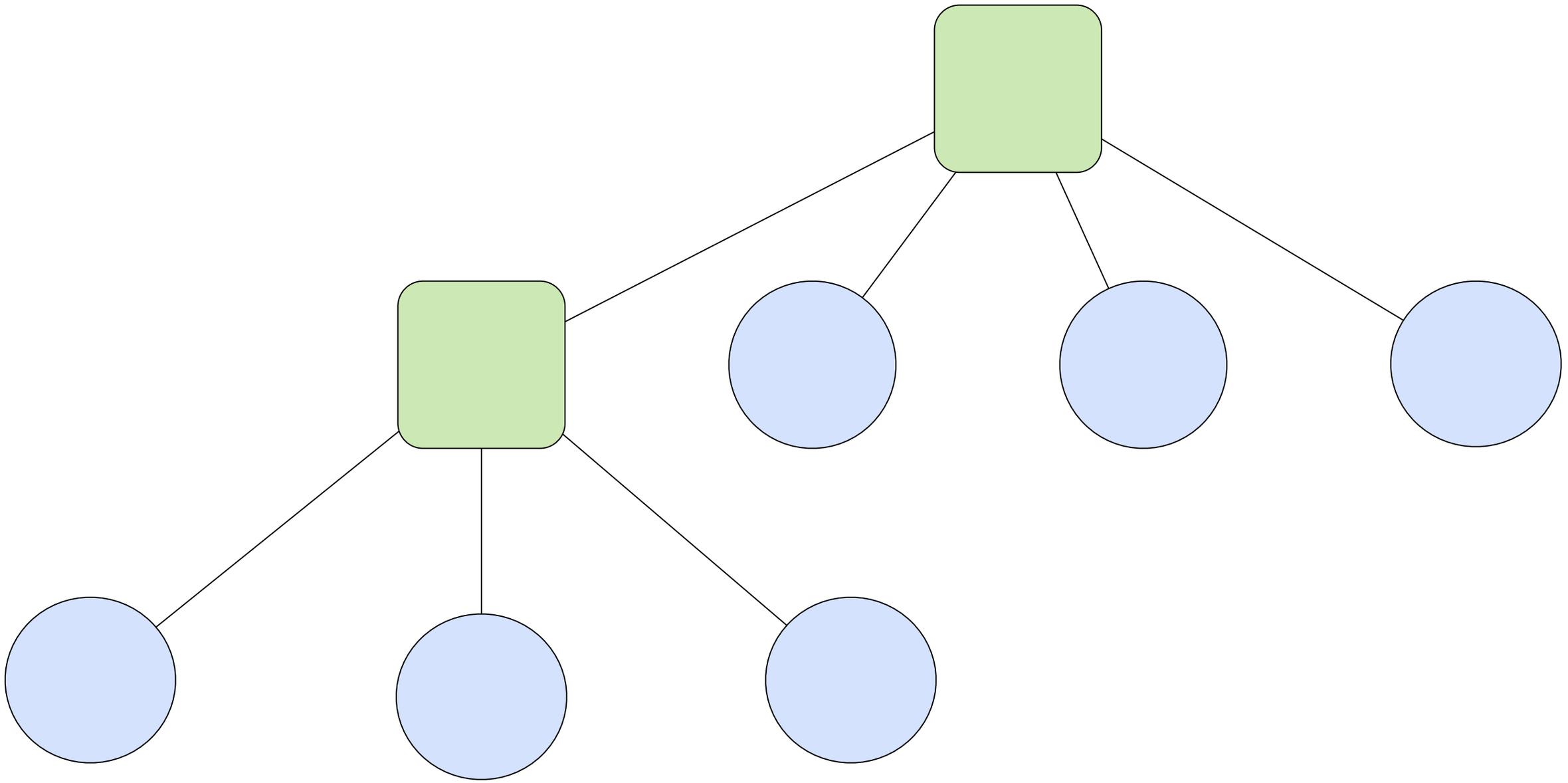


AllForOne

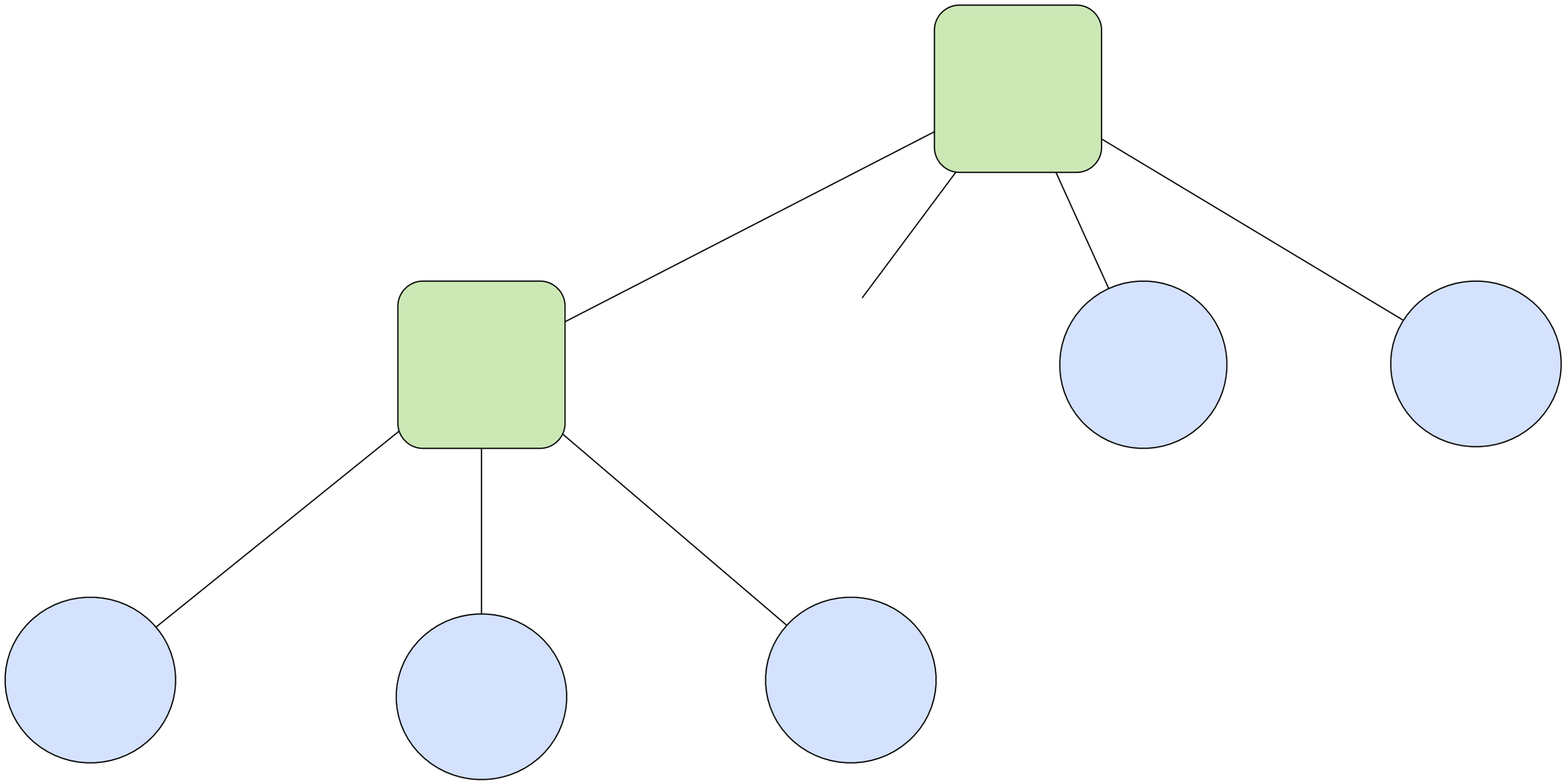
fault handling strategy



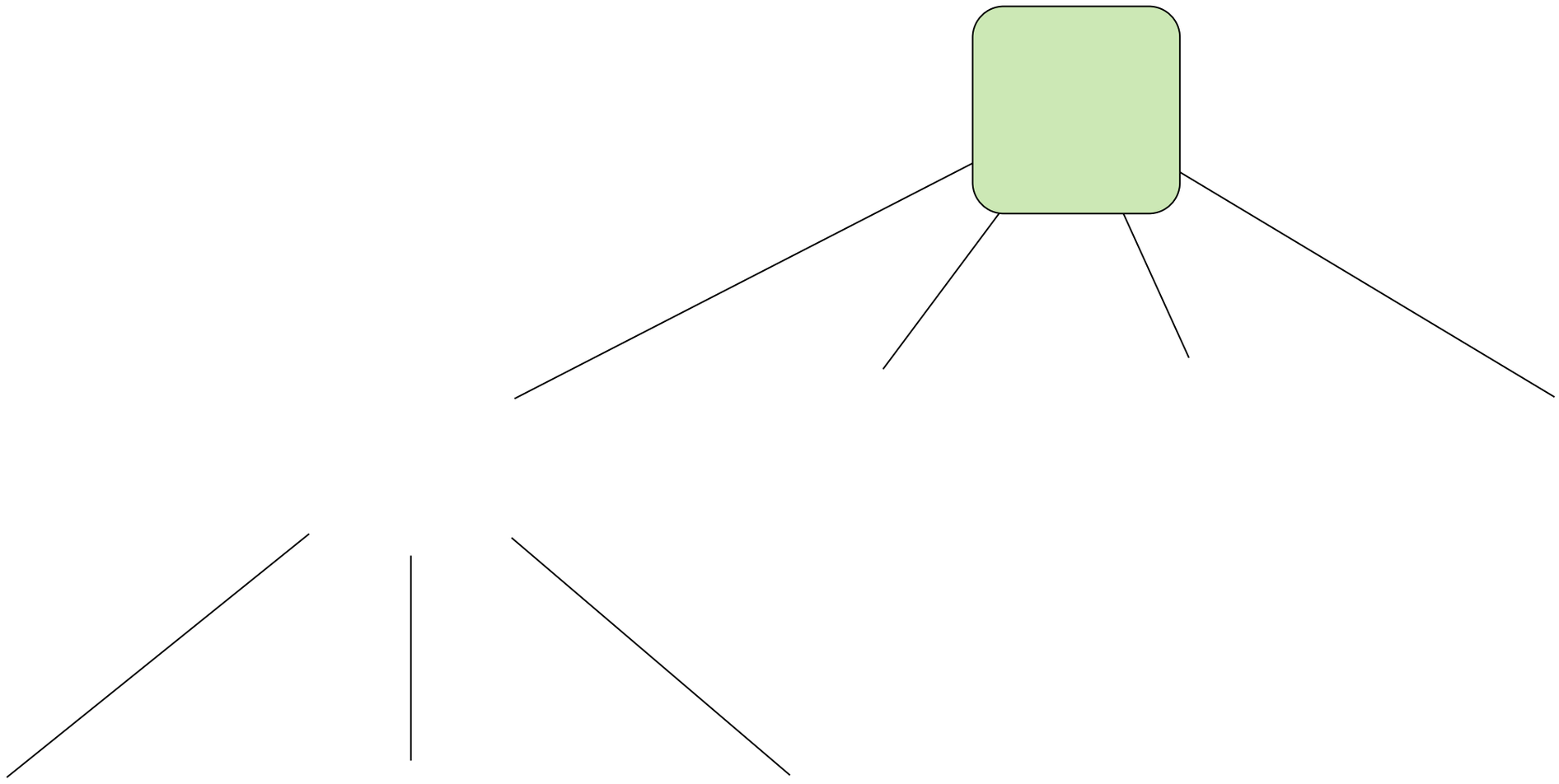
Supervisor hierarchies



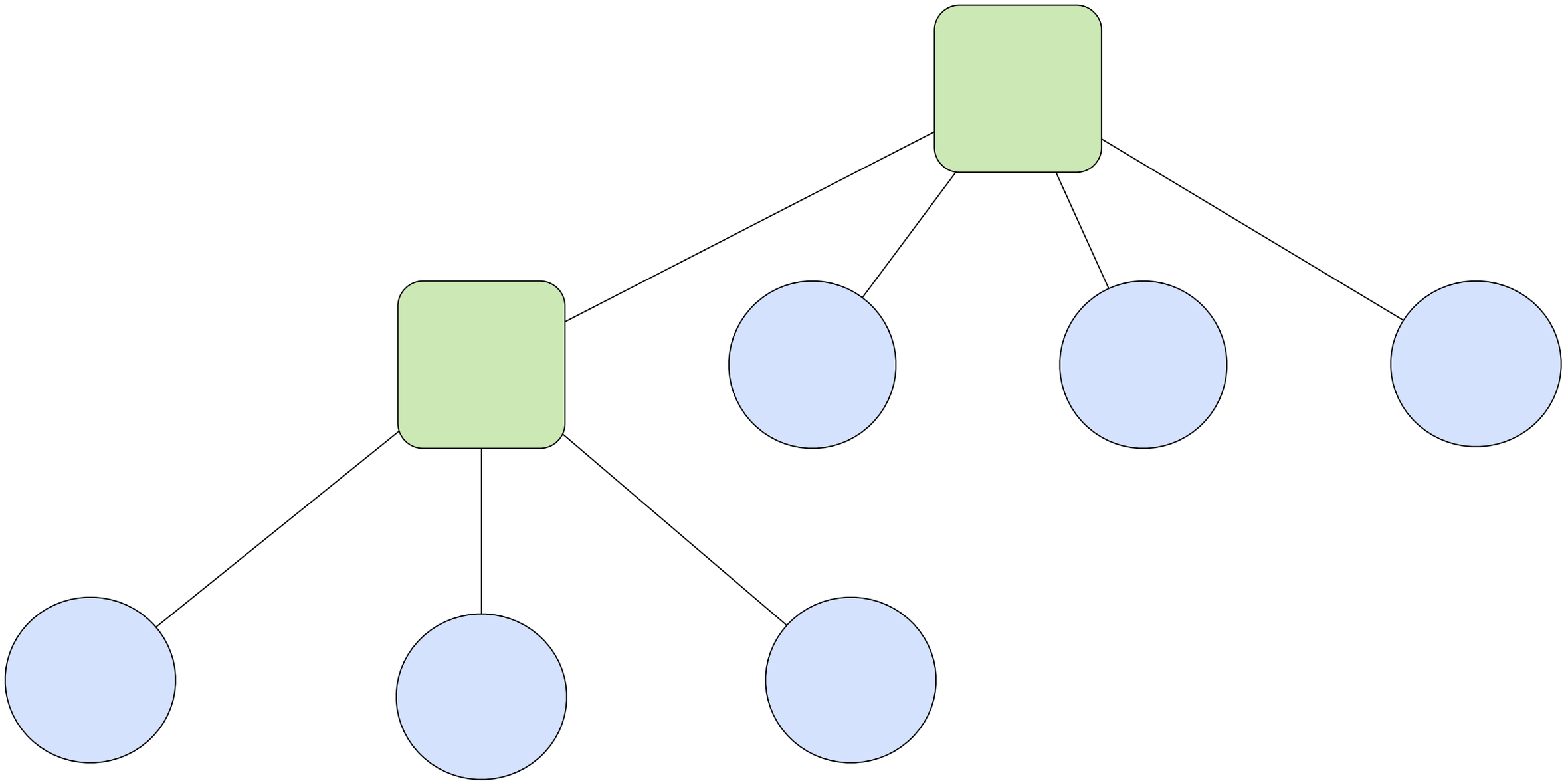
Supervisor hierarchies



Supervisor hierarchies



Supervisor hierarchies



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
  }
}
```

Declarative config

```
val supervisor = Supervisor(
  SupervisorConfig(
    RestartStrategy(AllForOne, 3, 10000),
     Supervise(
      actor1,
      LifeCycle(Permanent)) ::
     Supervise(
      actor2,
      LifeCycle(Temporary)) ::
    Nil))
```

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
```

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-initated and managed
- Server-initiated and 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)
```

Remote config

```
akka {
  remote {
    service = on
    hostname = "homer.lan"
    port = 9999
    connection-timeout = 1000
  }
}
```

STM

yet another tool in the toolbox

What is STM?

Software Transactional Memory (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

STM: overview

- Transactions can nest
- Transactions compose (yipee!!)

```
atomic {
    ..
    atomic {
        ..
    }
}
```

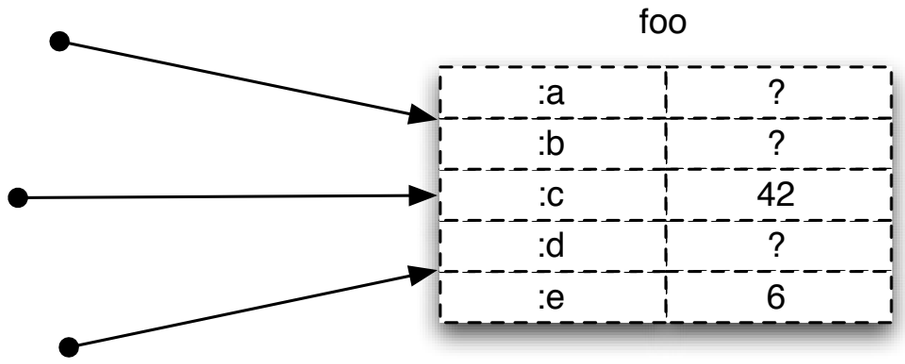
STM: restrictions

>All operations in scope of a transaction:

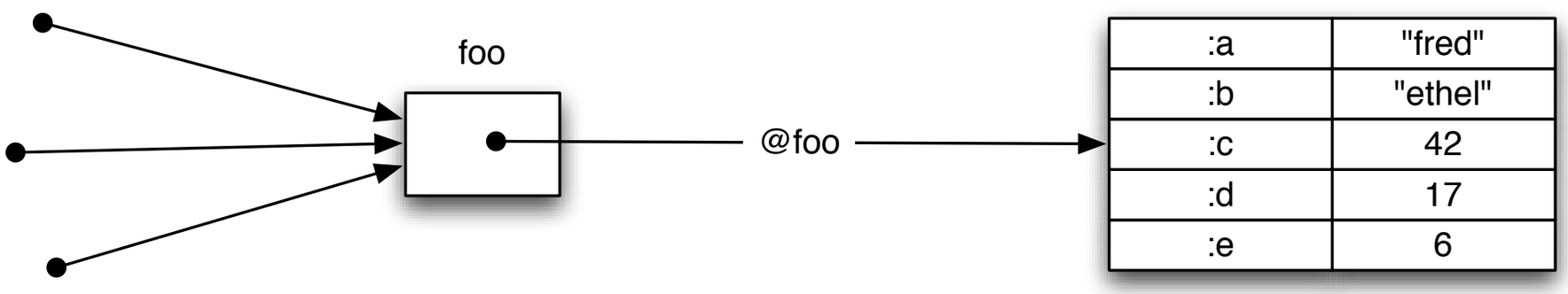
- Need to be idempotent
- Can't have side-effects

Managed References

- Typical OO: direct access to mutable objects



- Managed Reference: separates Identity & Value



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

Managed References

```
val ref = Ref(Map[String, User]())

val users = ref.get

val newUsers = users + (“bill” -> User(“bill”))

ref.swap(newUsers)
```

Transactional datastructures

```
val users = TransactionalMap[String, User]()

val users = TransactionalVector[User]()
```

atomic

```
import Transaction.Local._

atomic {
  ...
  atomic { // nested transactions compose
    ... // do something within a transaction
  }
}
```

Actors + STM =

Transactors

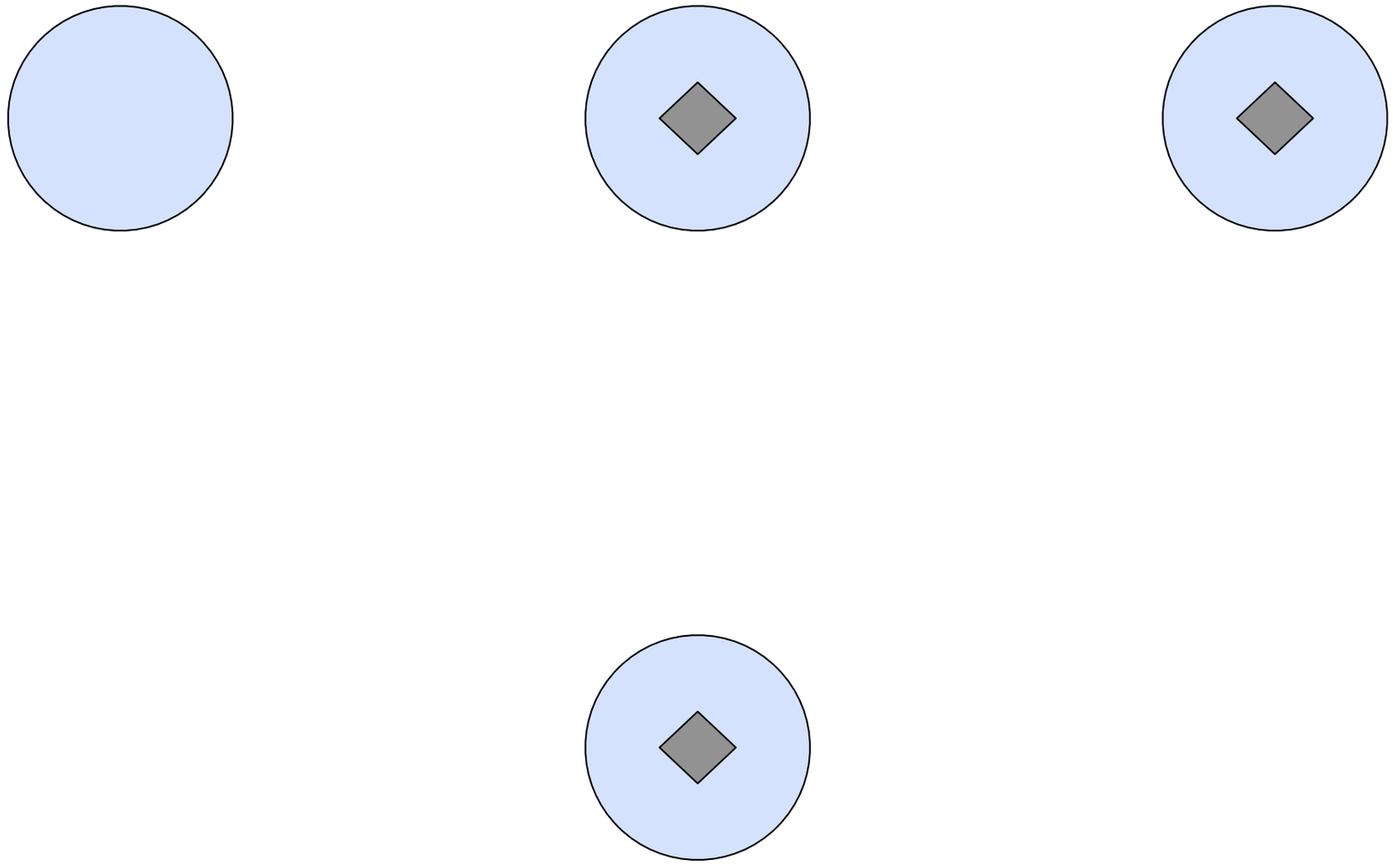
Transactors

```
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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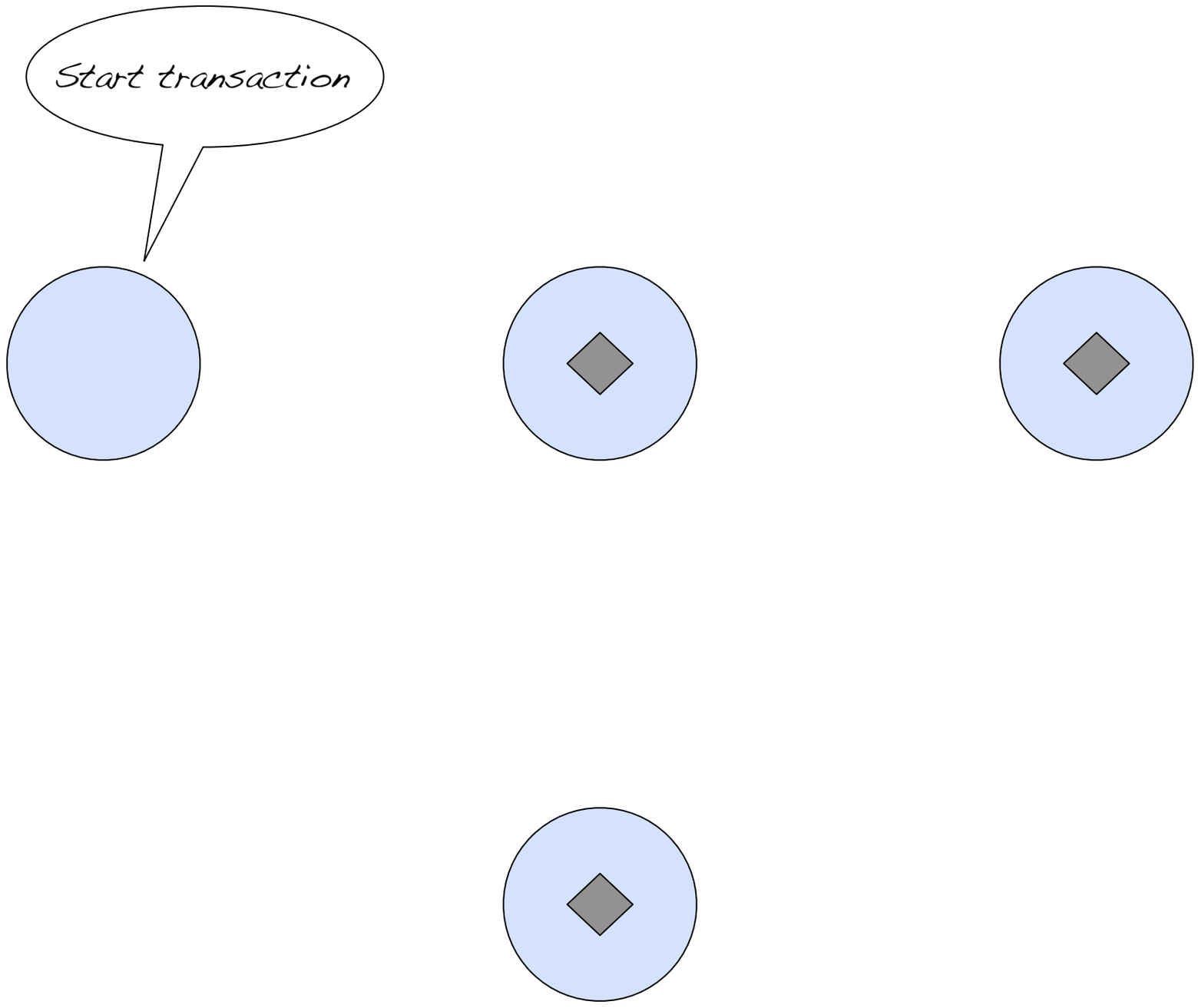

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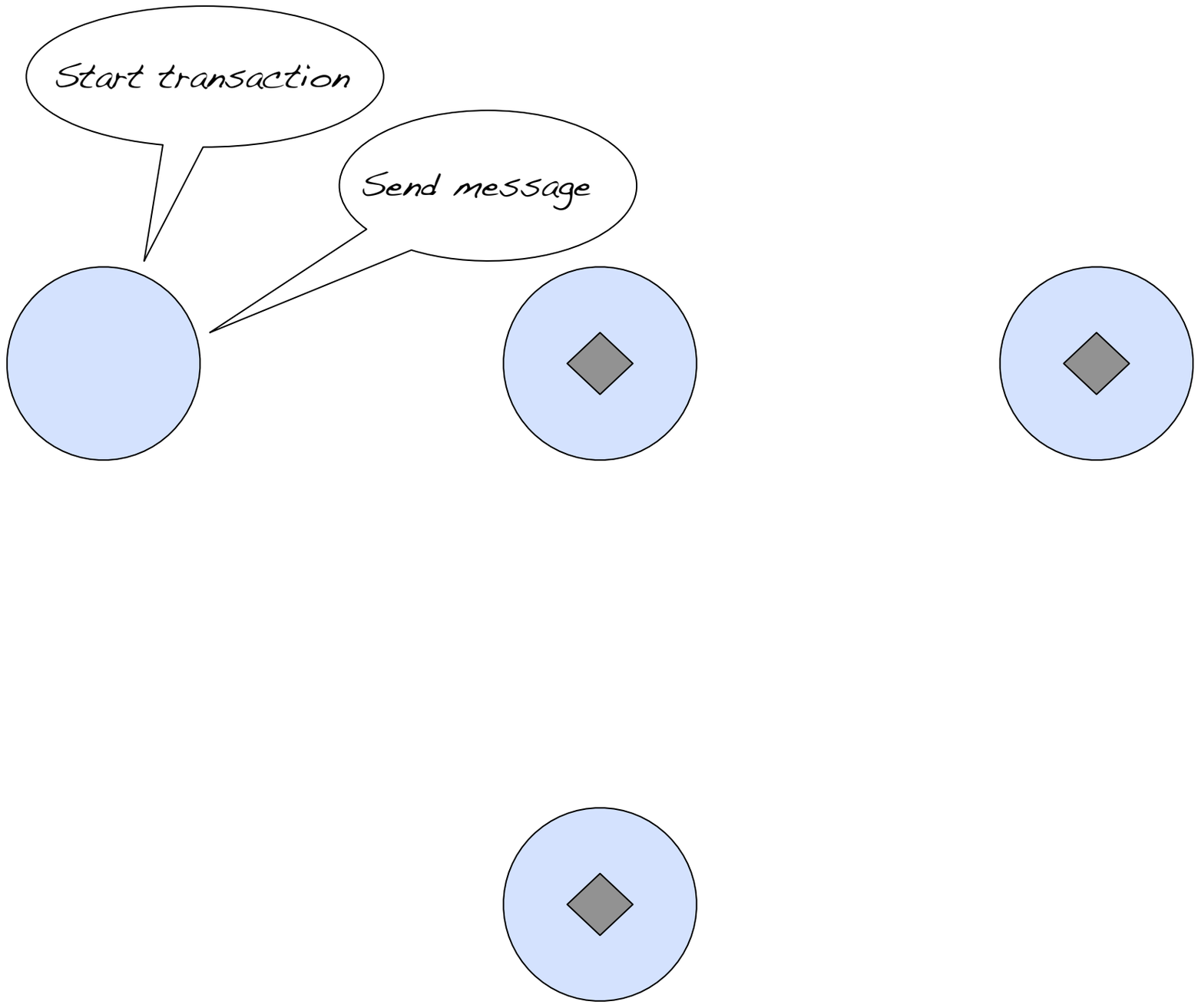

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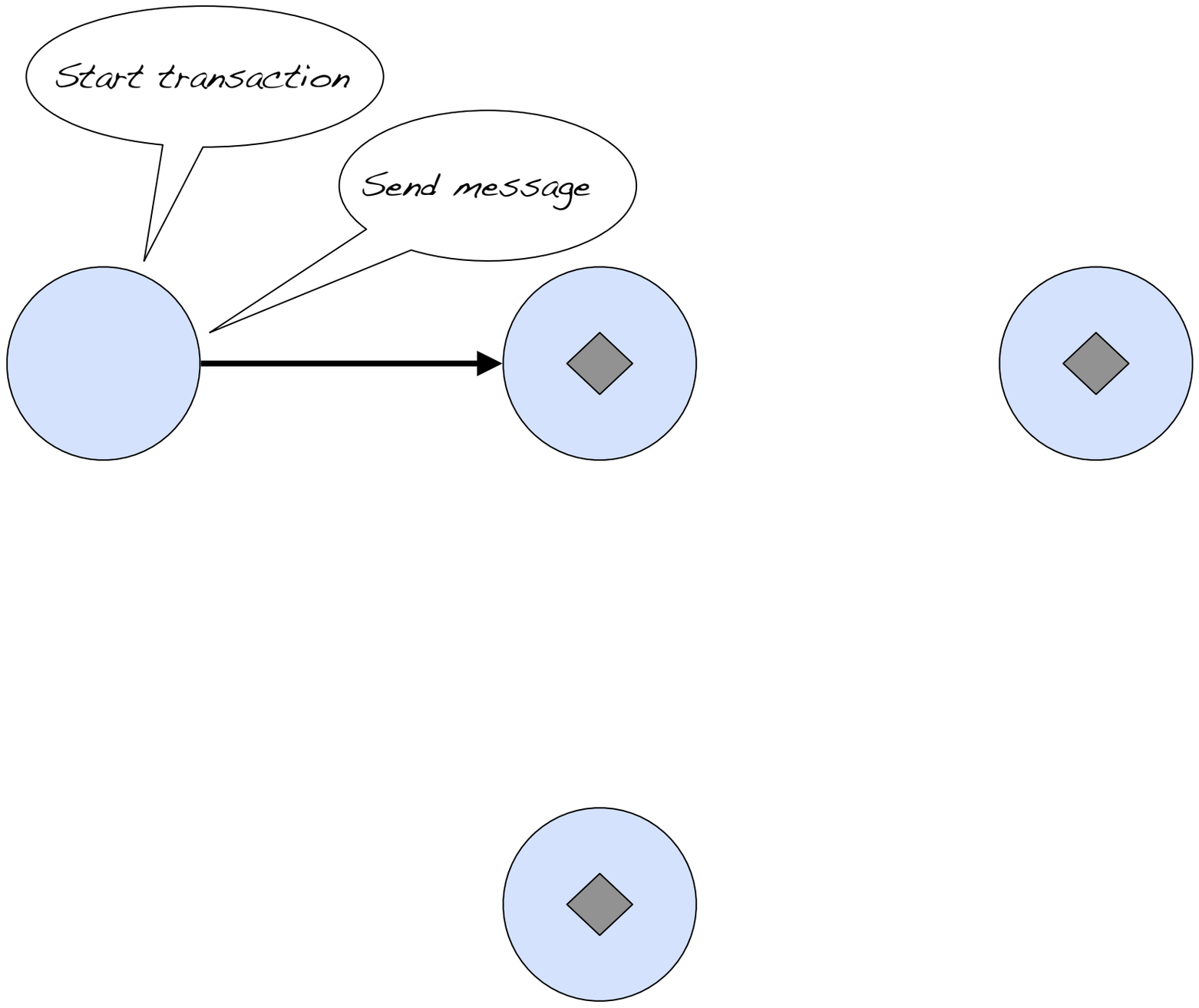

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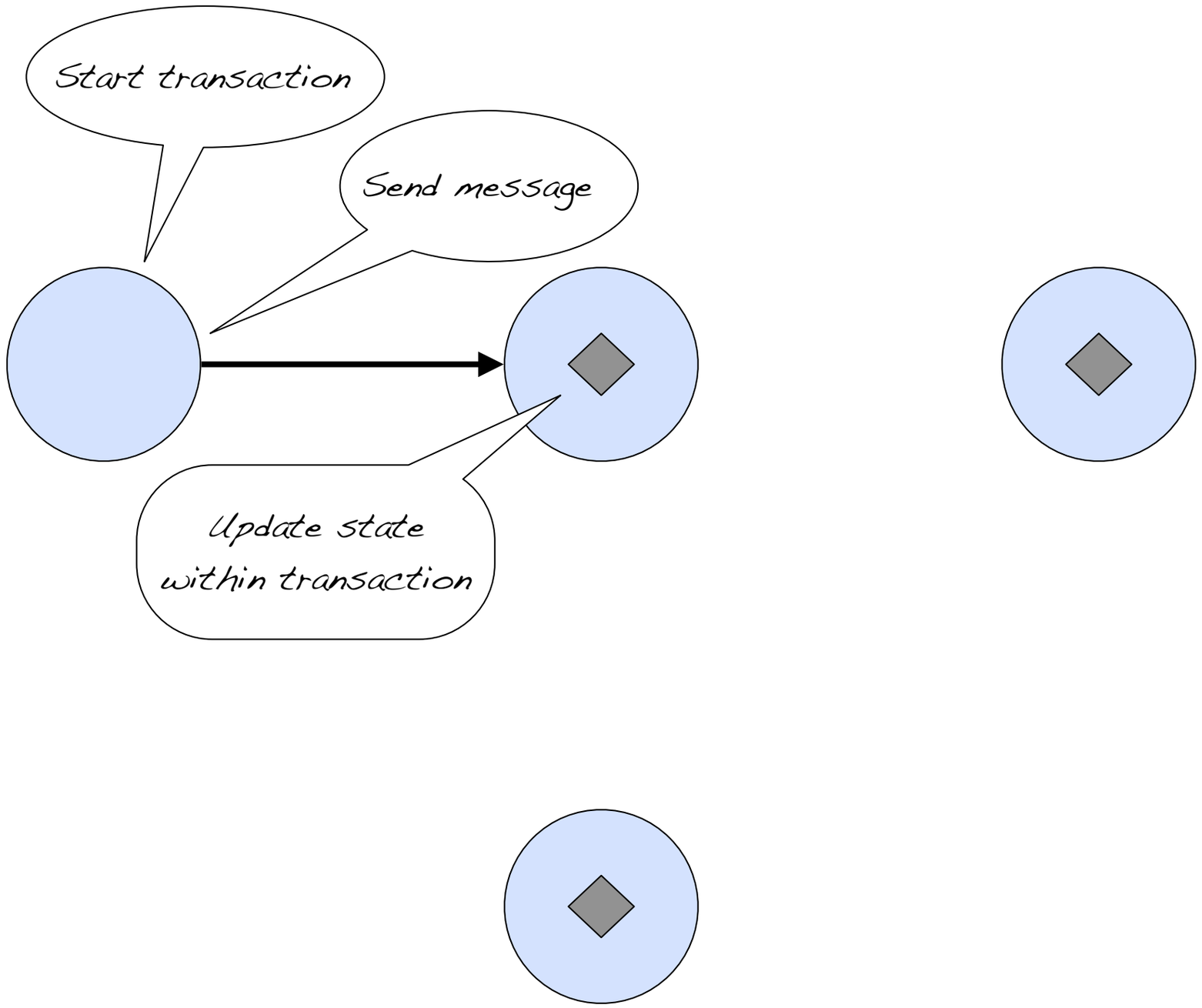

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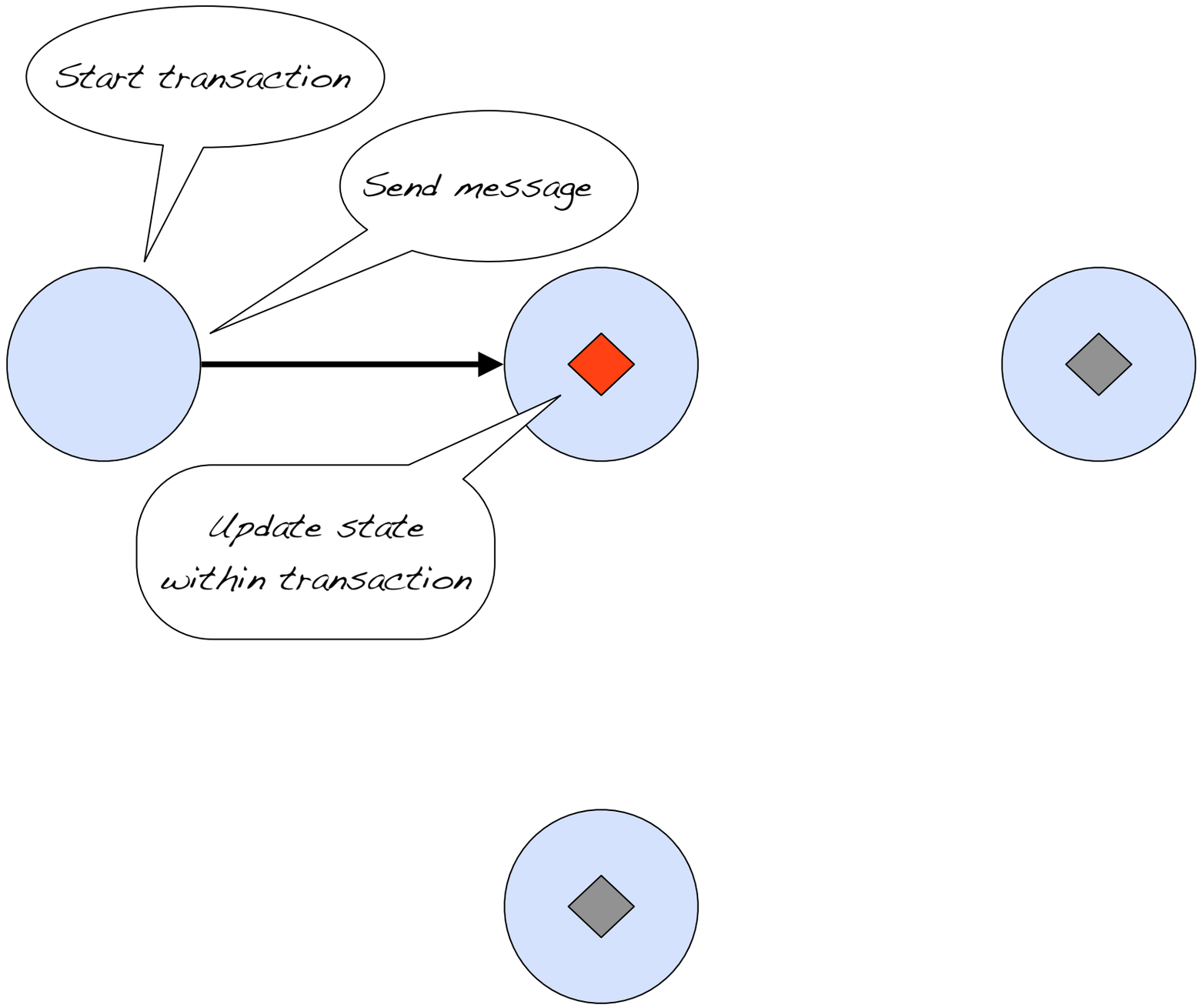

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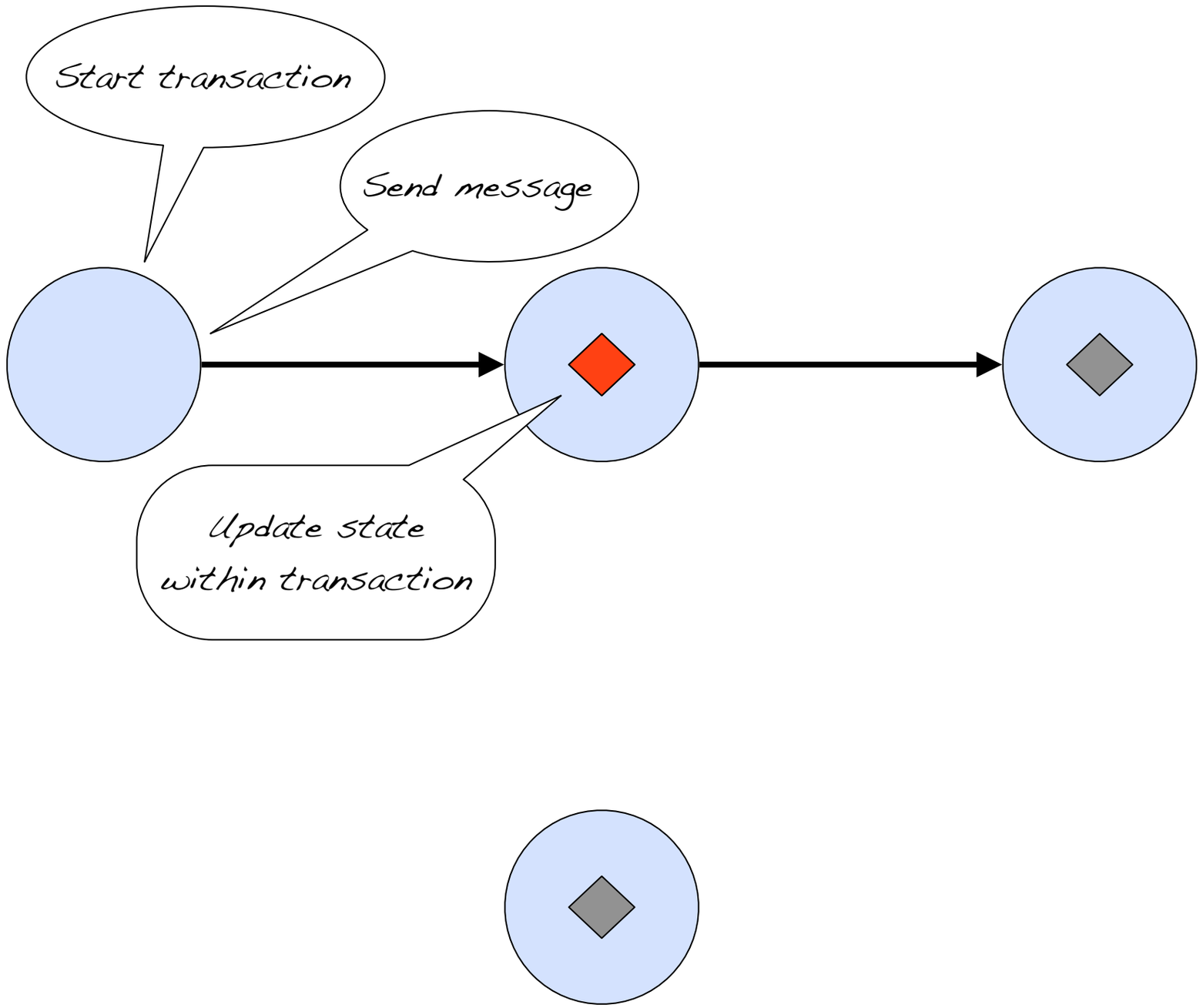
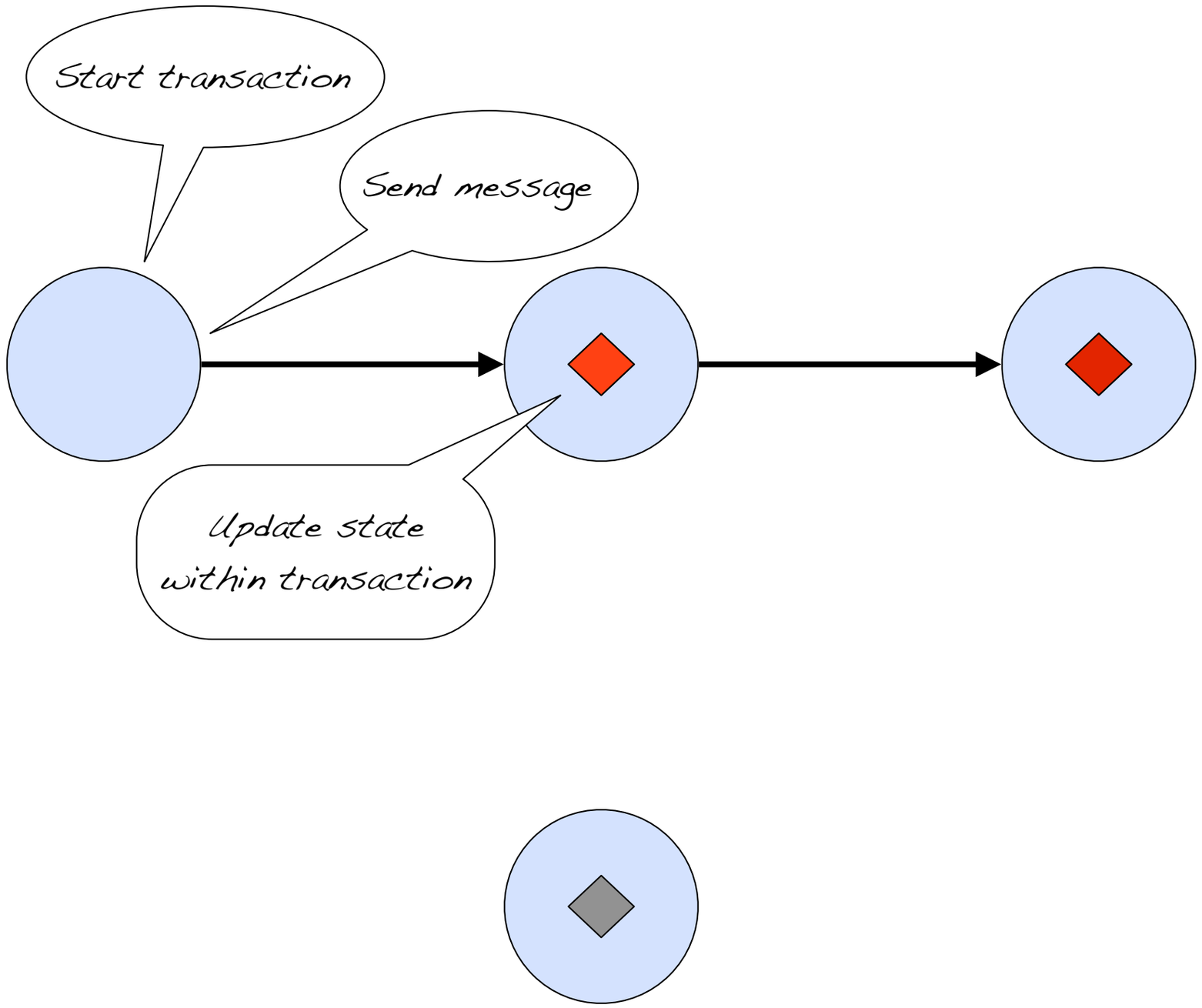
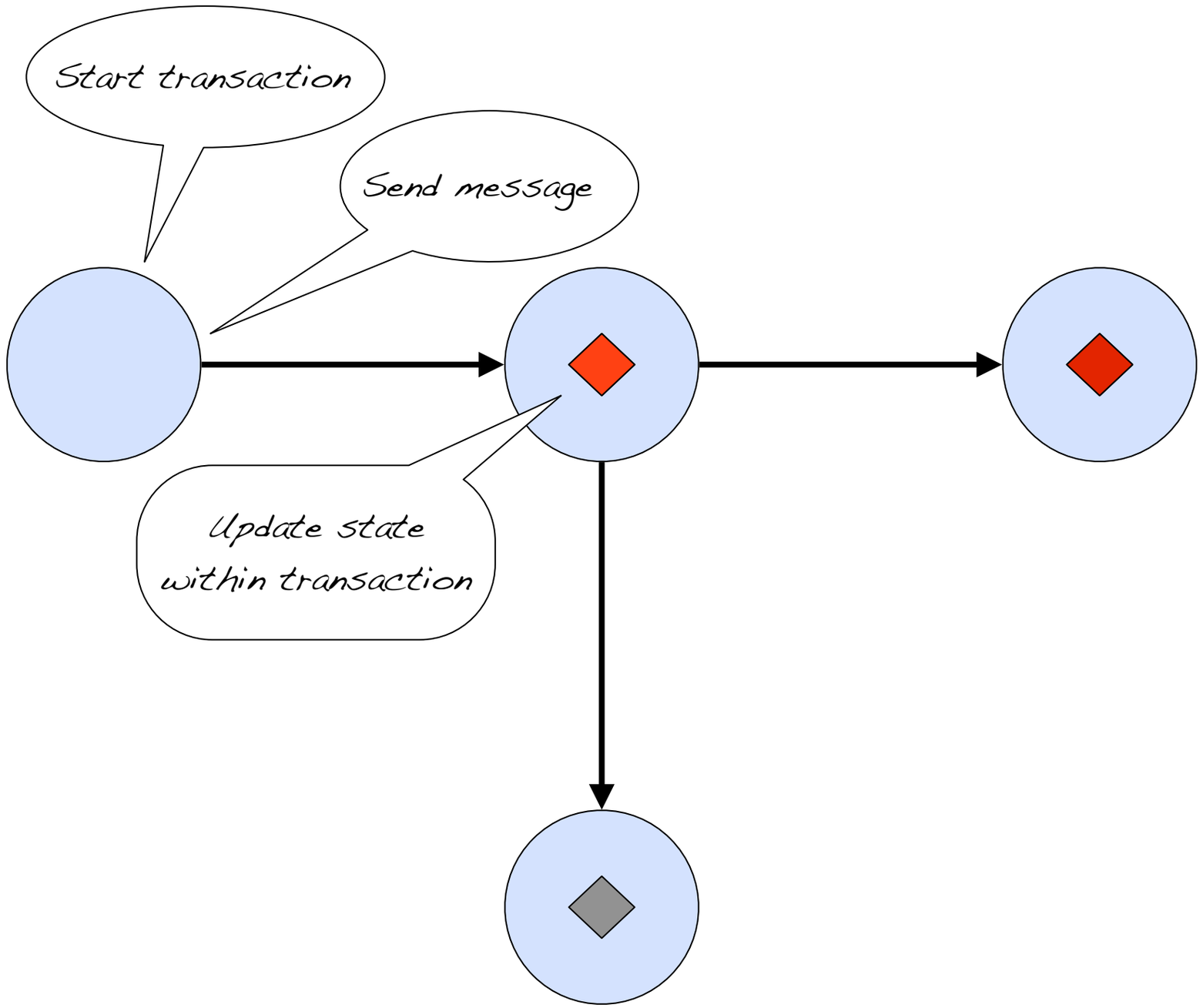


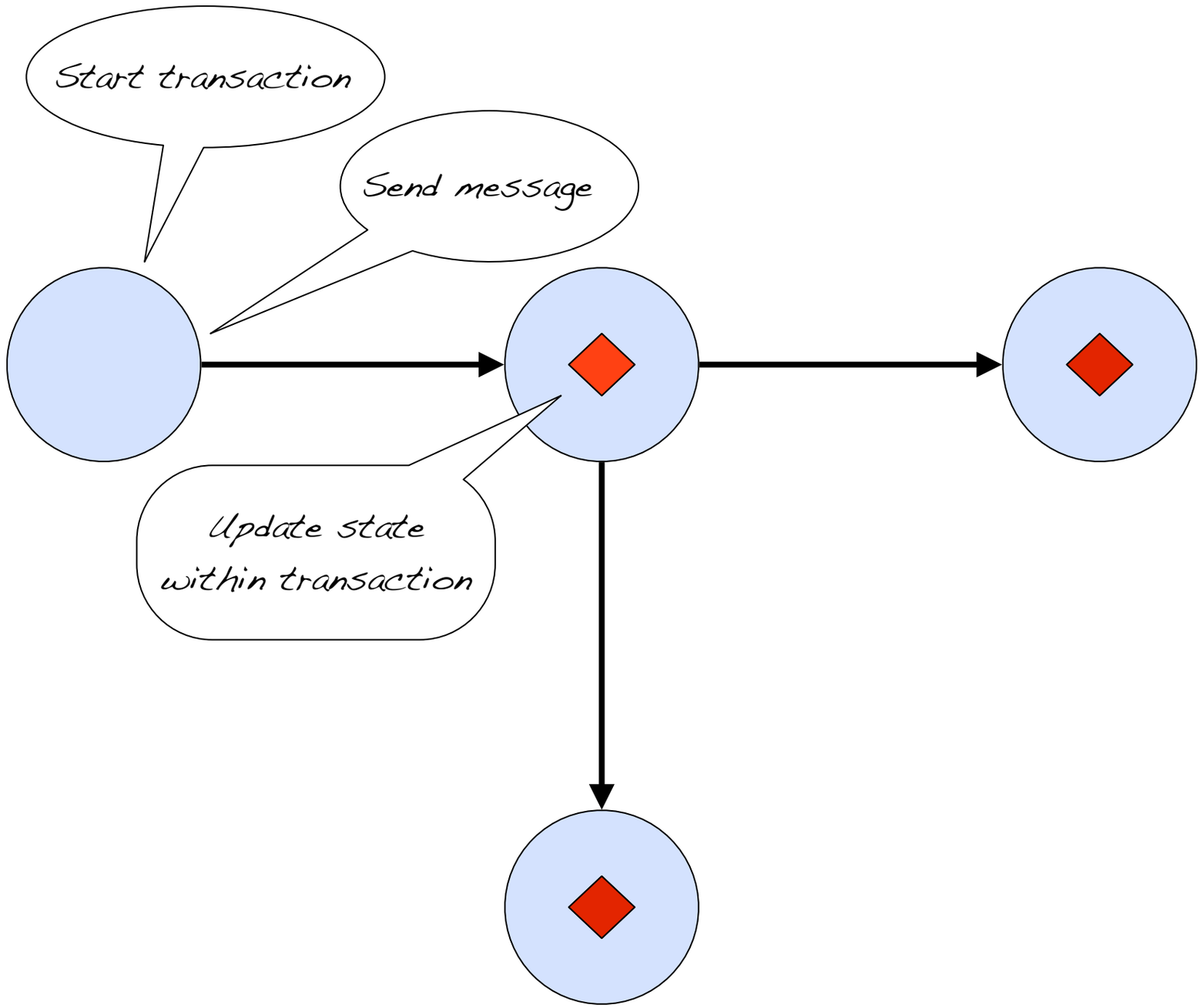
Transactors



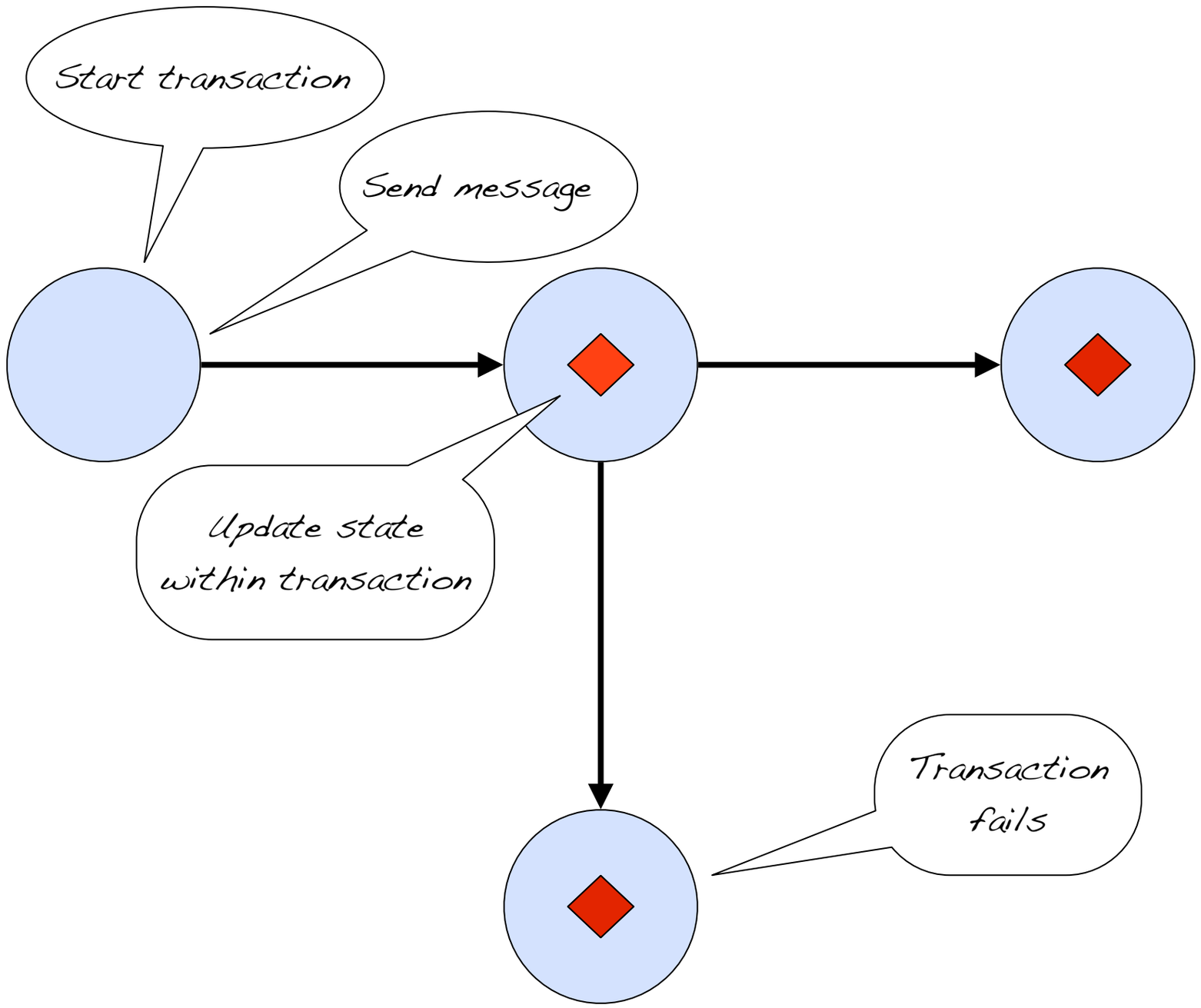
Transactors



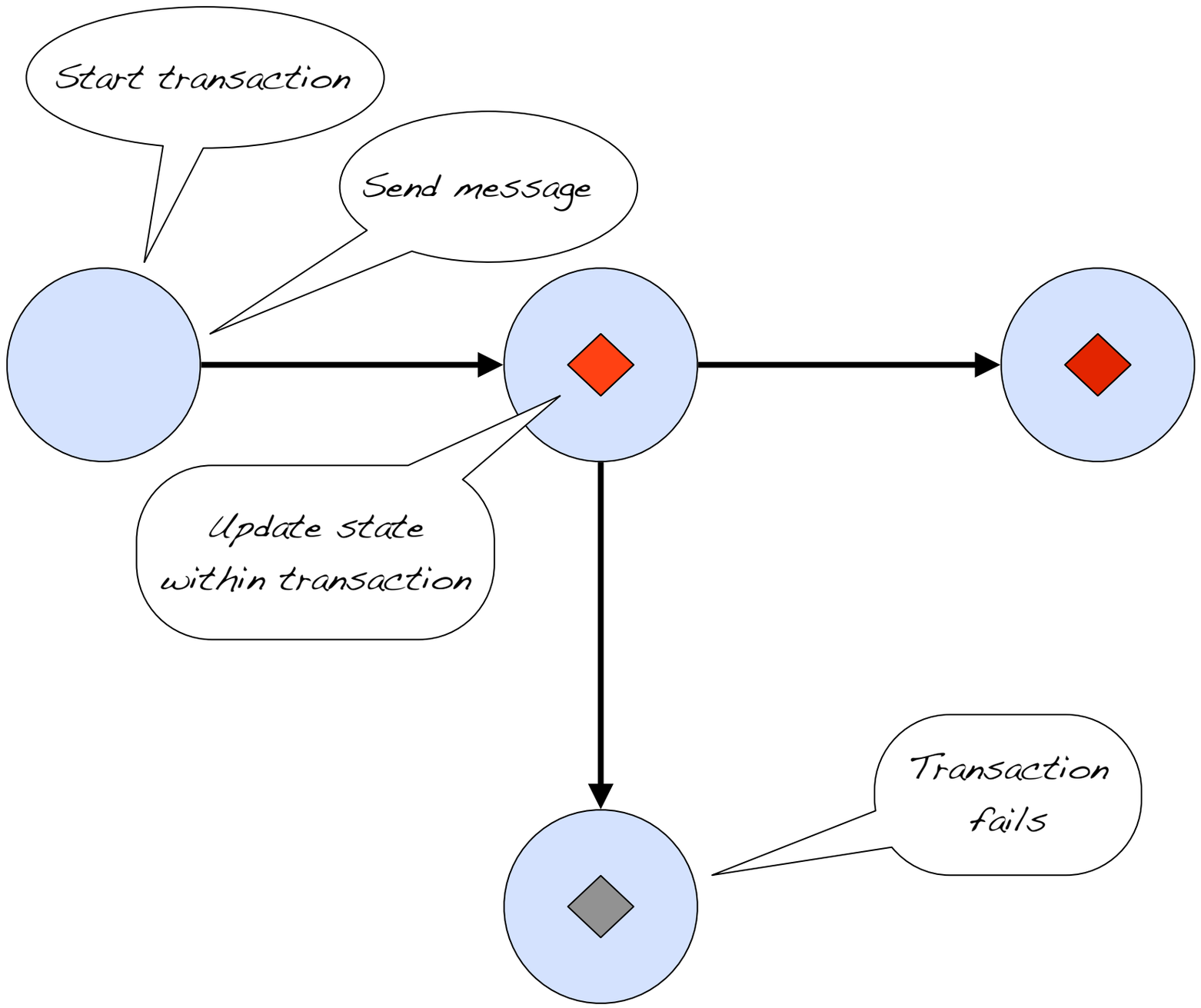
Transactors



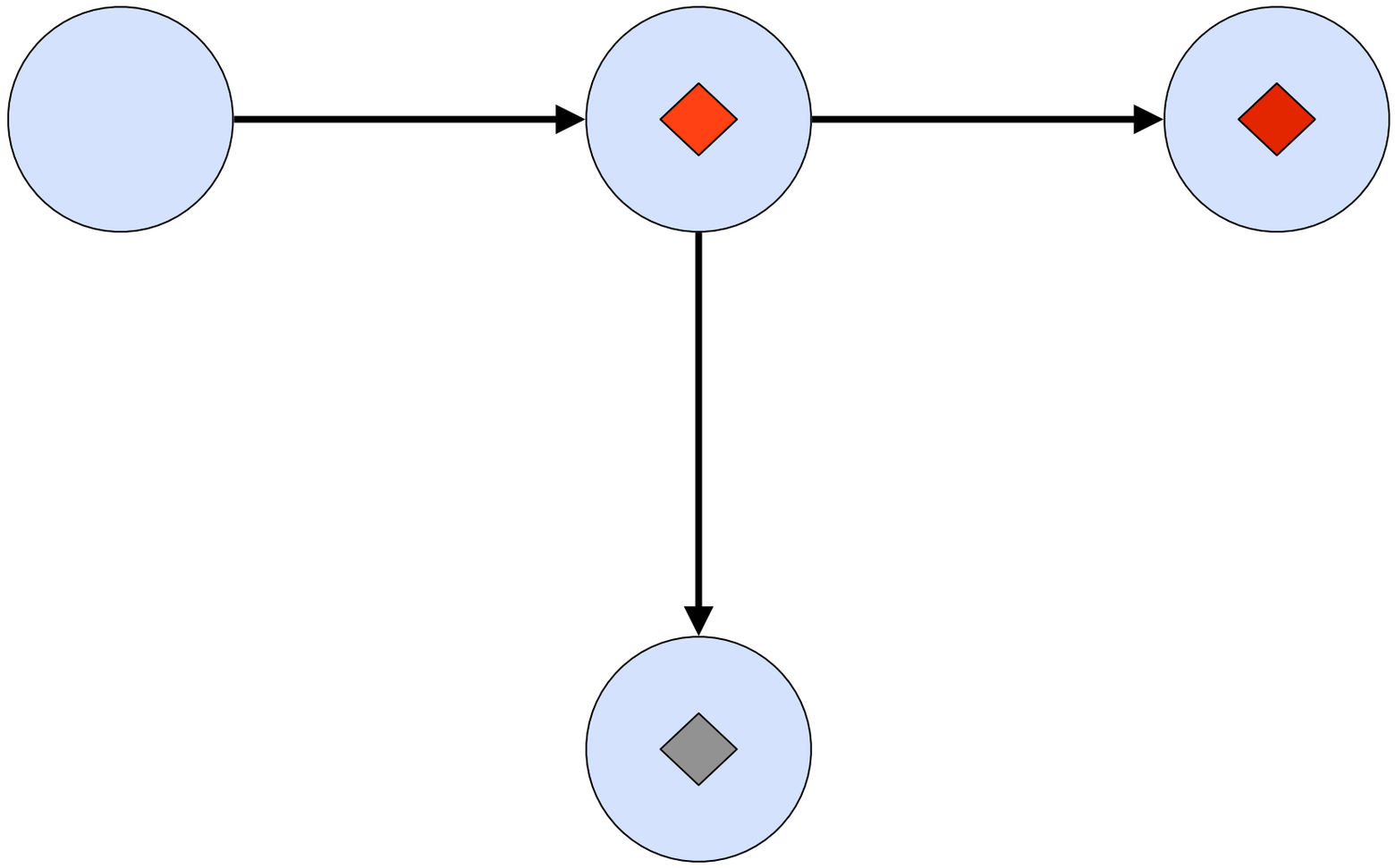
Transactors



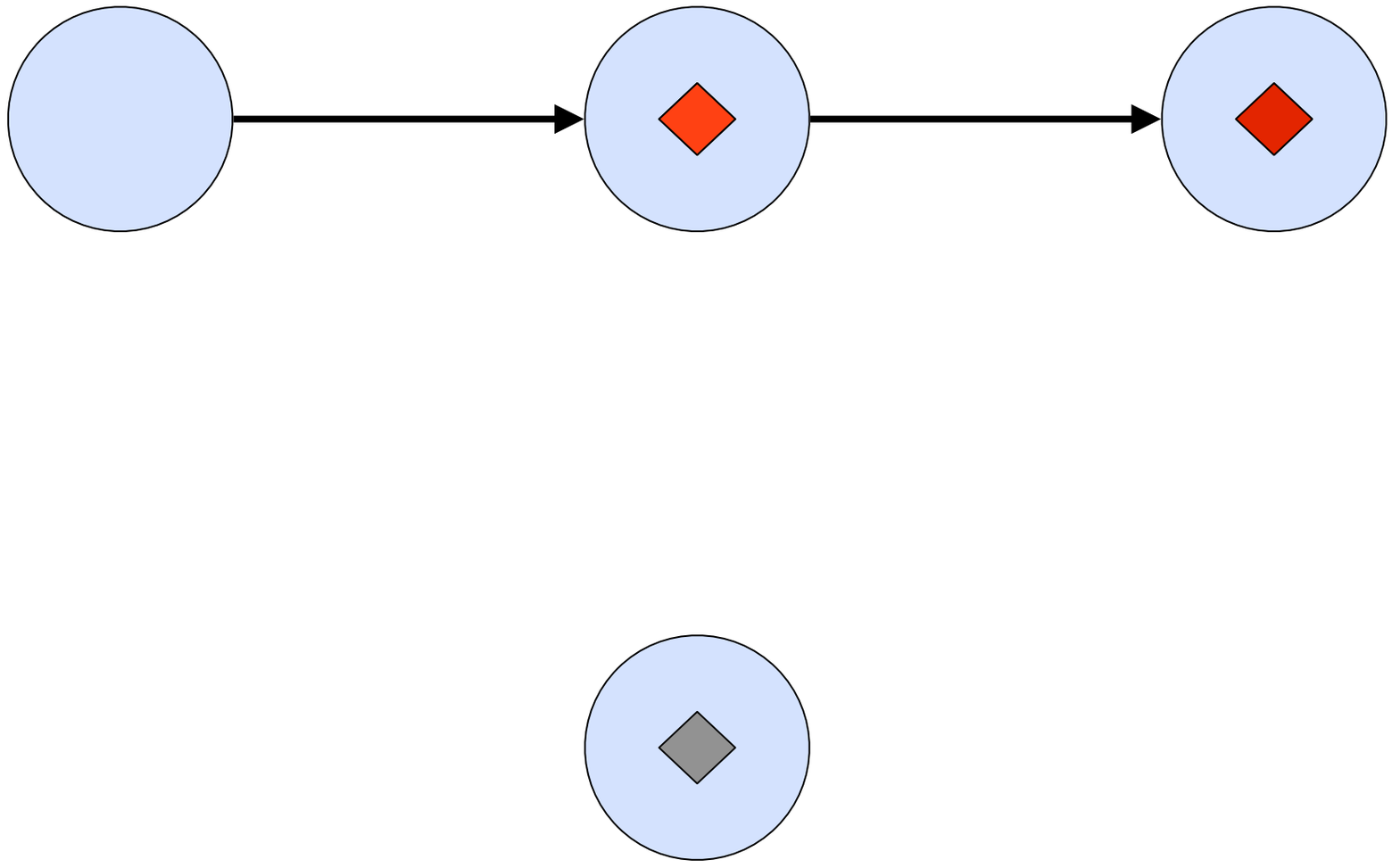
Transactors



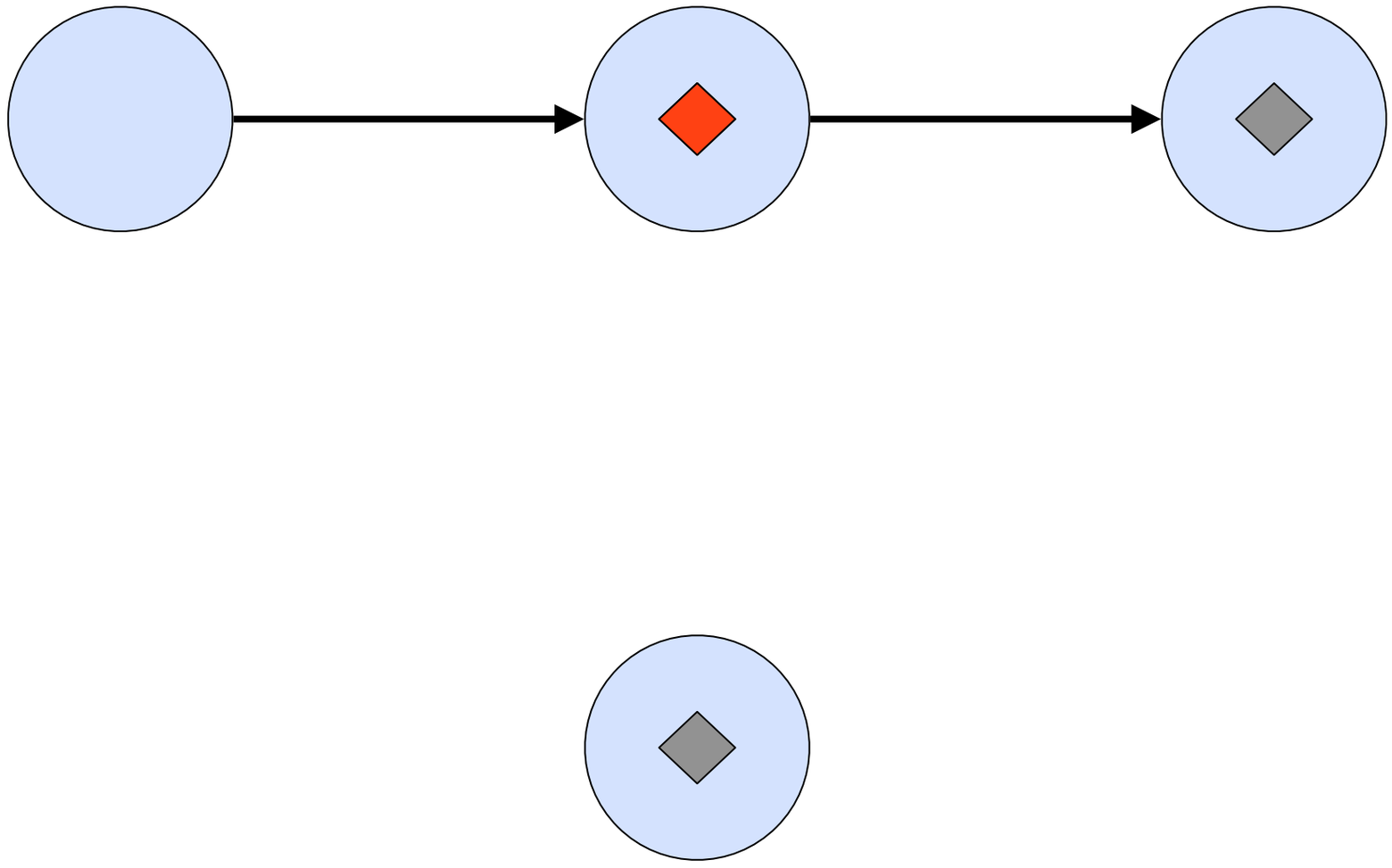
Transactors



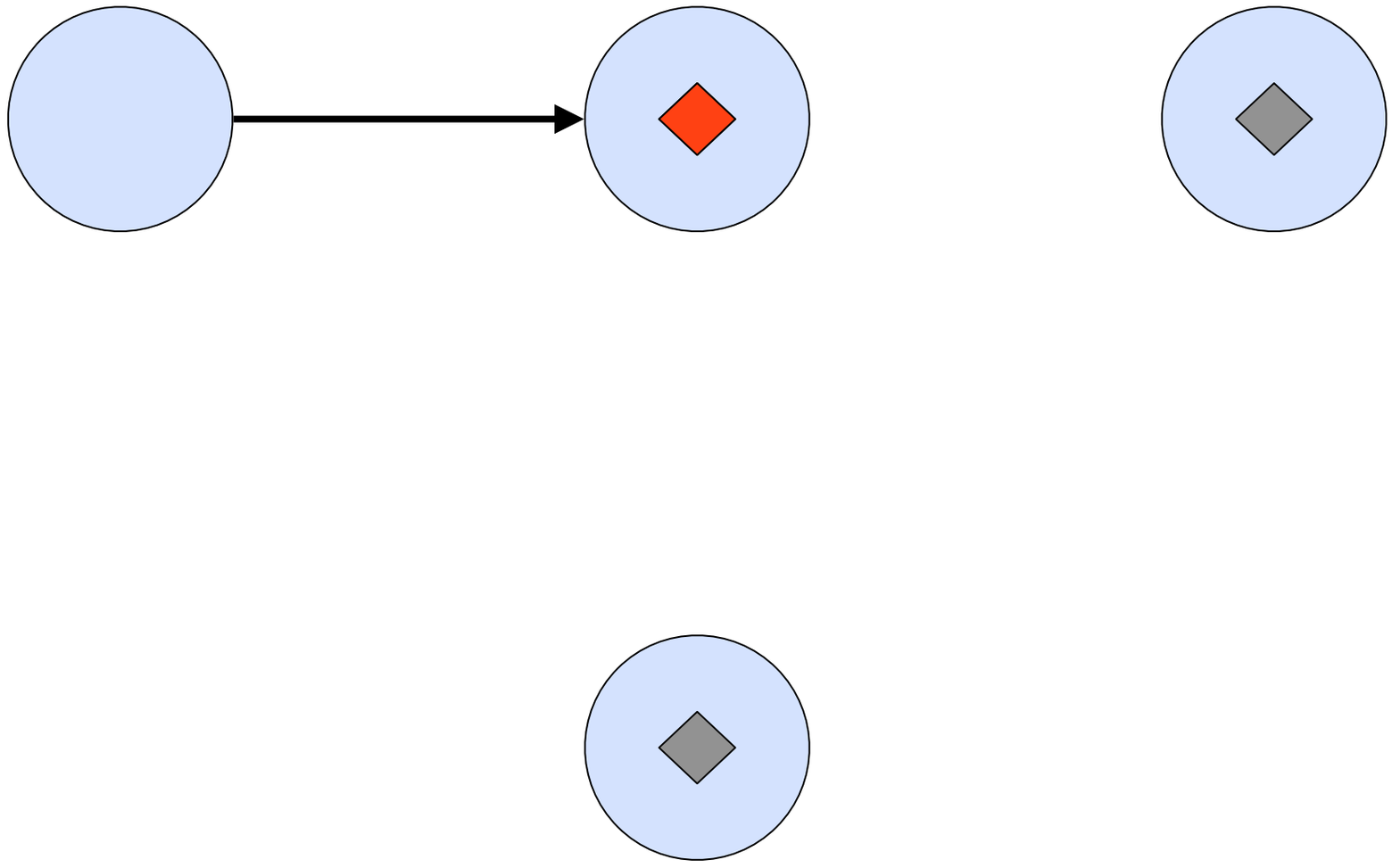
Transactors



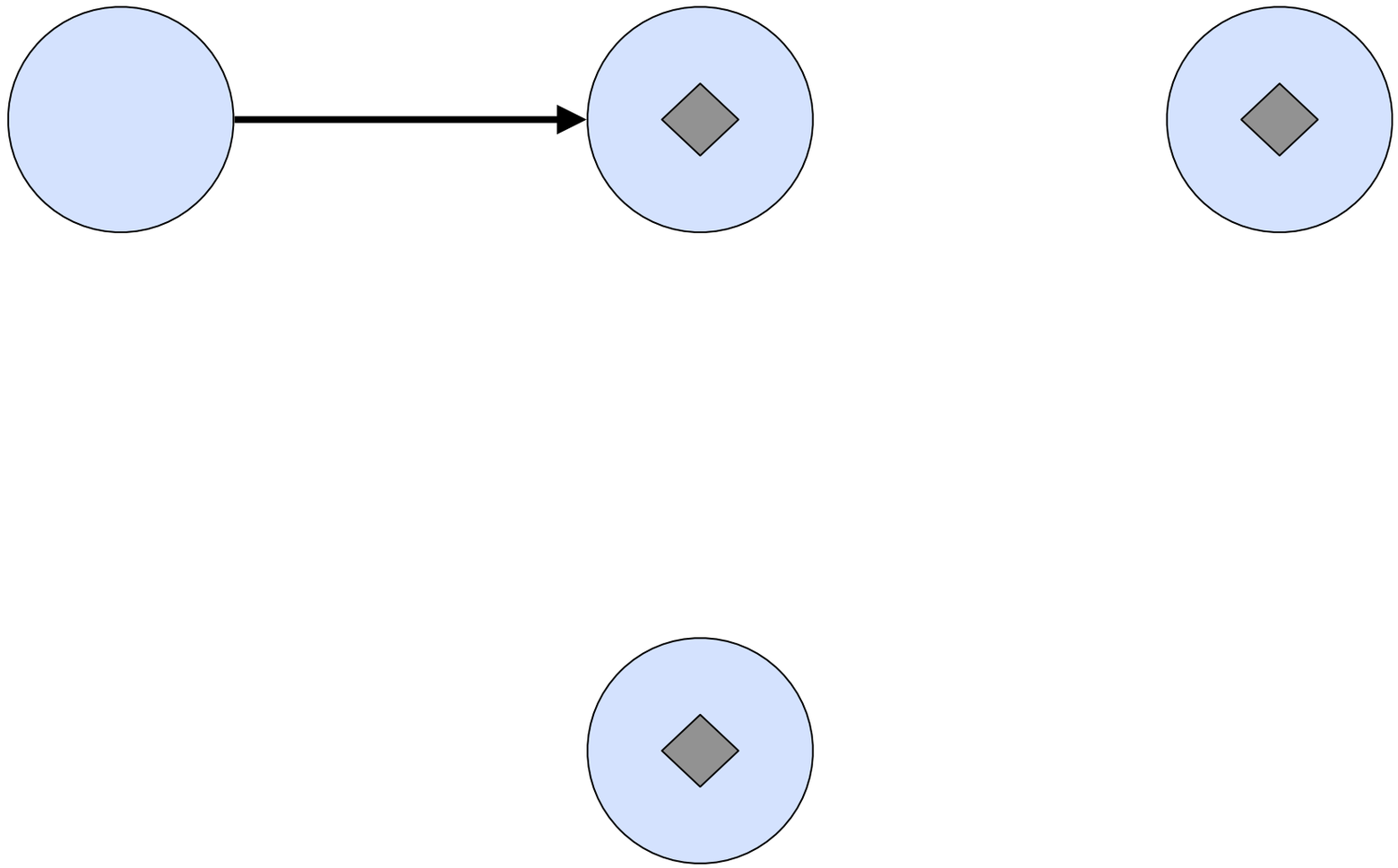
Transactors



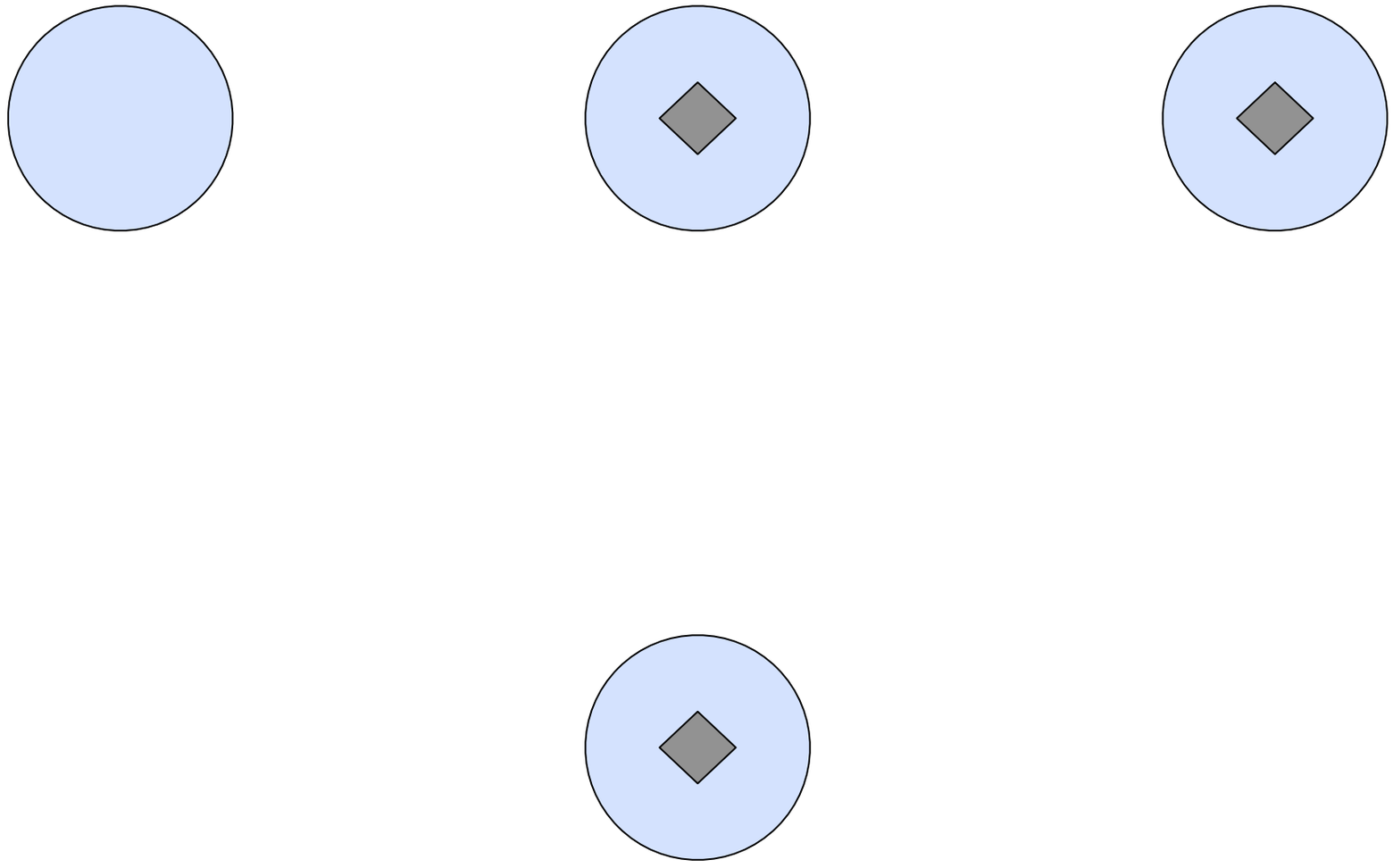
Transactors



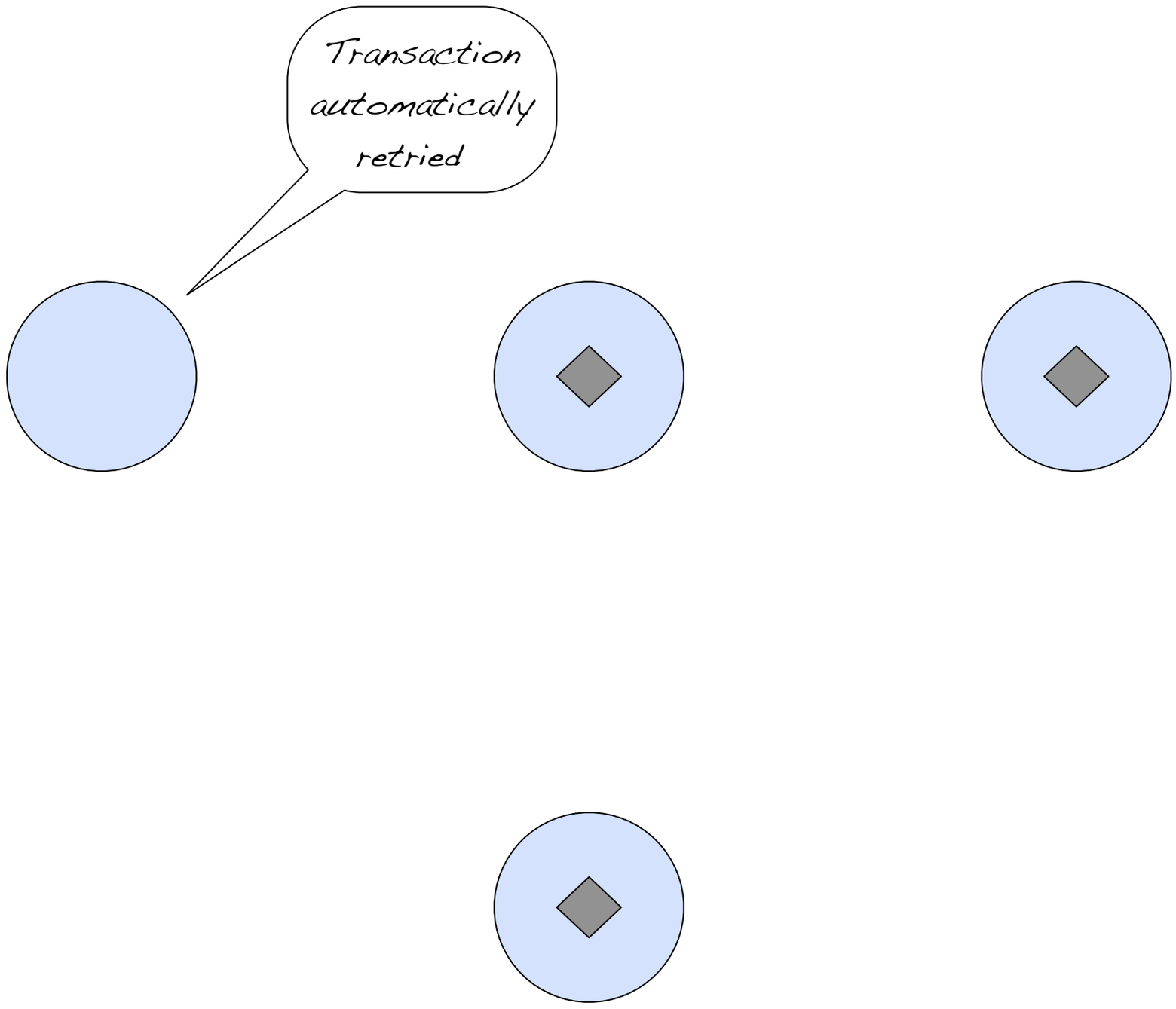
Transactors



Transactors



Transactors



STM: config

```
akka {
  stm {
    fair = on
    jta-aware = off
    timeout = 5
  }
}
```

STM: disable

```
TransactionManagement.disableTransactions
```

Akka Serialization

Serializers

Scala JSON

Java JSON

Protobuf

SBinary

Java

Serializers

Scala 2 JSON & JSON 2 Scala

```
val foo = new Foo
val json = Serializer.ScalaJSON.out(foo)
val fooCopy =
  Serializer.ScalaJSON.in(json).asInstanceOf[Foo]
```

Serializers

Scala 2 Binary & Binary 2 Scala

```
import sbinary.DefaultProtocol._
val users =
    ("user1", "passwd1") ::
    ("user2", "passwd2") ::
    ("user3", "passwd3") :: Nil
val bytes = Serializer.SBinary.out(users)

val usersCopy: List[Tuple2[String, String]]] =
  Serializer.SBinary.in(bytes)
```

Serializers

Protobuf

```
val pojo =
  ProtobufPOJO.getDefaultInstance.toBuilder
  .setId(1)
  .setName("protobuf")
  .setStatus(true).build
val bytes = pojo.toByteArray

val pojoCopy = Serializer.Protobuf.in(
  bytes, classOf[ProtobufPOJO])
```

Serializable

```
case class MyMessage(
  id: String,
  value: Tuple2[String, Int])
  extends Serializable.ScalaJSON

val message = MyMessage("id", ("hello", 34))
val json = message.toJSON
```

Modules

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

```
<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 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
```

Get data by id

```
// transactional Cassandra-backed Map
val map = CassandraStorage.getMap(uuid)

// transactional Redis-backed Vector
val vector = RedisStorage.getVector(uuid)

// transactional Mongo-backed Ref
val ref = MongoStorage.getRef(uuid)
```

For Redis only (so far)

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

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

Akka HotSwap

HotSwap

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

Akka AMQP

AMQP: producer

```
val producer = AMQP.newProducer(
   config,
   hostname, port,
   exchangeName,
   serializer,
    None, None, // listeners
   100)

producer ! Message("Hi there", routingId)
```

AMQP: consumer

```
val consumer = AMQP.newConsumer(
  config, hostname, port, exchangeName,
  ExchangeType.Direct, serializer,
  None, 100, passive, durable,
  Map[String, AnyRef())

consumer ! MessageConsumerListener(
  queueName, routingId, actor {
    case Message(payload, _, _, _, _) =>
      ... // process message
  })
```

How to run it?

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

Akka Kernel

Start Kernel

```
java -jar akka-0.9.1.jar \
   -Dakka.config=<path>/akka.conf
```

Or

```
export AKKA_HOME=<path to akka dist>
java -jar $AKKA_HOME/dist/akka-0.9.1.jar
```

Boot classes

```
class Boot {
  val supervisor = Supervisor(
    SupervisorConfig(
      RestartStrategy(OneForOne, 3, 100),
      Supervise(
        actorOf[Counter], LifeCycle(Permanent)) ::
      Supervise(
        actorOf[Chat], LifeCycle(Permanent)) ::
      Nil)))
}
```

Boot config

```
akka {
  boot = ["sample.rest.Boot",
          "sample.comet.Boot"]
  ...
}
```

Learn more

http://akkasource.org

EOF