The Art of Possible

CAKESOLUTIONS
ENTERPRISE SOFTWARE SERVICES

MANCHESTER LONDON NEW YORK

Chaos Engineering and Runtime Monitoring of Distributed Reactive Systems

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The Goal

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- Verify the correctness of a distributed system

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- Typical verification approaches
  - Testing
  - Static analysis
  - Formal/model based verification

What Happens Next?

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- Excellent, we now feel confident that the application is correct

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- Excellent, we now feel confident that the application is correct
- But what happens next?

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- DevOps then deploy to and orchestrate commodity cloud based hardware
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- Human intervention may occur during crisis scenarios
- Do you still feel confident that the application is correct?

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  - deployment typically uses unverified processes
- Potential for unanticipated failure is now highly likely
  - embrace and test for failure!

docker-compose-testkit

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- Open-source Scala library (under development)
  - (optionally) deploys, orchestrates and instruments Docker container code
  - agnostic of deployment environment
  - composable behaviour properties
  - reusable Chaos experiments *easily* defined

Demo Recipe

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  - view system as a black box
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  - view system as a black box
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- define the Chaos experiment
  - relate observed behaviours to data injection
- define runtime monitors (c.f. behaviours)
  - bind monitors to instrumented interface

Demo Overview

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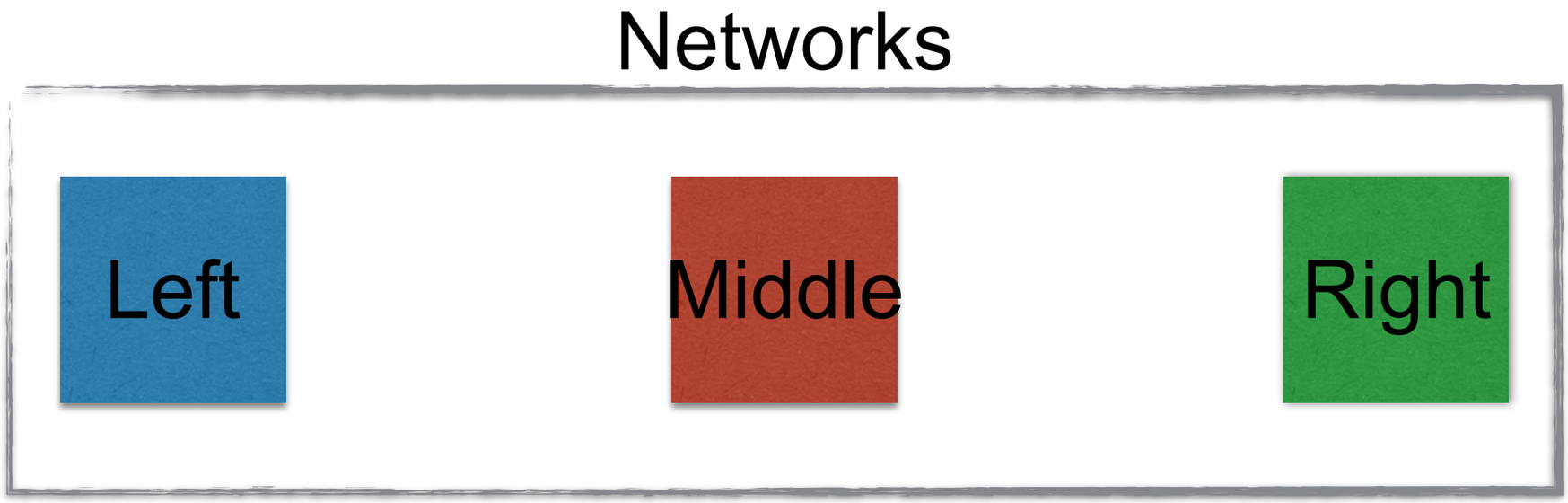

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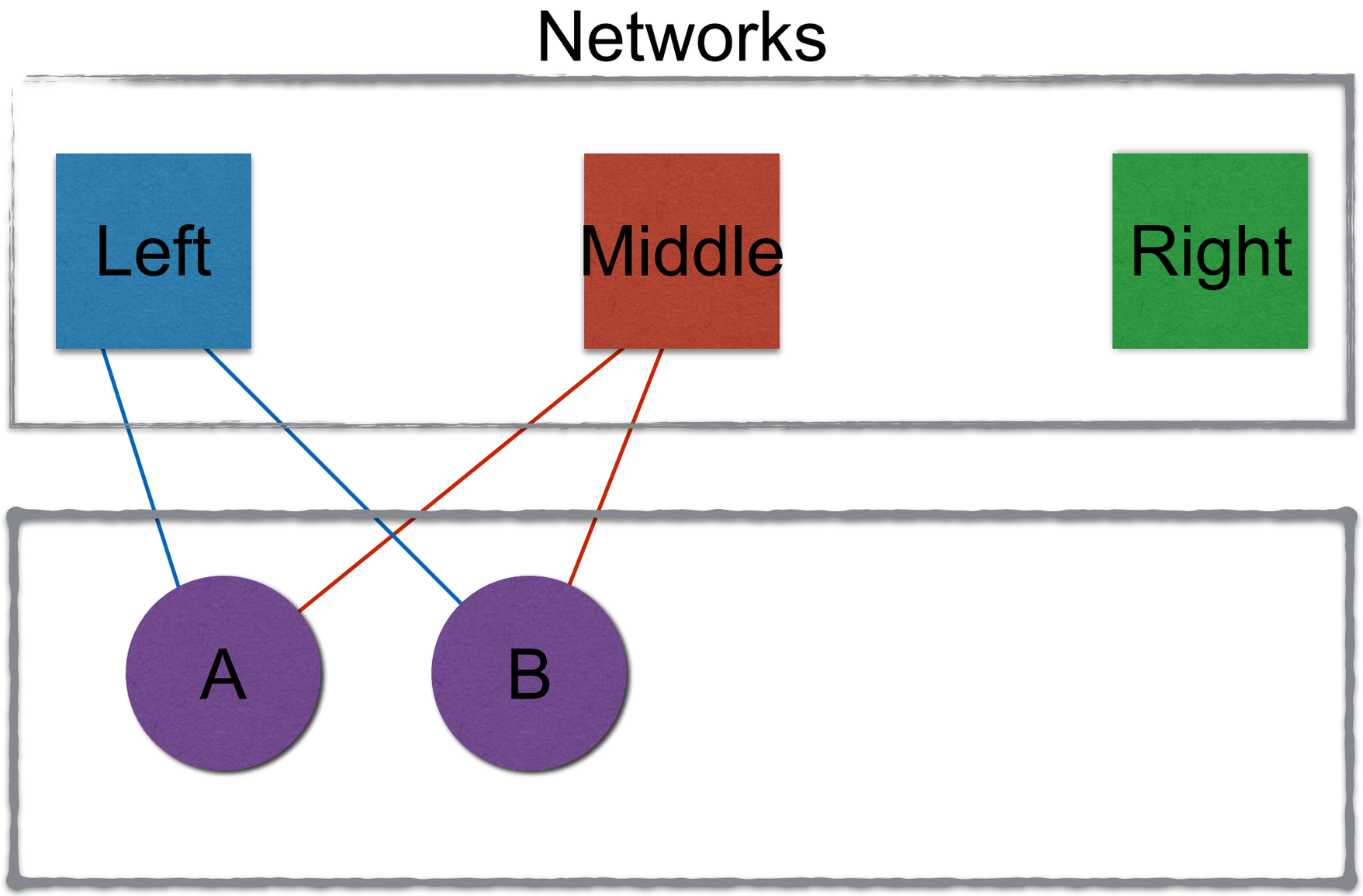

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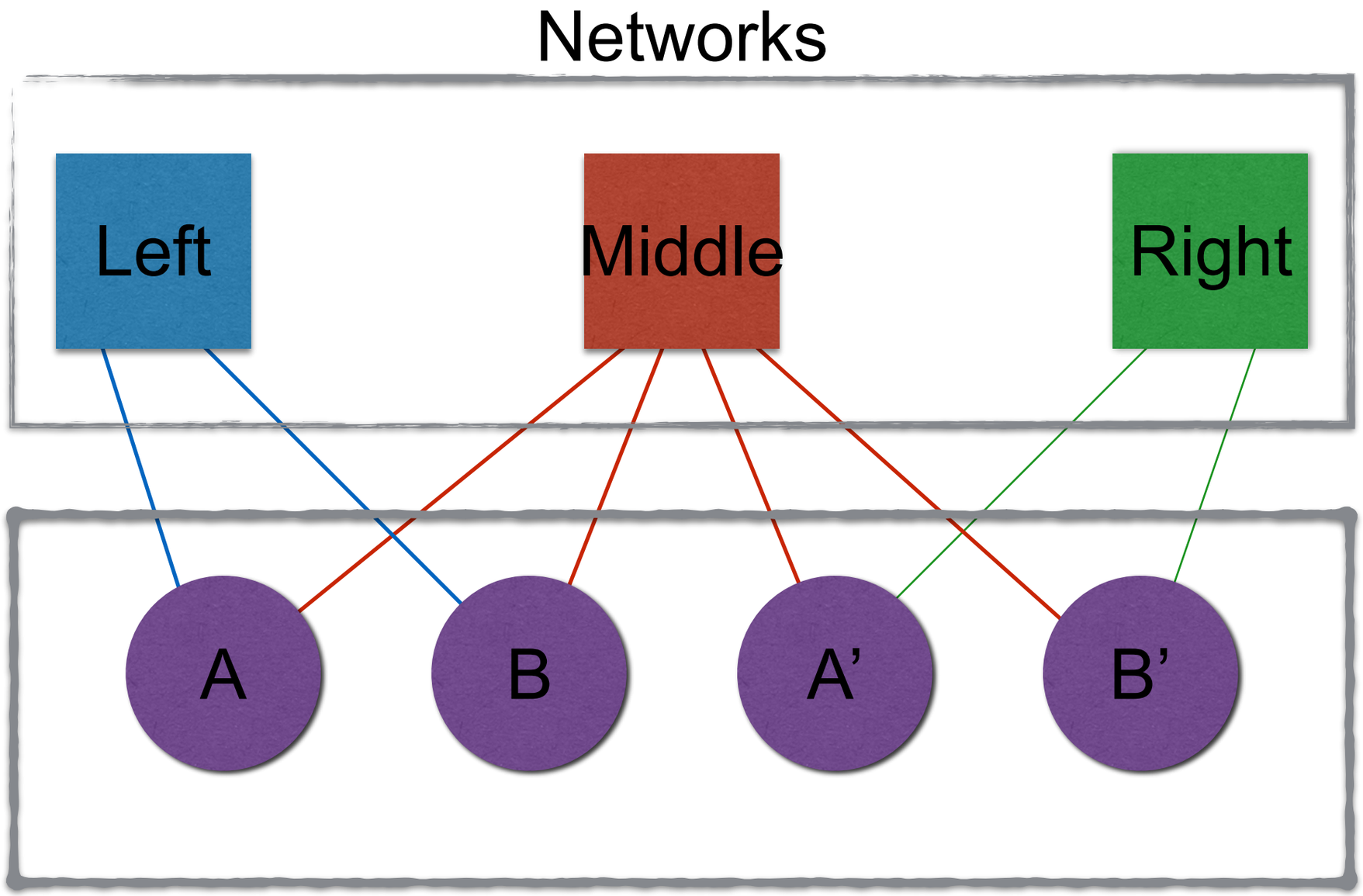

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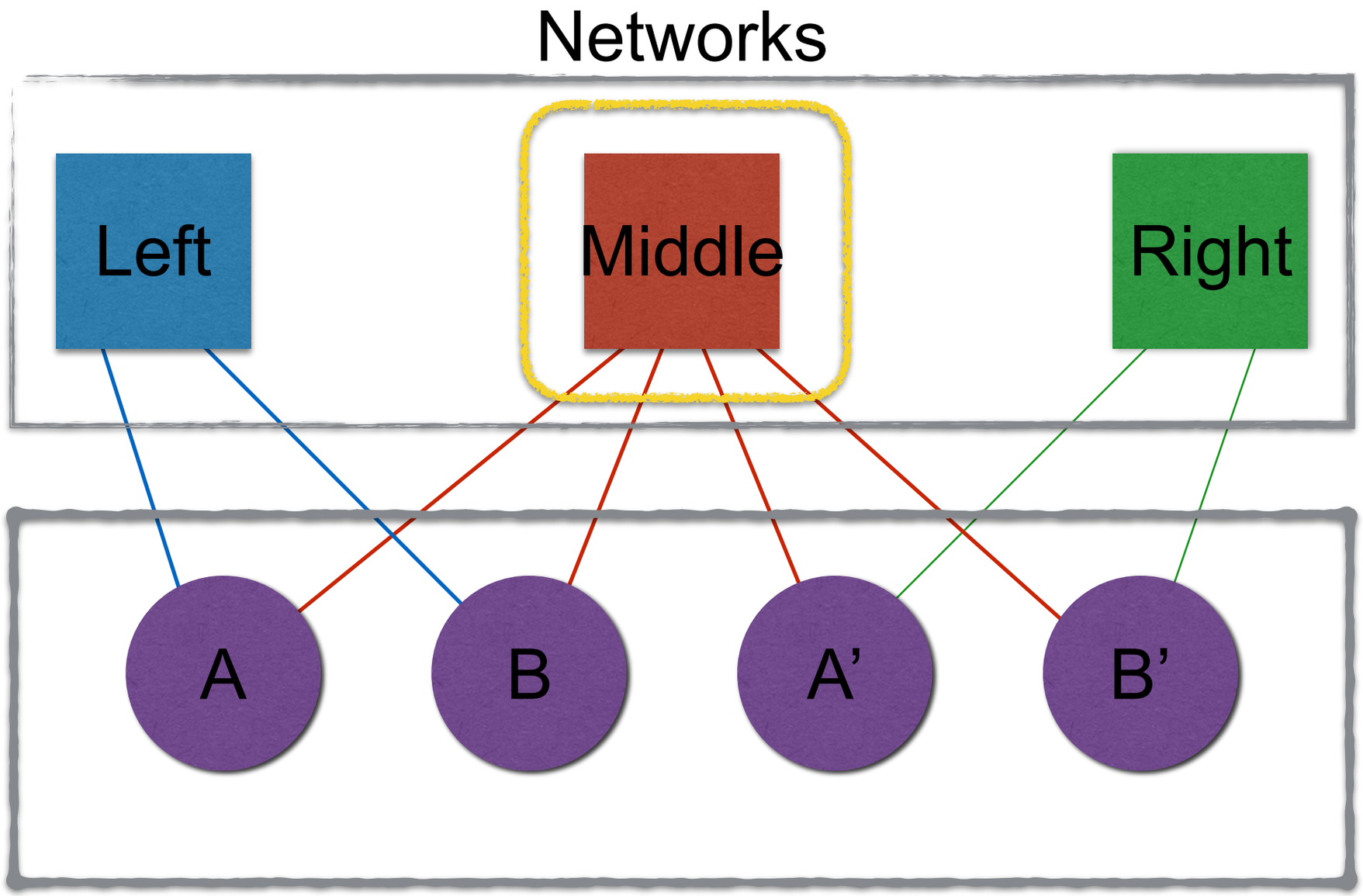

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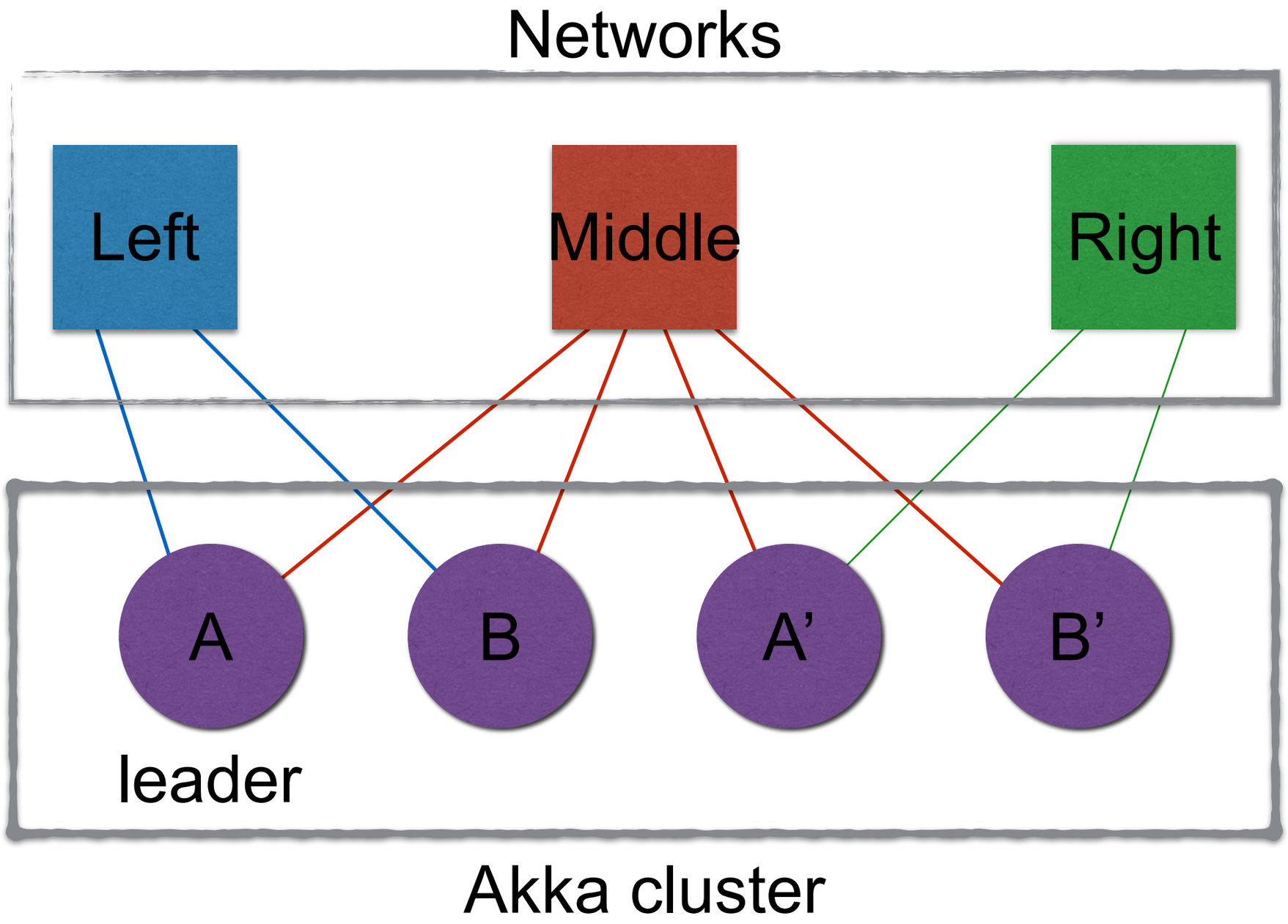

Auto-downing Enabled!!

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```
def clusterNode(name: String, network1: String, network2: String): String =
  s"""$name:
     |    template:
     |      resources:
     |        - cakesolutions.docker.jmx.akka
     |        - cakesolutions.docker.network.default.linux
     |      image: docker-compose-testkit-tests:$version
     |    environment:
     |      AKKA_HOST: $name
     |      AKKA_PORT: 2552
     |      CLUSTER_SEED_NODE: "akka.tcp://TestCluster@A:2552"
     |    expose:
     |      - 2552
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     |      - $network1
     |      - $network2
   """.stripMargin

val yaml = DockerComposeString(
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     |
     |services:
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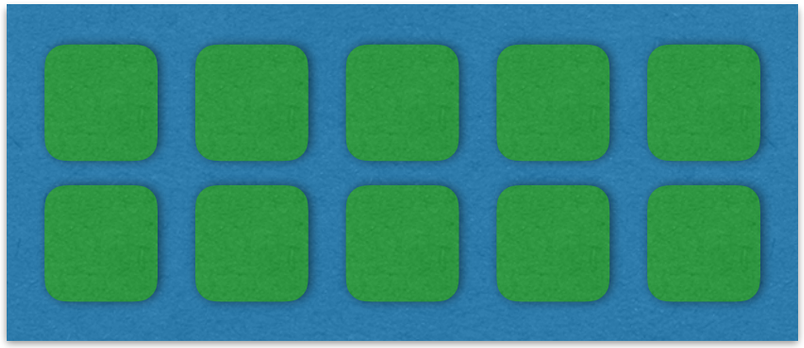
```

immutable container

System Instrumentation



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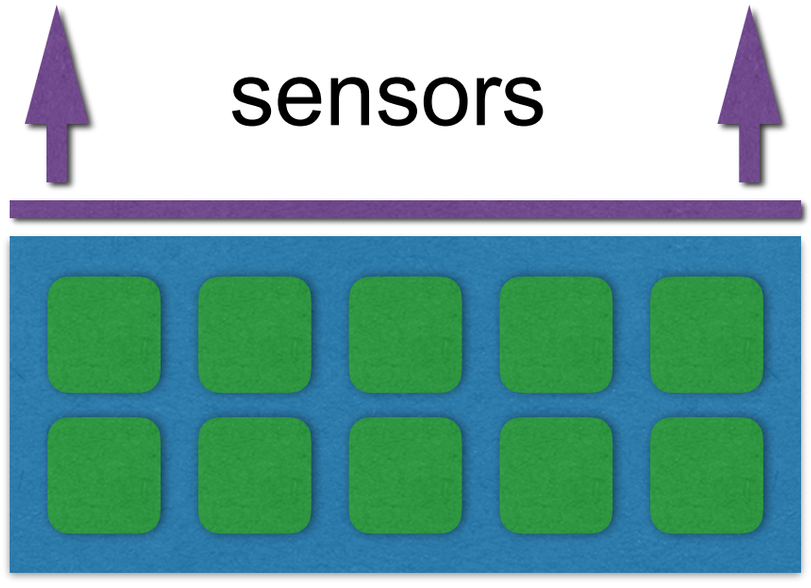

- define sensors
  - emit events of a fixed type
  - implemented using Monix Observables

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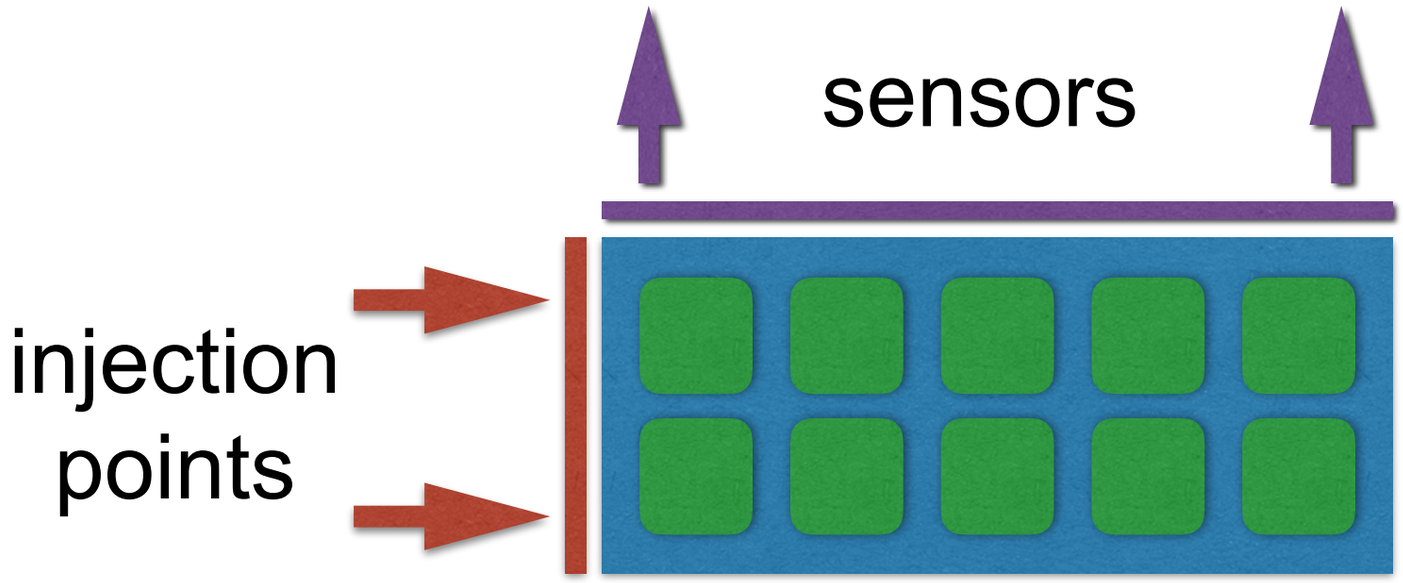

- define sensors
  - emit events of a fixed type
  - implemented using Monix Observables
- define injection points
  - allow typed data to influence the application
  - implemented using Monix Observers

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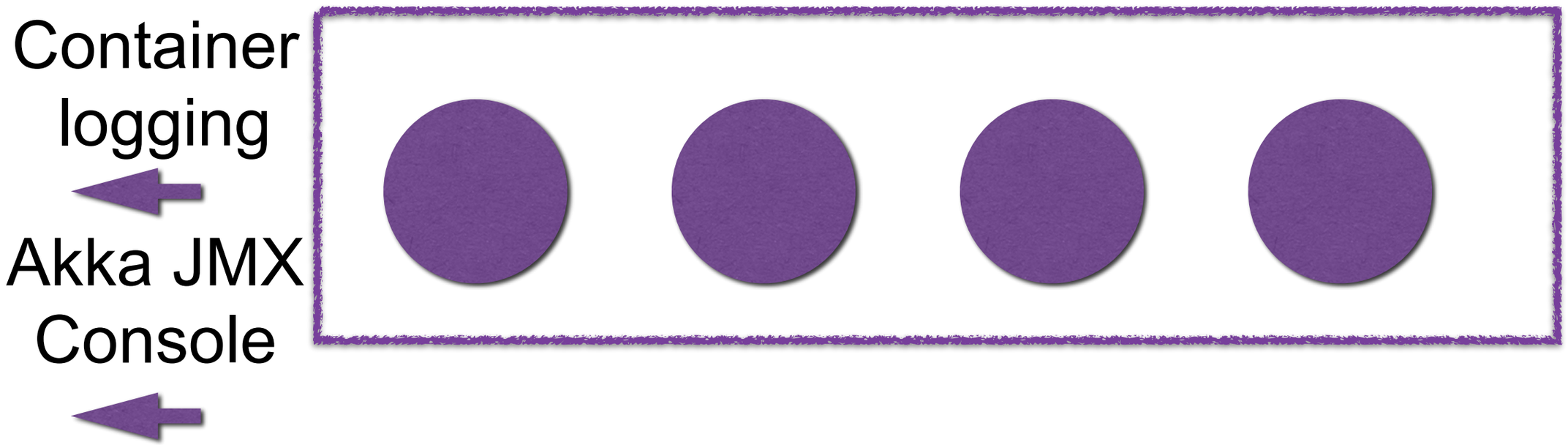

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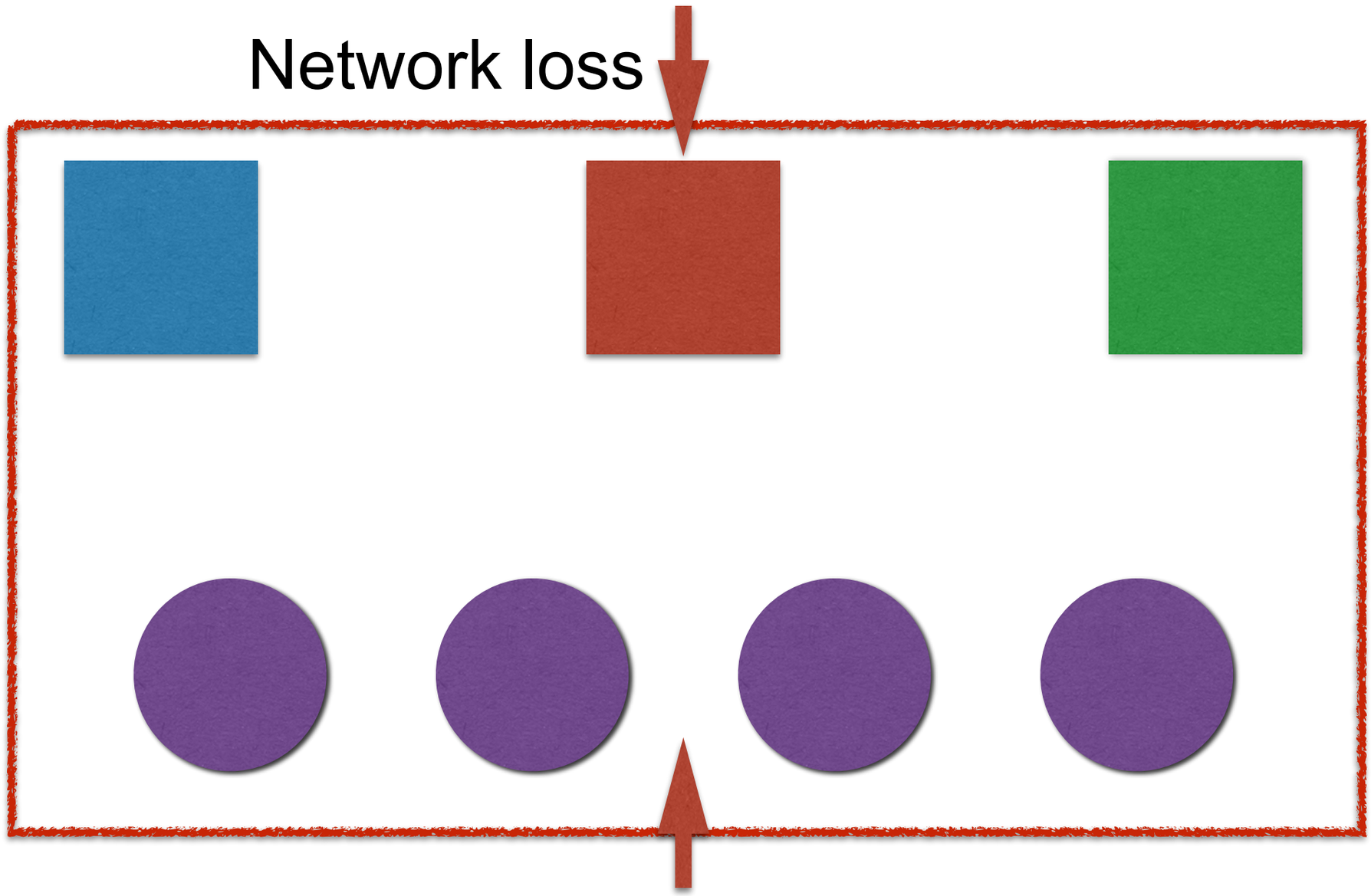

Demo Overview

```
final case class AkkaNodeSensors(
  log: TimedObservable.hot[LogEvent],
  members: TimedObservable.cold[AkkaClusterState]
)

object AkkaSensors {
  def apply(image: DockerImage)(implicit scheduler: Scheduler): AkkaNodeSensors = {
    AkkaNodeSensors(
      TimedObservable.hot(image.logging().publish),
      TimedObservable.cold(image.members())
    )
  }
}
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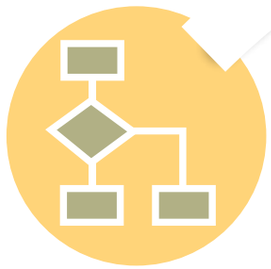
For this presentation, injection points will be implemented using side effecting code

Chaos Experiment



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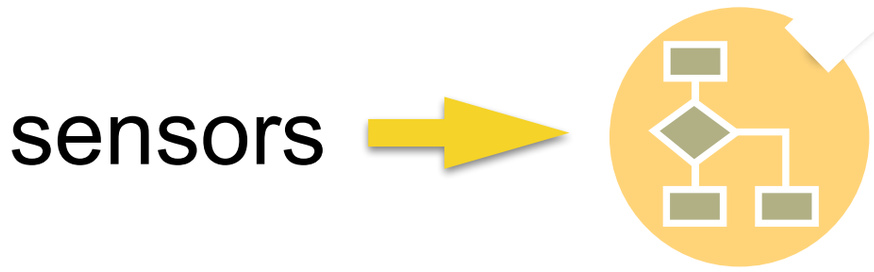

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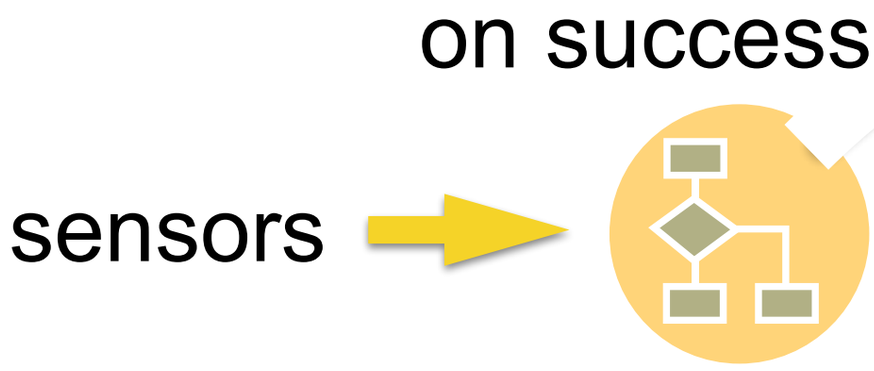

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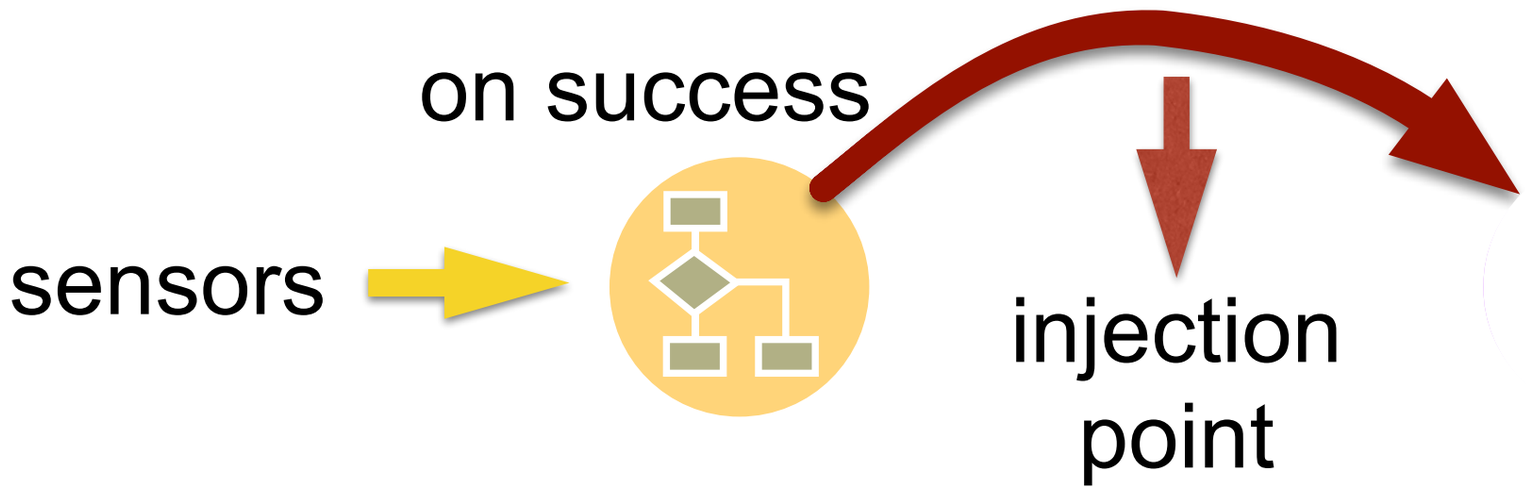

- Interpret this as follows:
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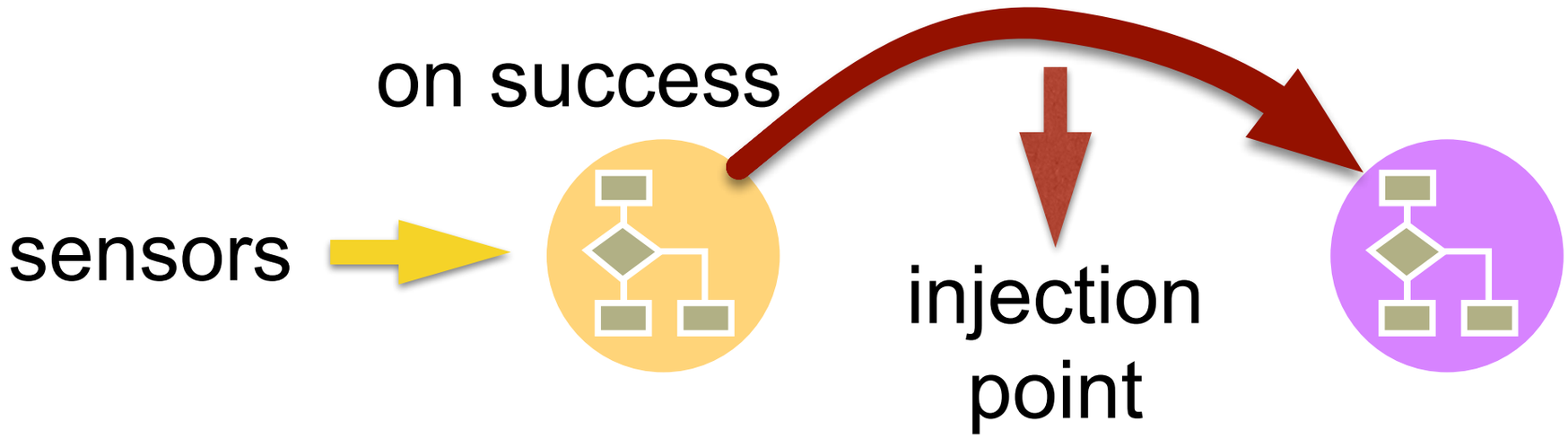

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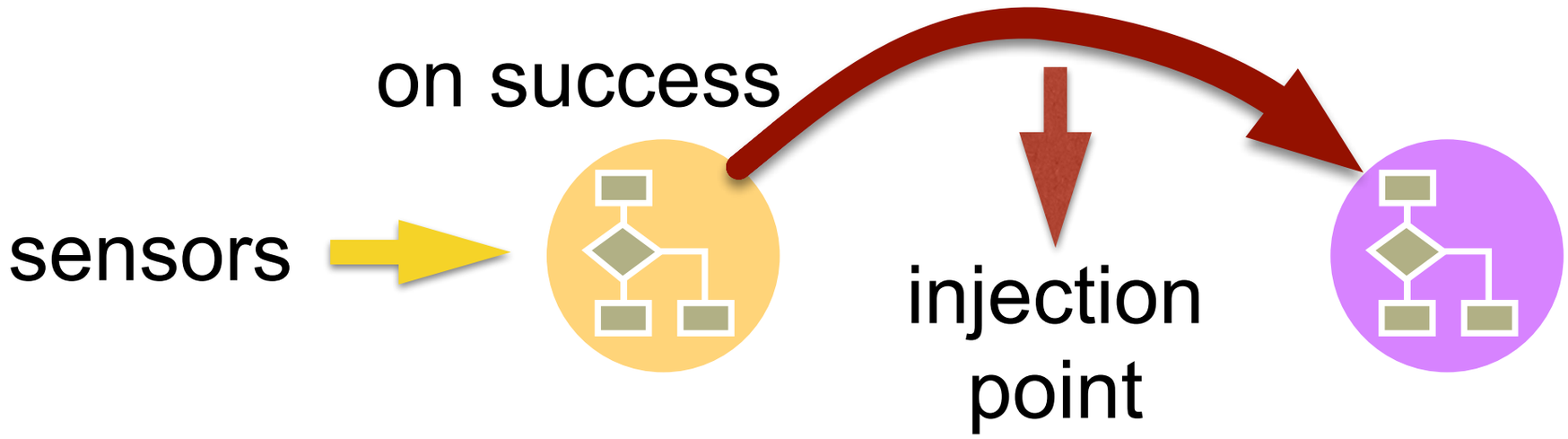

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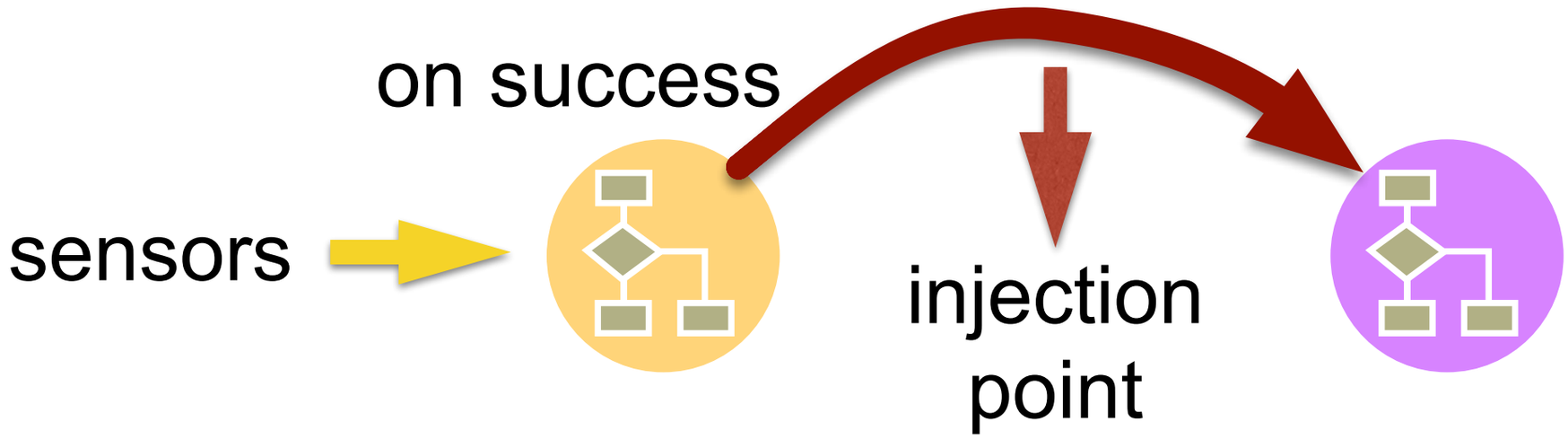

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Demo Overview

```
val testSimulation = for {
  _ <- ???
  _ = note("cluster formed, is stable and A an available leader")
  _ = rightNodeA.pause()
  _ = note("A' JVM GC pause starts")
  _ <- ???
  _ = note("A' is unreachable")
  _ = rightNodeA.unpause()
  _ = note("A' JVM GC pause ends")
  _ <- ???
  _ = note("cluster stabilised with A' as a member")
  _ = compose.network("middle").impair(Loss("100%"))
  _ = note("partition into left and right networks")
  _ <- ???
  _ = note("cluster split brains into 3 clusters: A & B; A'; B'")
} yield Accept()


testSimulation should observe(Accept())
```

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Behavioural Property

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  - sensor events (i.e. Observable) cause machine to change state
  - (potentially) limit how long we may *linger* in a particular state
  - *StateTimeout* is observed when we linger in a given state for too long
  - may generate notification events
- Definition consists in defining a series of nested partial functions

Demo Overview

```
val available =
  MatchingAutomata[WaitToBeAvailable.type, Boolean](WaitToBeAvailable) {
  case _ => {
    case true =>
      Stop(Accept())
  }
}


val leader =
  MatchingAutomata[WaitForLeaderElection.type, Address](WaitForLeaderElection) {
  case _ => {
    case addr: Address if addr.host.contains("A") =>
      Stop(Accept())
  }
}
```

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      Stop(Accept())
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Demo Overview

```
val stableCluster =
  MatchingAutomata[StableCluster.type, List[Address]](StableCluster, 3.seconds) {
   case _ => {
     case addrs: List[Address @unchecked] if addrs.nonEmpty =>
       Stop(Fail(s"Detected $addrs as unreachable"))
     case StateTimeout =>
       Stop(Accept())
   }
}
```

Demo Overview

```
def clusterMembers(nodes: String*) =
  MatchingAutomata[ClusterMemberCheck.type, AkkaClusterState](ClusterMemberCheck) {
  case _ => {
    case AkkaClusterState(_, members, unreachable)
      if unreachable.isEmpty
         && members.filter(_.status == Up).flatMap(_.address.host) == Set(nodes: _*) =>
      Stop(Accept())
  }
}
```

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  }
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clusterMembers("A", "B", "A'", "B'").run(clusterSensors("A").members)
```

- Behavioural properties are executed when they bind to 1 or more *physical* sensor streams (i.e. Observables) and injection points (i.e. Observers)

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```
available.run(clusterSensors("A").log) && leader.run(clusterSensors("A").log)
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- Behavioural properties are executed when they bind to 1 or more *physical* sensor streams (i.e. Observables) and injection points (i.e. Observers)
- May combine these using propositional connectives

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Demo Time!

Conclusion

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- Seen how to model real-world distributed systems extensionally
- Taken steady state behavioural specifications and developed a linear dynamic logic for experiments
  - by relating data injection traces to observed system behaviour
- Applied techniques to a range of fault-injection scenarios

References

- https://github.com/carlpulley/ docker-compose-testkit /tree/ scala-exchange-2016
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