Akka Streams

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TNG TECHNOLOGY CONSULTING

Streaming for Big Data Applications

Streaming Big Data

- Billions of events per day (Terabytes!)
- (Near) real-time processing
- Fault tolerance
- Bounded: Batch processing
- Unbounded: Stream processing

Why Use Akka Streams?

- Type-safe
- Compositional
- High-level
- Explicit semantics
- Integrates well (Alpakka)
- Fast (fusion & other optimizations!)

How do we use it?

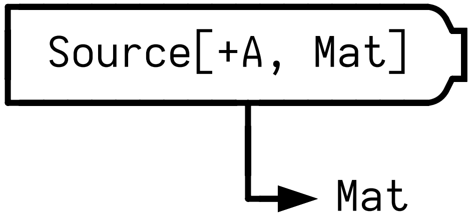
- Data ingestion:
    - Real-time, stateless, CPU heavy
    - Requirements:
        - Scalable
        - Adaptible to different clients
        - Flexible deployment
    - Solution: Akka HTTP/Streams Webservices

Other Streaming Solutions

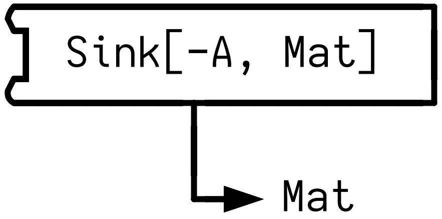
- JVM:
  - Java 8 Streams (synchronous, only trivial backpressure)
  - Java 9 Reactive Streams (rather low-level API)
  - Apache Flink (particularly for distributed systems)
- Haskell:
  - pipes
  - conduit
  - machines

Building Blocks of Akka Streams

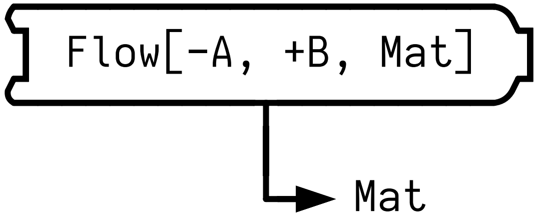
Sources, Sinks and Flows



A `Source` emits (produces) items of type `A`



A `Sink` accepts (consumes) items of type `A`



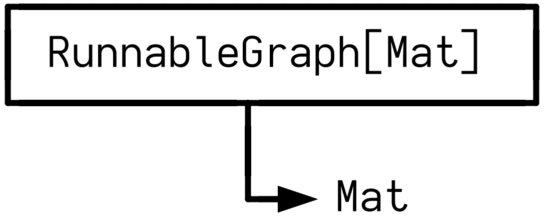
A `Flow` accepts items of type `A` and emits items of type `B`.

Materialized Values

Each stream element allows to return some information on the items processed. Usually, these are information like:

- `NotUsed` (no information available)
- The number of elements processed
- The result (Success/Failure) of an IO action
- Items collected from the stream

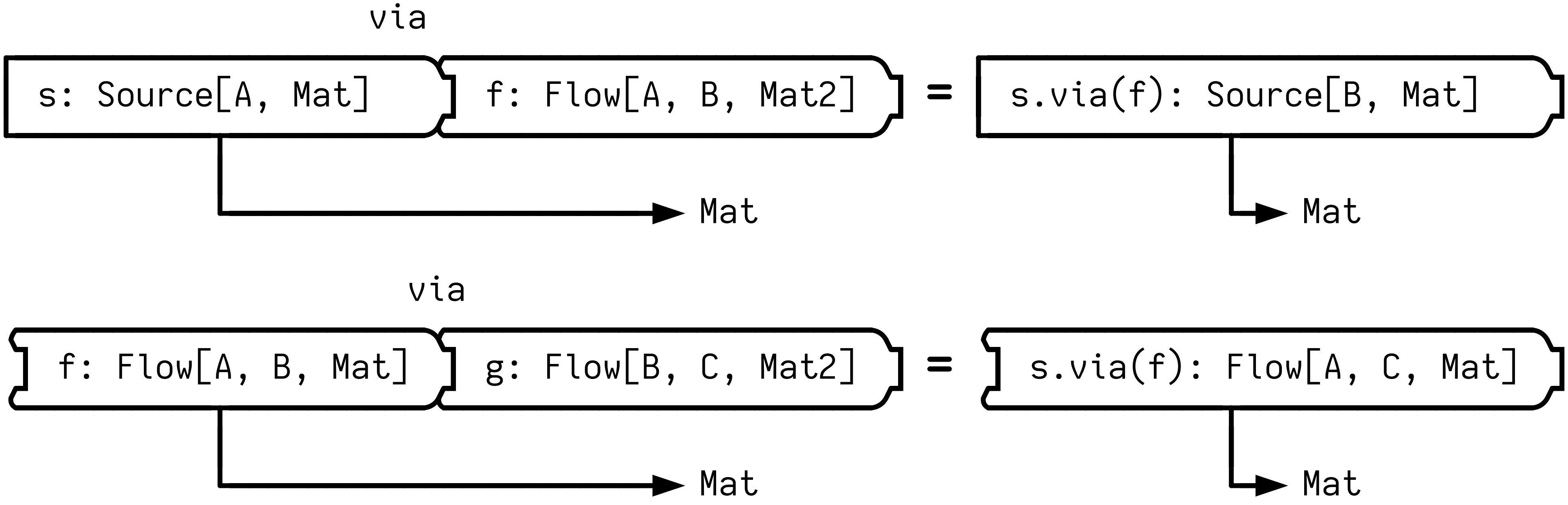
Runnable Graphs



A `RunnableGraph` is a black box that neither consumes nor produces items, but it still returns a materialized value.

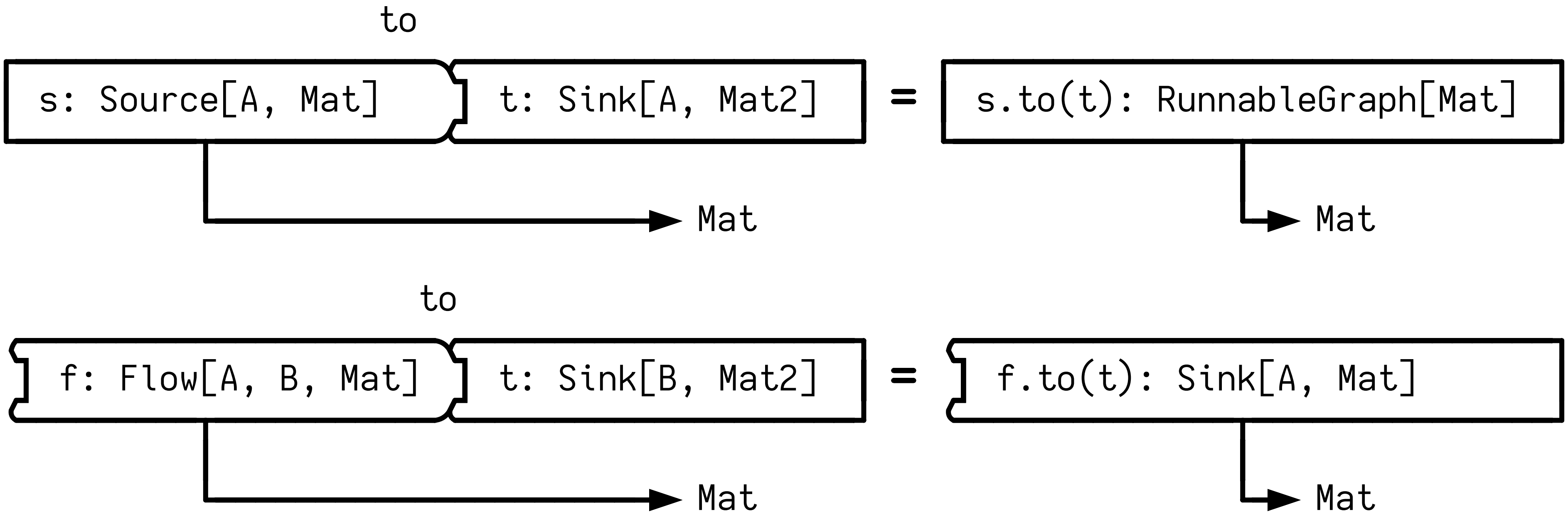
Connecting Stream Elements: `via`

`via` composes the the outlet of a `Source` or `Flow` with another `Flow`, keeping the materialized value:



Connecting Stream Elements: `to`

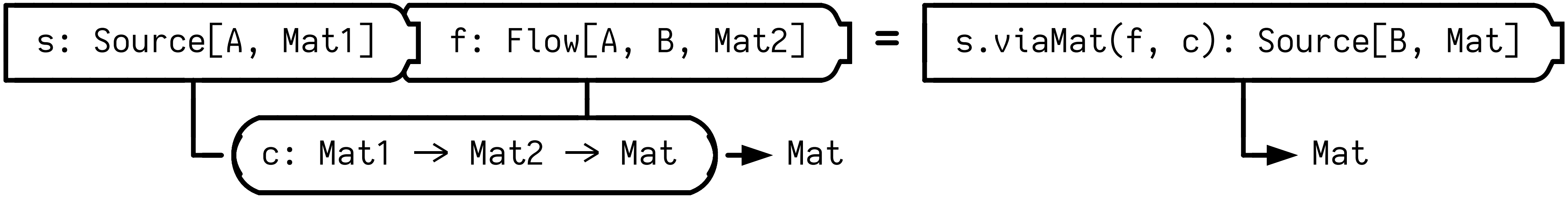
`to` connects the the outlet of a `Source` or `Flow` to a `Sink`, keeping the materialized value:



But What About the Materialized Value?

`viaMat` and `toMat` do the same, but allow to combine the materialized values:

viaMat



s: Source[A, Mat1]

f: Flow[A, B, Mat2]

=

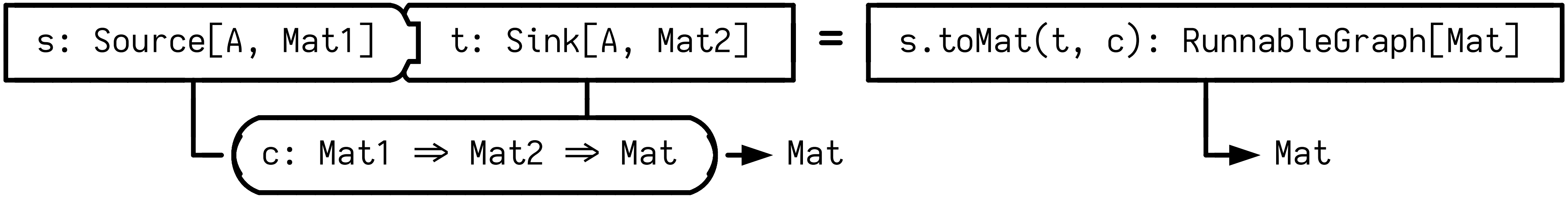
s.viaMat(f, c): Source[B, Mat]

c: Mat1 → Mat2 → Mat

Mat

Mat

toMat



s: Source[A, Mat1]

t: Sink[A, Mat2]

=

s.toMat(t, c): RunnableGraph[Mat]

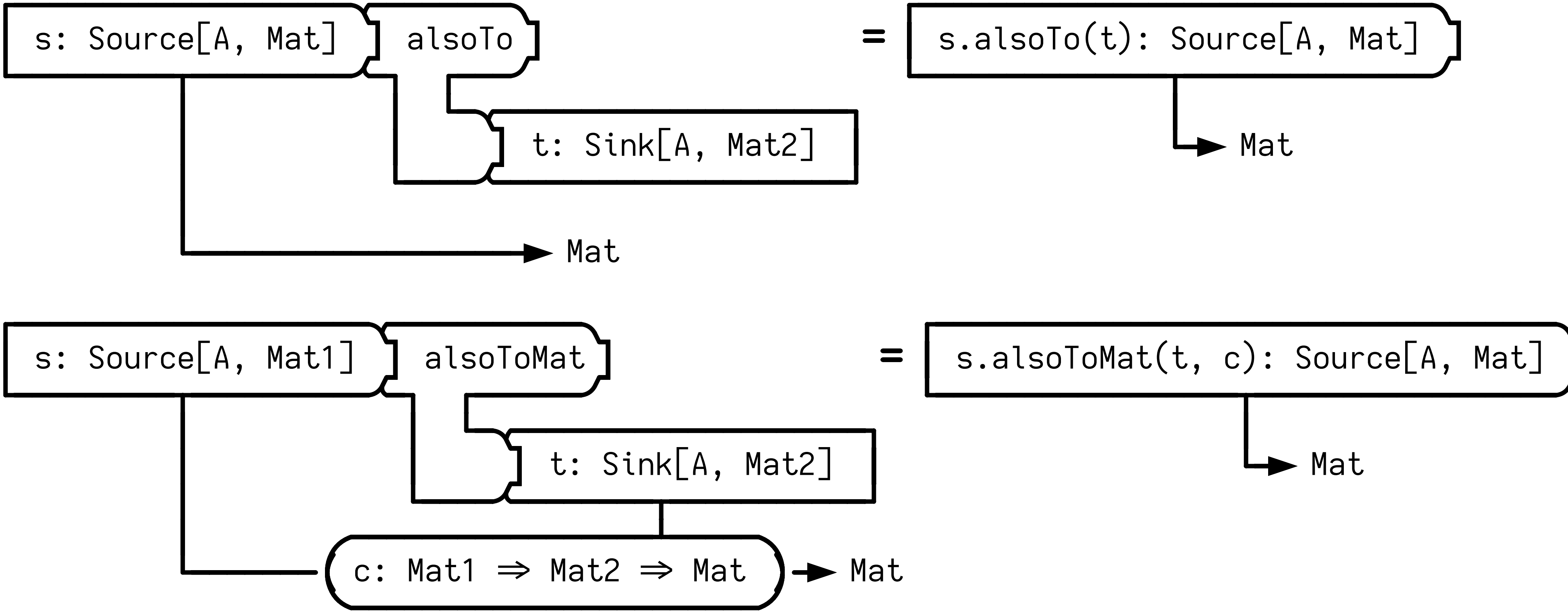
c: Mat1 ⇒ Mat2 ⇒ Mat

Mat

Mat

`via(·)` is the same as `viaMat(·)(Keep.left)`. You can also Keep `right`, `both` (returns a pair), or `none`.

Tee Pieces: `alsoTo` and `alsoToMat`



s: Source[A, Mat]

alsoTo

t: Sink[A, Mat2]

Mat

=

s.alsoTo(t): Source[A, Mat]

Mat

s: Source[A, Mat1]

alsoToMat

t: Sink[A, Mat2]

c: Mat1 ⇒ Mat2 ⇒ Mat

Mat

=

s.alsoToMat(t, c): Source[A, Mat]

Mat

Algebraic Properties

- `Source`, `Sink` and `Flow` and `RunnableGraph` are Functors in `Mat`: They all have a `mapMaterializedValue` method.
- `Source` is a Functor in its item type: It has a method

```
map: (A ⇒ B) ⇒ Source[A, Mat] ⇒ Source[B, Mat]
```

- `Sink` is a contravariant Functor in its item type:

```
contramap: (A ⇒ B) ⇒ Sink[B, Mat] ⇒ Sink[A, Mat]
```

- `Flow` is contravariant and covariant in its both item types, respectively (aka: Profunctor): It supports both `map` and `contramap`.

Some Source, Flow and Sink examples

```
Source[T](xs: Iterable[T]): Source[T, NotUsed]

Sink.ignore: Sink[Any, Future[Done]]

Sink.foreach[T](f: T ⇒ Unit): Sink[T, Future[Done]]
// e.g. Sink.foreach(System.out.println(_))

Sink.fold[U, T](zero: U)(f: (U, T) ⇒ U): Sink[T, Future[U]]

Flow.fromFunction[A, B](f: A ⇒ B): Flow[A, B, NotUsed]

FileIO.fromPath(f: Path): Source[ByteString, Future[IOResult]]
FileIO.toPath(f: Path): Sink[ByteString, Future[IOResult]]

// Akka HTTP client/server is a Flow[HttpRequest, HttpResponse, …]:
Http.outgoingConnection(…): Flow[HttpRequest, HttpResponse, Future[OutgoingConne
Http.bindAndHandle(handler: Flow[HttpRequest, HttpResponse, Any], …)
```

Materialization

`Sources`, `Sinks` and `Flows` are just *blueprints*.

`RunnableGraph.run` builds and optimizes the actual stream.

```
implicit val system : ActorSystem = ActorSystem()
implicit val materializer : Materializer = ActorMaterializer()

val blueprint: RunnableGraph[Future[Int]] =
  Source(List(1, 2, 3)).toMat(Sink.fold(0)(_ + _))(Keep.right)

val result: Future[Int] = blueprint.run
```

Backpressure

What is Backpressure?

```
FileIO.fromPath(Paths.get("requests.txt"))                        // ← fast-ish
    .via(Framing.delimiter("\n", 1024))                           // ← fast
    .via(Fold.fromFunction(request ⇒ send(request)))              // ← slow
    .to(Sink.foreach(response ⇒ System.out.println(response)))    // ← fast
```

Default backpressuring: Only produce/consume as fast as the slowest link in the chain.

Backpressure Boundaries

What if I can't (or don't want to) control the speed of a Source?

```
incomingRequests       // ← will turn away requests if they come too fast
    .to(slowSink)
```

```
incomingRequests                               // ← won't turn away requests
    .buffer(50, OverflowStrategy.dropNew)      // ← may lose requests
    .to(slowSink)
```

```
incomingRequests                                 // ← will turn away requests
    .buffer(50, OverflowStrategy.backpressure)   //   if buffer is full
    .to(slowSink)
```

Throtteling

What if a `Sink` chokes if items come in too fast?

```
fastSource                                                          // ← fast
    .to(chokingSink)                                                // ← chokes :-(
```

```
fastSource                                                          // ← fast
    .throttle(elements = 5, per = 1 second, mode = shaping) // ← slow down!
    .to(chokingSink)                                                // ← doesn't choke
```

Backpressure Boundaries (II)

```
fastSource
    .alsoTo(slowSink)       // ← slows everything down :-(
    .to(fastSink)
```

```
fastSource
    .alsoTo(Flow()
        .buffer(50, backpressure)  // ← Tries to buffer
        .to(slowSink))             //    before slowing everything down
    .to(fastSink)
```

Particularly useful if the source produces at irregular intervals.

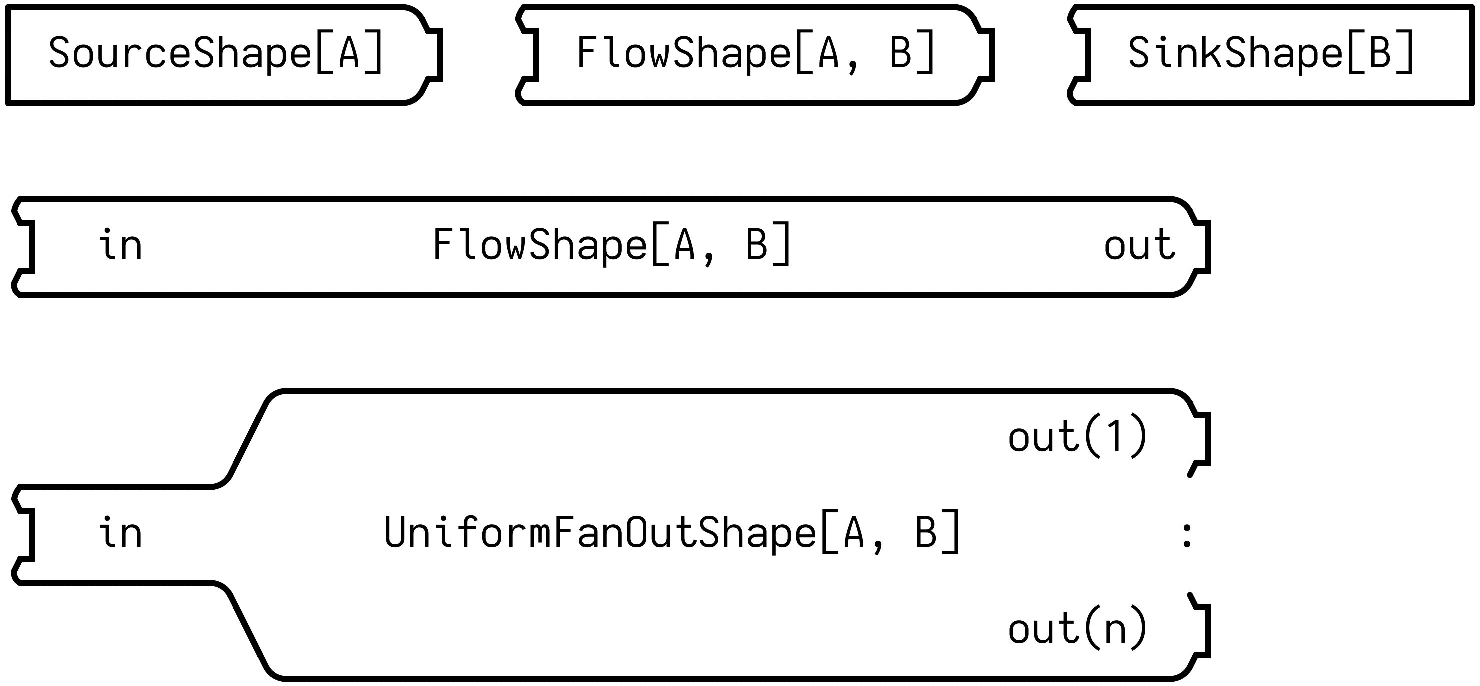
Batching

Another way to connect a fast `Source` to a slow `Sink`:

```
fastSource
    .batch(max = 10, seed = List(_))(_ :+ _)   // ←  backpressures only if
                                               //     batch size is exceeded
    .to(slowBatchSink)                         // ←  consumes batches faster
                                               //     than individual elements
```

Graph DSL for More Complex Streams

Talk About Shapes



SourceShape[A]

FlowShape[A, B]

SinkShape[B]

in

FlowShape[A, B]

out

out(1)

in

UniformFanOutShape[A, B]

:

out(n)

Shapes & Graphs

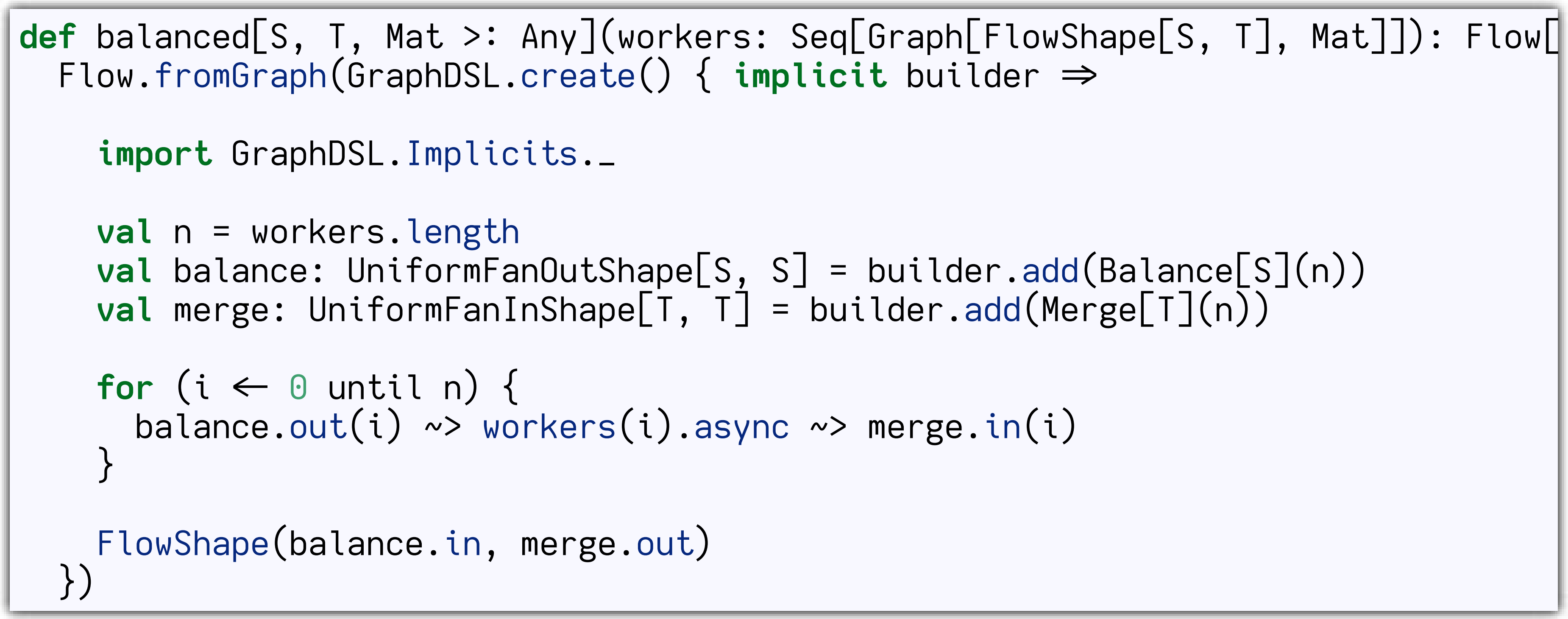
`Flow[A, B, Mat]`

is just a decorator around

`Graph[FlowShape[A, B], Mat]`

Constructing Graphs from Shapes

Balancing between workers:



```
def balanced[S, T, Mat >: Any](workers: Seq[Graph[FlowShape[S, T], Mat]]): Flow[
  Flow.fromGraph(GraphDSL.create() { implicit builder ⇒

    import GraphDSL.Implicits._

    val n = workers.length
    val balance: UniformFanOutShape[S, S] = builder.add(Balance[S](n))
    val merge: UniformFanInShape[T, T] = builder.add(Merge[T](n))

    for (i ← 0 until n) {
      balance.out(i) ~> workers(i).async ~> merge.in(i)
    }

    FlowShape(balance.in, merge.out)
  })
```

Also one way to speed up slow `Flow` elements!

Some Useful Shapes

- `SourceShape[A]`(`Source[A, Mat]`)
- `SinkShape[A]`(`Sink[A, Mat]`)
- `FlowShape[A, B]`(`Flow[A, B, Mat]`)
- `ClosedShape`(`RunnableGraph[Mat]`)
- `FanOutShape2[A, B1, B2]`,`FanInShape2[A1, A2, B]` (up to 22 inlets/outlets)
- `BidiShape[In1, Out1, In2, Out2]`

Connecting to the World

Akka Streams Connectors

- Akka HTTP
- Slick (JDBC, Functional Relational Mapping)
- Apache Kafka
- Apache Camel
- AWS (S3, Kinesis, …)
- Have a look at Alpakka for more connectors

Thank you!

Questions?

Slides on Github: TBD
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