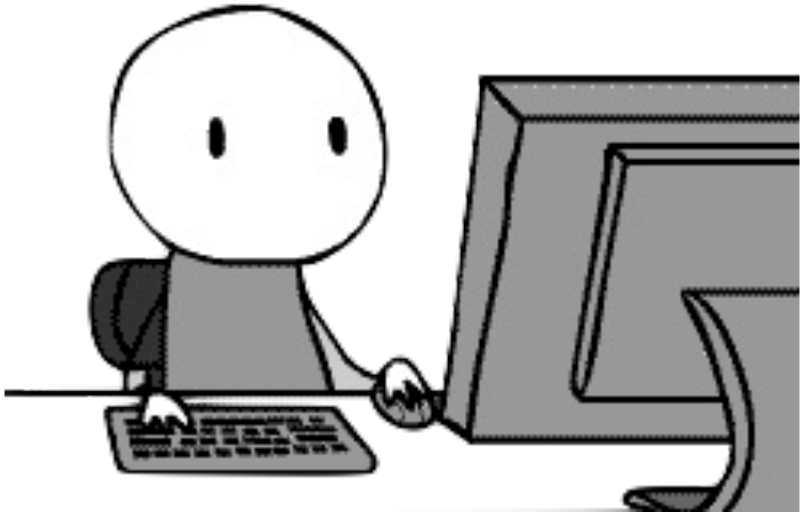
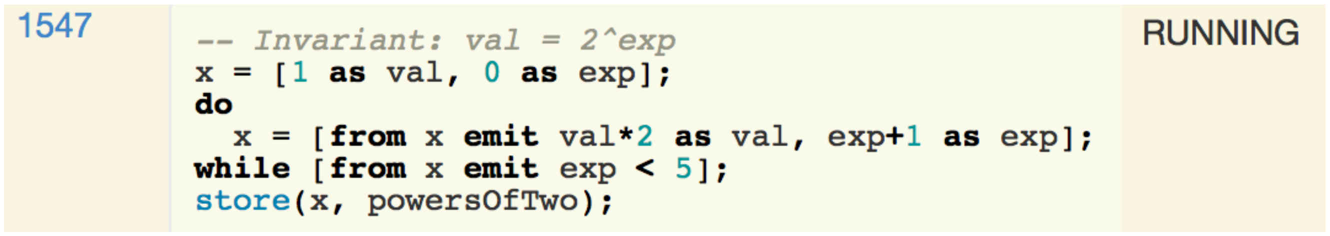
A World without Out-Of-Memory

a.k.a. Elastic Memory in the Cloud

Jingjing Wang
Magdalena Balazinska

Big-Data Analytics



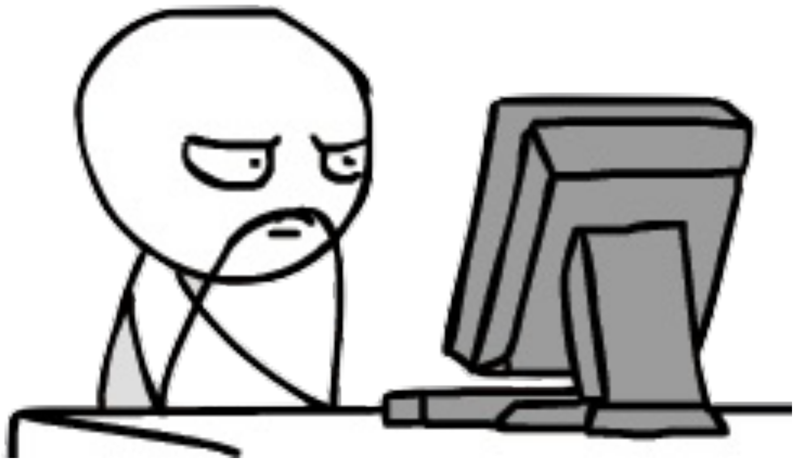


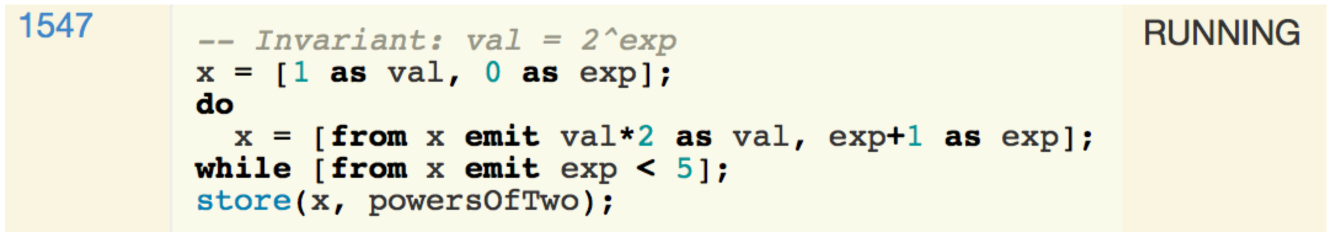
1547

```
-- Invariant: val = 2^exp
x = [1 as val, 0 as exp];
do
  x = [from x emit val*2 as val, exp+1 as exp];
while [from x emit exp < 5];
store(x, powersOfTwo);
```

RUNNING

Wait…



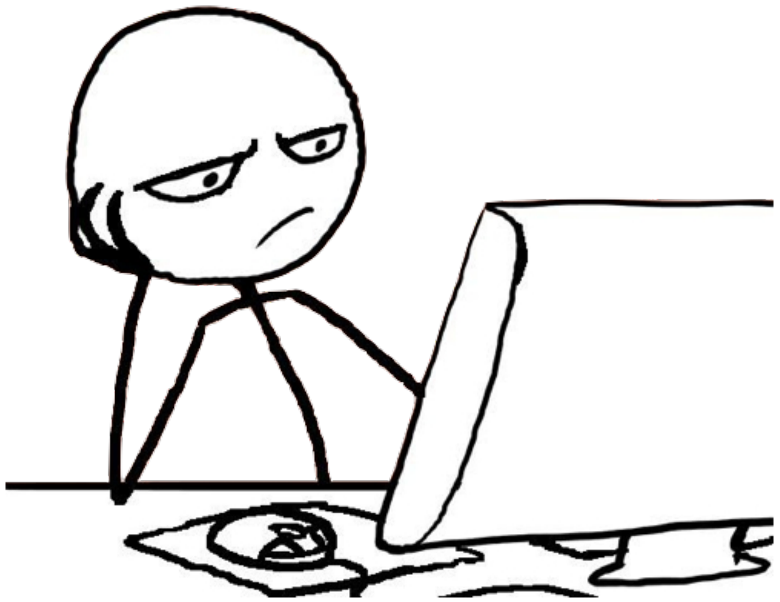


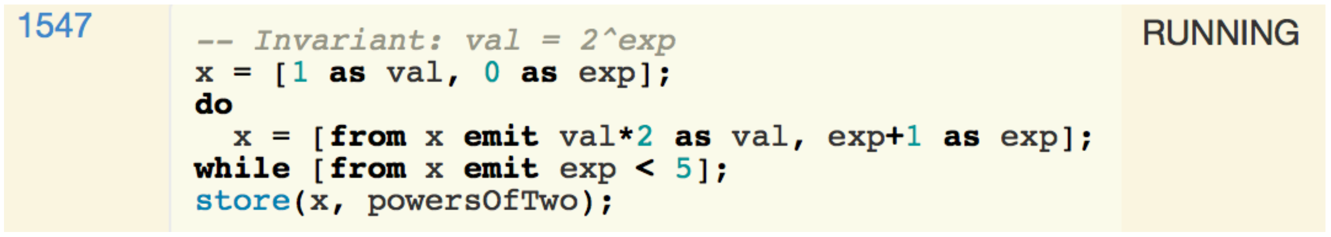
1547

```
-- Invariant: val = 2^exp
x = [1 as val, 0 as exp];
do
  x = [from x emit val*2 as val, exp+1 as exp];
while [from x emit exp < 5];
store(x, powersOfTwo);
```

RUNNING

Wait…



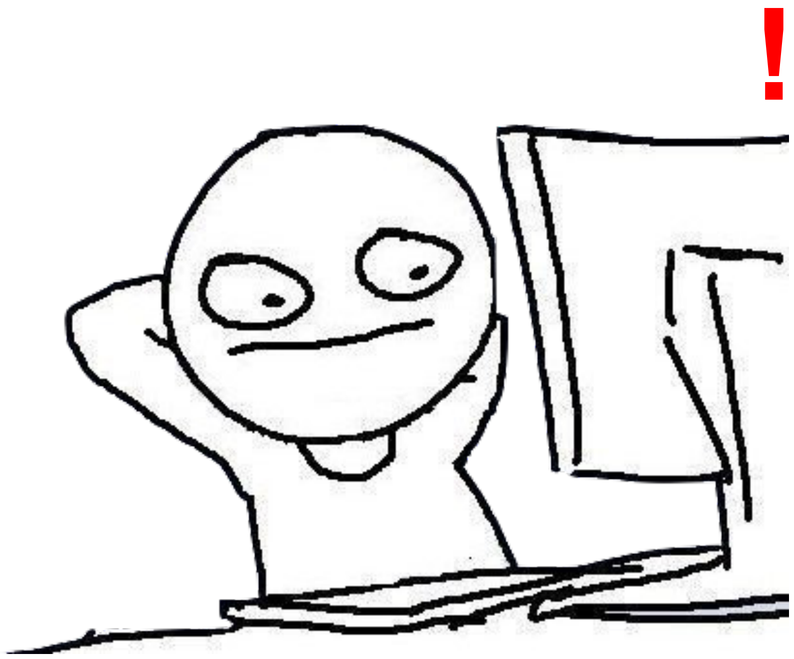


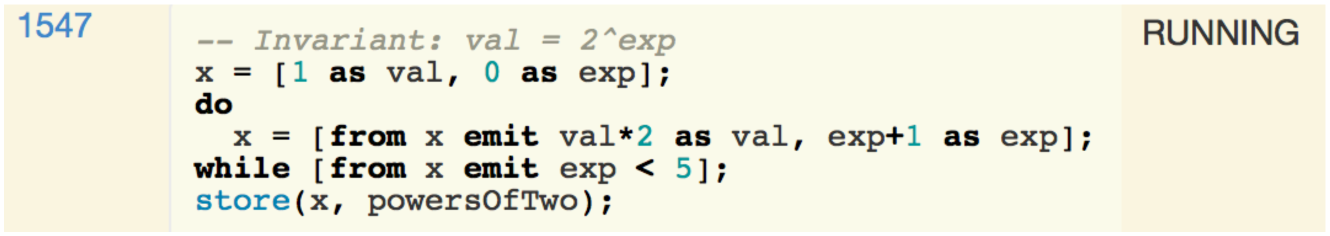
1547

```
-- Invariant: val = 2^exp
x = [1 as val, 0 as exp];
do
  x = [from x emit val*2 as val, exp+1 as exp];
while [from x emit exp < 5];
store(x, powersOfTwo);
```

RUNNING

Wait…

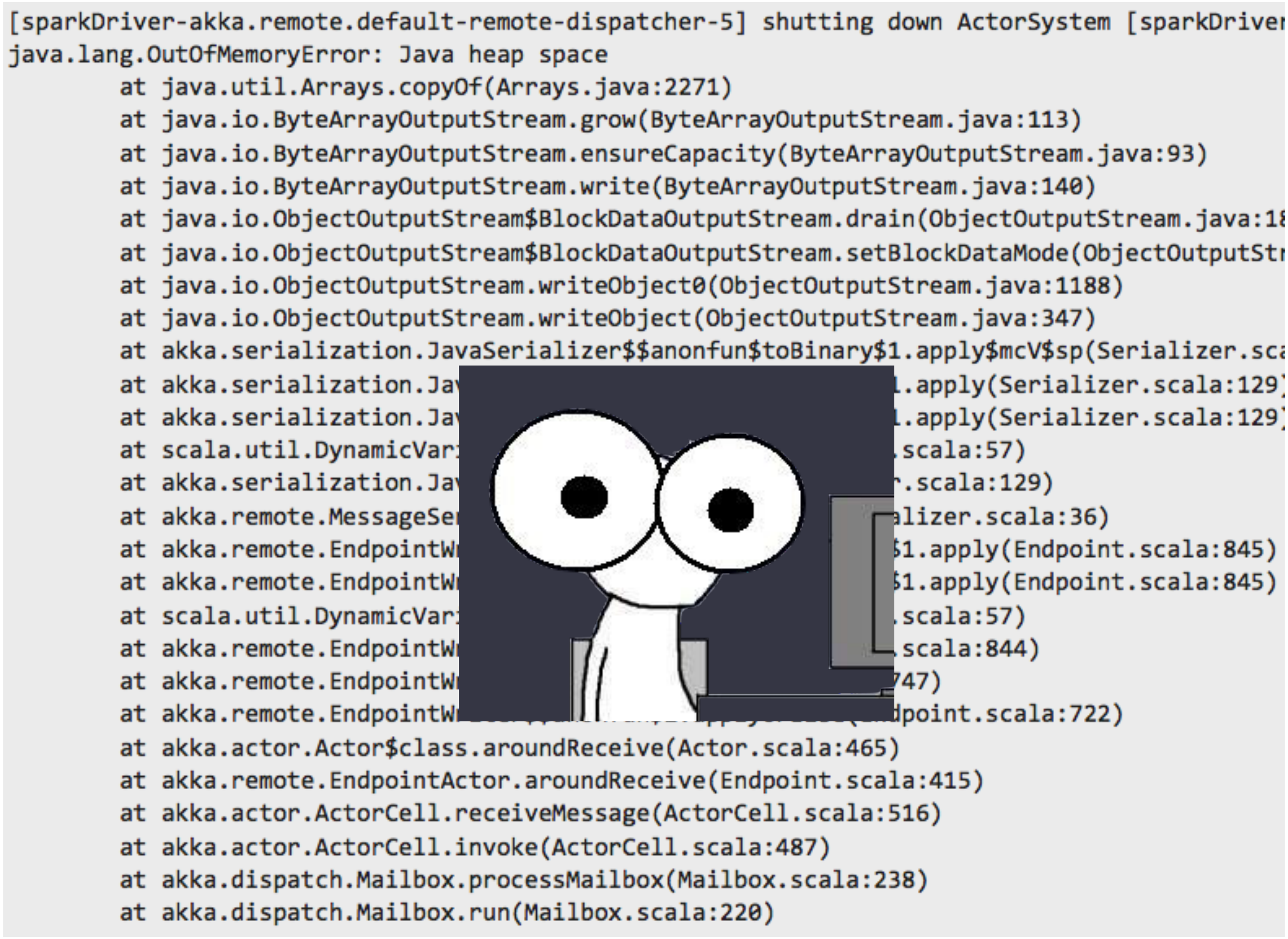




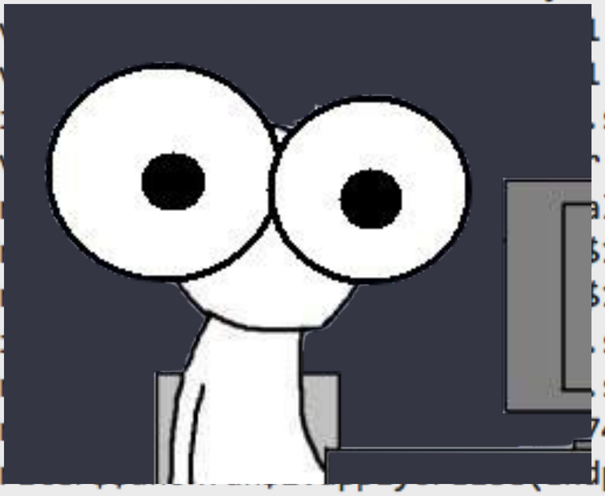
1547

```
-- Invariant: val = 2^exp
x = [1 as val, 0 as exp];
do
  x = [from x emit val*2 as val, exp+1 as exp];
while [from x emit exp < 5];
store(x, powersOfTwo);
```

RUNNING



```
[sparkDriver-akka.remote.default-remote-dispatcher-5] shutting down ActorSystem [sparkDriver
java.lang.OutOfMemoryError: Java heap space
        at java.util.Arrays.copyOf(Arrays.java:2271)
        at java.io.ByteArrayOutputStream.grow(ByteArrayOutputStream.java:113)
        at java.io.ByteArrayOutputStream.ensureCapacity(ByteArrayOutputStream.java:93)
        at java.io.ByteArrayOutputStream.write(ByteArrayOutputStream.java:140)
        at java.io.ObjectOutputStream$BlockDataOutputStream.drain(ObjectOutputStream.java:18
        at java.io.ObjectOutputStream$BlockDataOutputStream.setBlockDataMode(ObjectOutputStr
        at java.io.ObjectOutputStream.writeObject0(ObjectOutputStream.java:1188)
        at java.io.ObjectOutputStream.writeObject(ObjectOutputStream.java:347)
        at akka.serialization.JavaSerializer$$anonfun$toBinary$1.apply$mcV$sp(Serializer.sca
        at akka.serialization.Jav                     1.apply(Serializer.scala:129)
        at akka.serialization.Jav                     1.apply(Serializer.scala:129)
        at scala.util.DynamicVar                      .scala:57)
        at akka.serialization.Jav                     r.scala:129)
        at akka.remote.MessageSer                     alizer.scala:36)
        at akka.remote.EndpointW                      $1.apply(Endpoint.scala:845)
        at akka.remote.EndpointW                      $1.apply(Endpoint.scala:845)
        at scala.util.DynamicVar                      .scala:57)
        at akka.remote.EndpointW                      .scala:844)
        at akka.remote.EndpointW                      747)
        at akka.remote.EndpointW                      dpoint.scala:722)
        at akka.actor.Actor$class.aroundReceive(Actor.scala:465)
        at akka.remote.EndpointActor.aroundReceive(Endpoint.scala:415)
        at akka.actor.ActorCell.receiveMessage(ActorCell.scala:516)
        at akka.actor.ActorCell.invoke(ActorCell.scala:487)
        at akka.dispatch.Mailbox.processMailbox(Mailbox.scala:238)
        at akka.dispatch.Mailbox.run(Mailbox.scala:220)
```



Memory: Whose Responsibility

- User's:
  - Claim resources from service provider
  - Pay for them
  - Run the application

- Provider's:
  - Shared resources
  - Users/Applications with SLAs
  - Put them in containers, schedule them in a smart way

How Much Memory to Allocate

- Allocate more:
  - Waste resource
- Allocate less:
  - Out-Of-Memory
  - Performance degradation due to Garbage Collections

- Problem: precise estimation before execution is hard

Solution: Be Elastic

- Change memory quota on-the-fly
  - Cloud, flexible resource (within budget)

  - Use the best strategy that benefits us
  - Real-time performance characteristics

Work-In-Progress

- Decisions to allocate memory among applications
  - Allocate more memory on the same machine
  - Add machines
  - Kill them
- Ability to change the memory quota of a container
  - JVMs are black boxes once launched
    - Need to hack
- Cost model
  - Predict application behavior in terms of resources
  - GC time given memory quota & application state
  - Data analytics

A World without Out-Of-Memory