ASYNCHRONOUS FILE TRANSFER IN CONDOR

Parag Mhashilkar (Fermi National Accelerator Laboratory)
Cathrin Weiss (Condor Project, University of Wisconsin at Madison)

Overview

- CEDPS Project
- Motivation: Asynchronous sandbox management
- Asynchronous sandbox management
- Sandbox Management & Sandbox Manager
- Sandbox Transfer in Condor
  - Current Protocol
  - Asynchronous sandbox transfer
- Prototype & Its Performance
- Ongoing & Future Work
- Acknowledgements

CEDPS Project

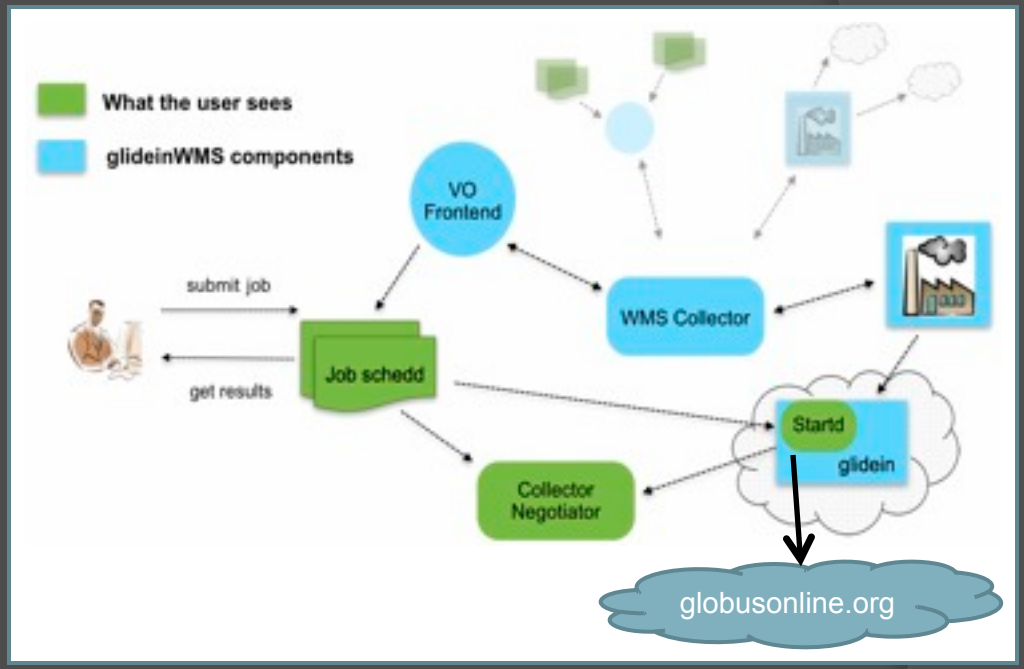
- CEDPS: The five year project started in 2006, funded by Department of Energy (DOE)
- Goals
  - Produce technical innovations for rapid and dependable **data placement** within a distributed high performance environment and for the construction of **scalable science services** for data and computing from many clients.
  - Address performance and functionality troubleshooting of these and other related distributed activities.
- Collaborative Research
  - Mathematics & Computer Science Division, Argonne National Laboratory
  - Computing Division, Fermi National Accelerator Laboratory
  - Lawrence Berkeley National Laboratory
  - Dept of Computer Science, University of Wisconsin Madison
  - Information Sciences Institute, University of Southern California

CEDPS Activities at FNAL

- Investigating data movement mechanisms for data stage-out on Grids
  - globusonline.org needs integration with SRM interface for OSG
- Supporting the integration of data movement mechanisms with scientific DH frameworks
  - Supporting the integration of globusonline.org with Dark Energy Survey (DES) data handling system
- Integration of asynchronous data stage-out mechanisms in overlay workload management systems (…this talk…)
  - Release resources at job termination. Delegate data stage-out to external agents.
  - Integrate support for globusonline.org into glideinWMS

glideinWMS

- Pilot-based WMS that creates on demand a dynamically-sized overlay condor batch system on Grid resources to address the complex needs of VOs in running application workflows
- Components
  - WMS Collector
  - Glidein Factory
  - User Pool Collector
  - User Scheduler
  - VO Frontend



- Factory knows about the sites and how to submit glideins to the sites
- VO frontend knows about the user job details
- WMS Collector acts as a dashboard for Factory - VO Frontend communication.
- Provides an end-to-end solution for several VOs in OSG

Motivation

- Typical life cycle for a job on a worker node
  - Transfer input sandbox
  - Run computational phase and produce output
  - Transfer output sandbox
- We will be focusing on output sandbox transfer during this talk.

Motivation [contd.]

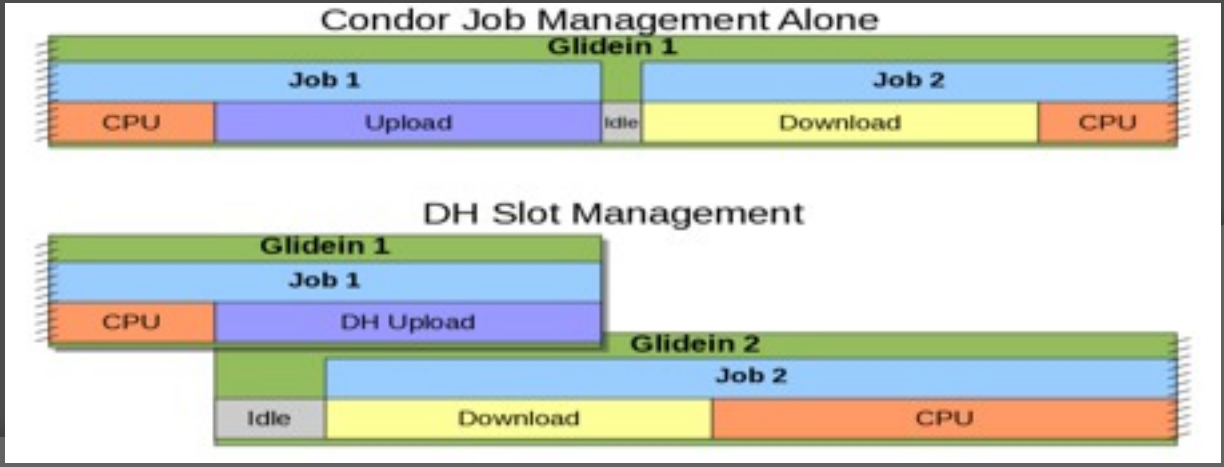
- Sandbox transfer failures & inefficiencies have less impact on throughput for -
  - Short running jobs
    - Less CPU wasted
  - Jobs with small output sandbox
- But …
  - They have different set of problems (not covered here) like -
    - Higher overhead before the jobs starts running
    - Black-hole effect

Motivation [contd.]

- Seen by glideinWMS users, failures & inefficiencies have significant impact on throughput for –
  - Jobs with large input sandbox
    - CPU is not utilized when a sandbox is transferred in
  - Long running jobs
    - Output sandbox transfer can fail wasting CPU consumed by the job
  - Jobs with large output sandbox
    - CPU is not utilized when a sandbox is transferred back
    - Wasted resources in case of intermittent failures during the transfer
- Can we do better?

Asynchronous Sandbox Management

- Enhance glideinWMS by
  - Increasing the CPU utilization of Condor-managed resources in a wide area environment through CPU and network I/O overlap enabled by asynchronous transfers of sandboxes – Miron Livny
- What does this mean?
  - Pipeline the transfer of asynchronous sandboxes in Condor using globusonline.org or other transfer protocols
  - Multiple transfers can take place via transfer slots
  - New job can start running if the previous job has entered stage-out state
  - Can reattempt failed transfers as needed
  - Support multiple transfer protocols using transfer Plug-ins



First Prototype: Condor Hooks

- Support at the Application Layer (glideinWMS).
- Use Condor Hooks
  - To identify end of CPU stage
  - Initiate the output sandbox transfer
- Start another condor_startd to accept new job

Asynchronous Sandbox Management in Condor

- Rather than the application, let condor transfer the output sandboxes asynchronously
  - Generic
  - Robust
  - Reliable
  - Scalable

Sandbox Manager

- Sandbox Manager module extends the sandbox management functionality of the Condor.
- Collaborative Effort
  - **Fermi team** is implementing the Sandbox Manager
    - A repository for sandboxes
  - **Condor team** working on output sandbox management in the Condor
    - Internal protocol changes
    - Details to follow …

Sandbox Manager

- Condor_startd interfaces with the sandbox manager to keep track of output sandboxes
- Sandbox Manager manages the sandbox objects
  - Register sandboxes
  - Update sandboxes
  - Transfer sandboxes
  - Unregister sandboxes
  - […]

What is necessary to integrate this into Condor?

Current sandbox transfer

New Claim

Current sandbox transfer

New Claim

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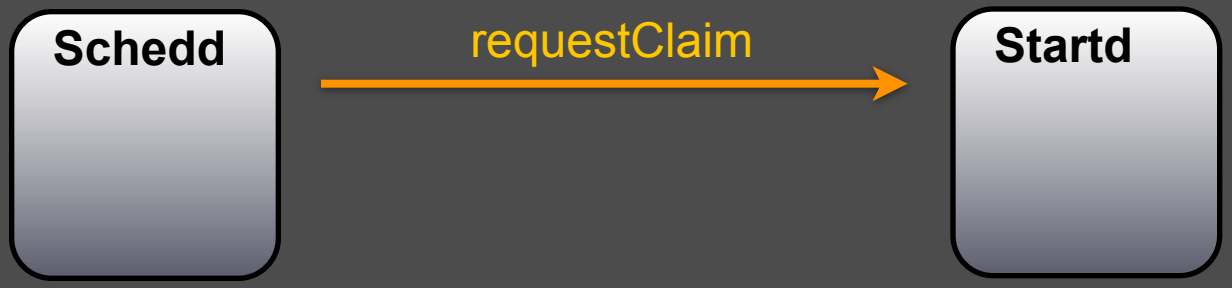
New Claim



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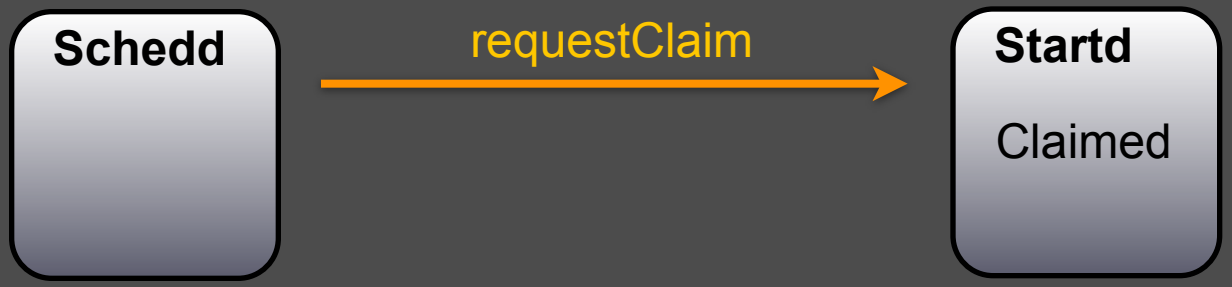

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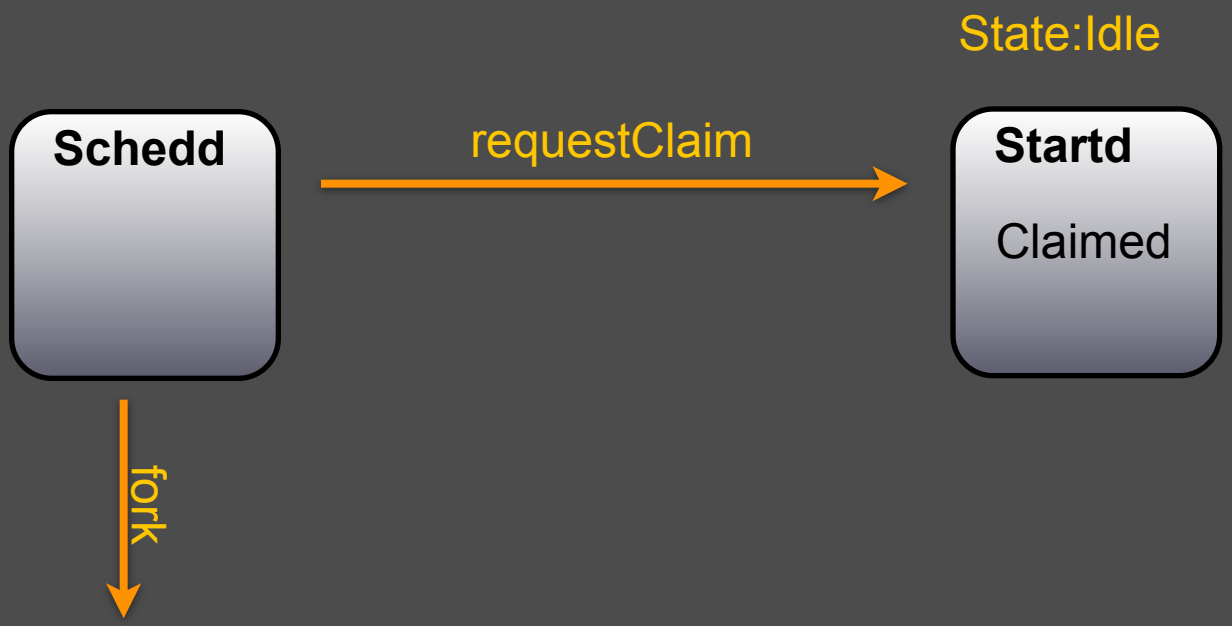

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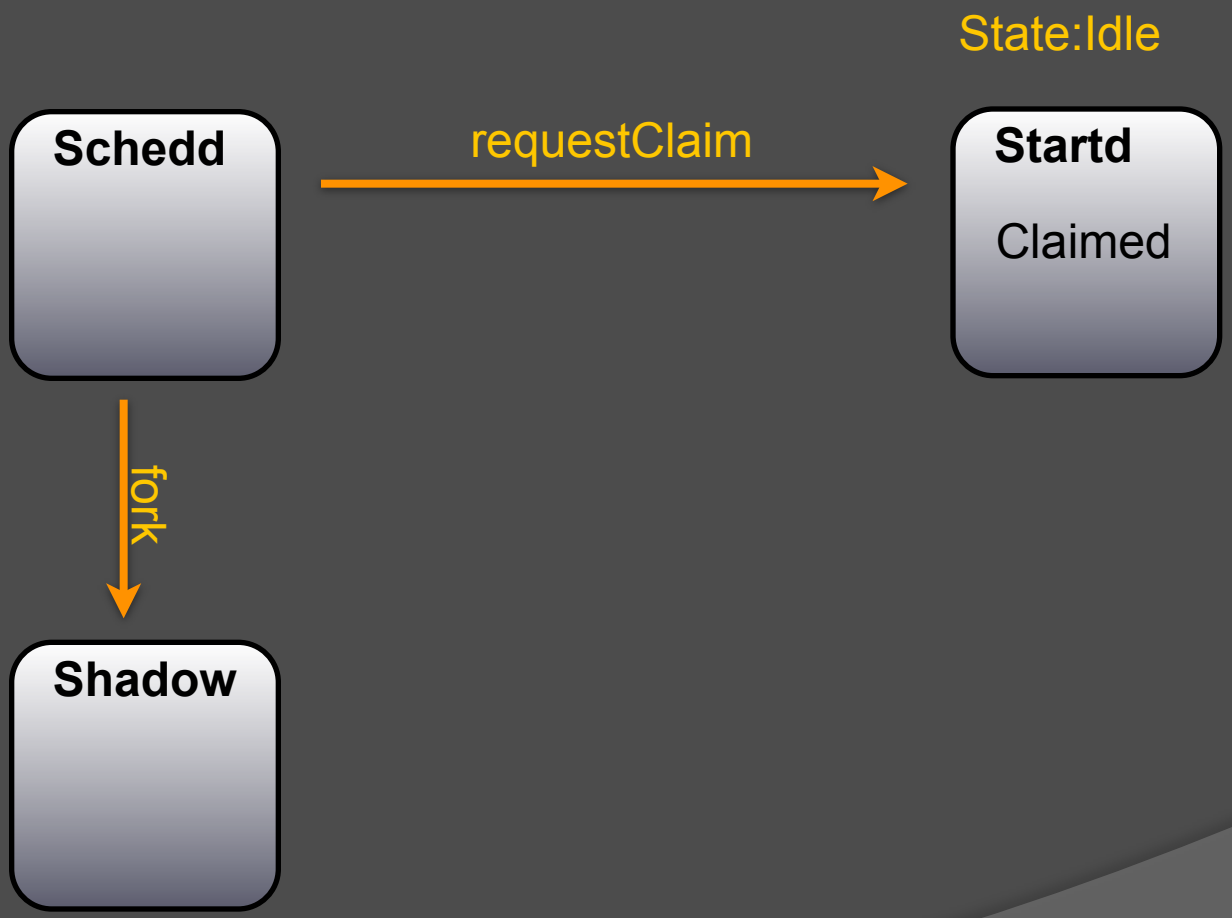

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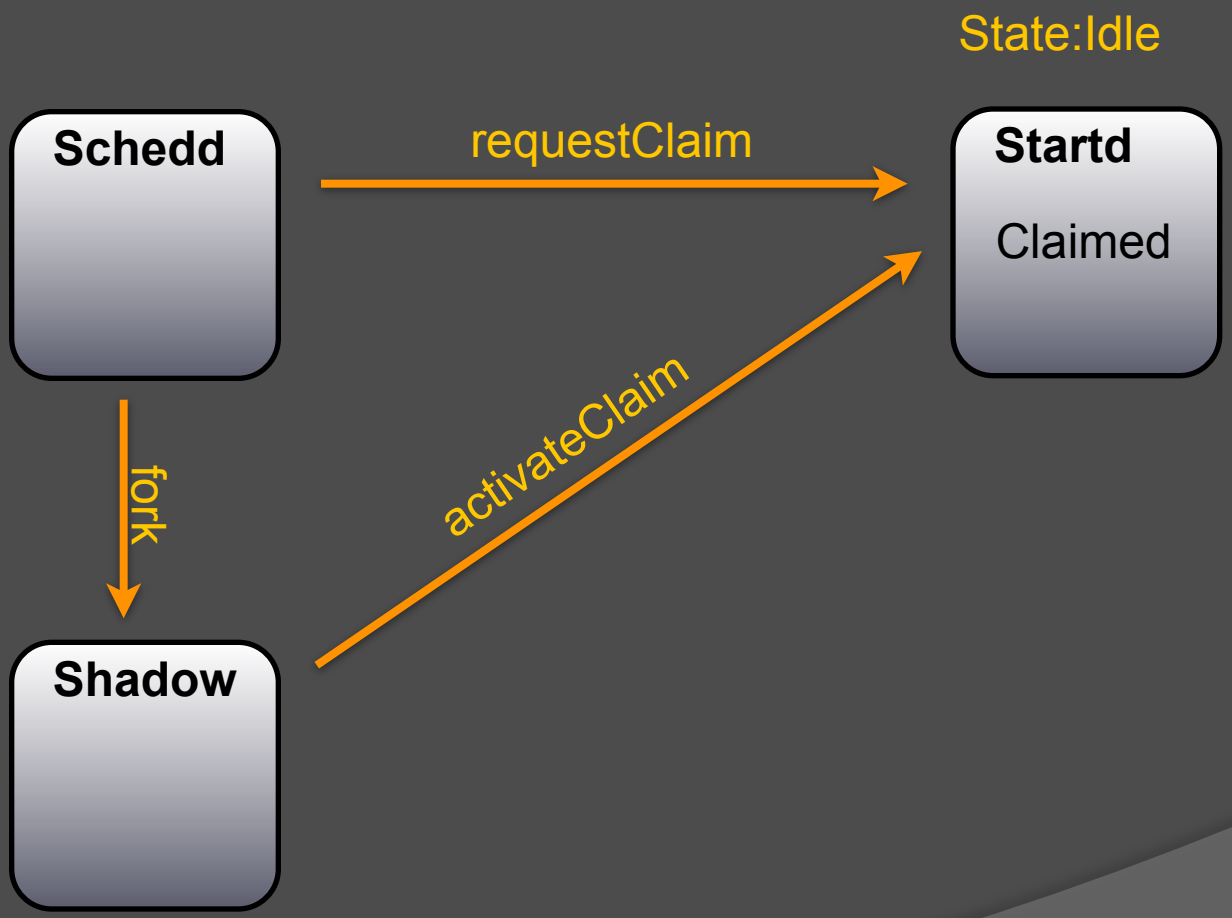

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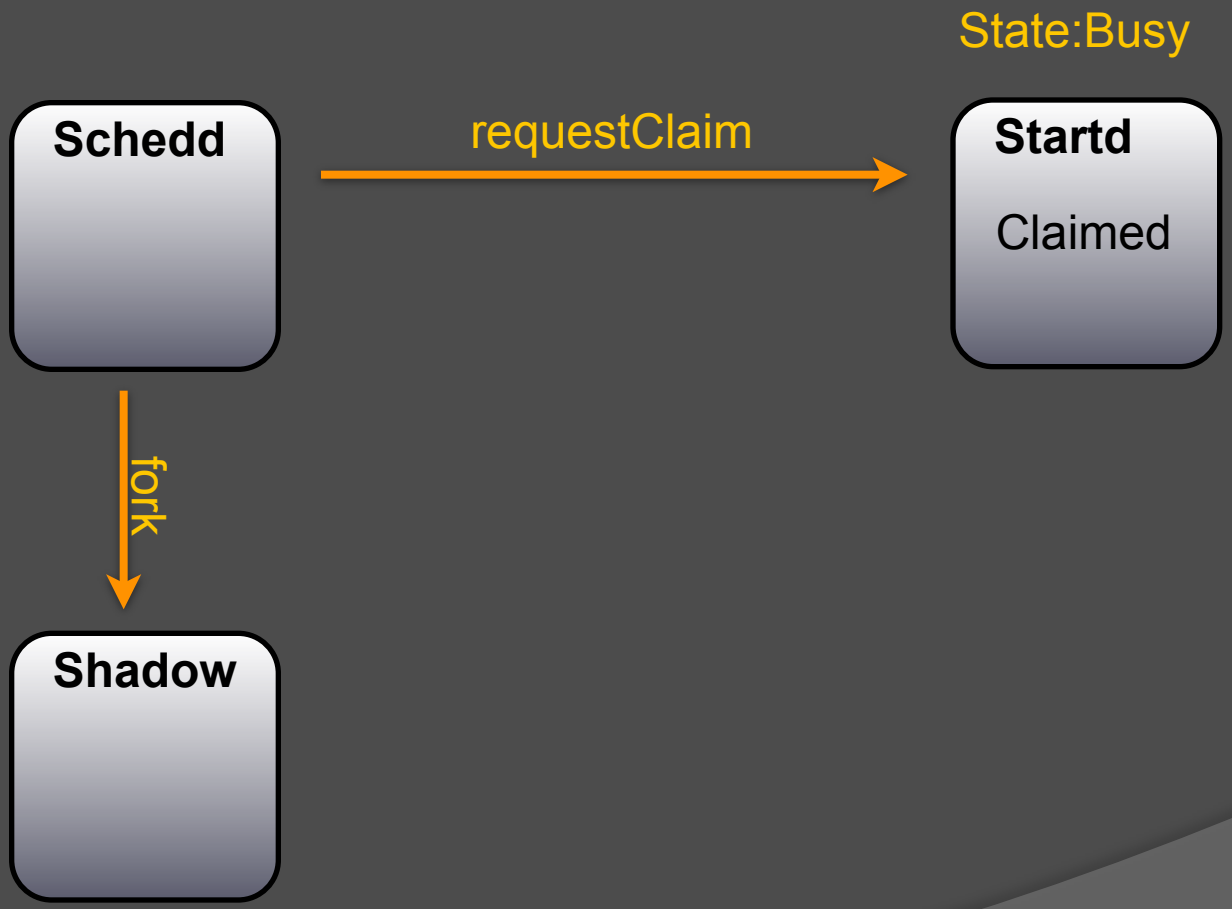

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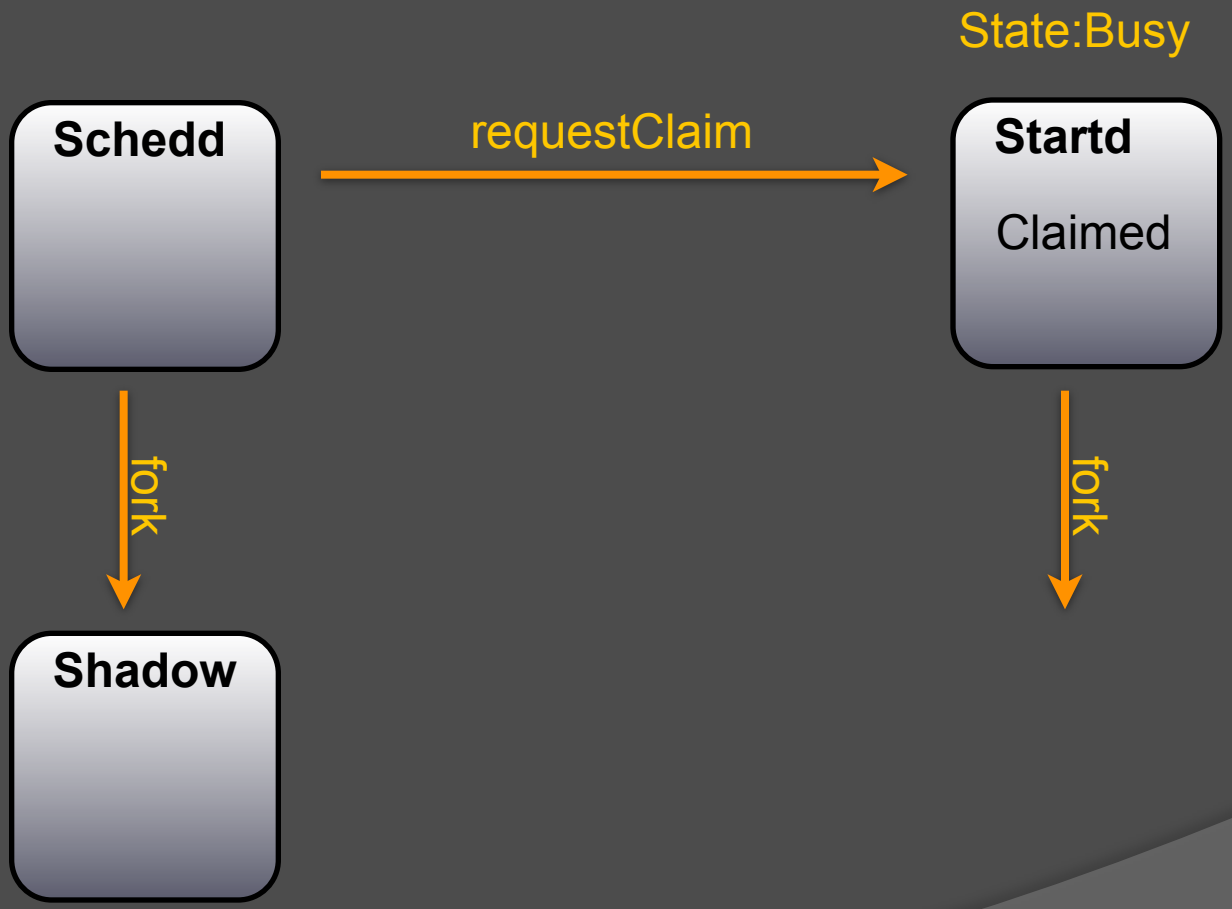

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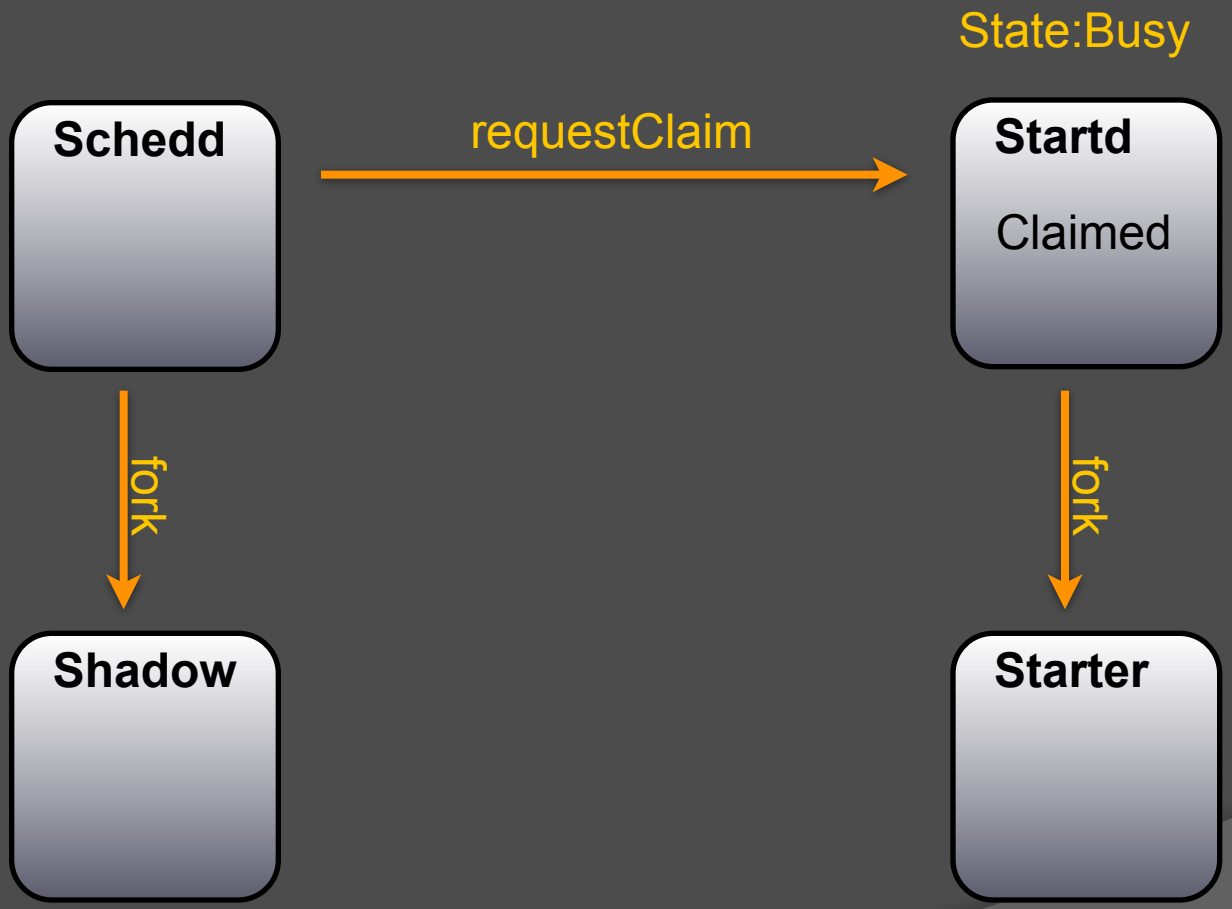

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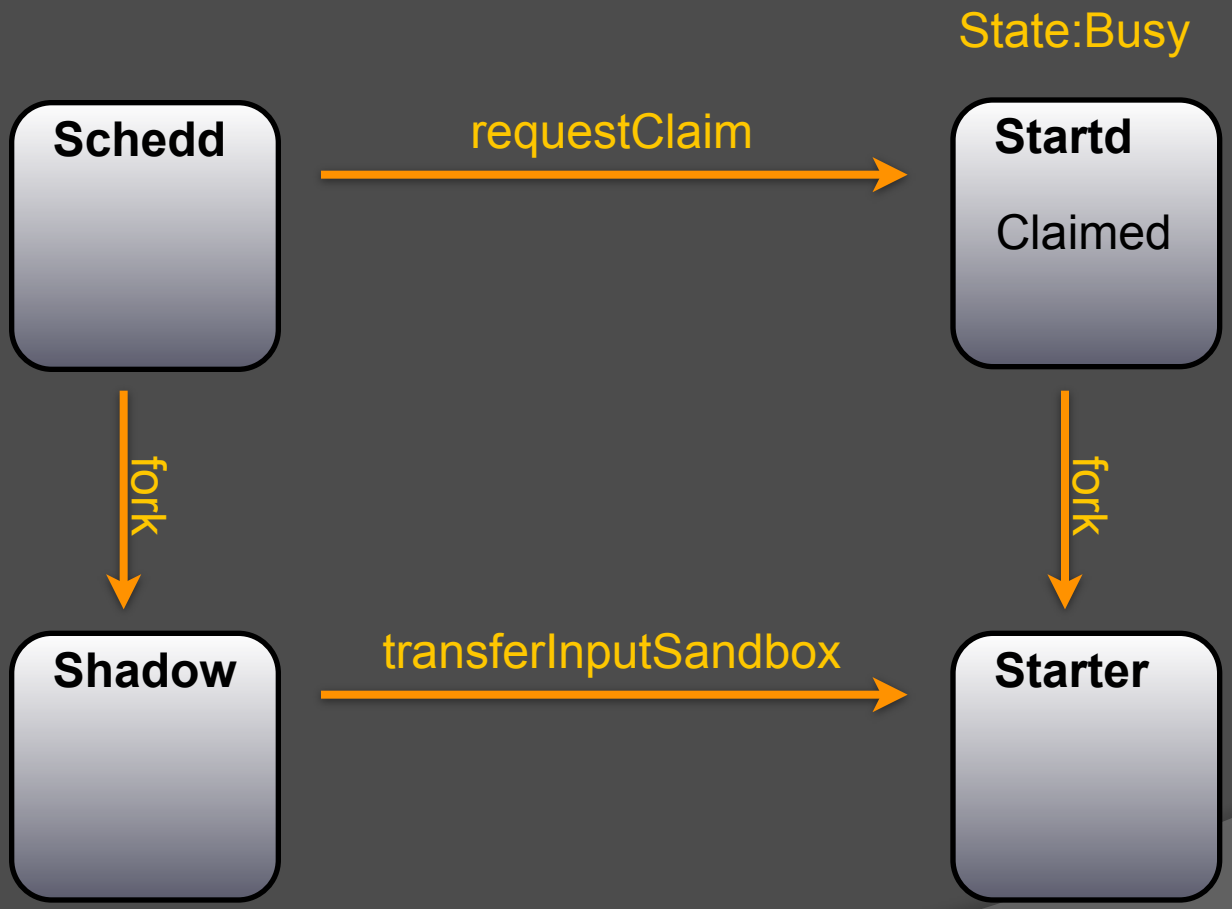

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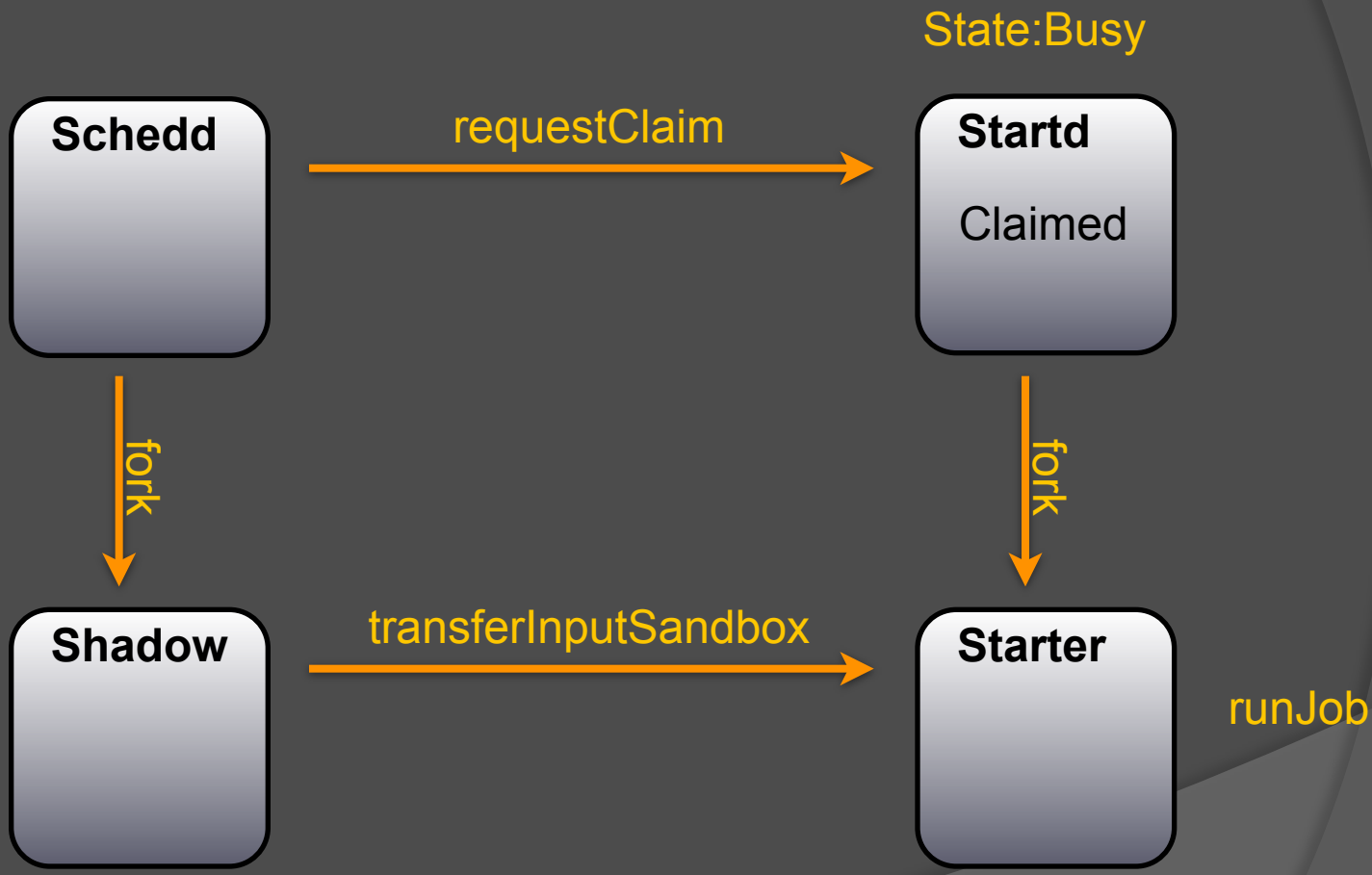

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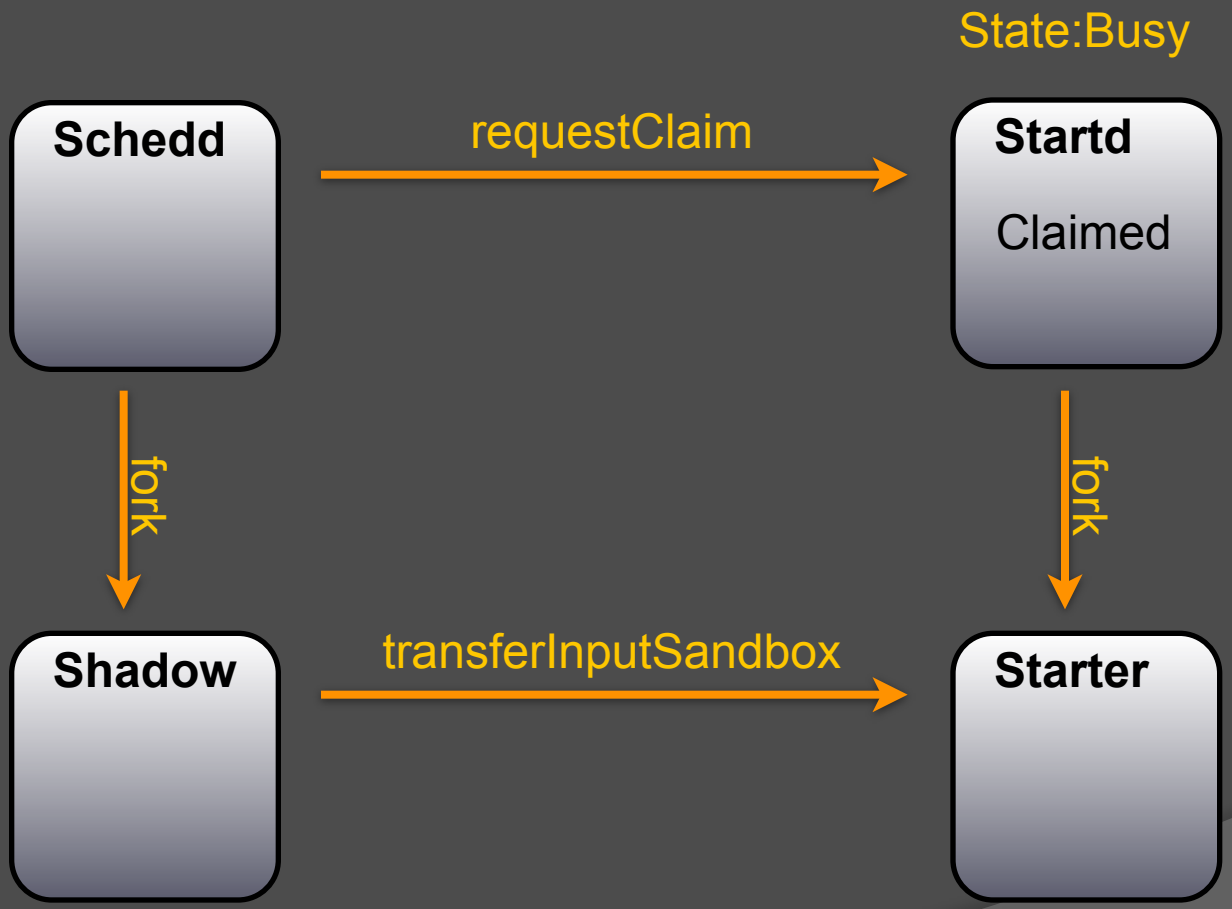

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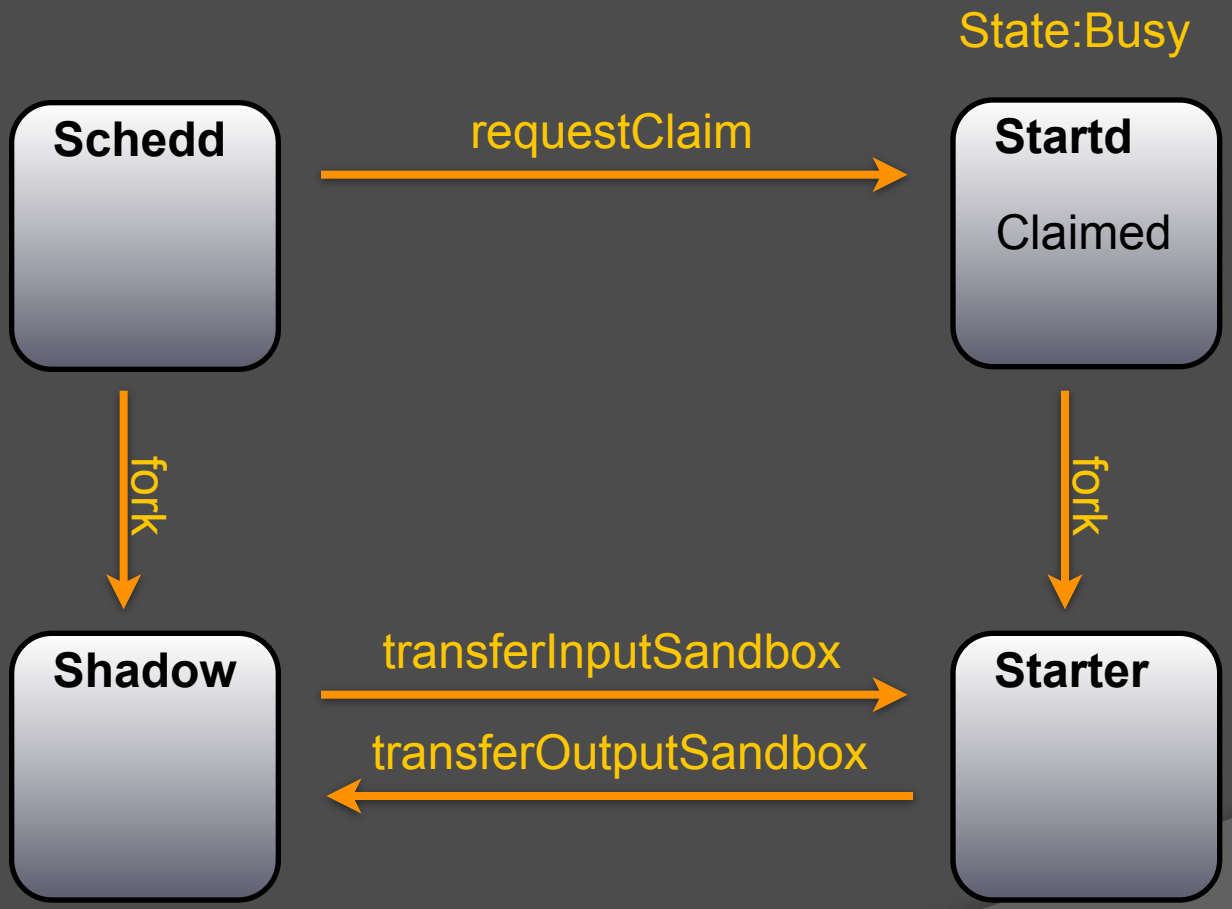

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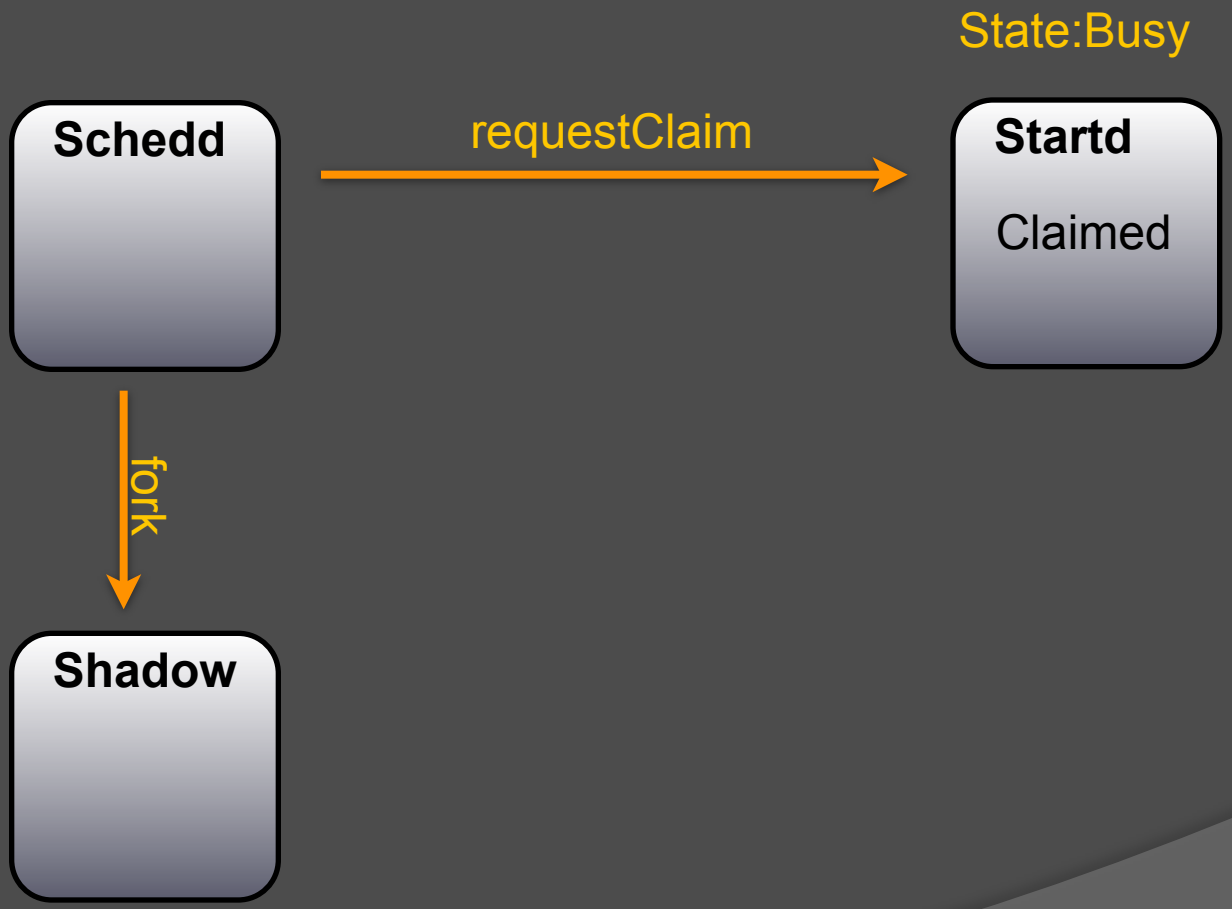

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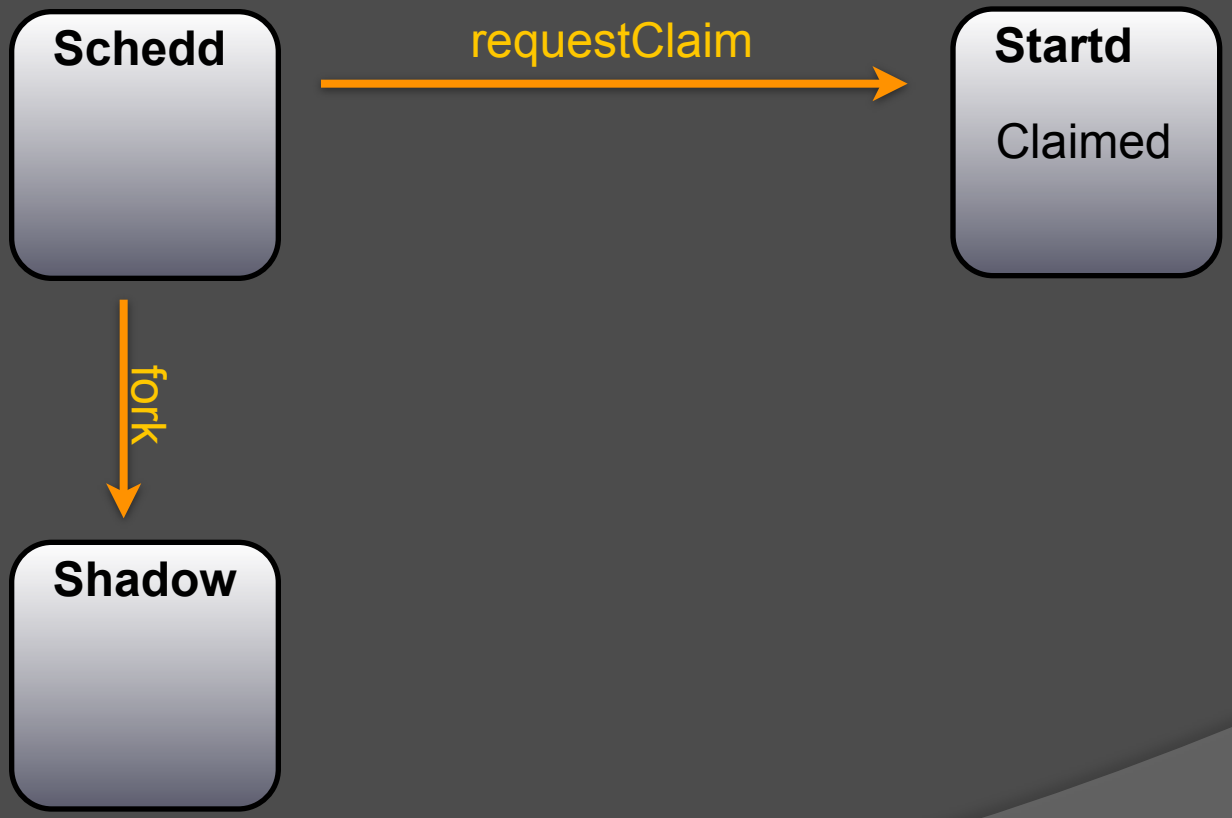

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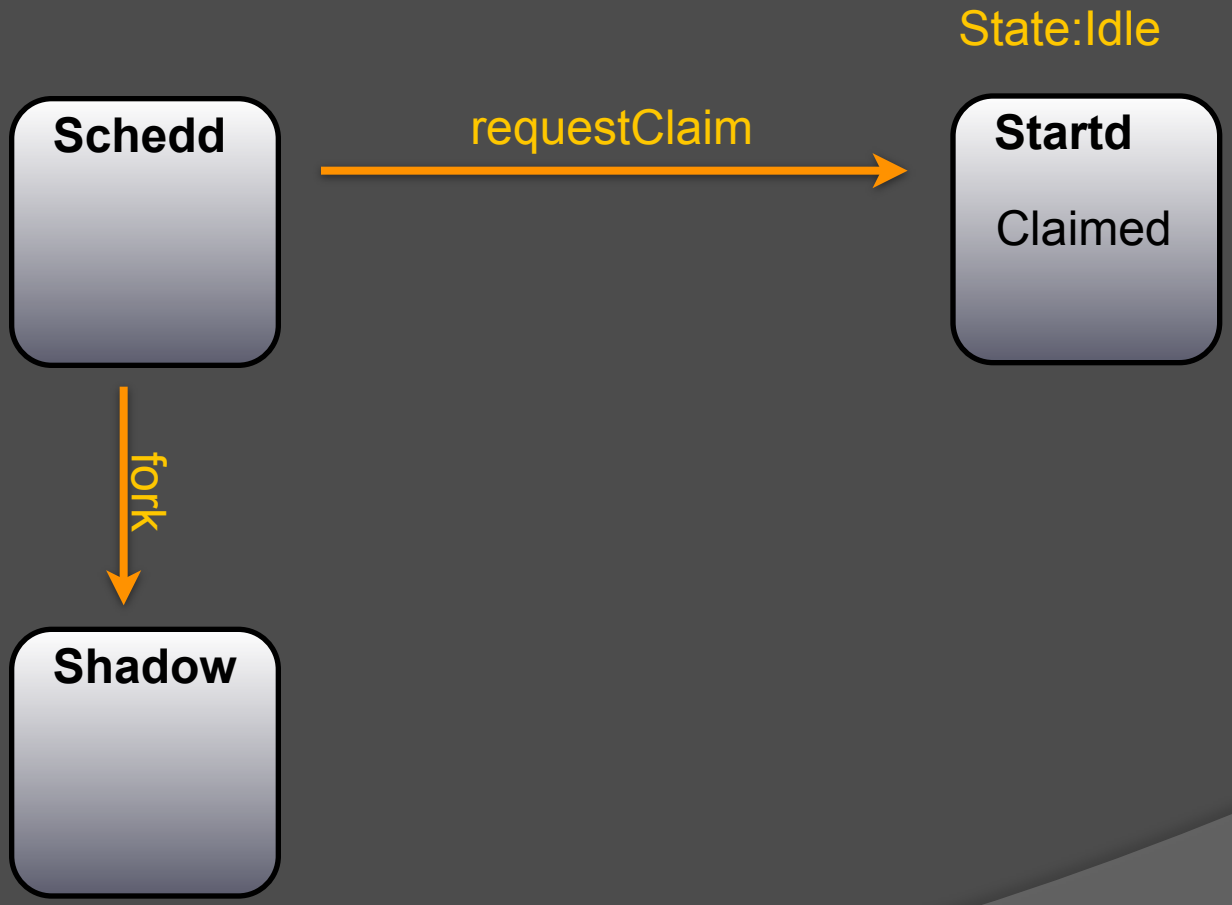

Current sandbox transfer

Existing Claim

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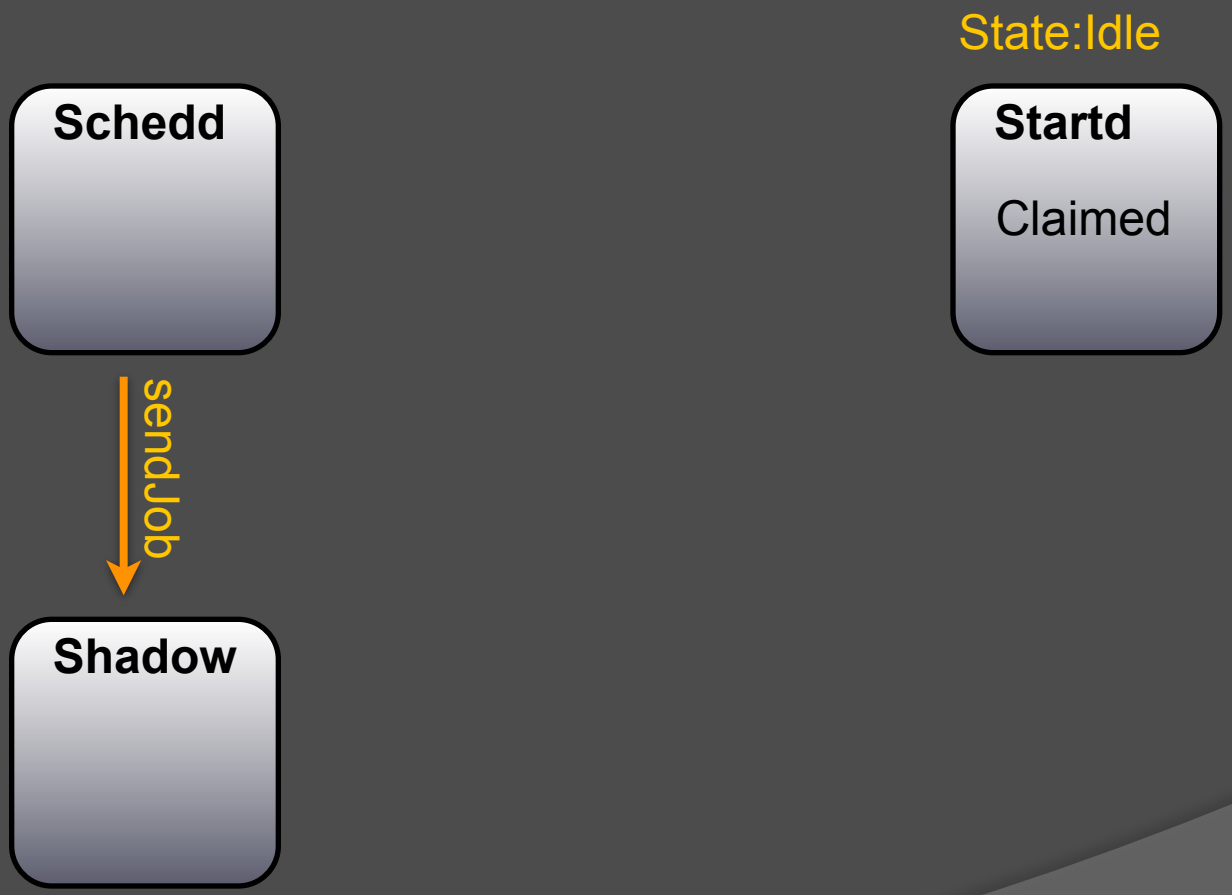

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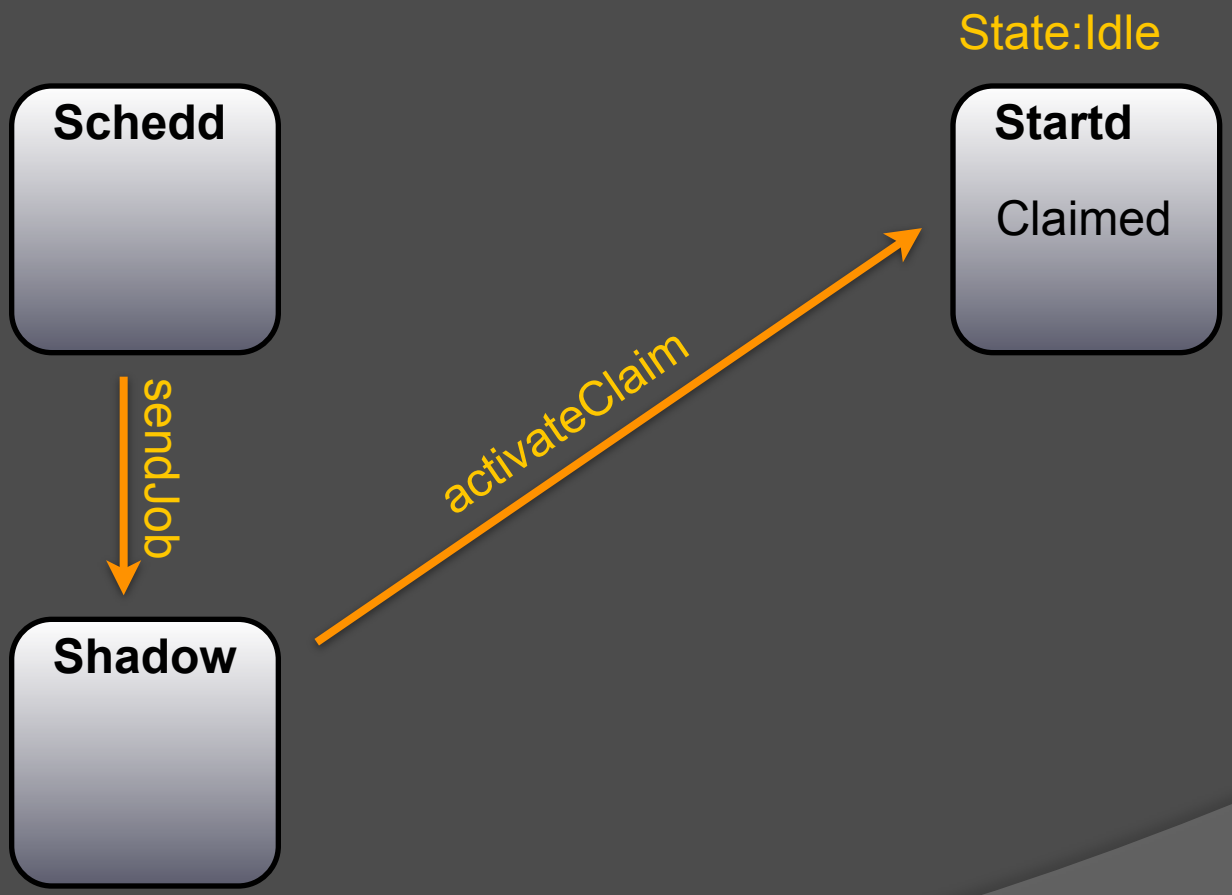

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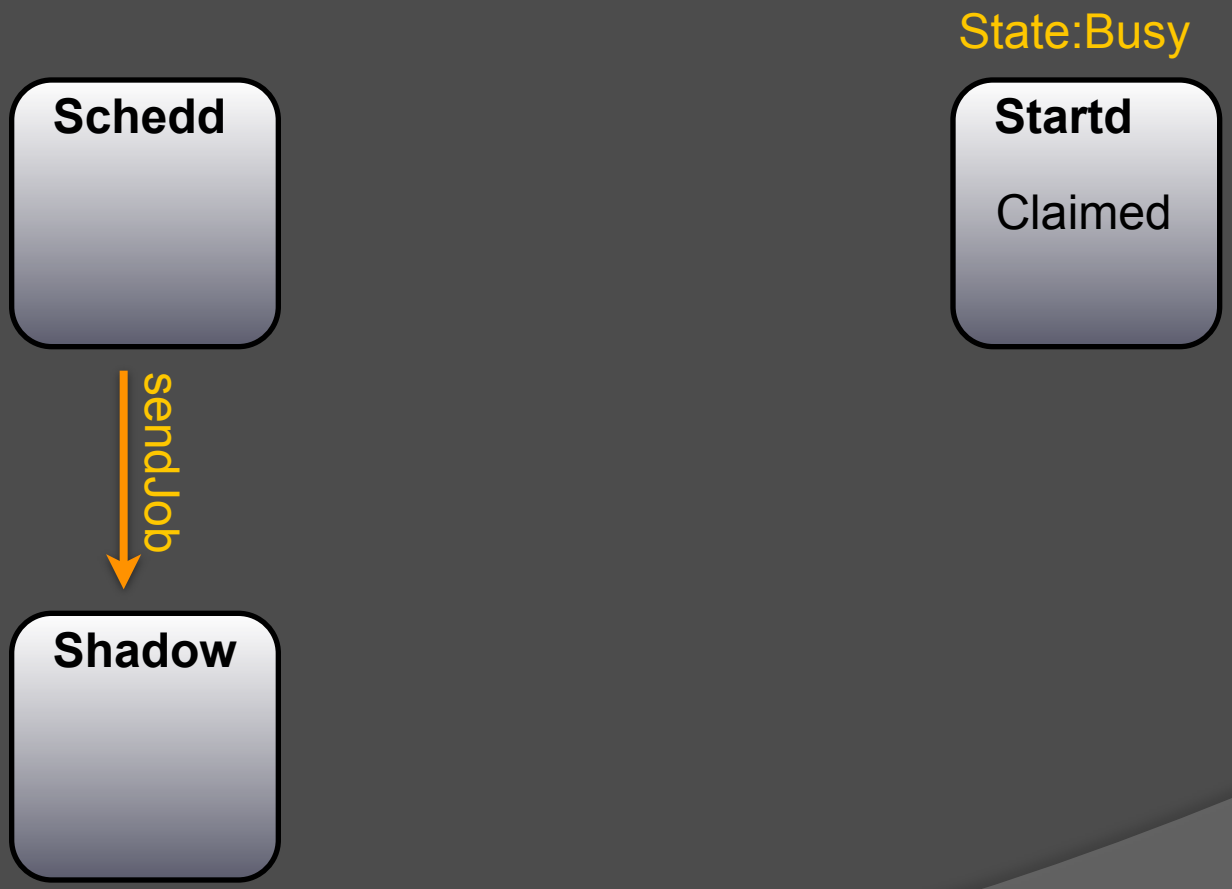

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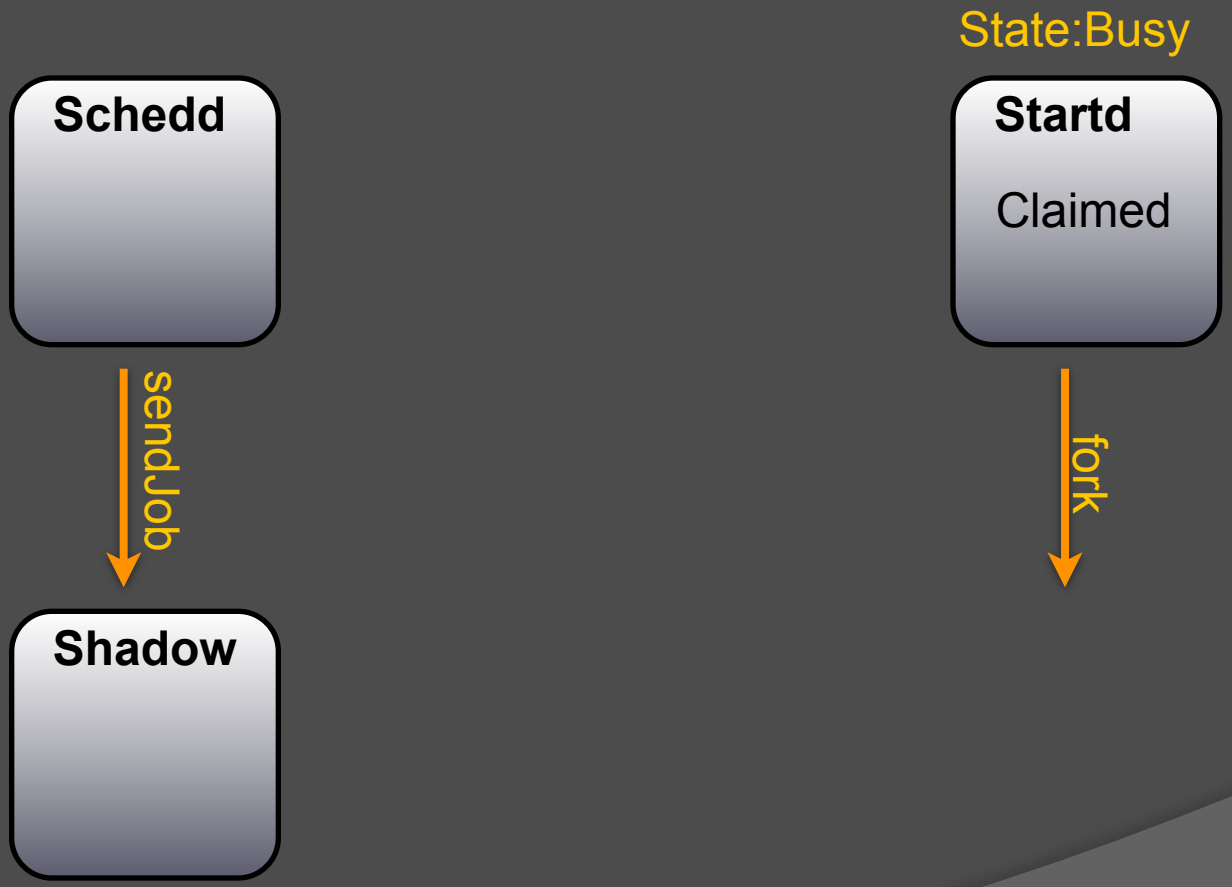

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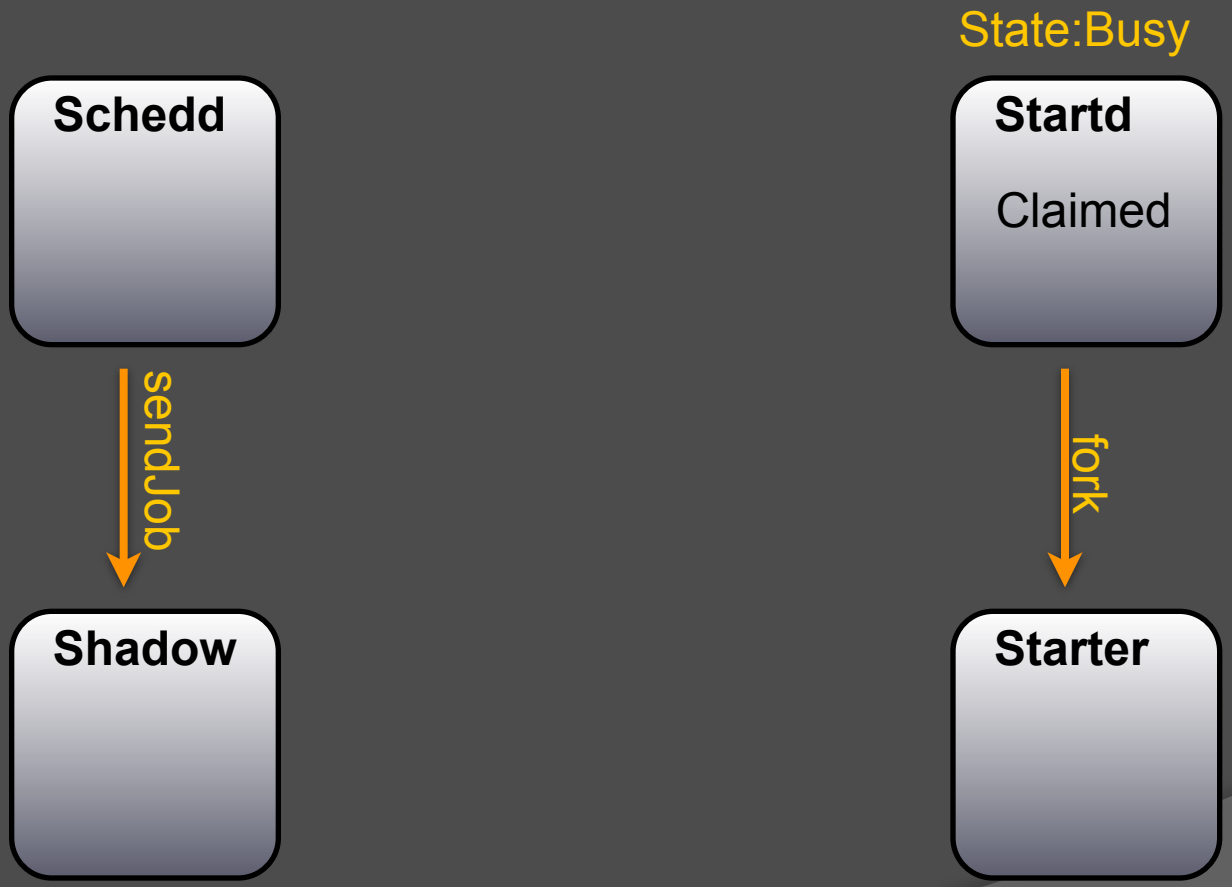

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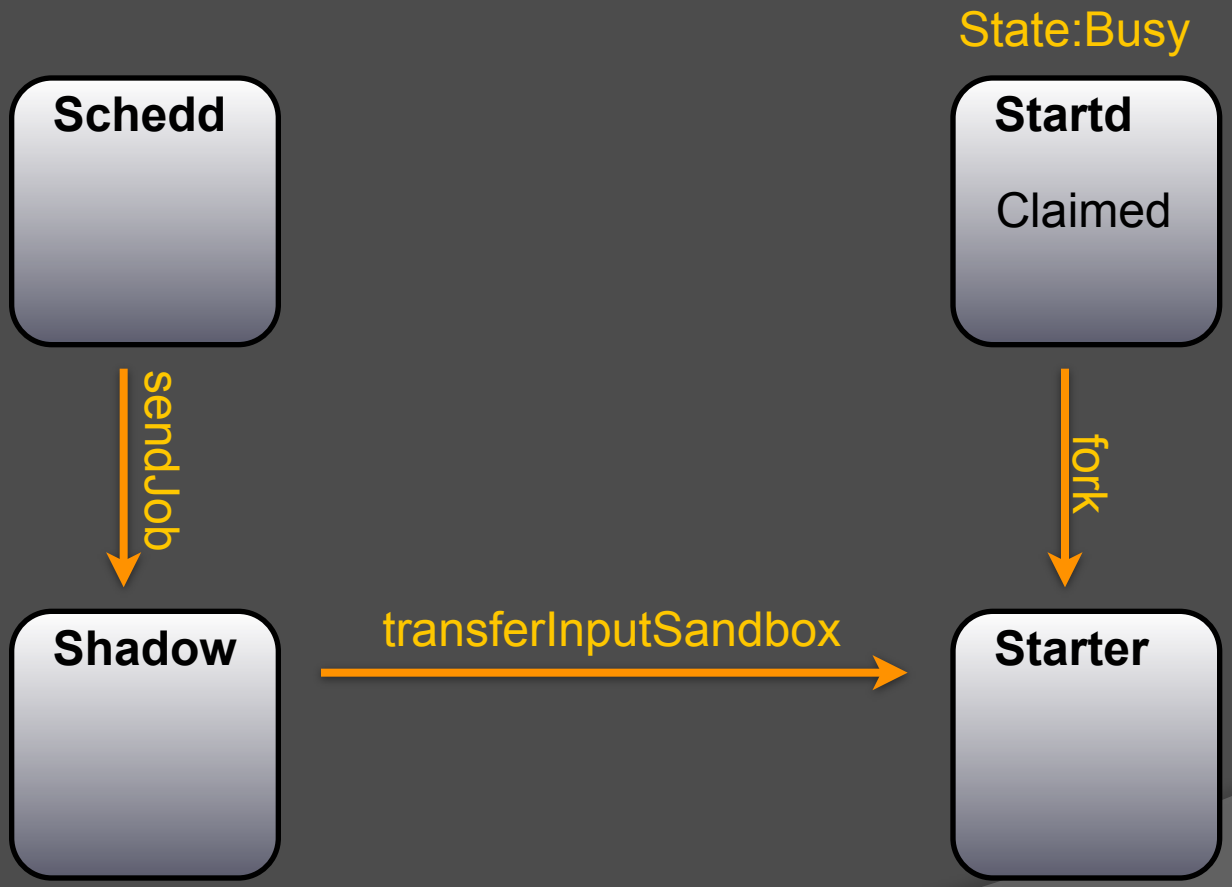

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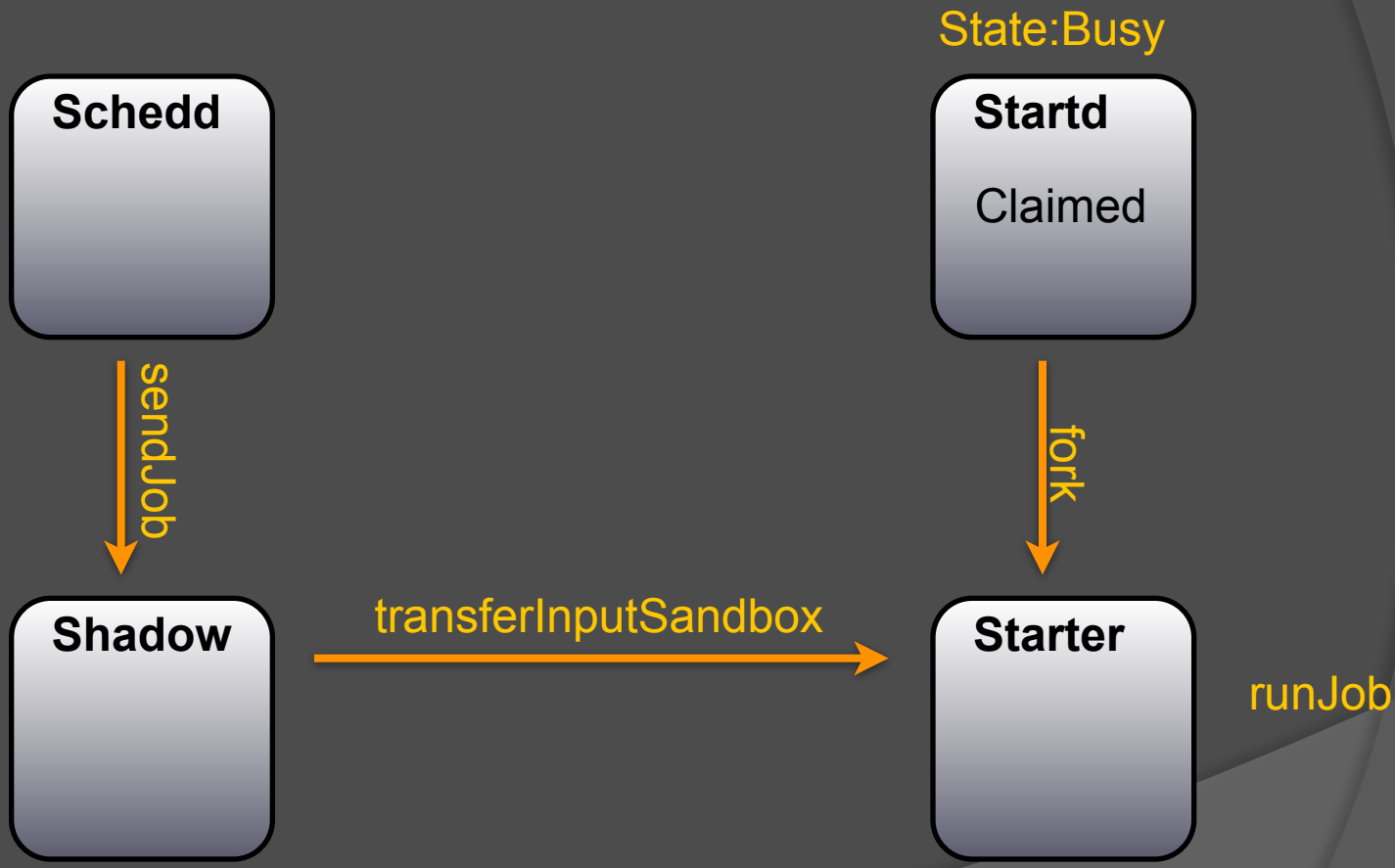

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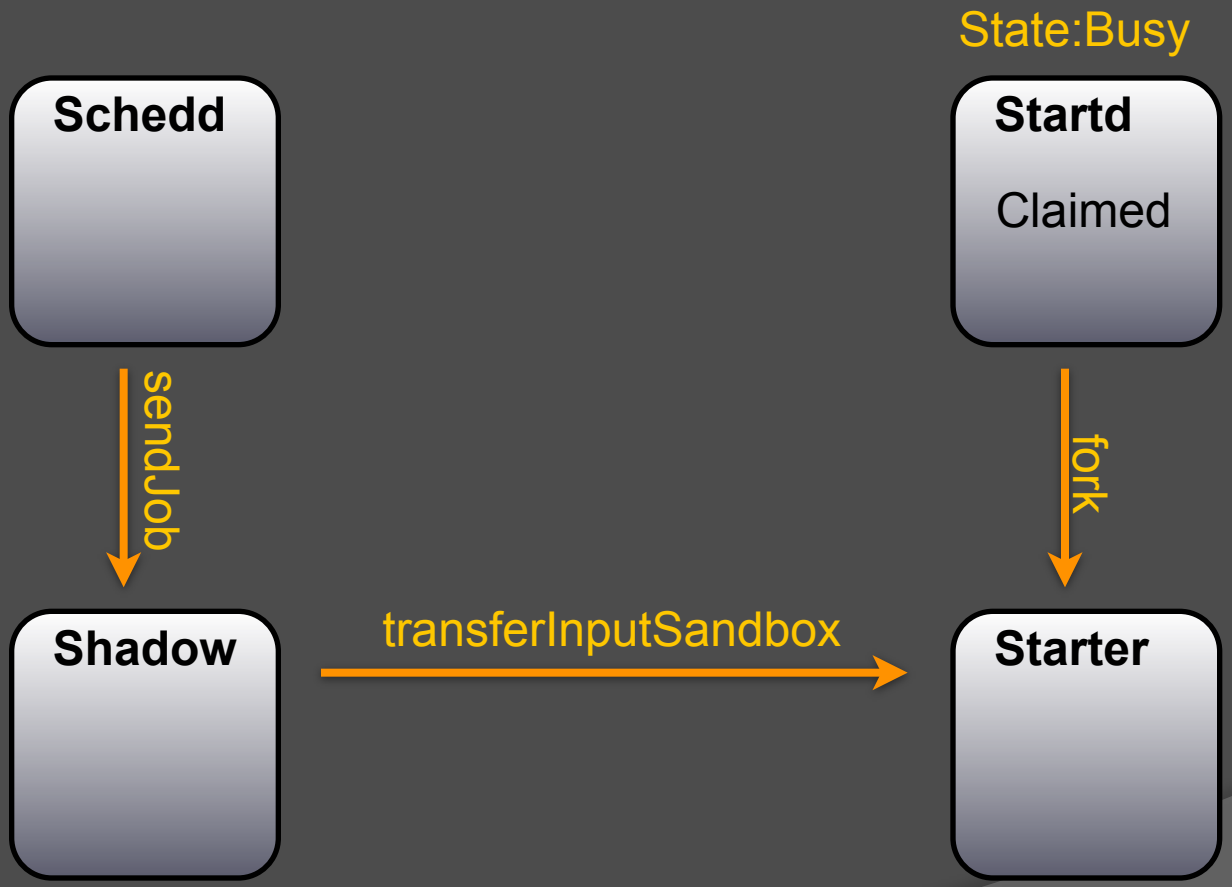

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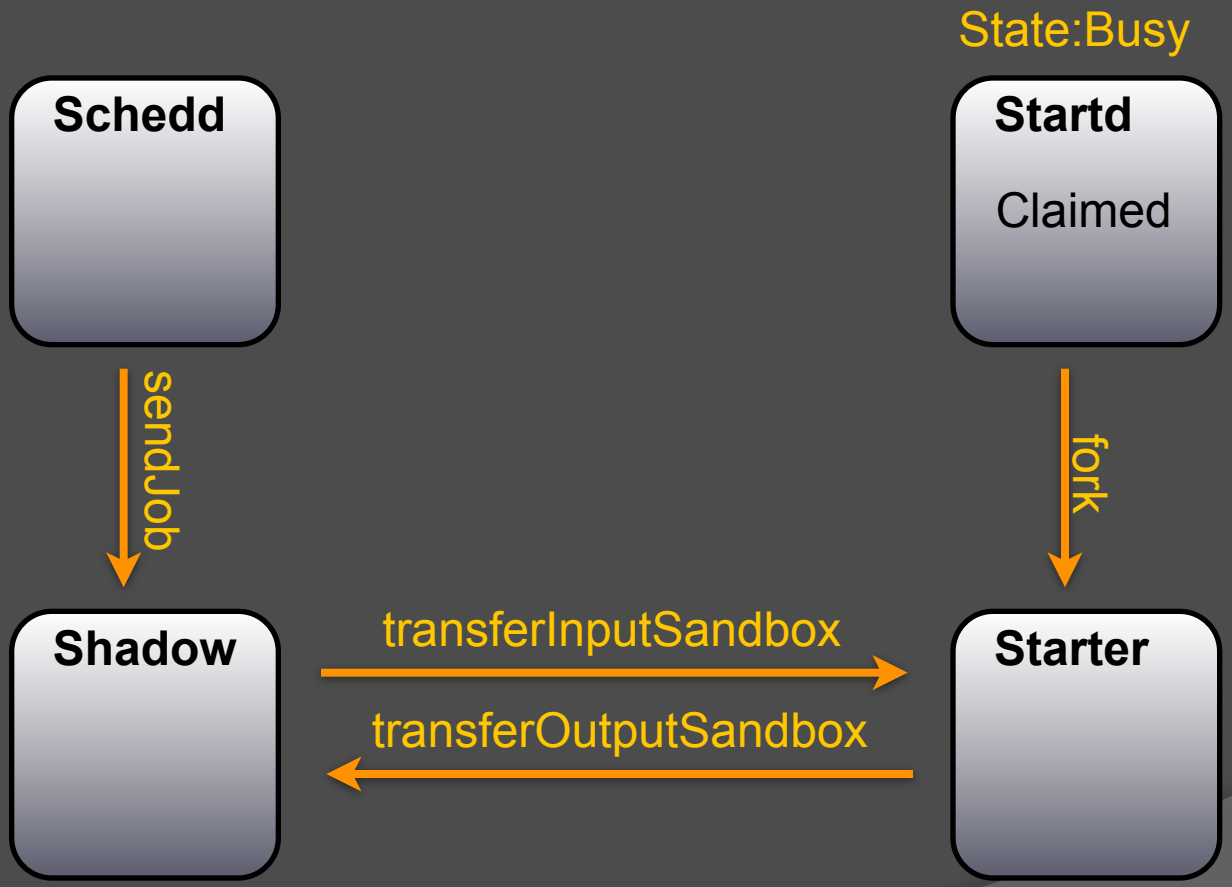

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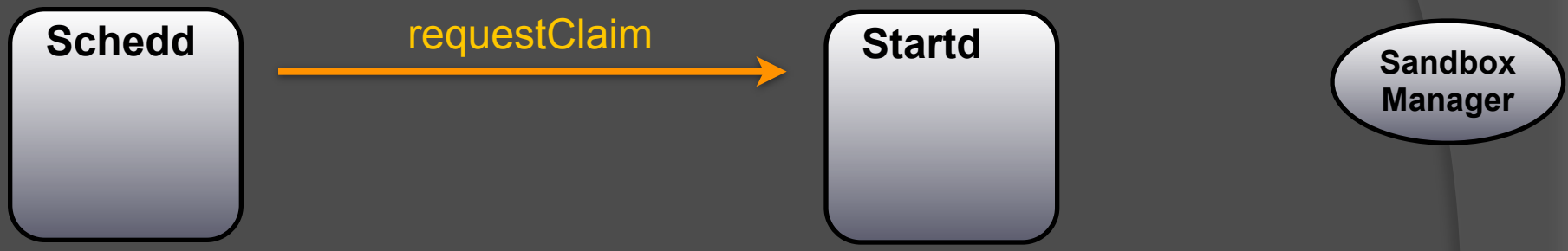

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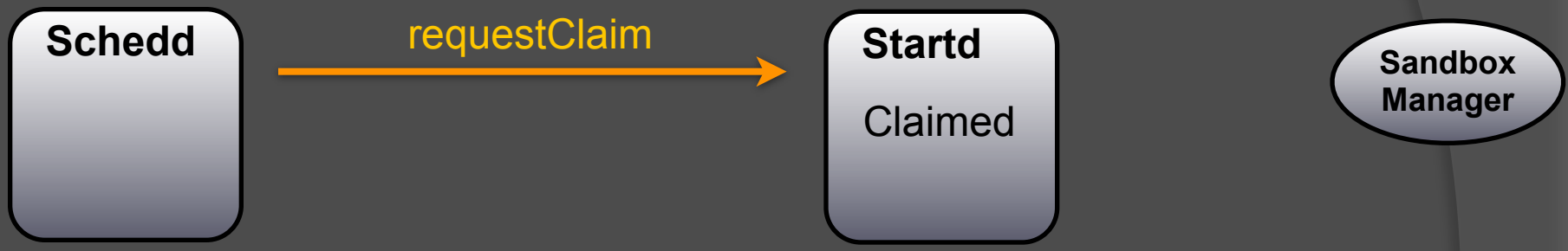

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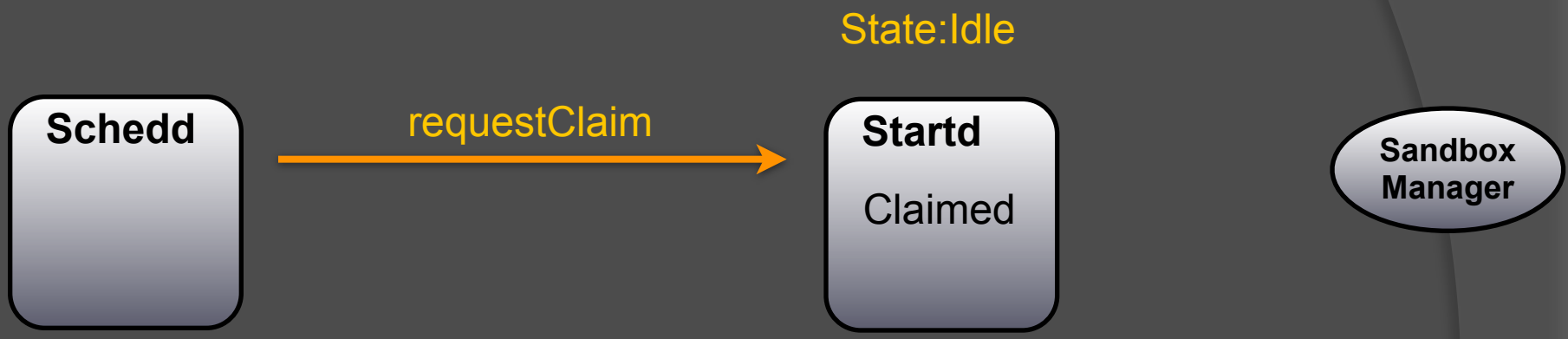

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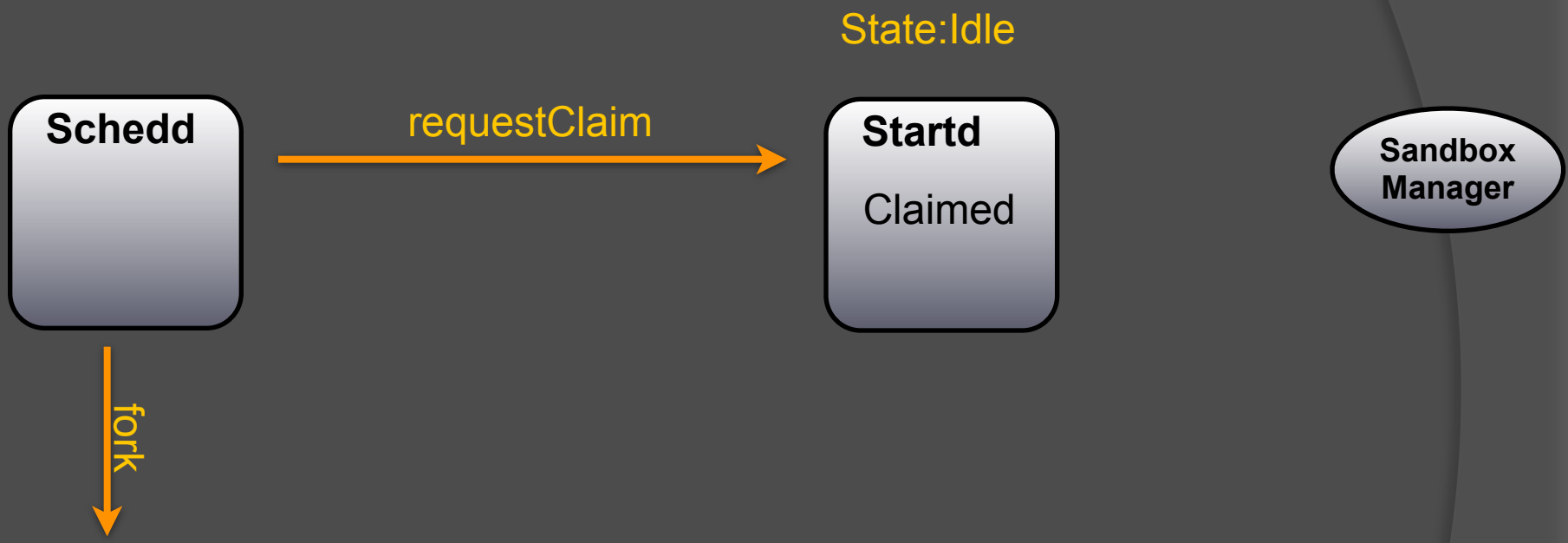

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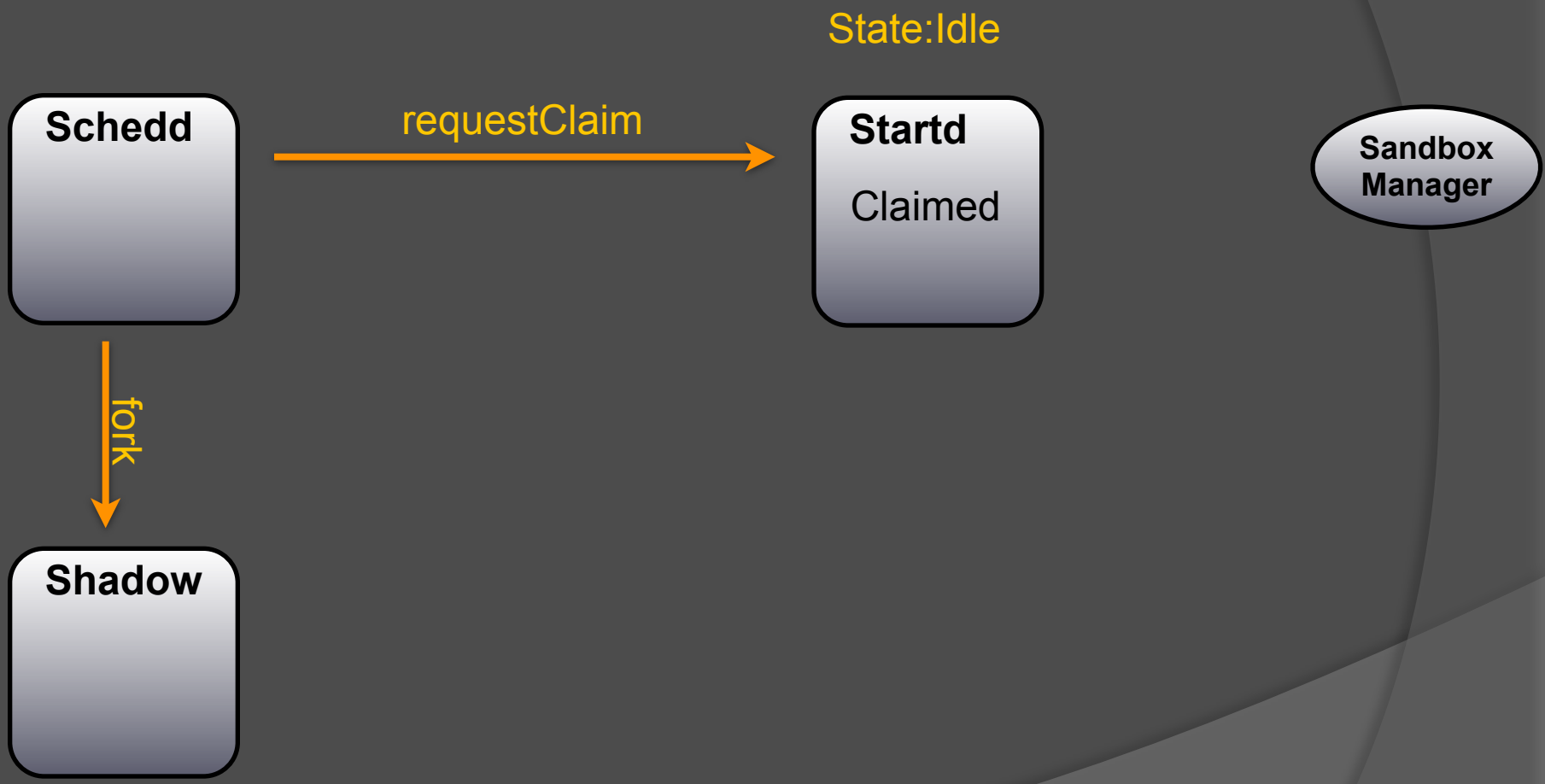

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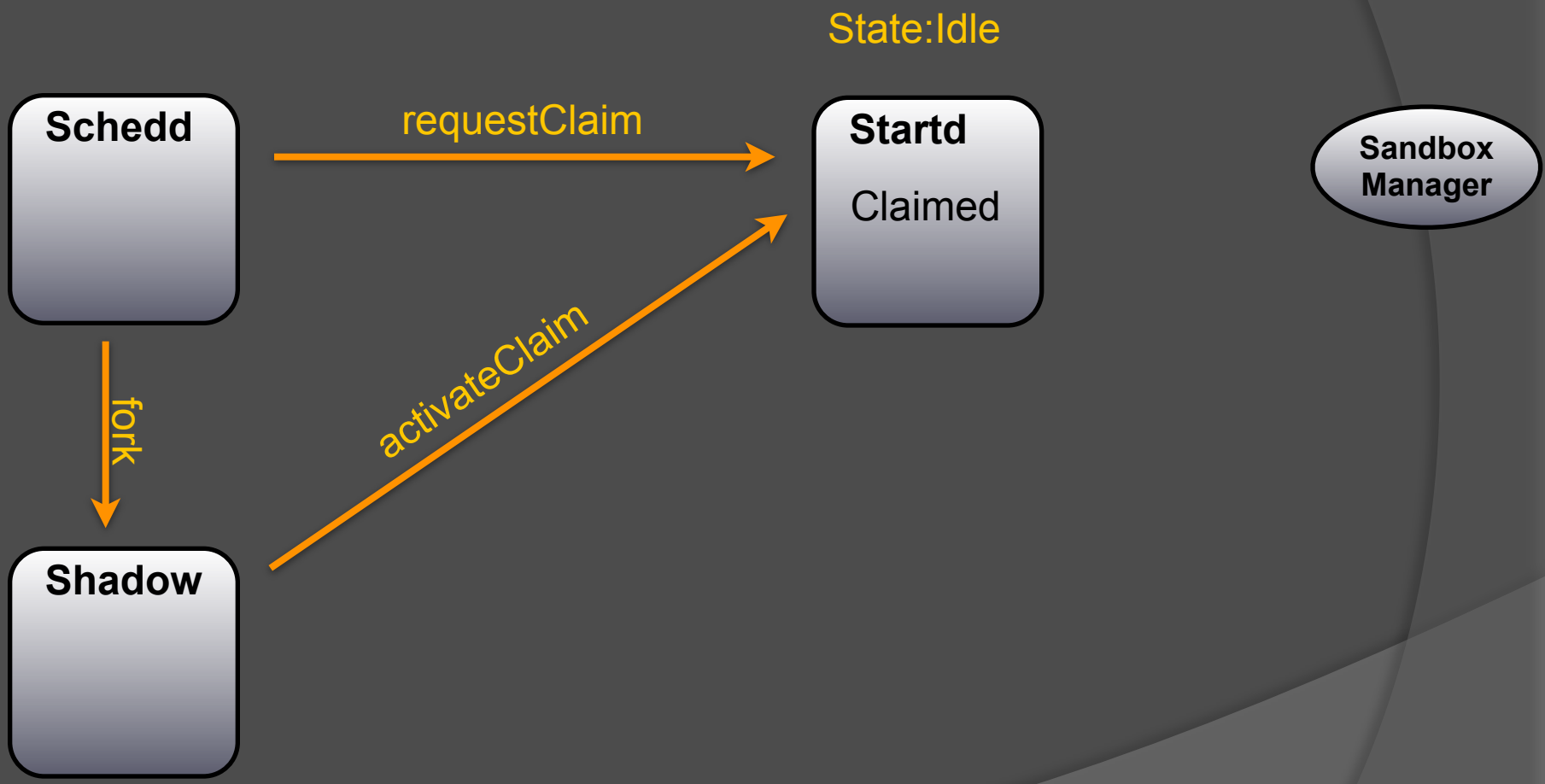

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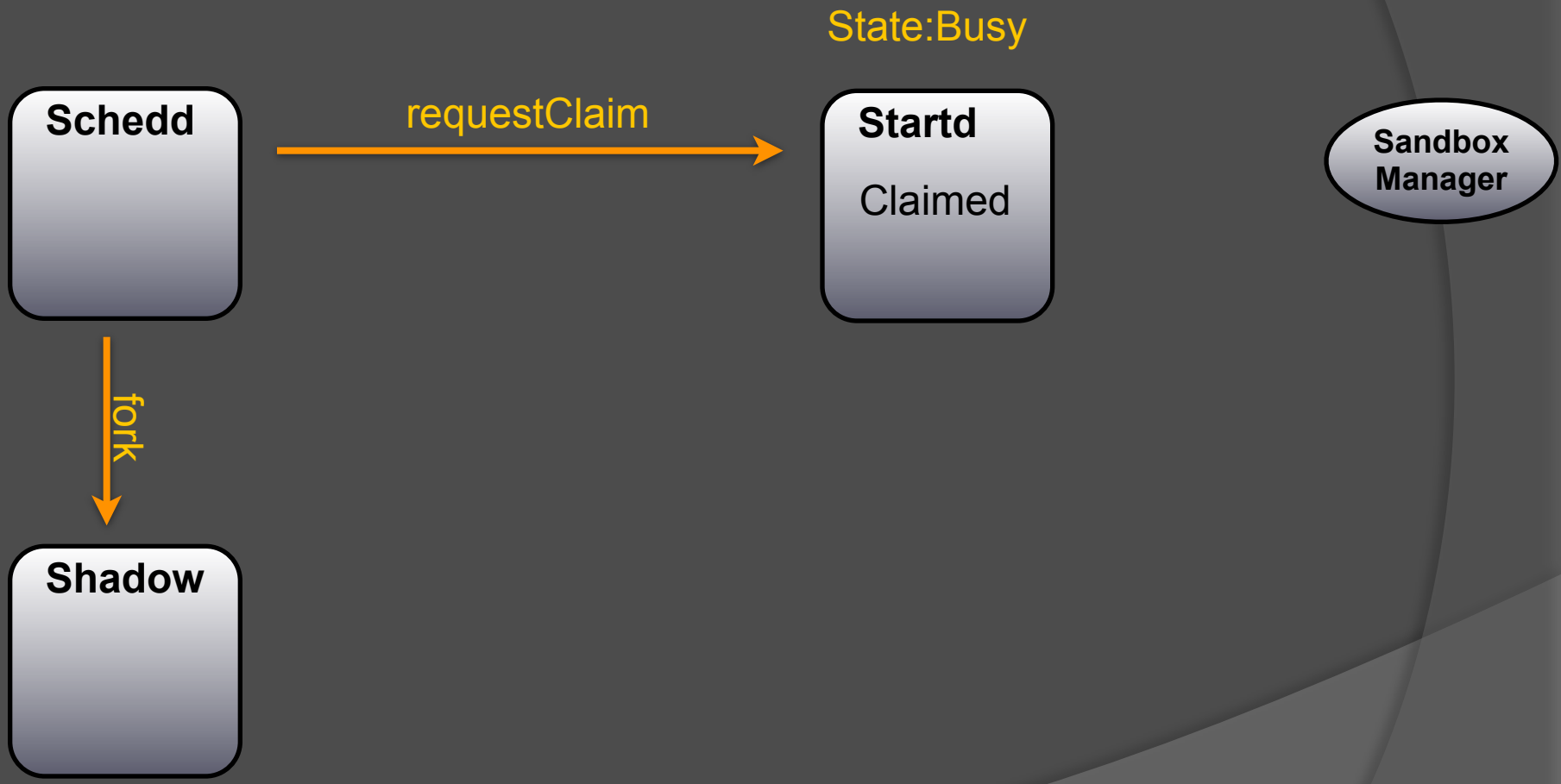

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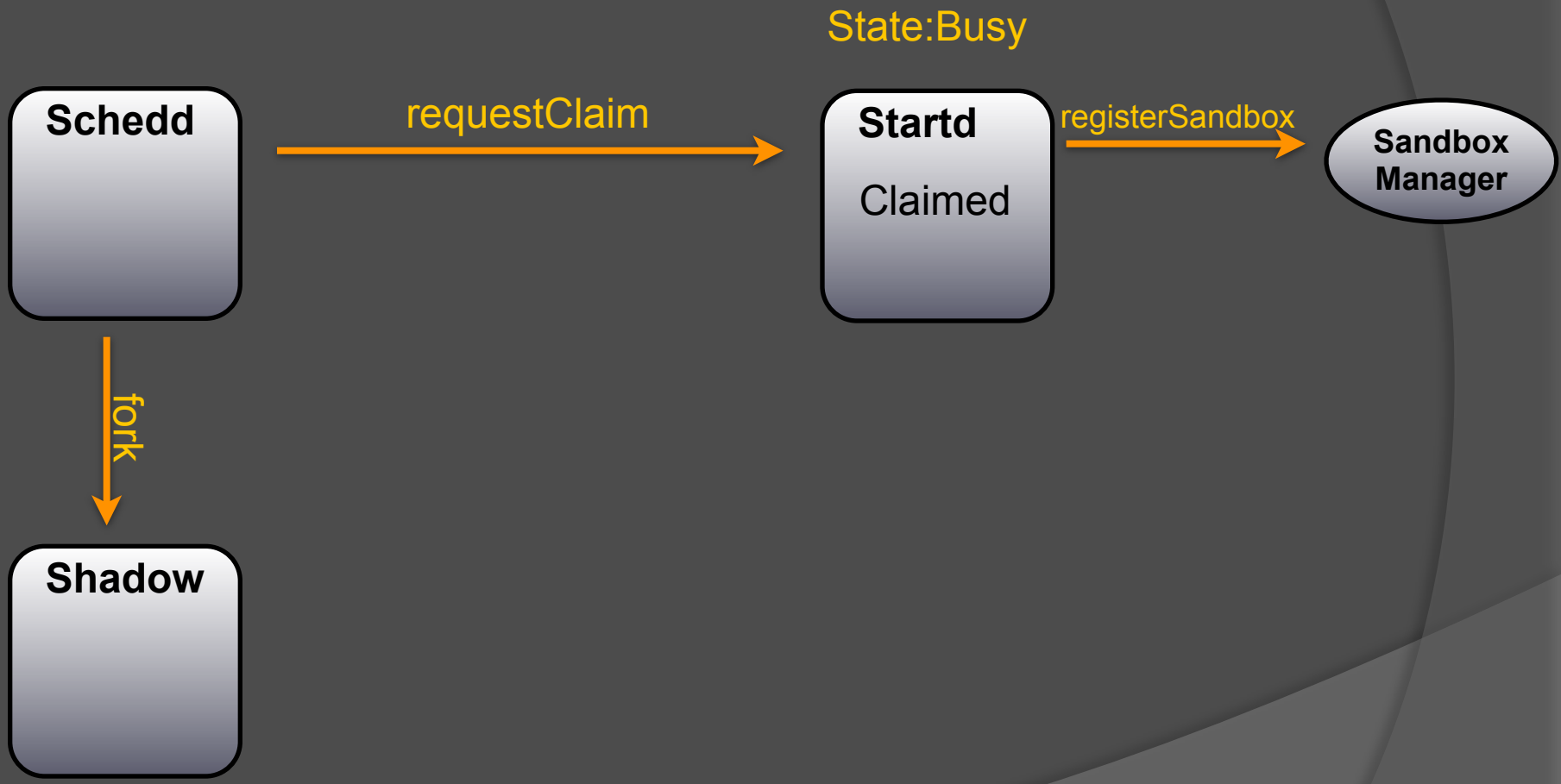

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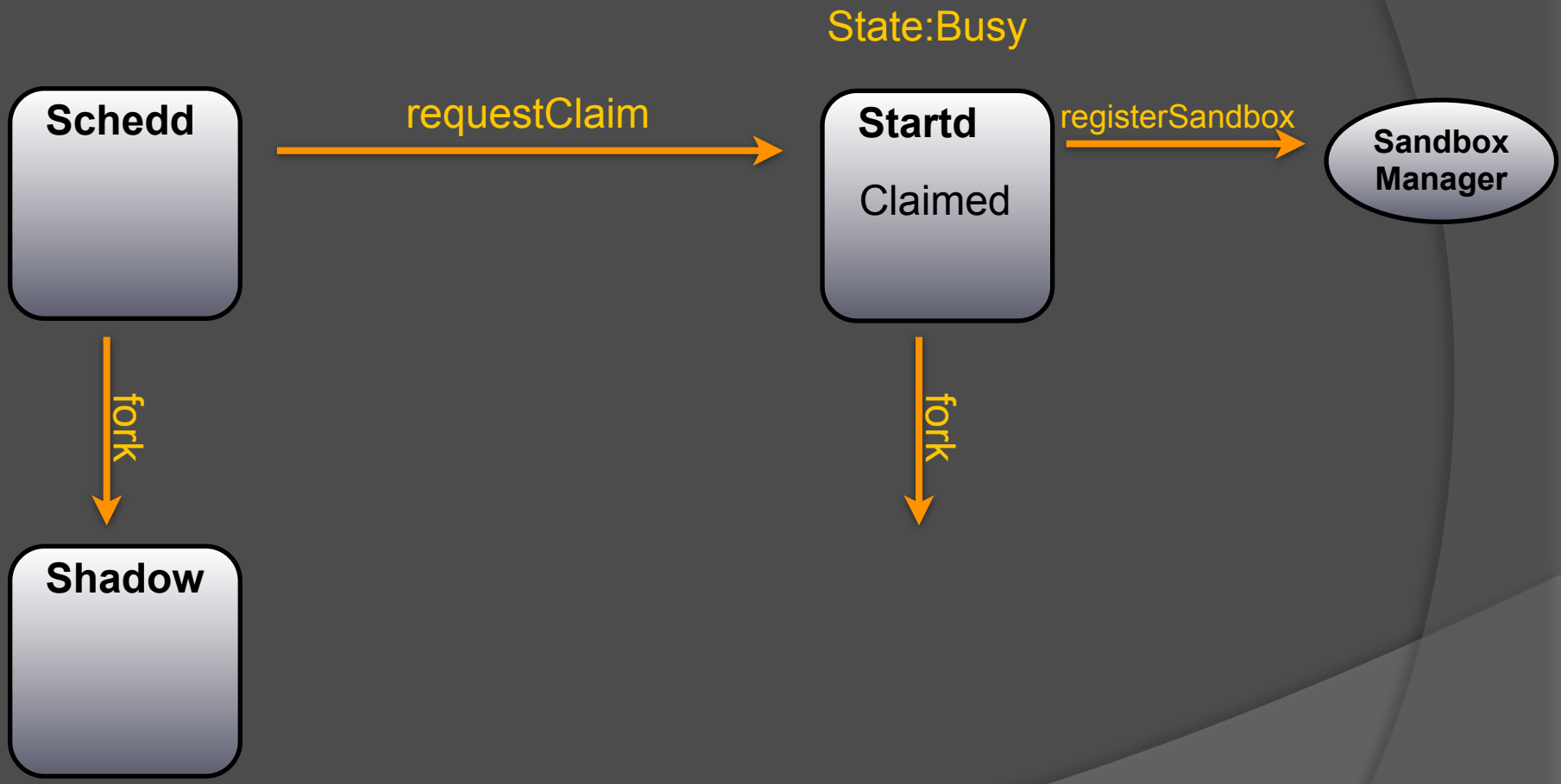

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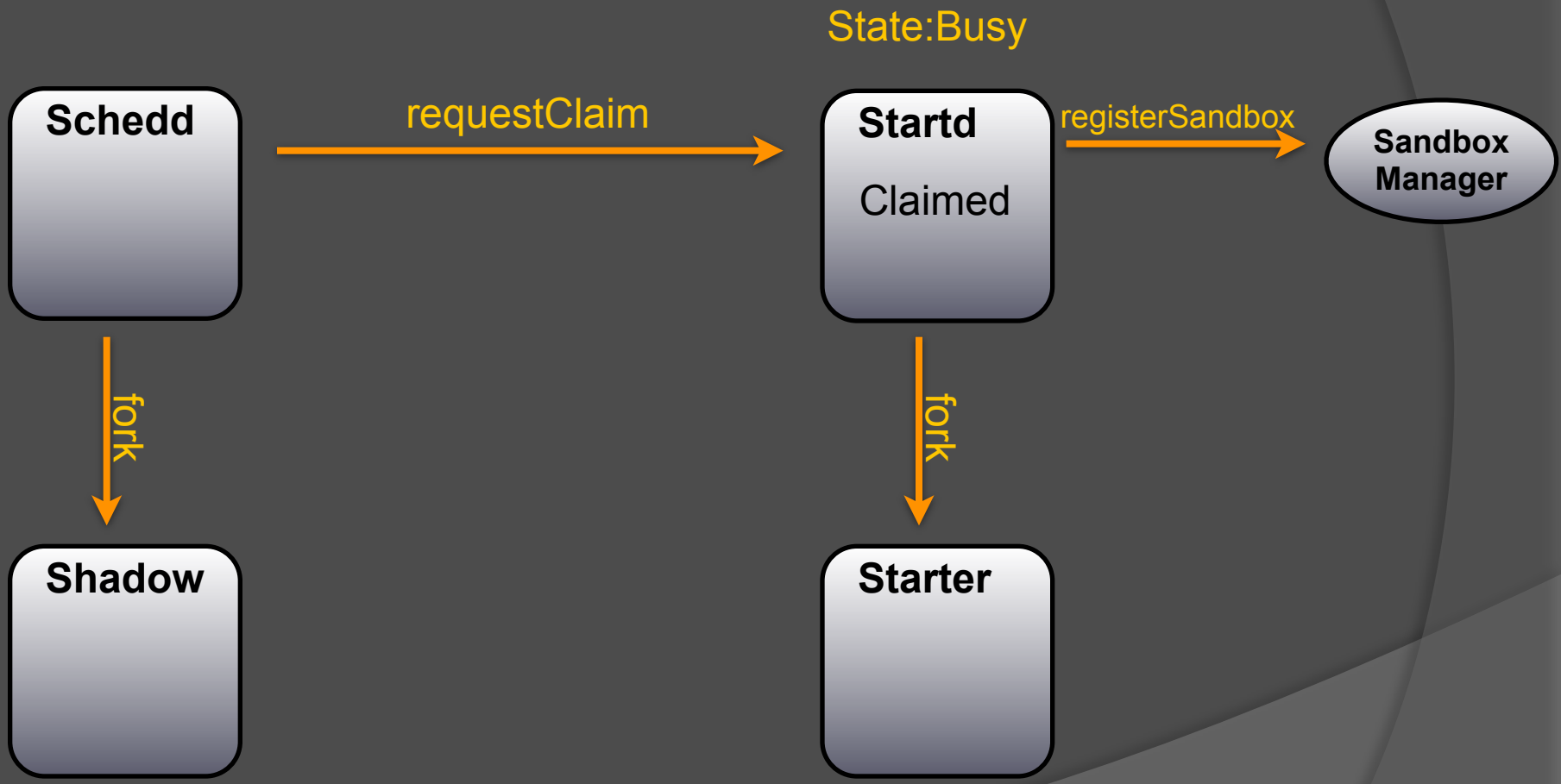

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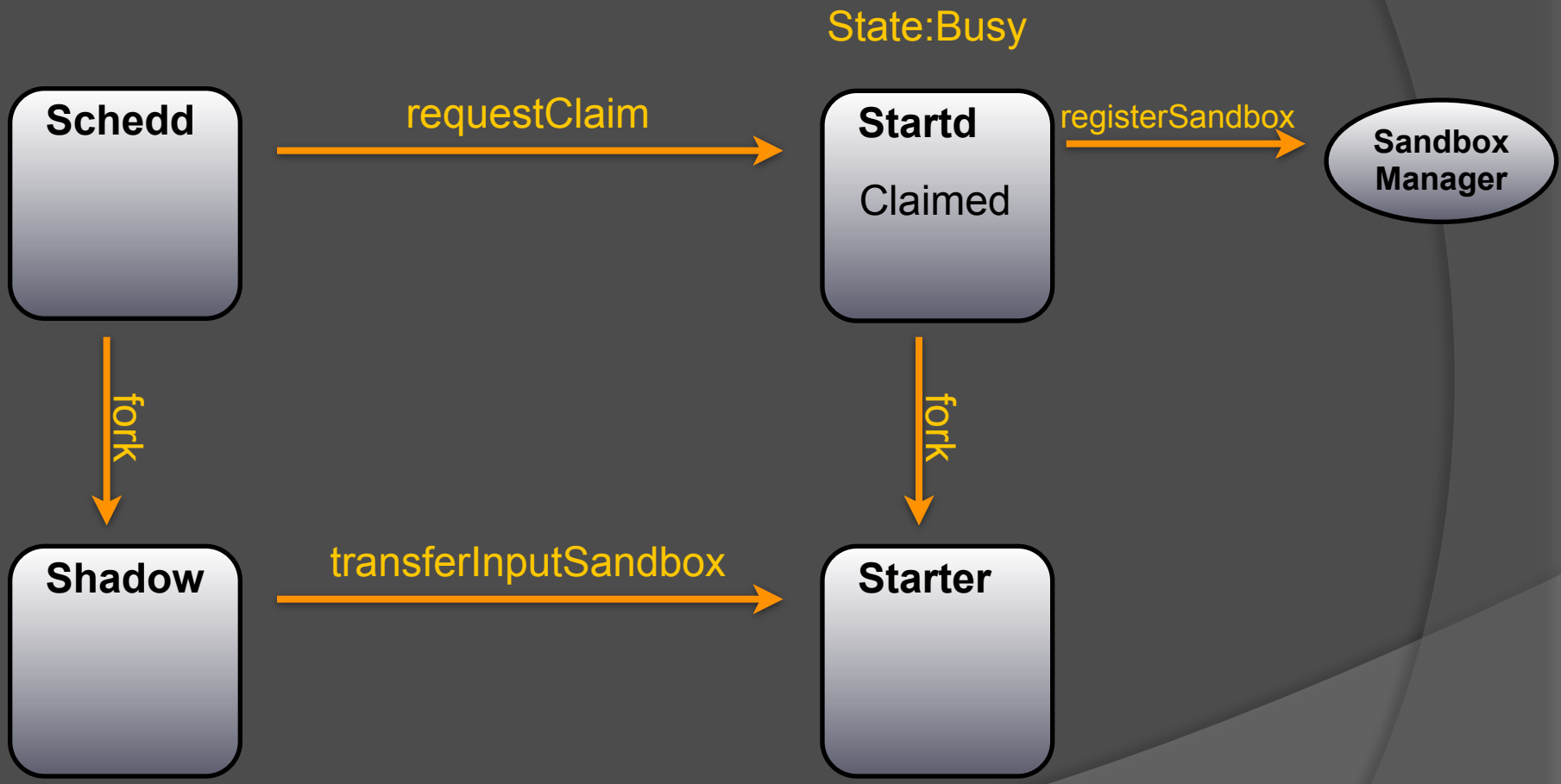

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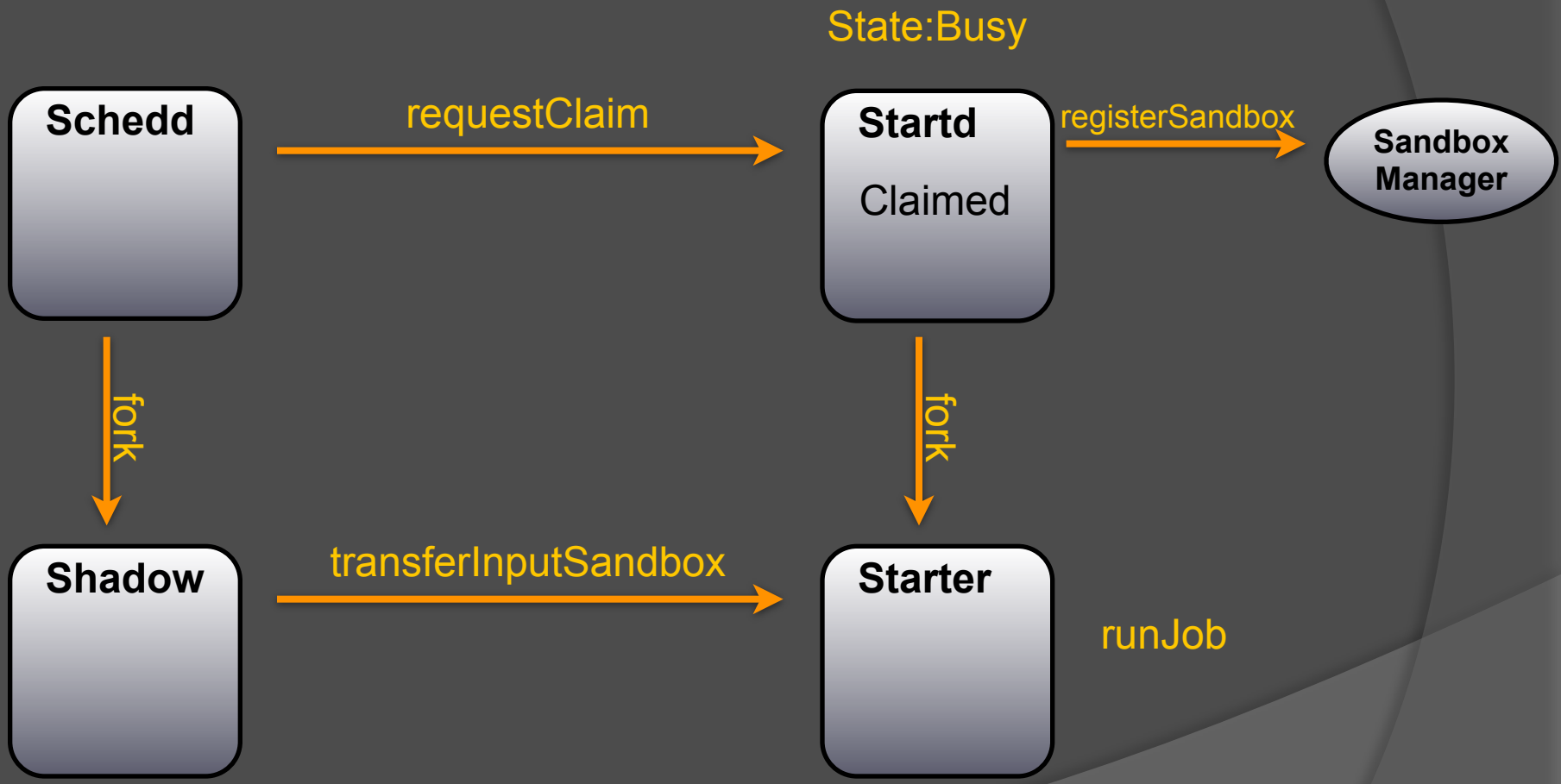

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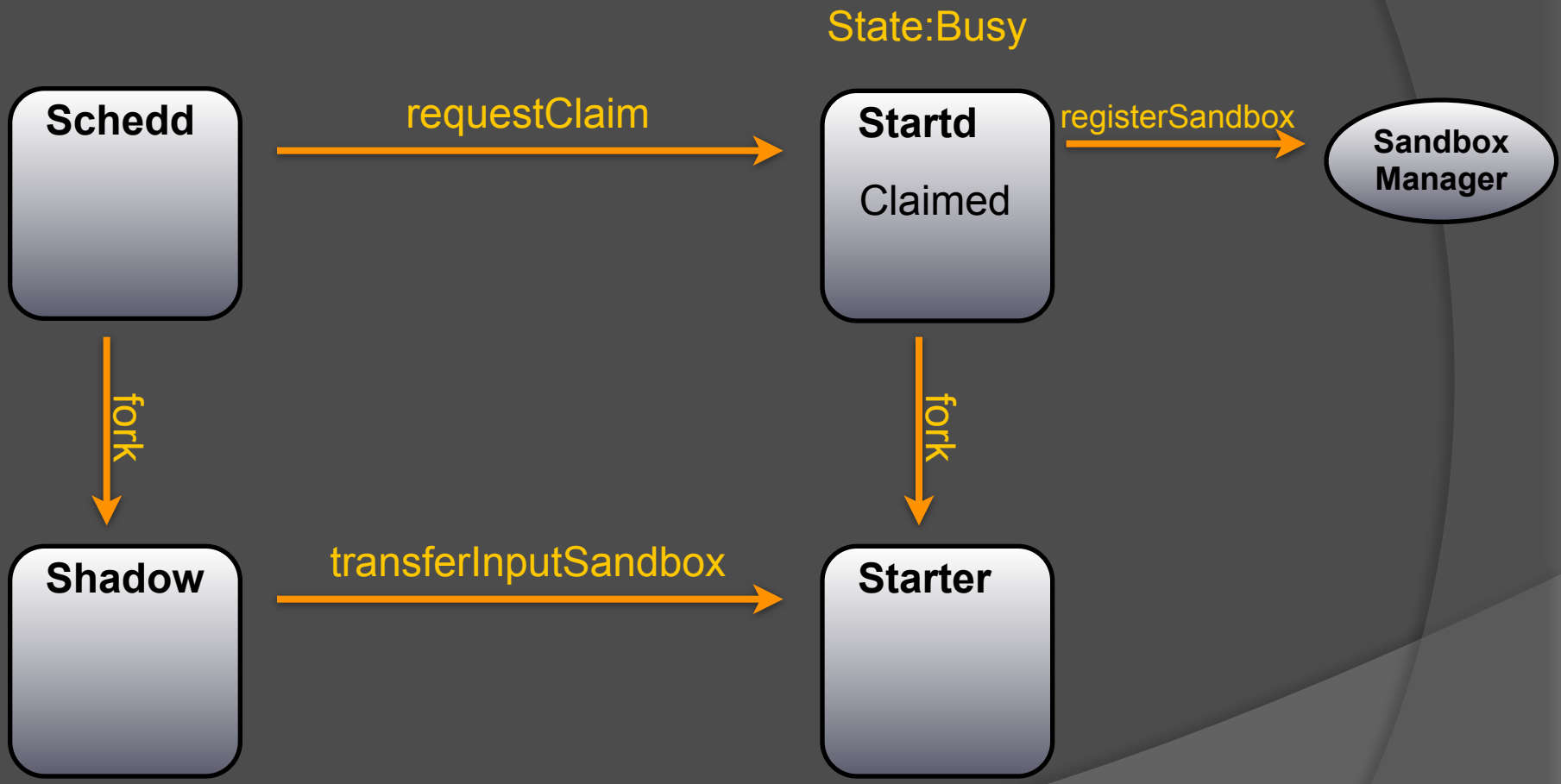

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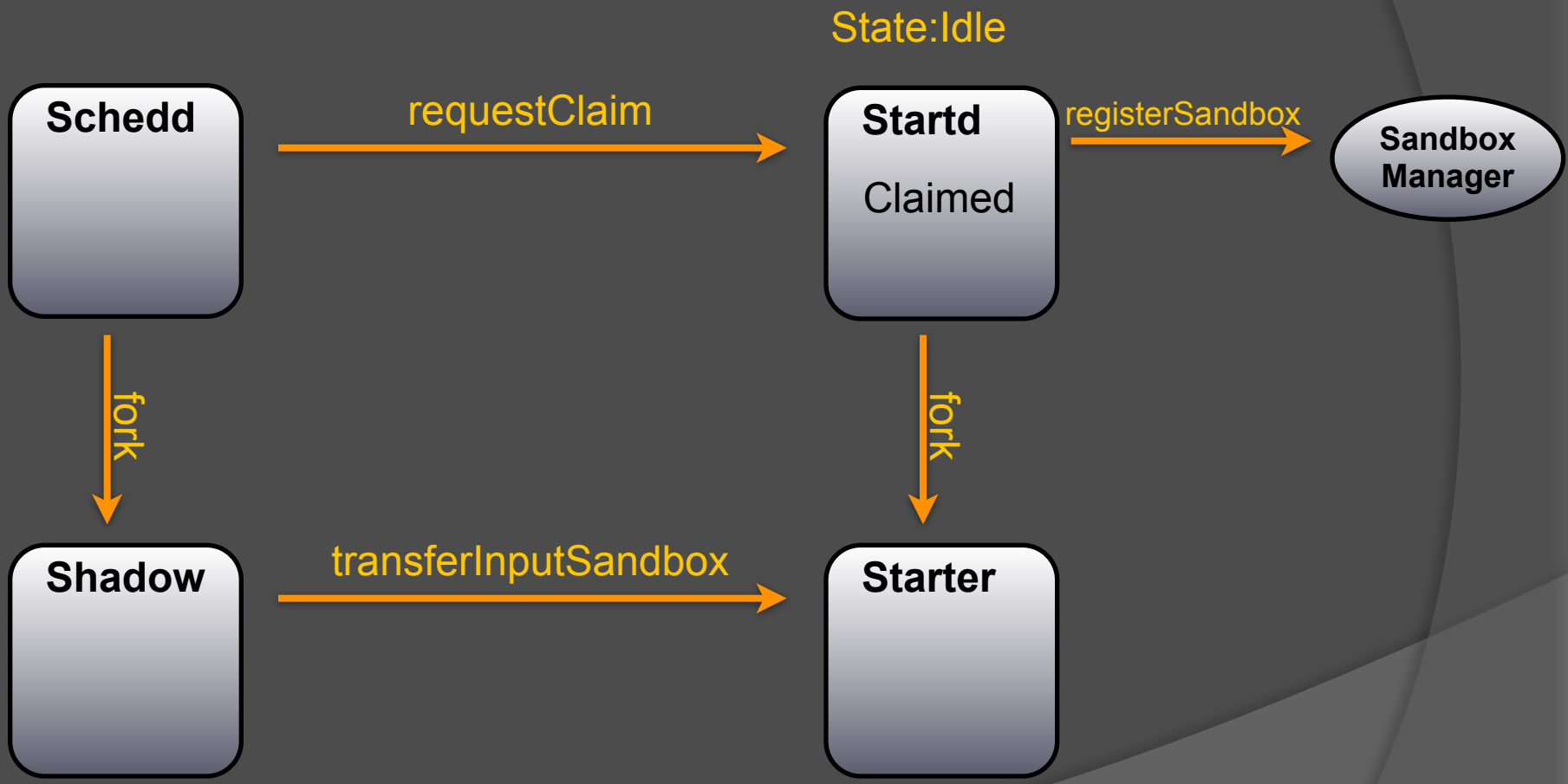

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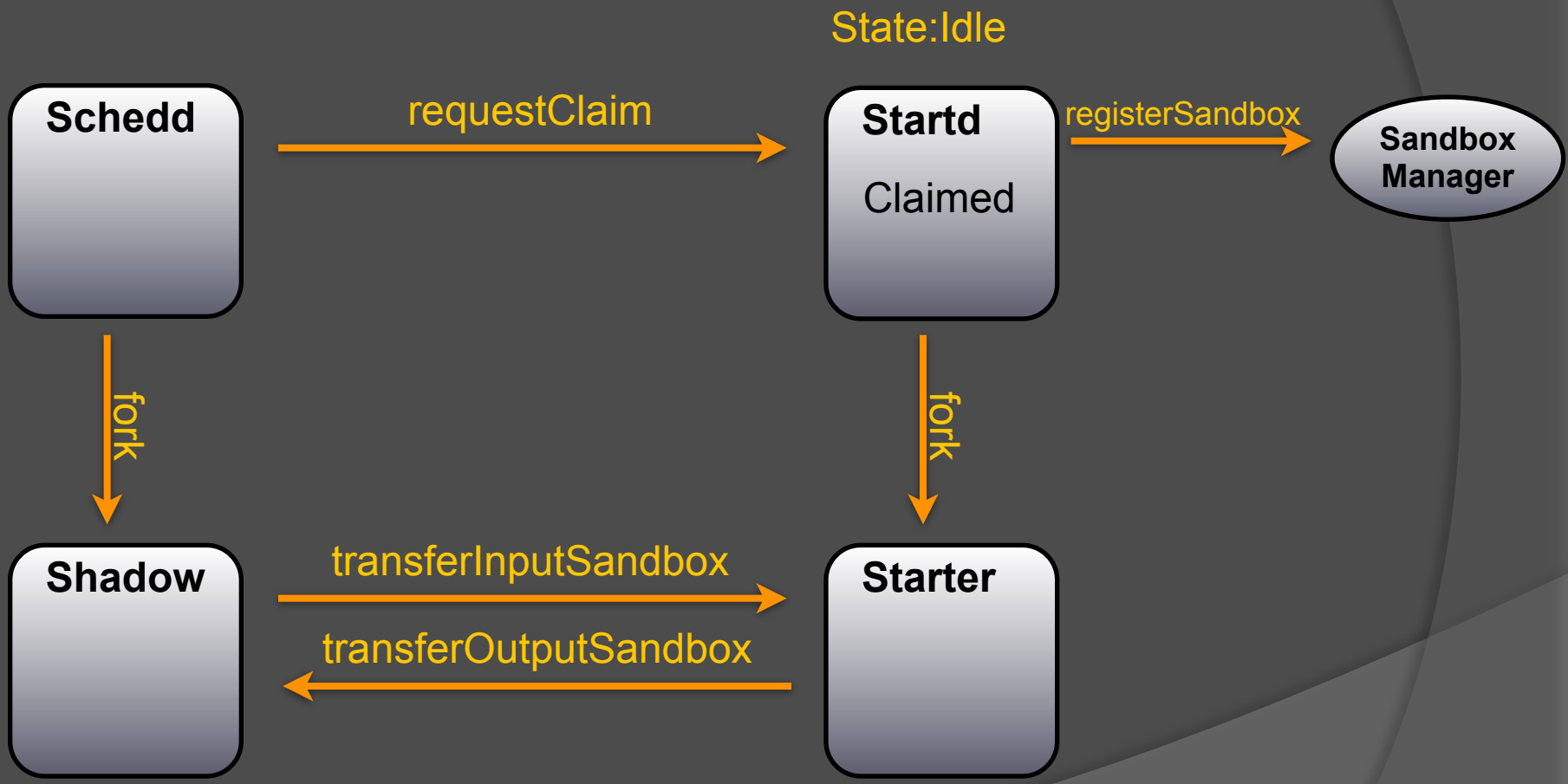

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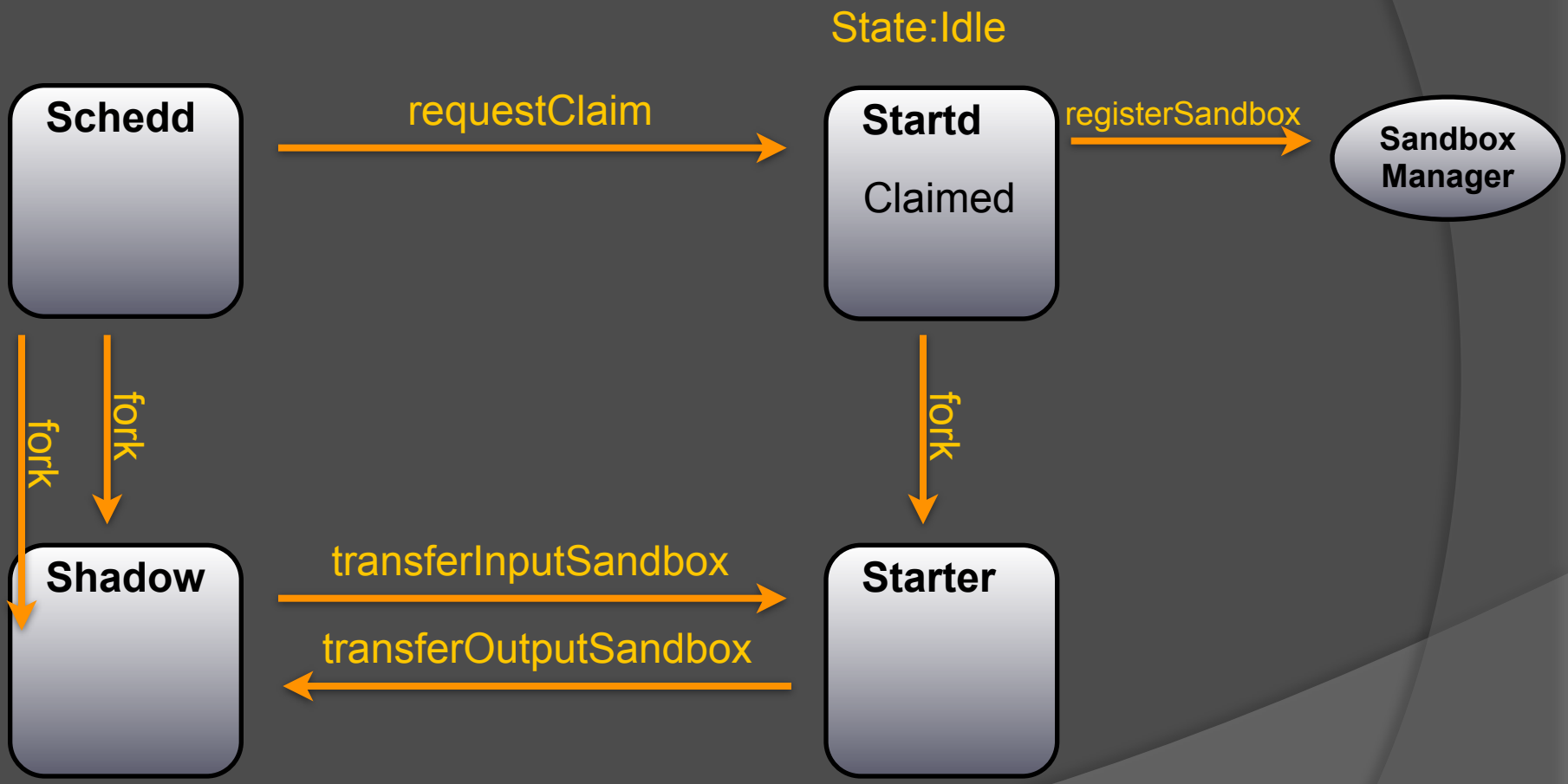

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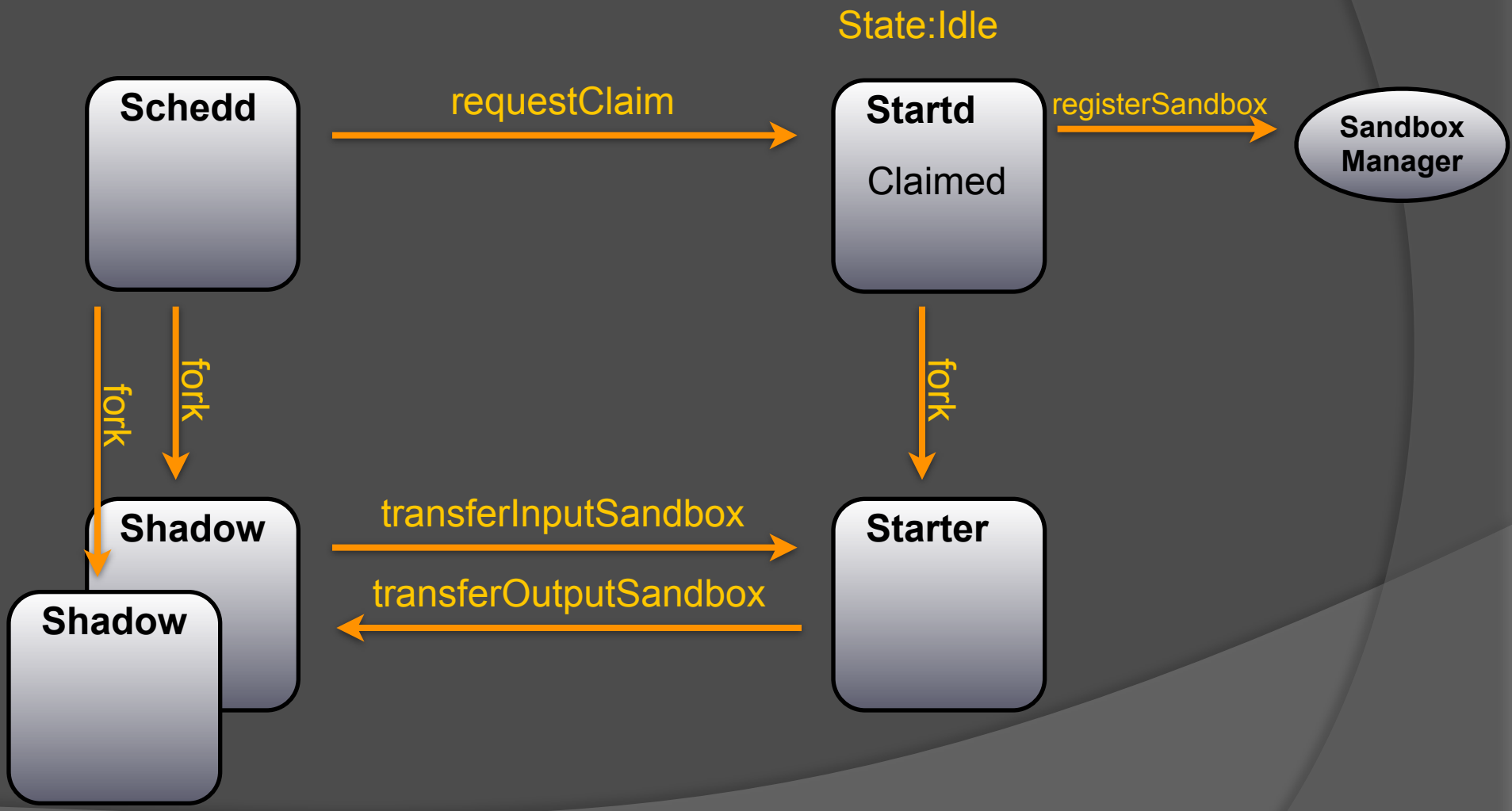

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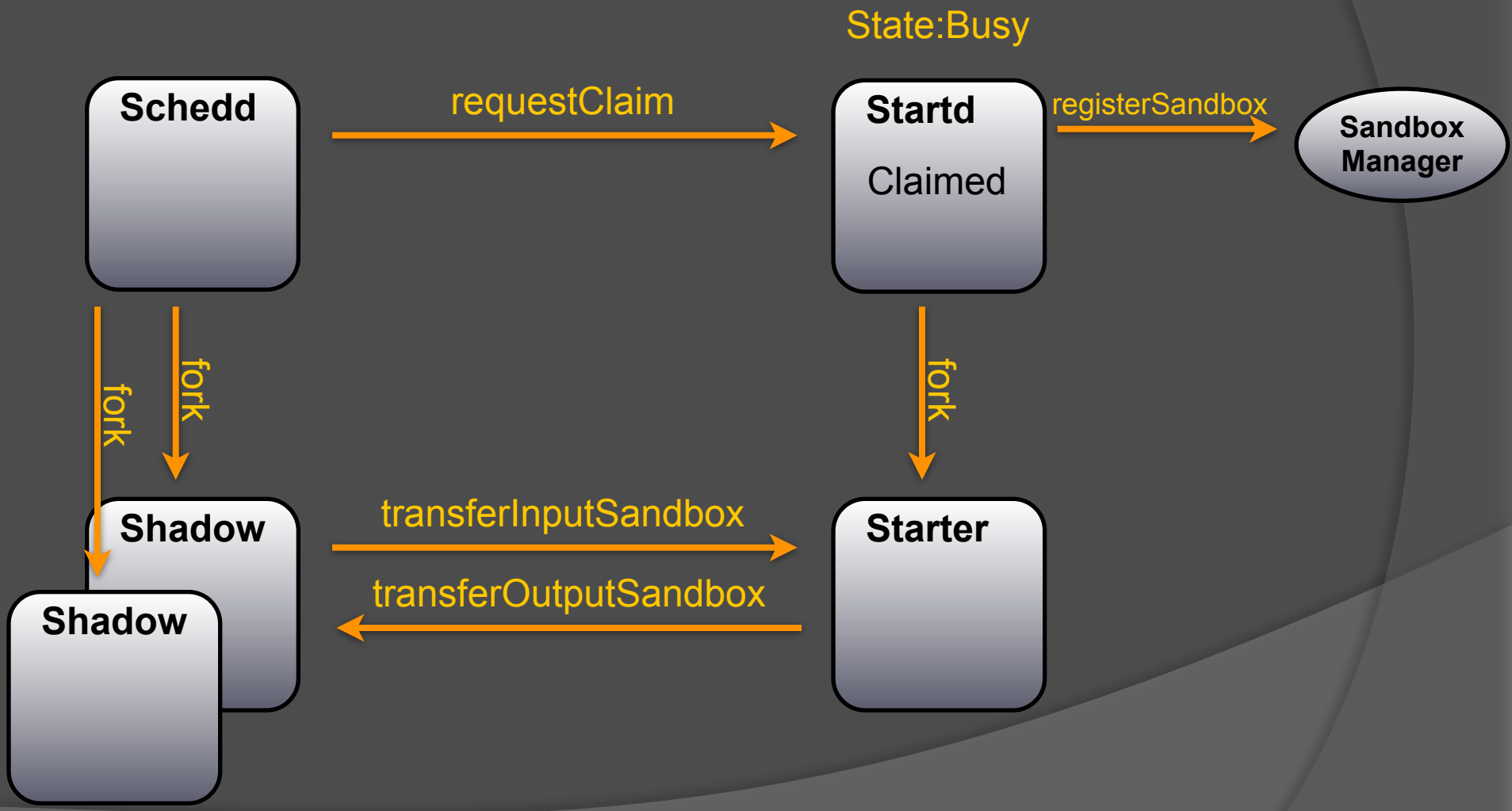

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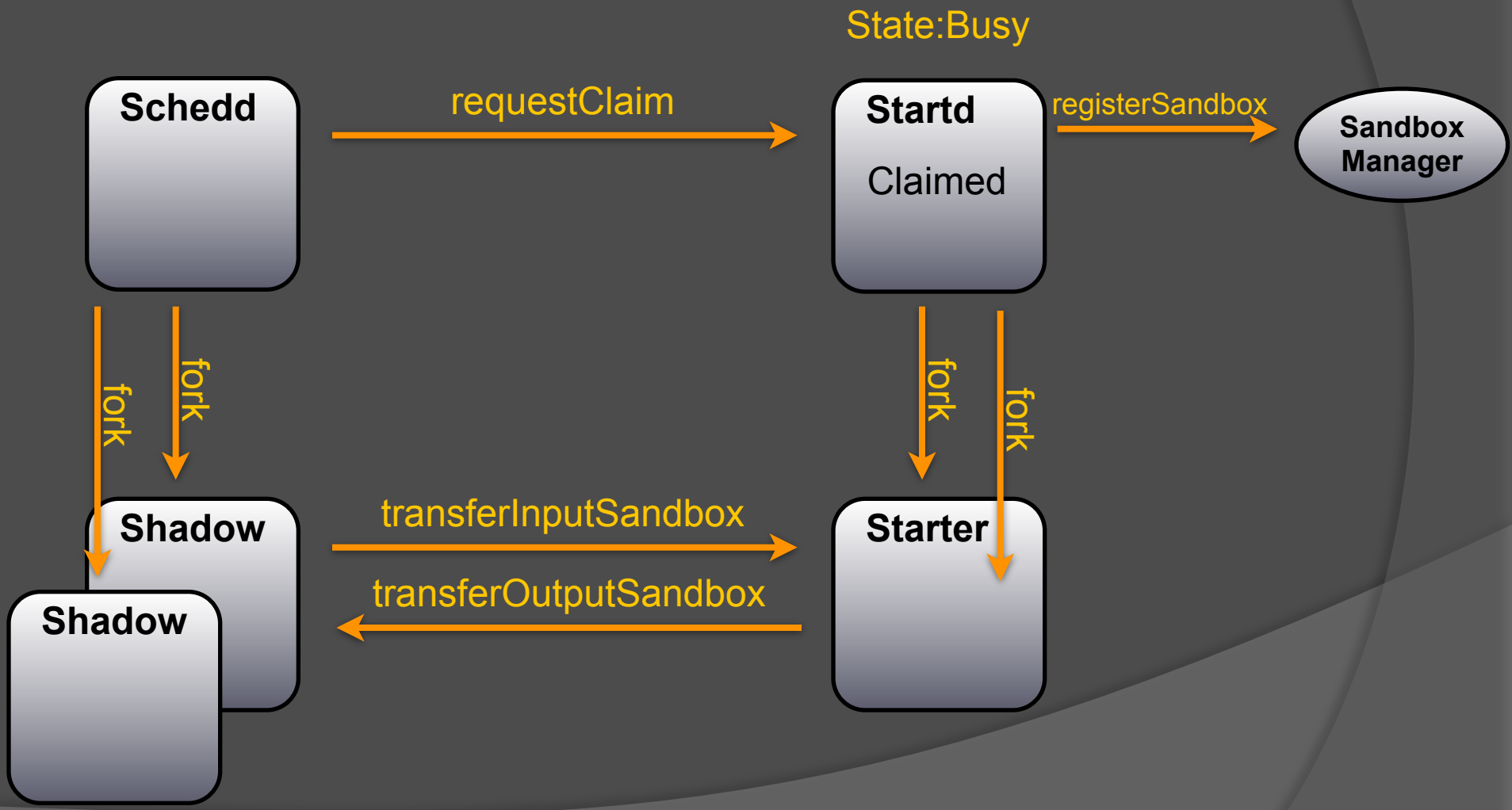

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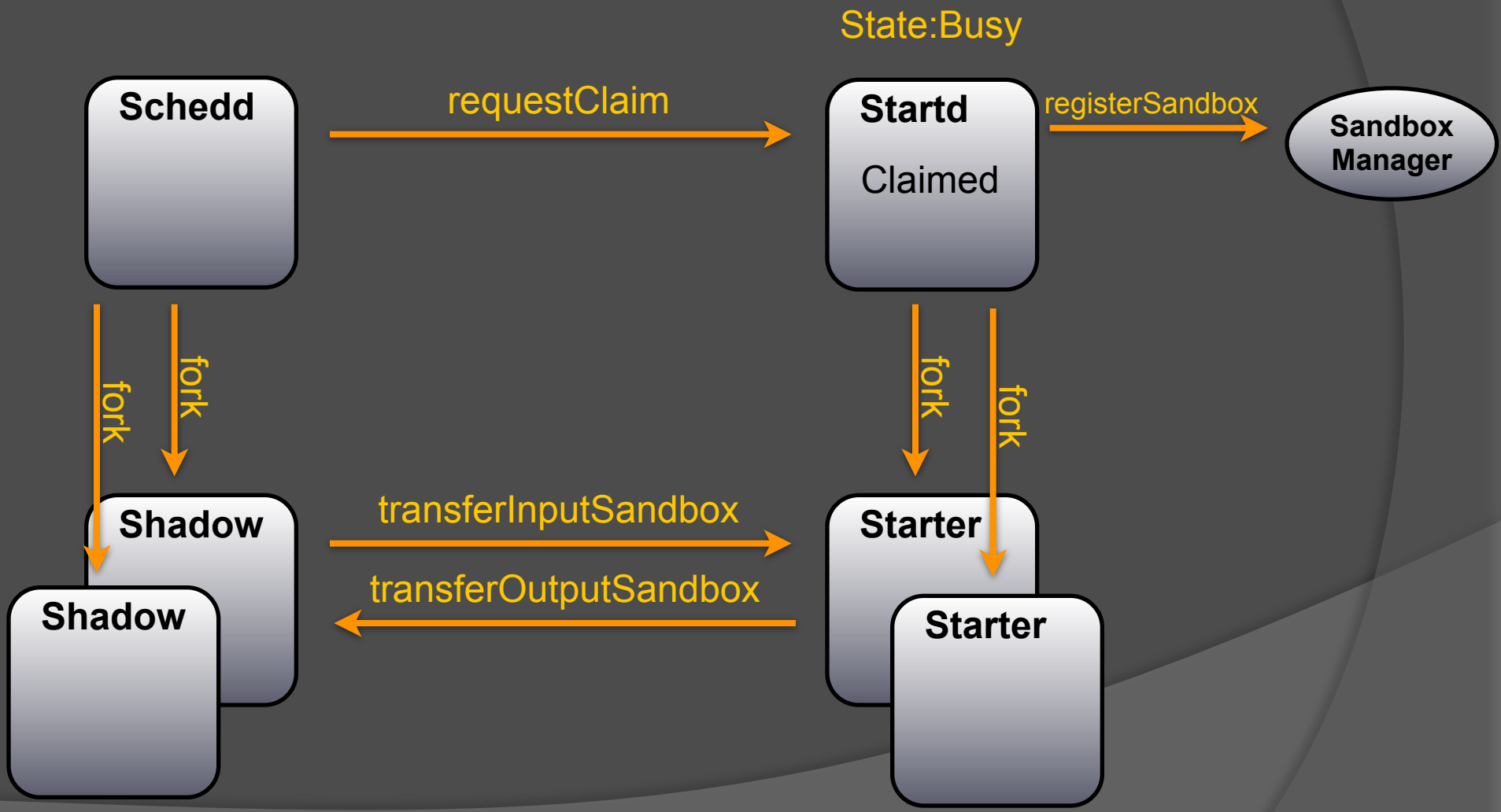

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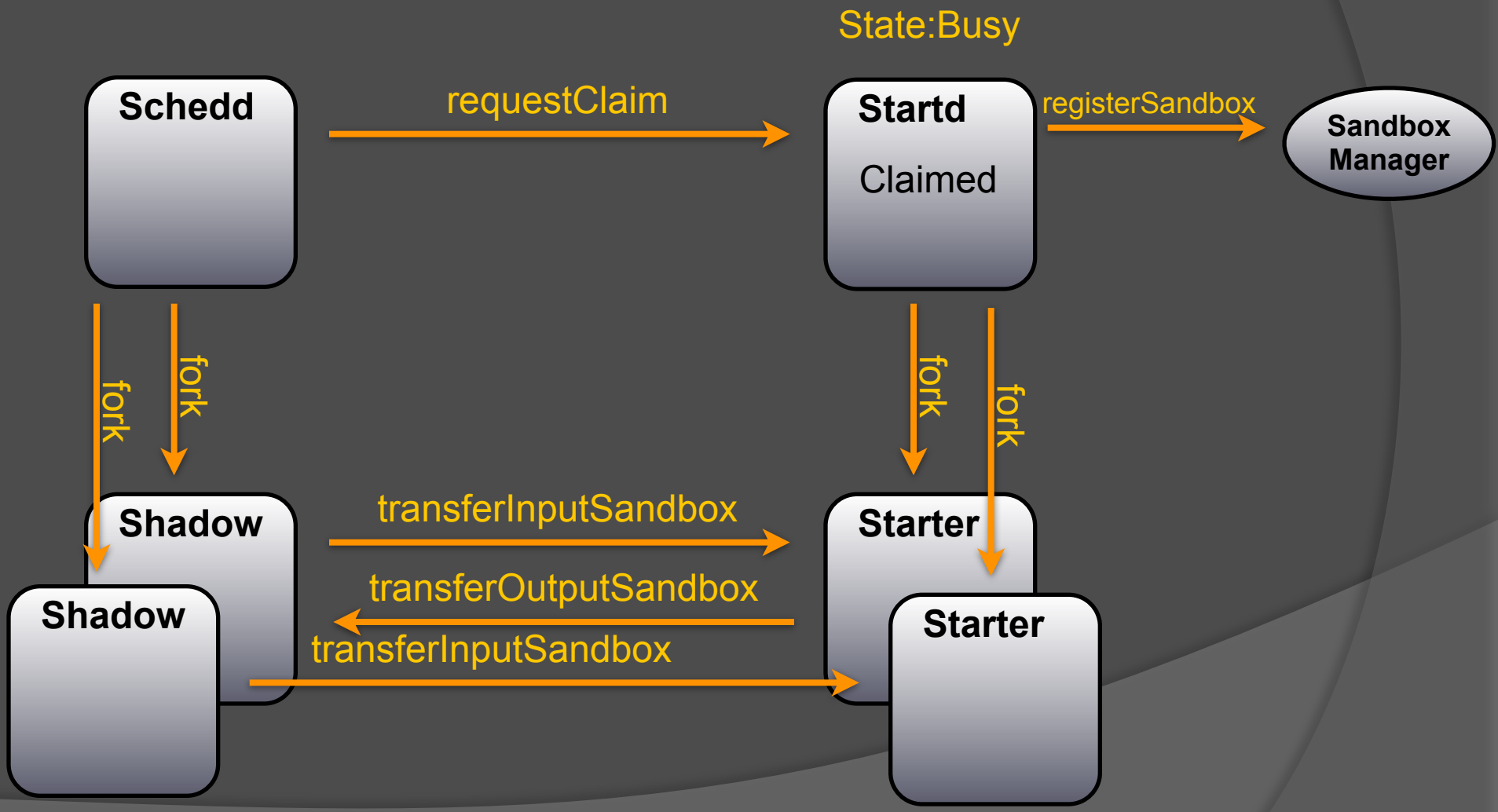

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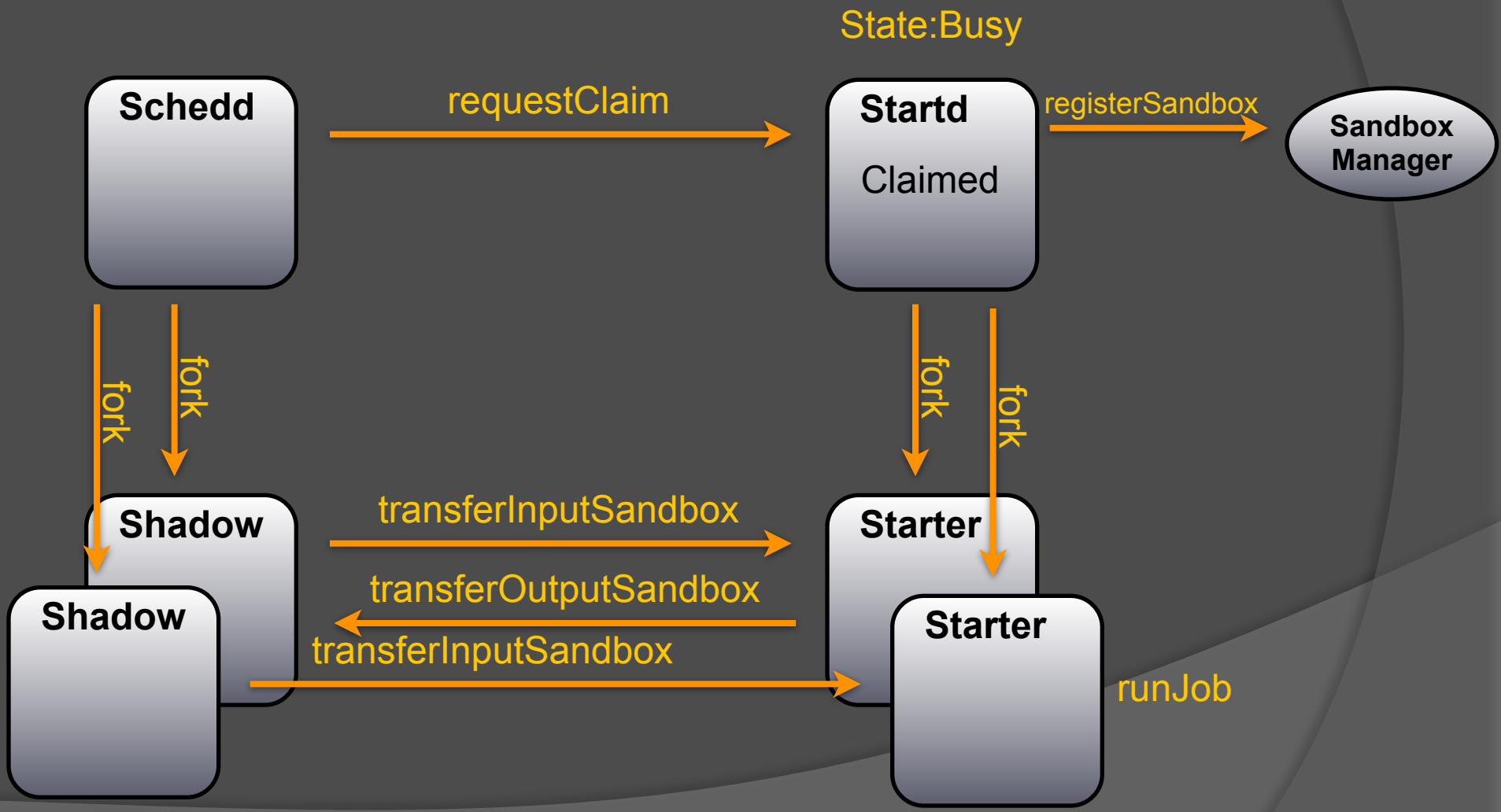

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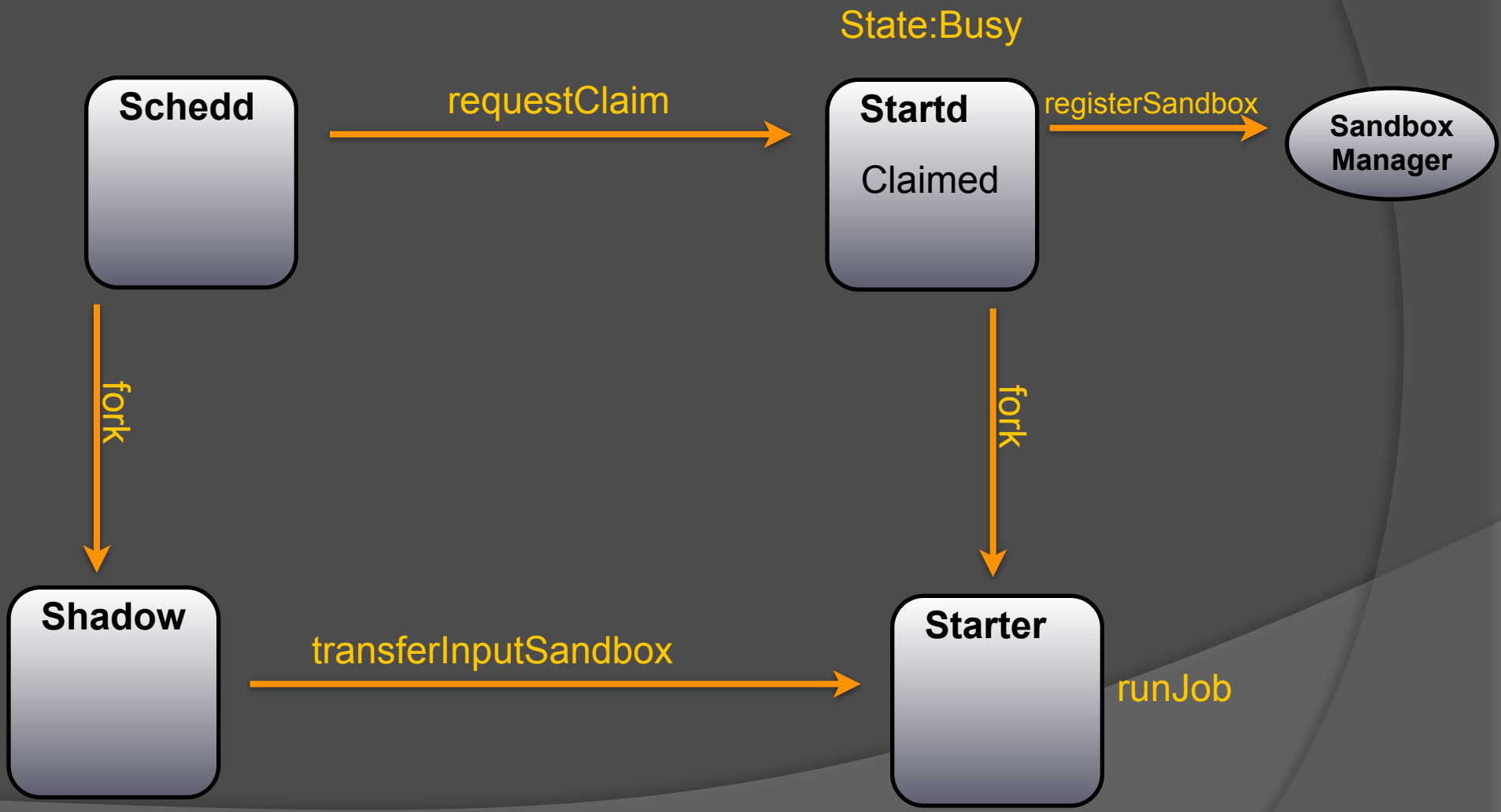
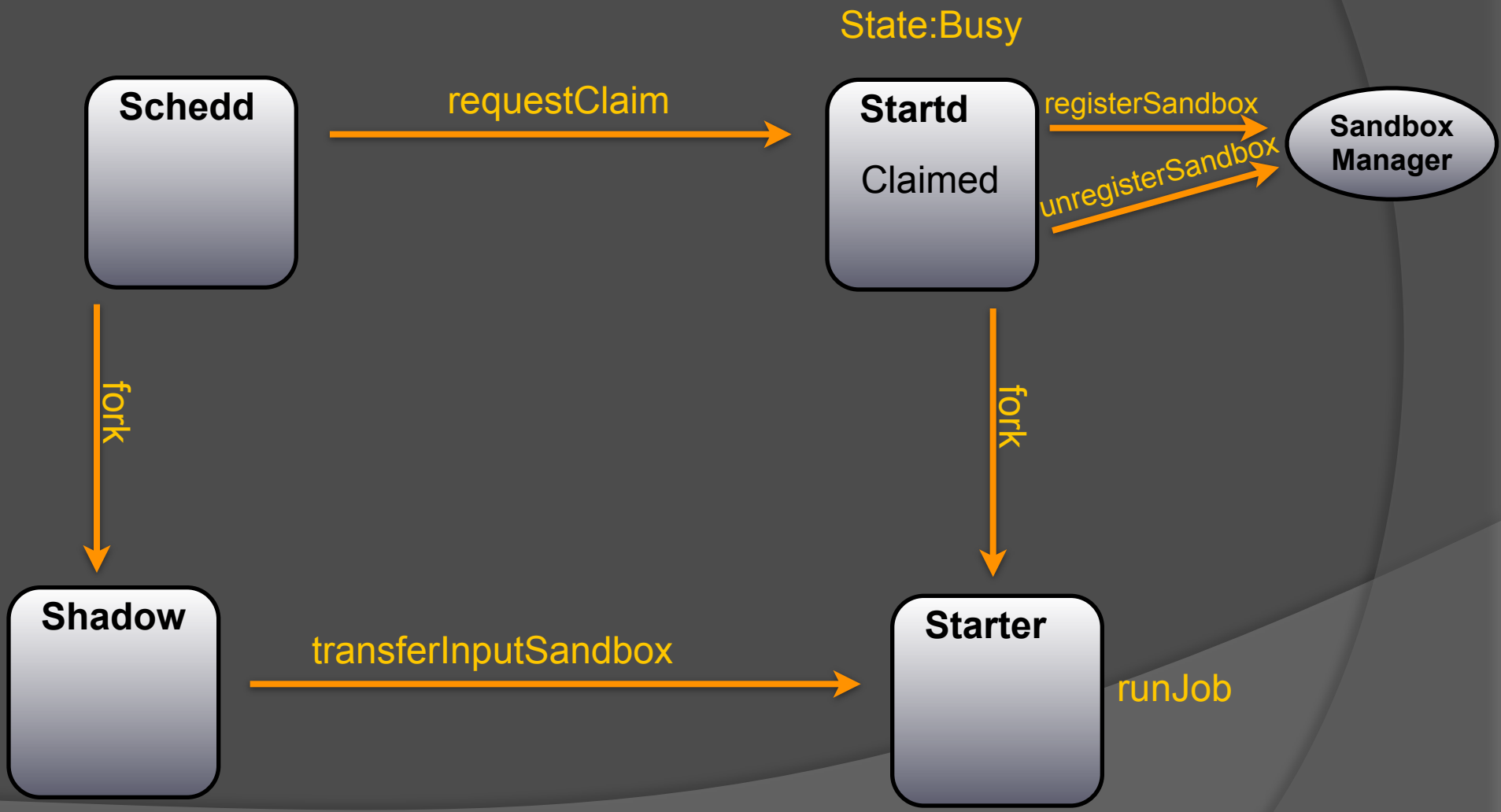


Asynchronous sandbox transfer



Asynchronous sandbox transfer

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Asynchronous sandbox transfer

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Asynchronous sandbox transfer

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- Job needs to change state once execution is completed (“`transferring_output`”)
- *Startd* needs to be able to accept a new job while previous job(s) are still transferring (if in same claim)
- *Schedd* needs to be able to forward next job in claim while previous job is in transfer mode

Asynchronous sandbox transfer

Changes in Condor: Requirements (2)

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Asynchronous sandbox transfer

Changes in Condor: Requirements (2)

- Failure tolerance: System needs to deal with failure on submit and execute side
- File transfer failures need to be detected and accordingly handled: Do we rerun the whole job? How often do we retry? How long do we keep the output data around?
- Another open question: How many file transfers should run concurrently?

Asynchronous sandbox transfer

Changes in Condor: where are we at?

Asynchronous sandbox transfer

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Asynchronous sandbox transfer

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Asynchronous sandbox transfer

Changes in Condor: where are we at?

- Job state is changed to `transferring_output` once execution completed
- *Startd* changes state to `claimed/idle` once job execution completed and is therefore able to accept next job in claim
- *Startd* maintains a sandbox manager object

Asynchronous sandbox transfer

Prototype assumptions

Asynchronous sandbox transfer

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- No failures

Asynchronous sandbox transfer

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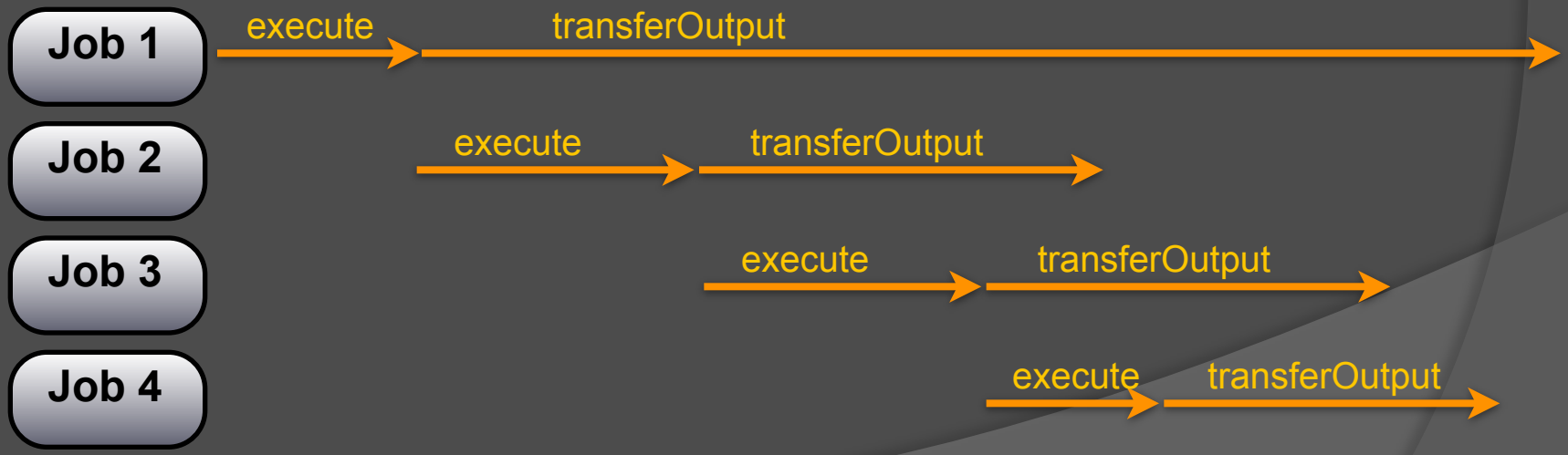

Asynchronous sandbox transfer

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Asynchronous sandbox transfer

Prototype limitations

- Not production-ready yet: *Schedd* does only know about one job per claim, others run “hidden”
- Therefore all jobs in the claim are killed once the “known” job terminates (claim is deactivated)
- Failure on either side leads to rerun (“hidden” jobs cannot reconnect to respective *Starters*)

Asynchronous sandbox transfer

Prototype performance results

Asynchronous sandbox transfer

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- Setup: Series of *n* identical jobs, execution time *t*, output transfer time *u*, total time *v* = *t*+*u*

Asynchronous sandbox transfer

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Asynchronous sandbox transfer

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Asynchronous sandbox transfer

Prototype performance results

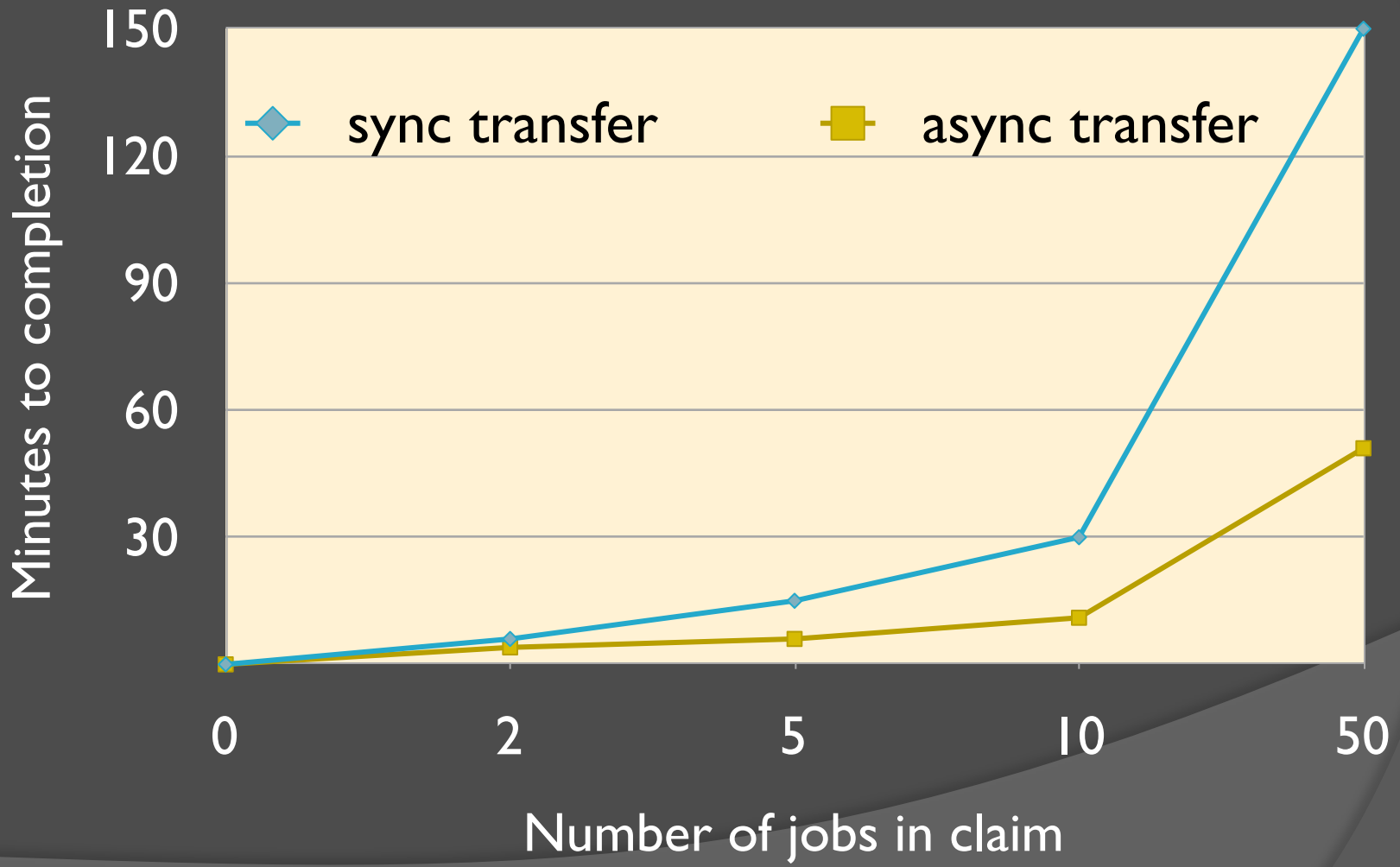
- Setup: Series of *n* identical jobs, execution time *t*, output transfer time *u*, total time *v* = *t*+*u*
- First job in series has a very long running output transfer time to cover rest of series (see limitations)
- No input data transfer
- Short running job, producing lots of output data (*u* = *2t*)

Asynchronous sandbox transfer

Prototype performance results

Asynchronous sandbox transfer

Prototype performance results



Asynchronous sandbox transfer

What needs to be done

- Needed: Concept of multiple activations per claim
- *Schedd* must maintain a list of current activations per claim (currently there is only one activation possible)
- *Startd* needs to be able to map a particular activation to a particular *Starter*

Asynchronous sandbox transfer

When will we be able to use it?

Asynchronous sandbox transfer

When will we be able to use it?

- Soon!

Asynchronous sandbox transfer

When will we be able to use it?

- Soon!
- Feature for 7.7.x development series!

Asynchronous sandbox transfer

What else?

Asynchronous sandbox transfer

What else?

- As usual: We like to make our users happy.

Asynchronous sandbox transfer

What else?

- As usual: We like to make our users happy.
- Tell us what you like about it and how you would like to use it.

Acknowledgments

- The work is being done as a part of the CEDPS project
- This work is an ongoing collaboration between the Computing Division, Fermilab and the Condor team at University of Wisconsin-Madison
- The GlideinWMS project was developed and is supported by Fermilab Computing Division and the CMS Experiment
- The Condor project is developed and supported by Condor Team at University of Wisconsin at Madison
- Fermilab is operated by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the United States Department of Energy.
- The Open Science Grid (OSG) collaborates with CEDPS for solutions on data movement and stage-out