State Machines

Tobias Nyholm

What?

a way of thinking

Why state machines?

- Separates business logic from your models
- Makes the code more:
  - Reusable
  - Maintainable
  - Readable

Tobias Nyholm

- Full stack unicorn on Happyr.com
- Open source
- Sound of Symfony podcast
- Open source
- Certified Symfony developer
- Open source

So how?

Graph theory

Historic and Estimated Worldwide Population Growth by Region

Source: Wikipedia.org

Billions: 10, 7.5, 5, 2.5, 0

Years: 1750, 1800, 1850, 1900, 1950, 1999, 2050

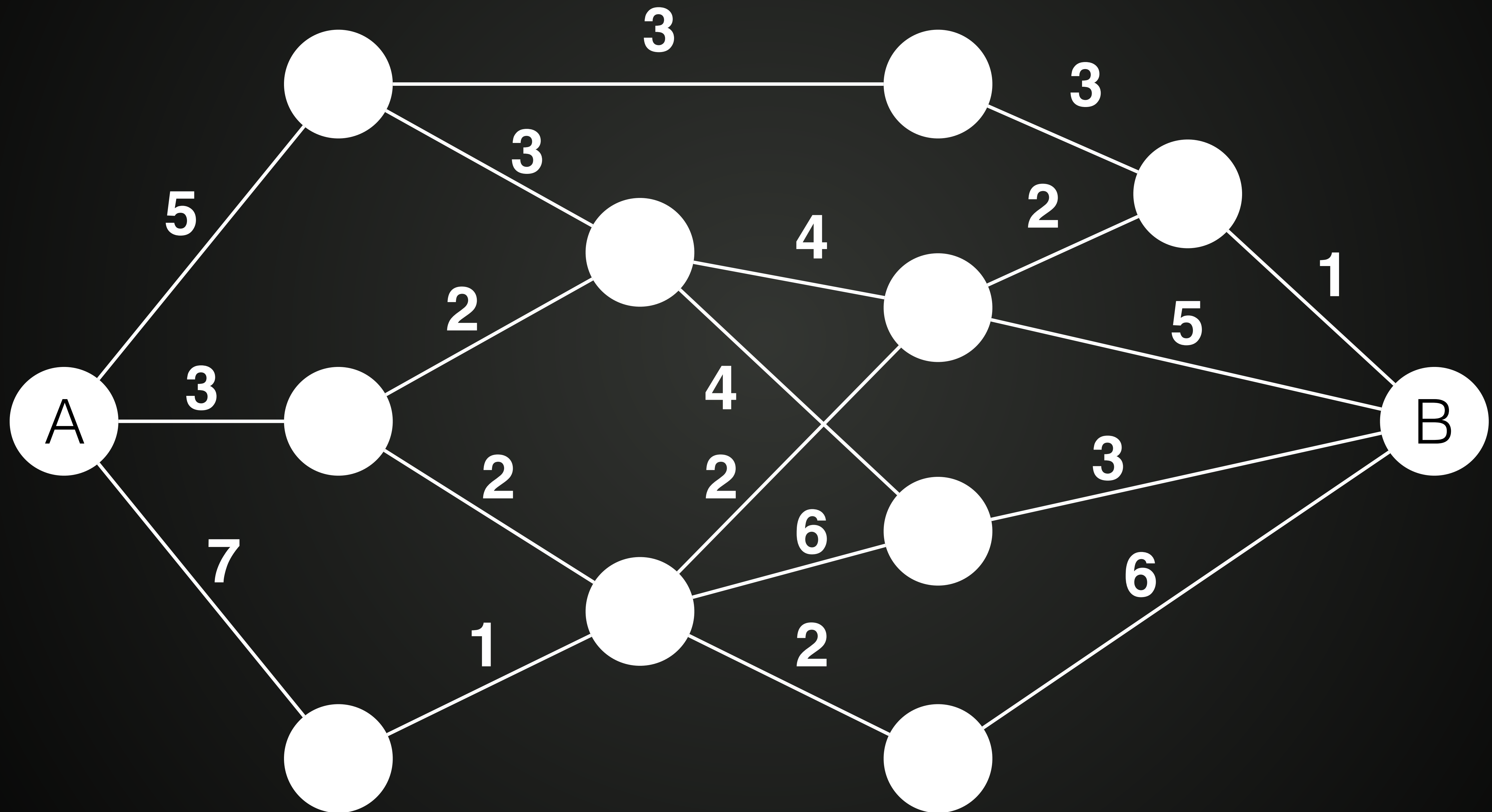
Legend: Asia, Africa, Europe, America, Oceania

Highcharts.com

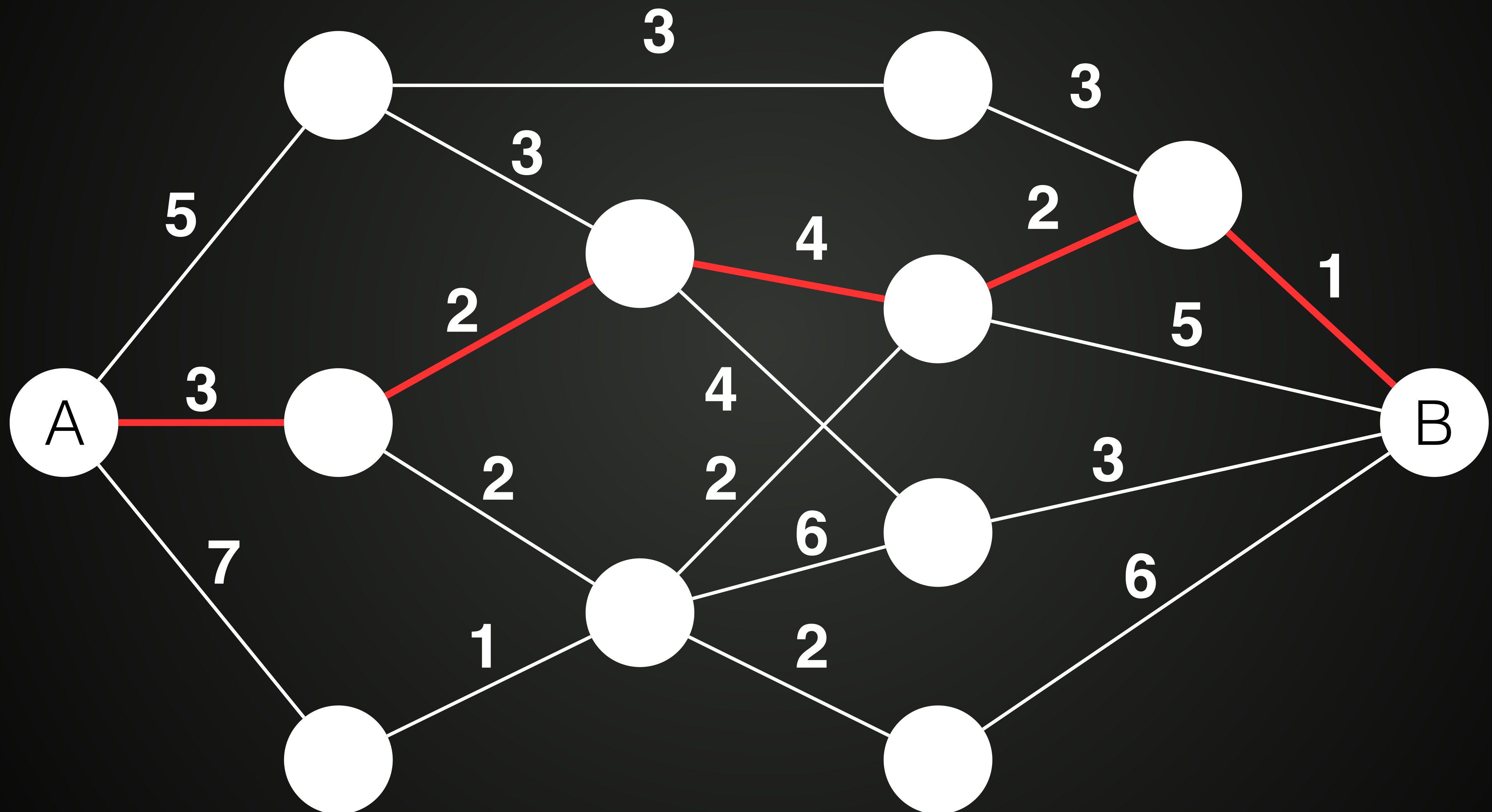
Highcharts.com

Graph theory

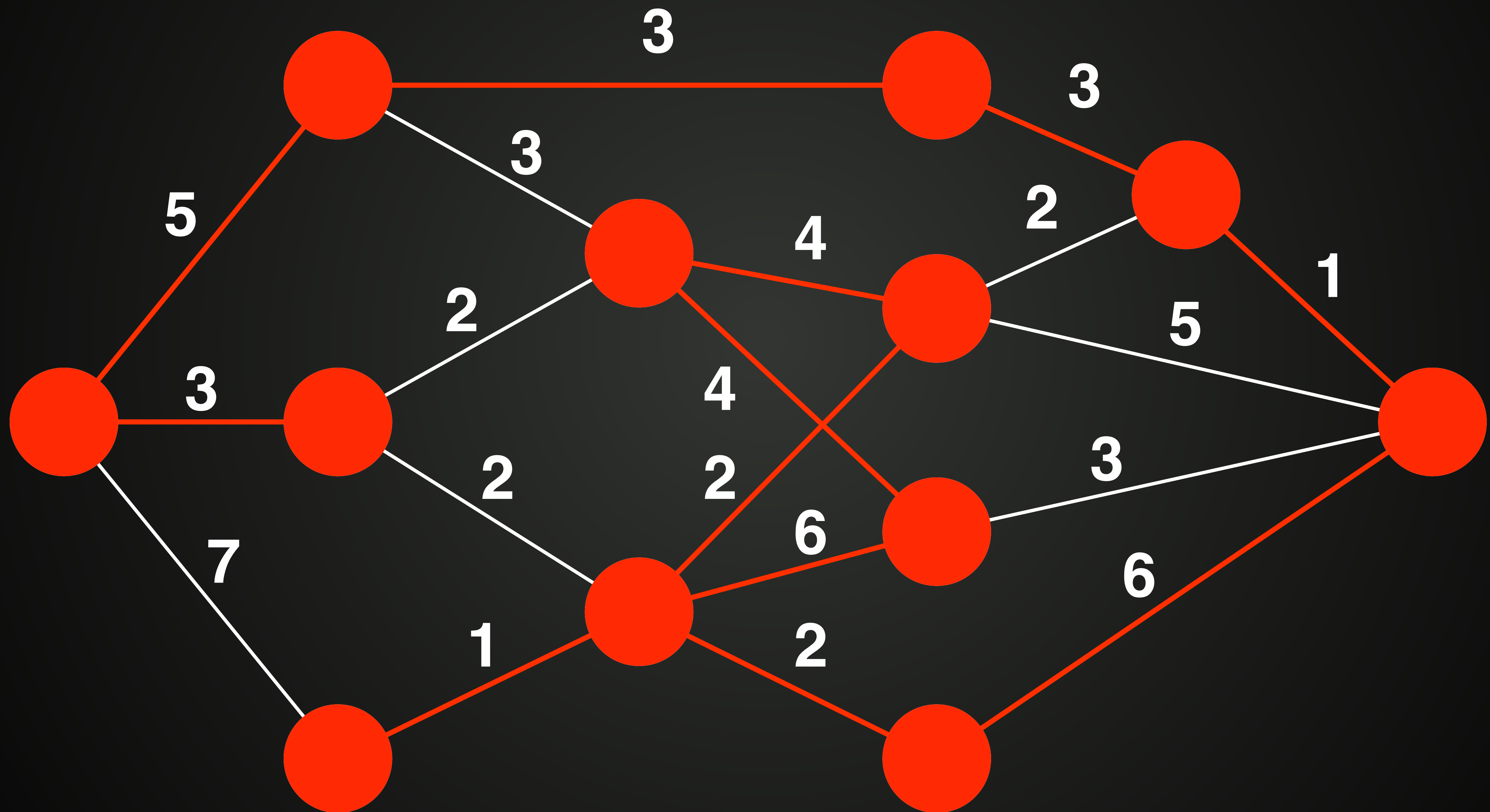
Graph theory



Graph theory



Graph theory



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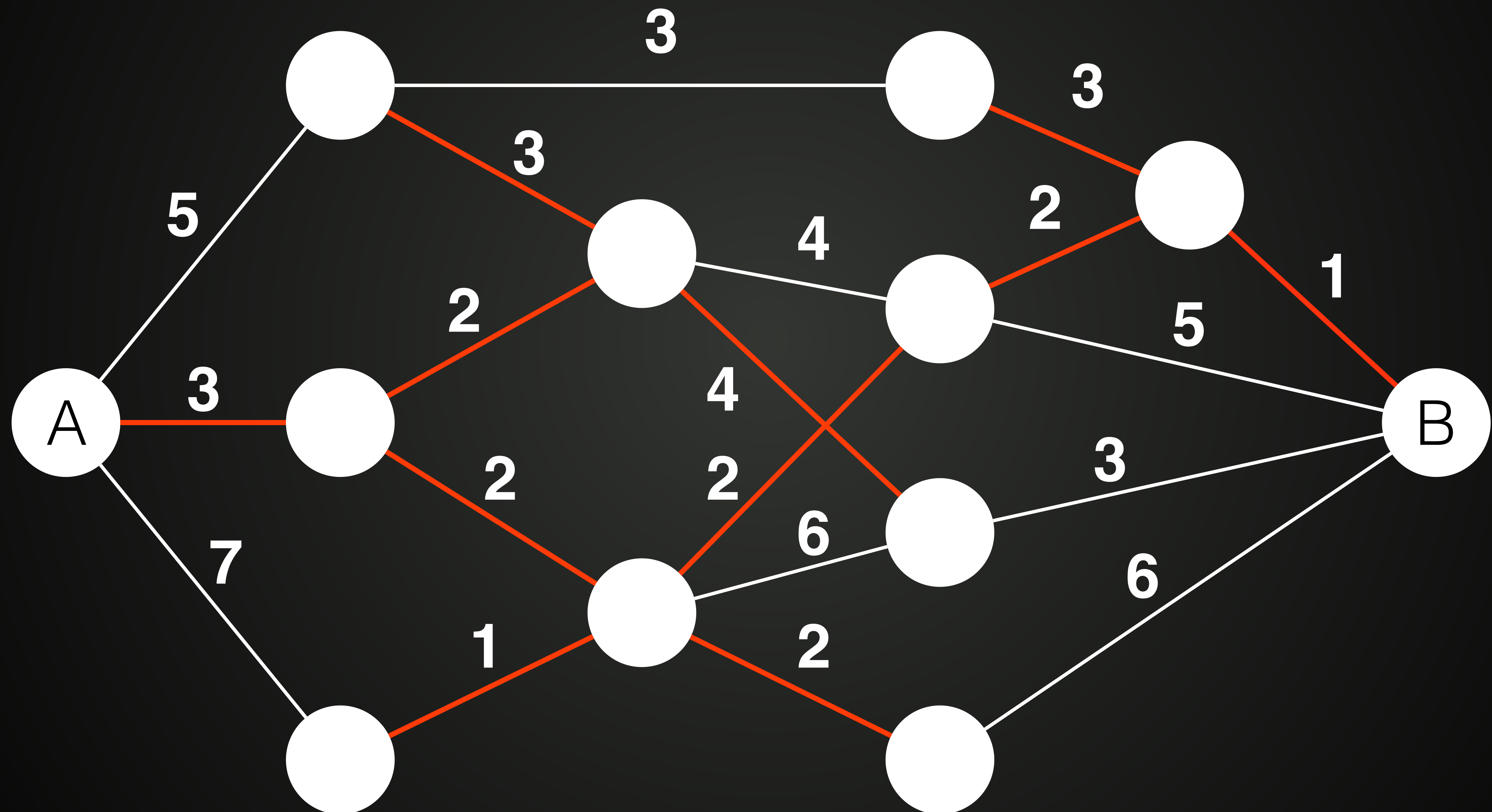
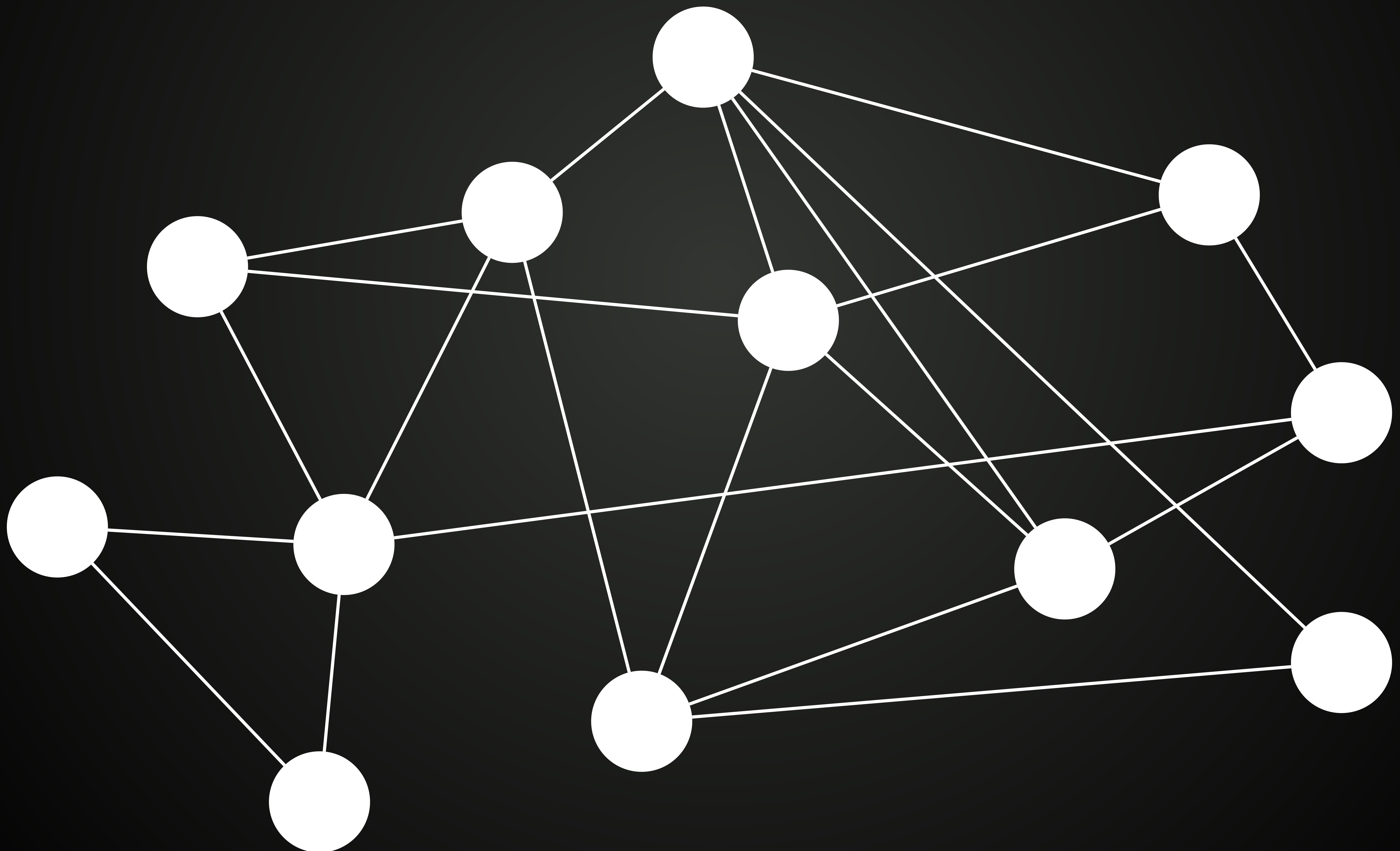
Graph theory

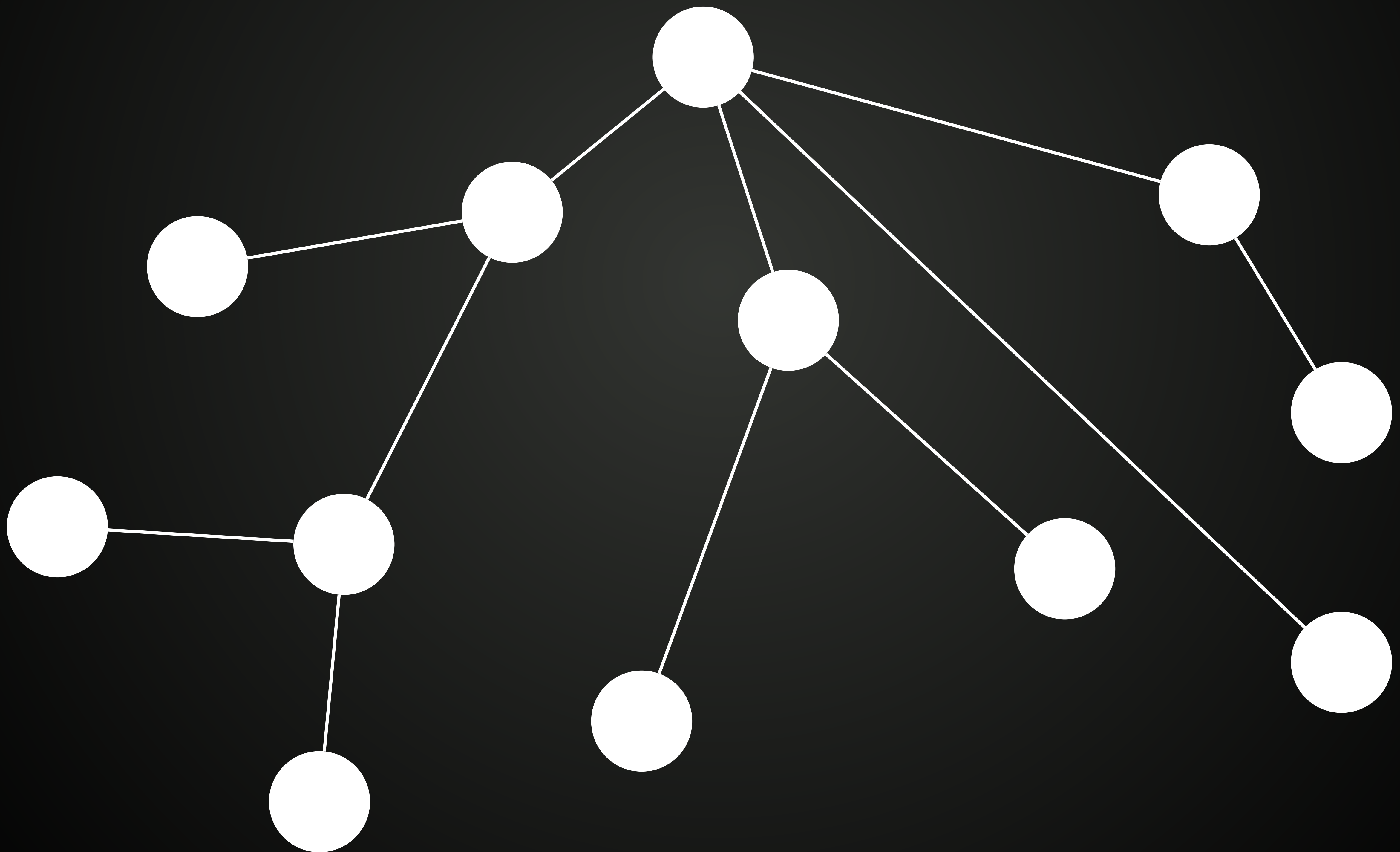


Theory

Graph theory



Graph theory



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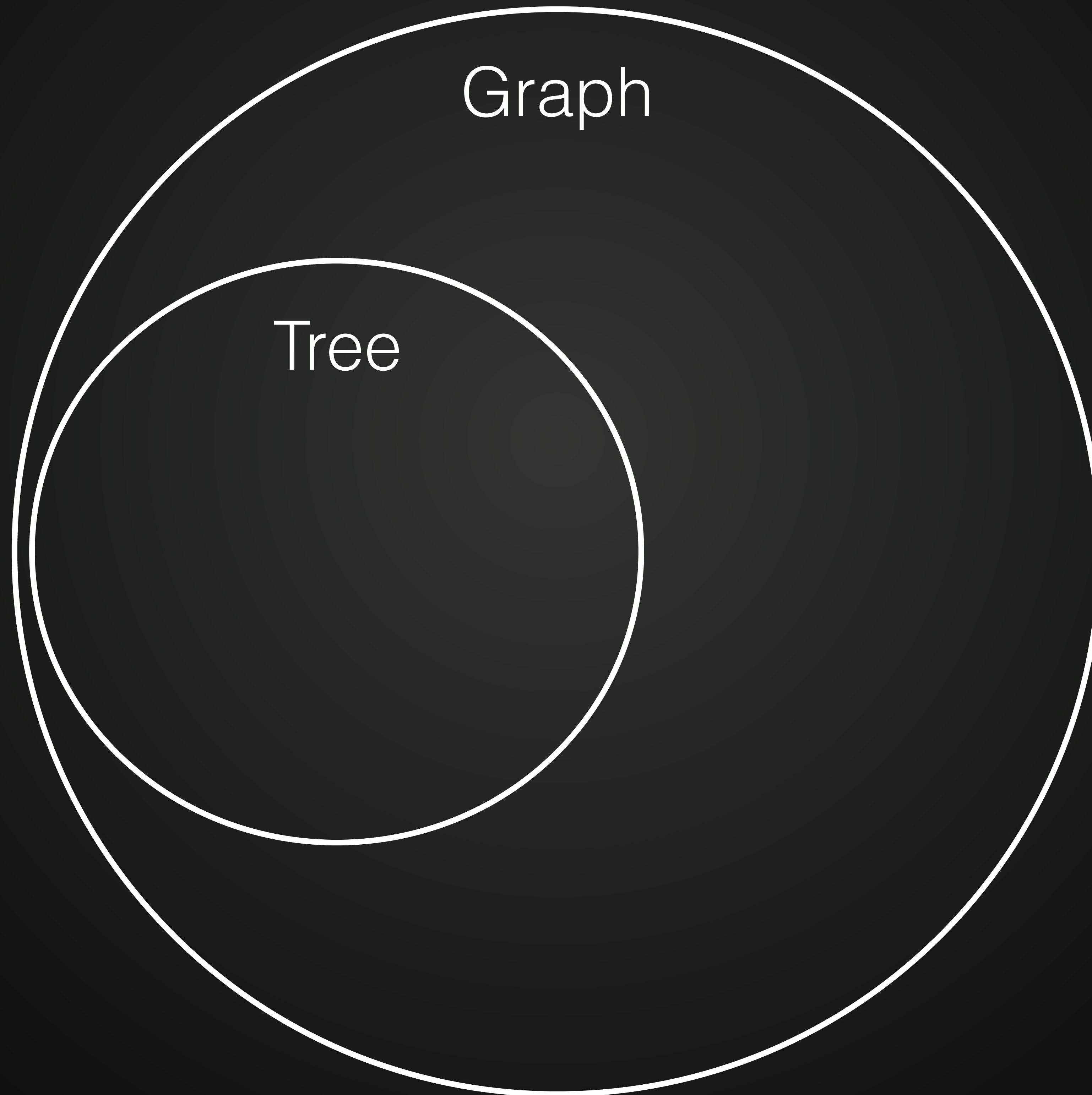
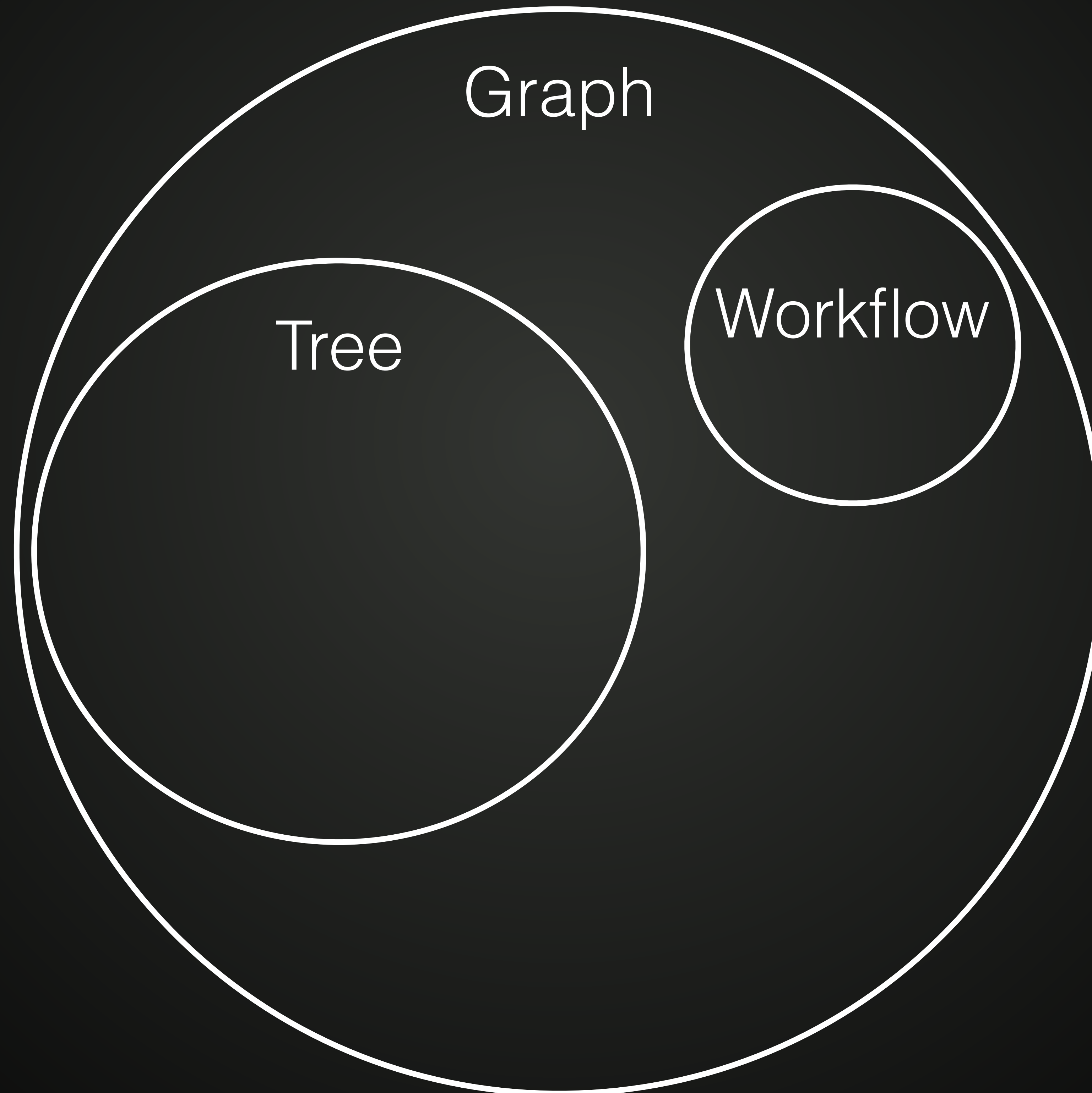
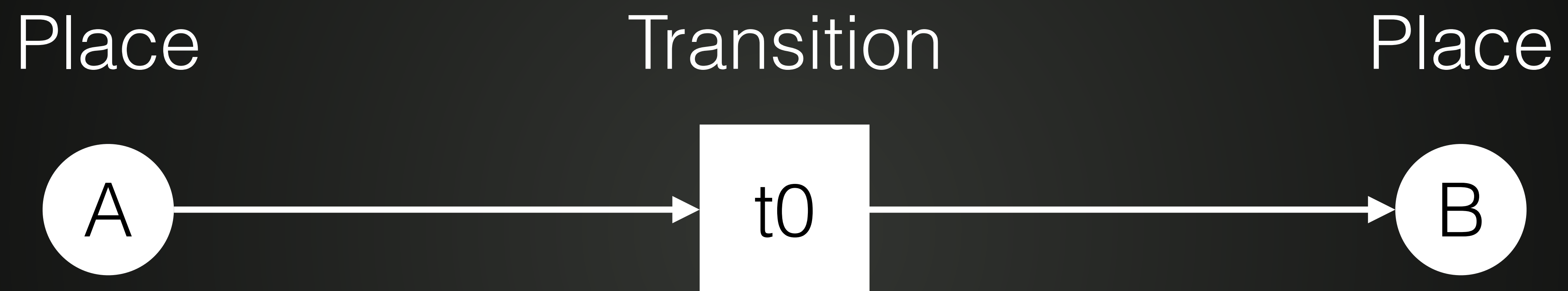
Theory



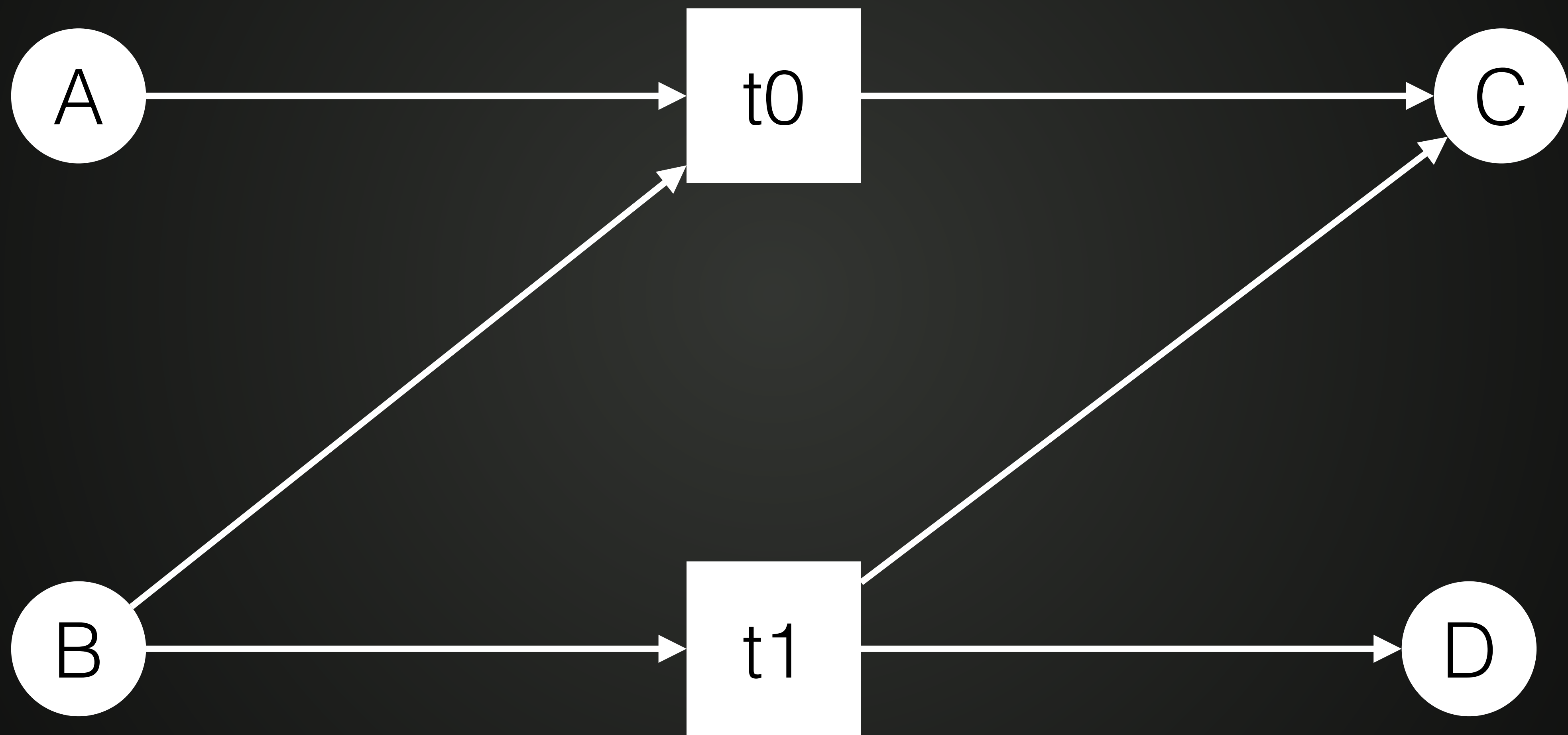
Theory



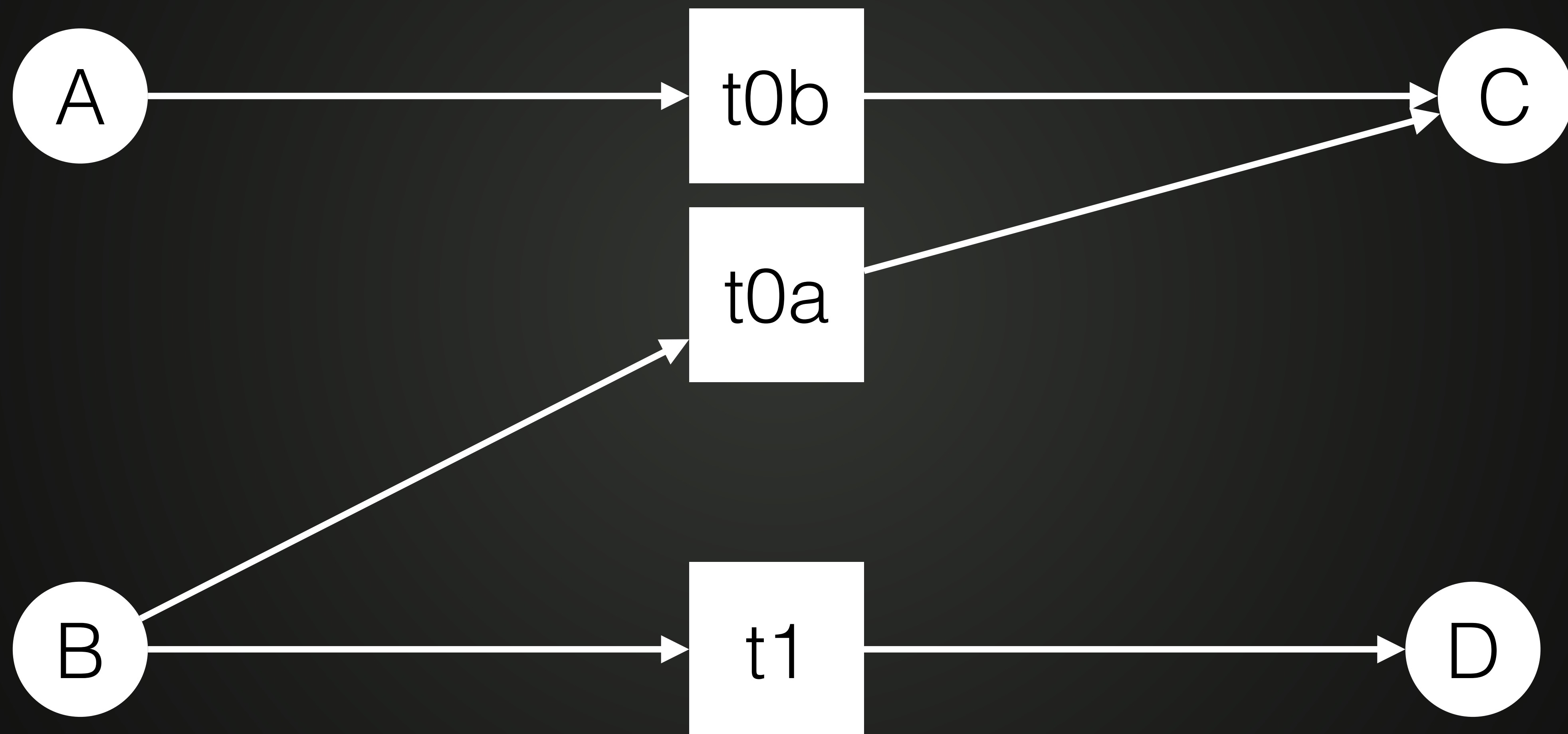
Workflow



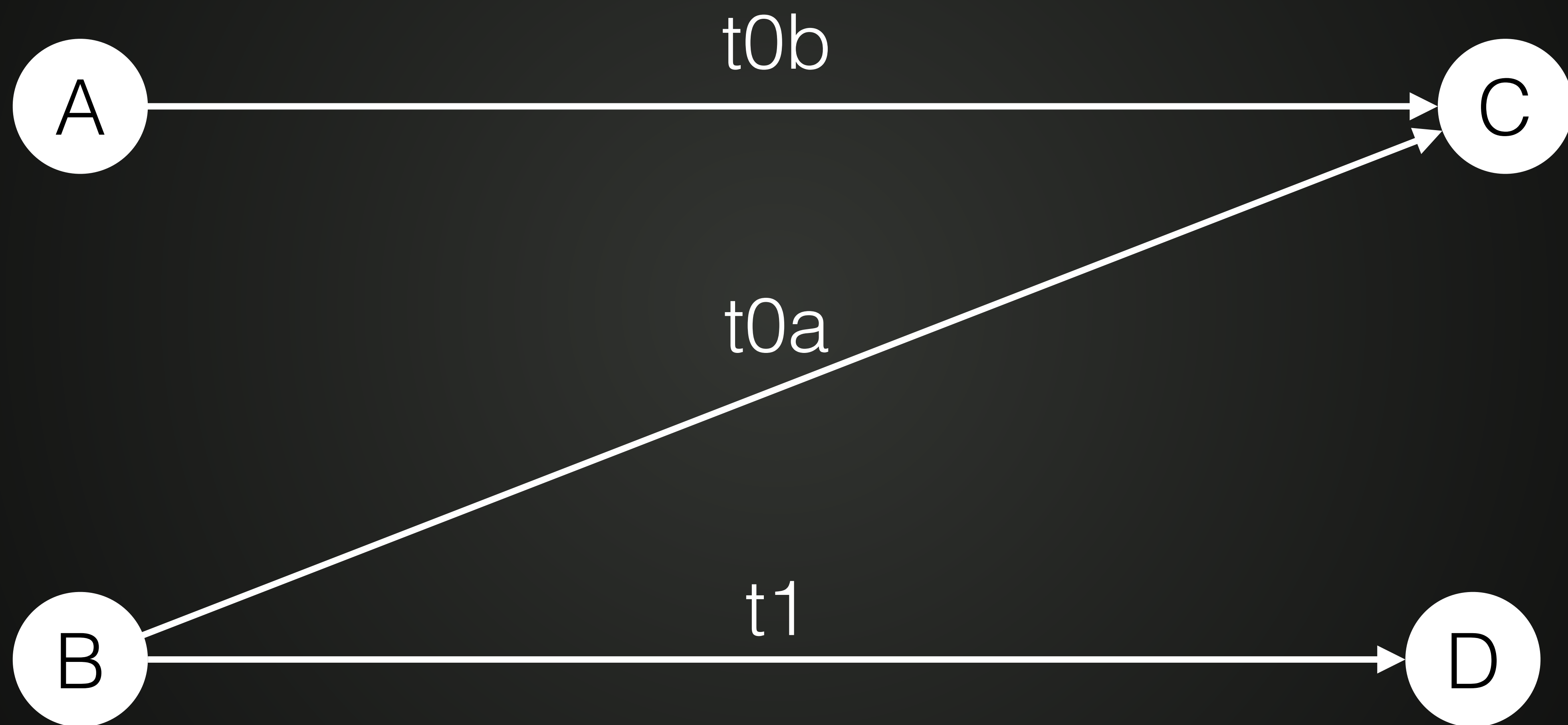
Workflow



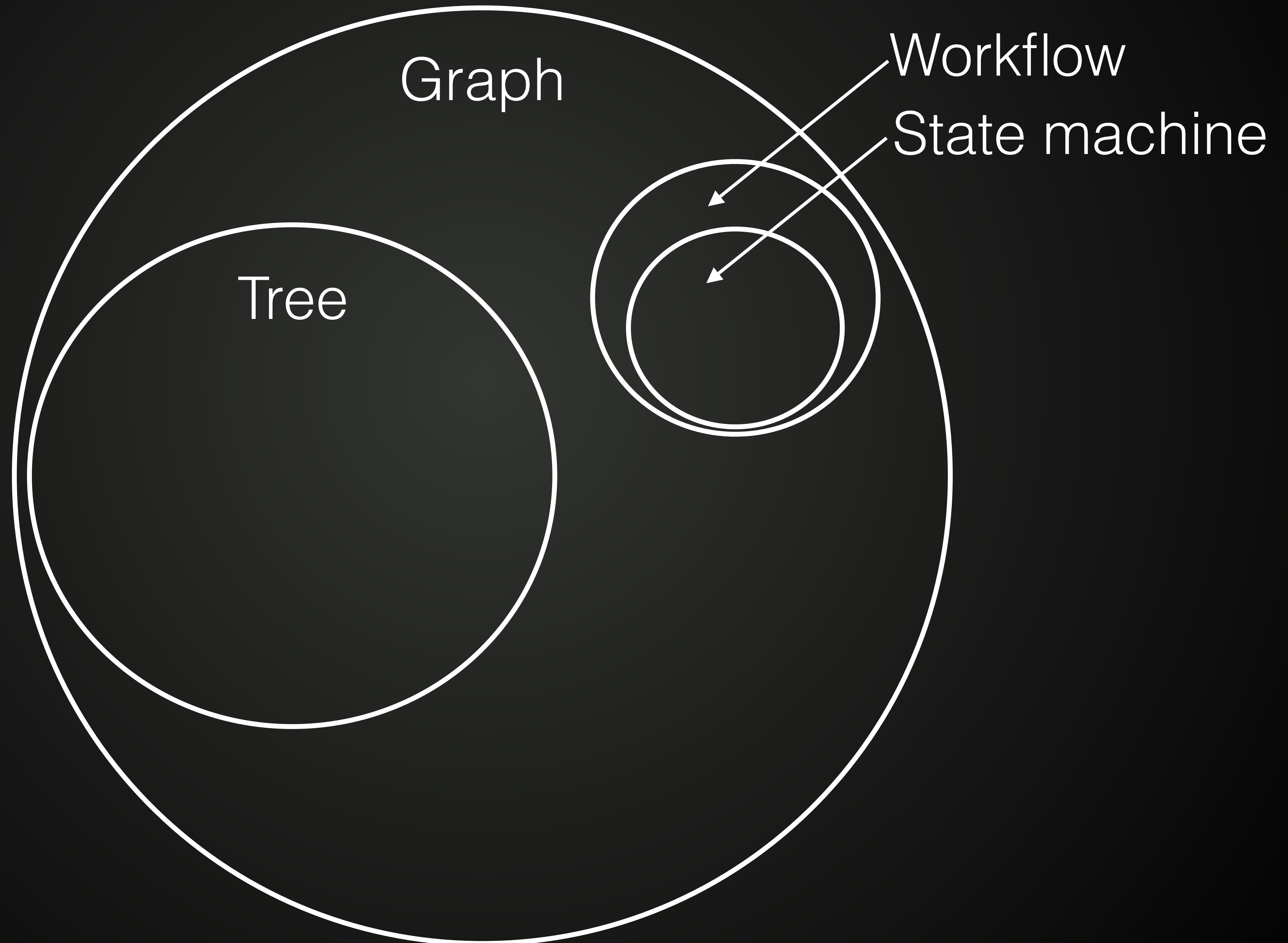
State Machine



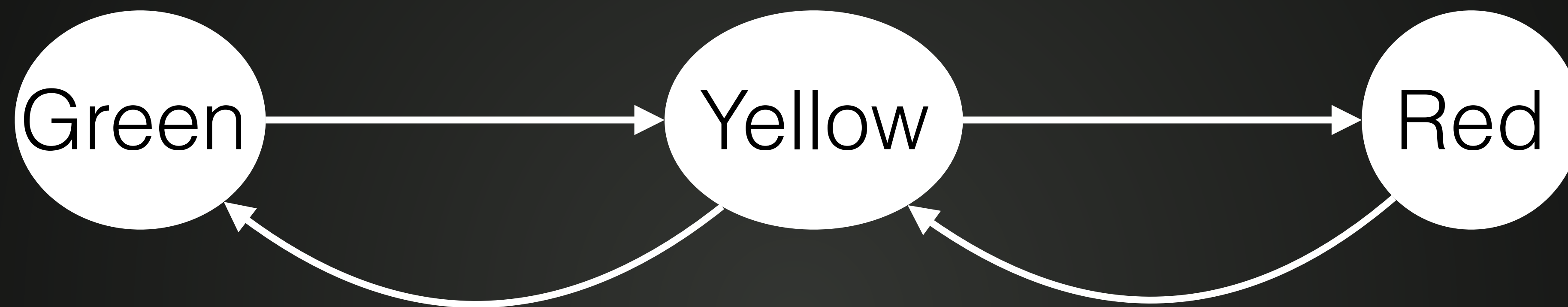
State Machine



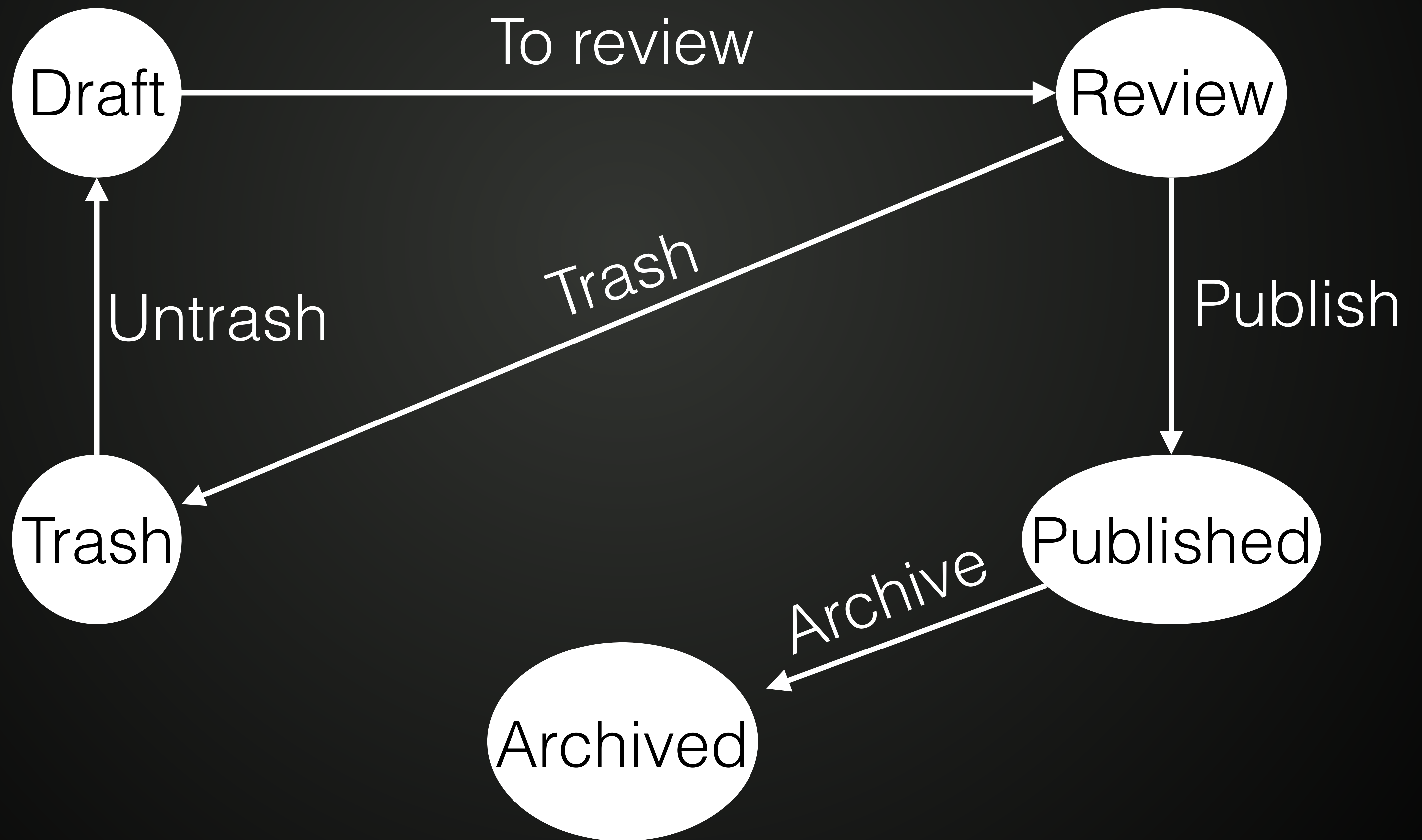
Theory



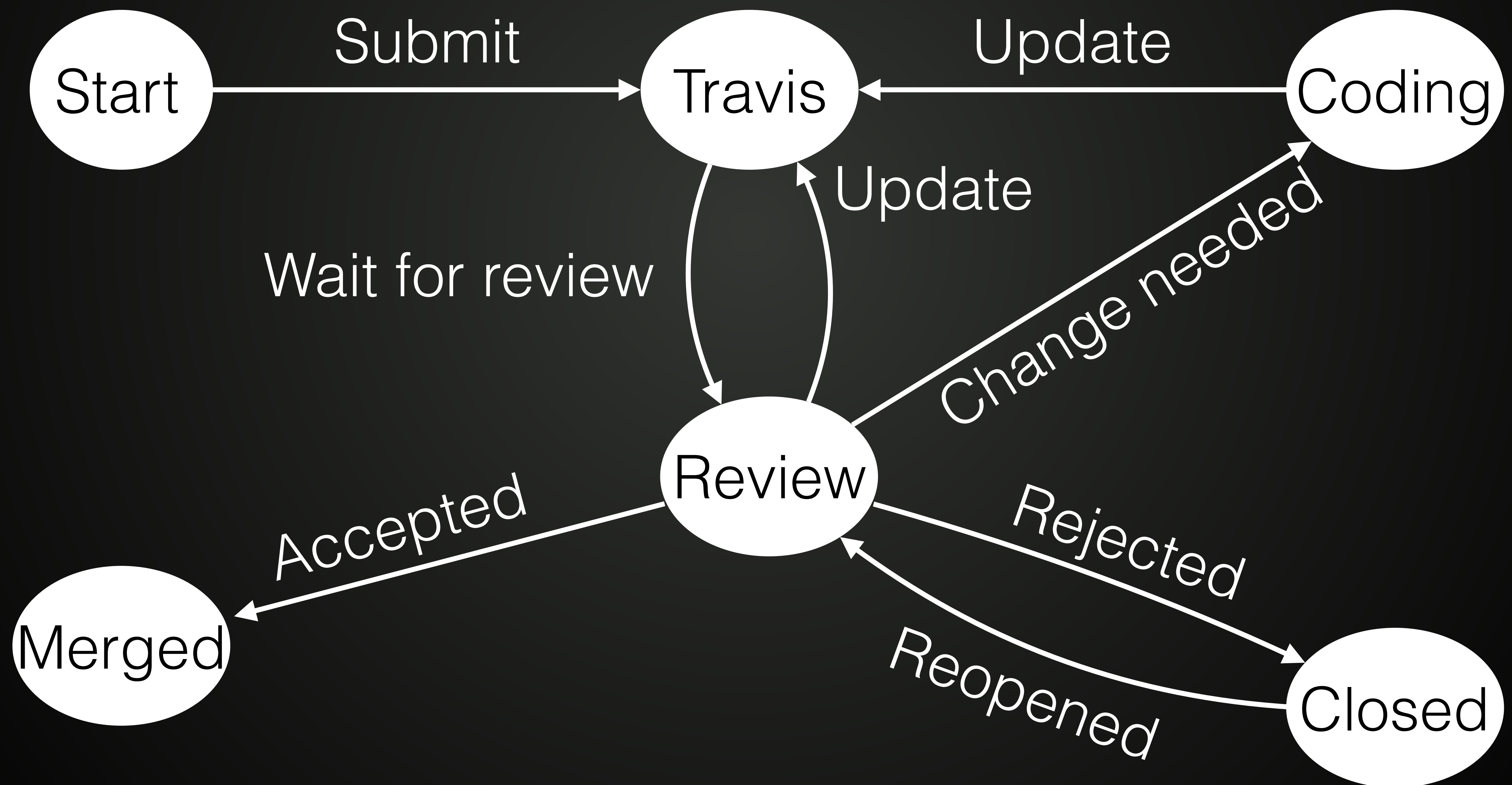
Traffic Light



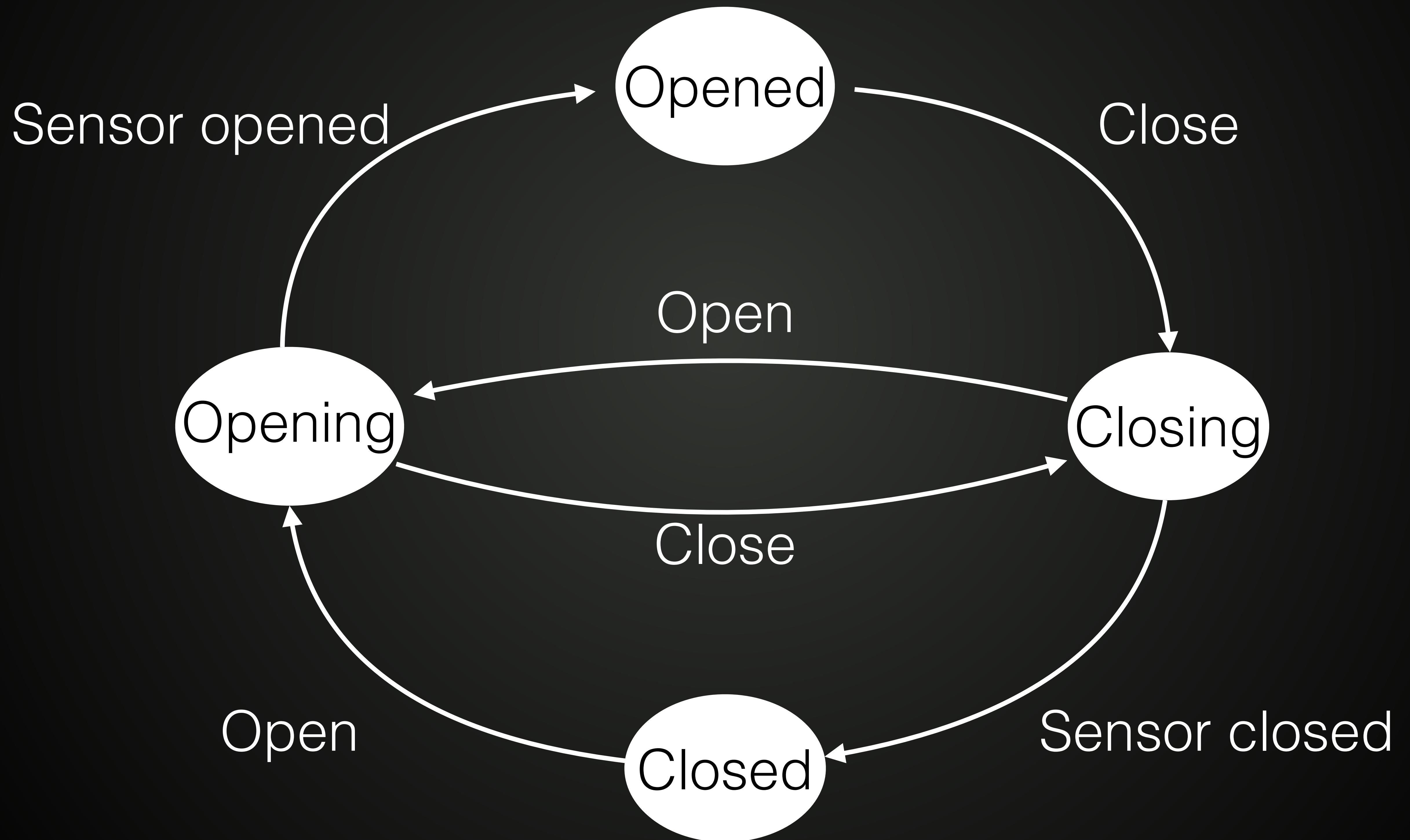
Job advert



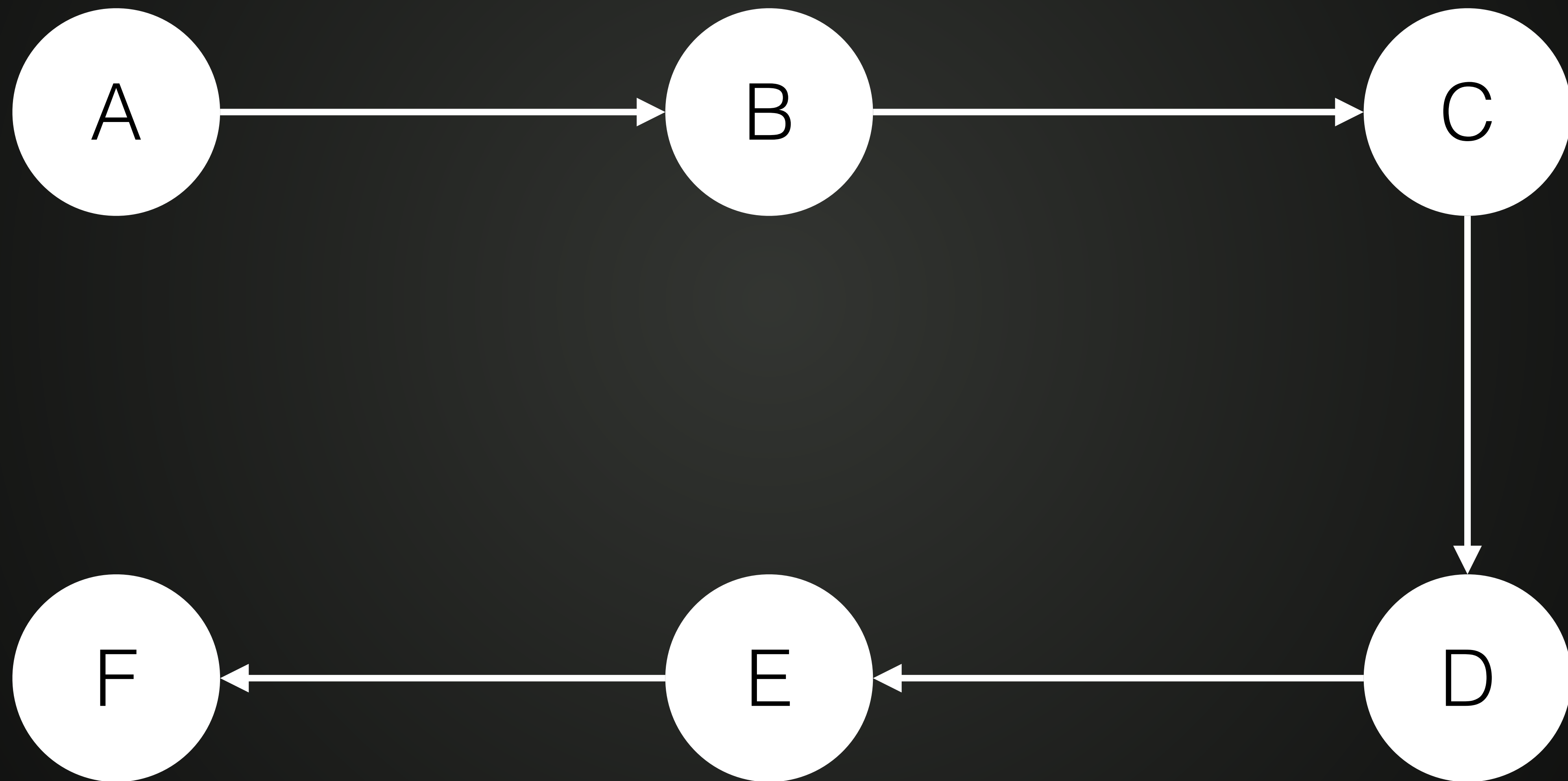
Pull Request



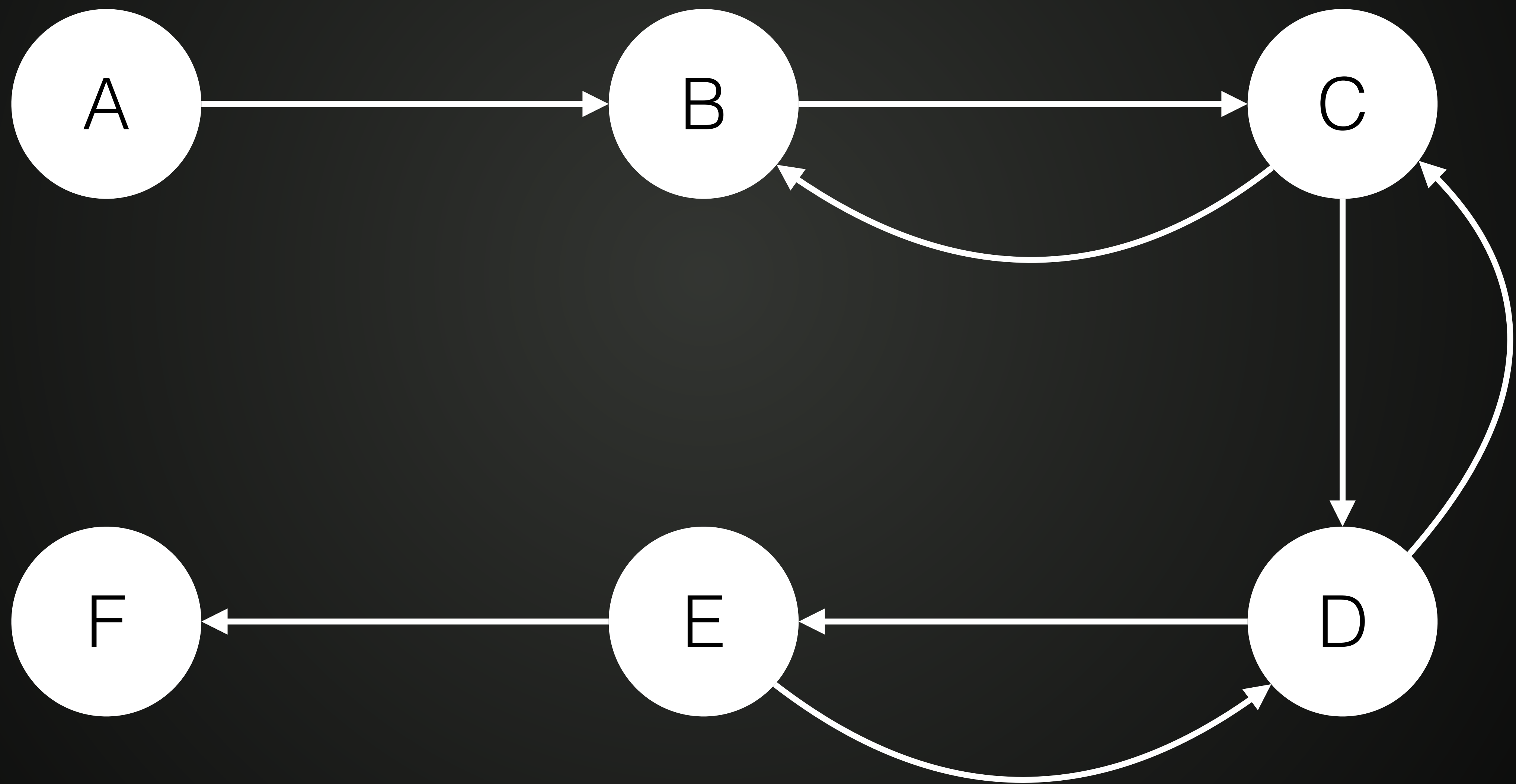
Elevator doors



Multi step form



Multi step form

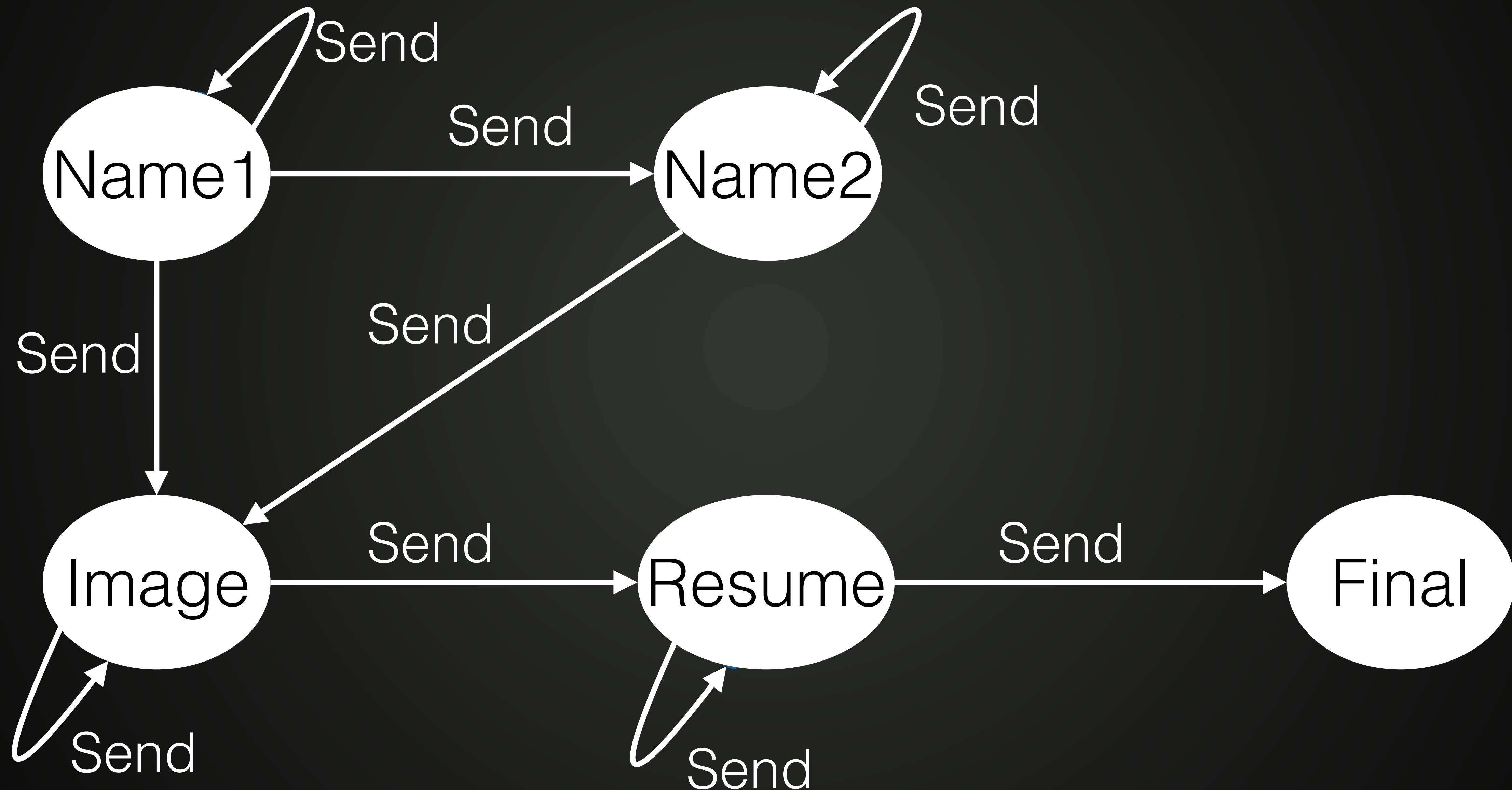


Two Implementations

State Pattern

Moore

Complete Profile Reminder



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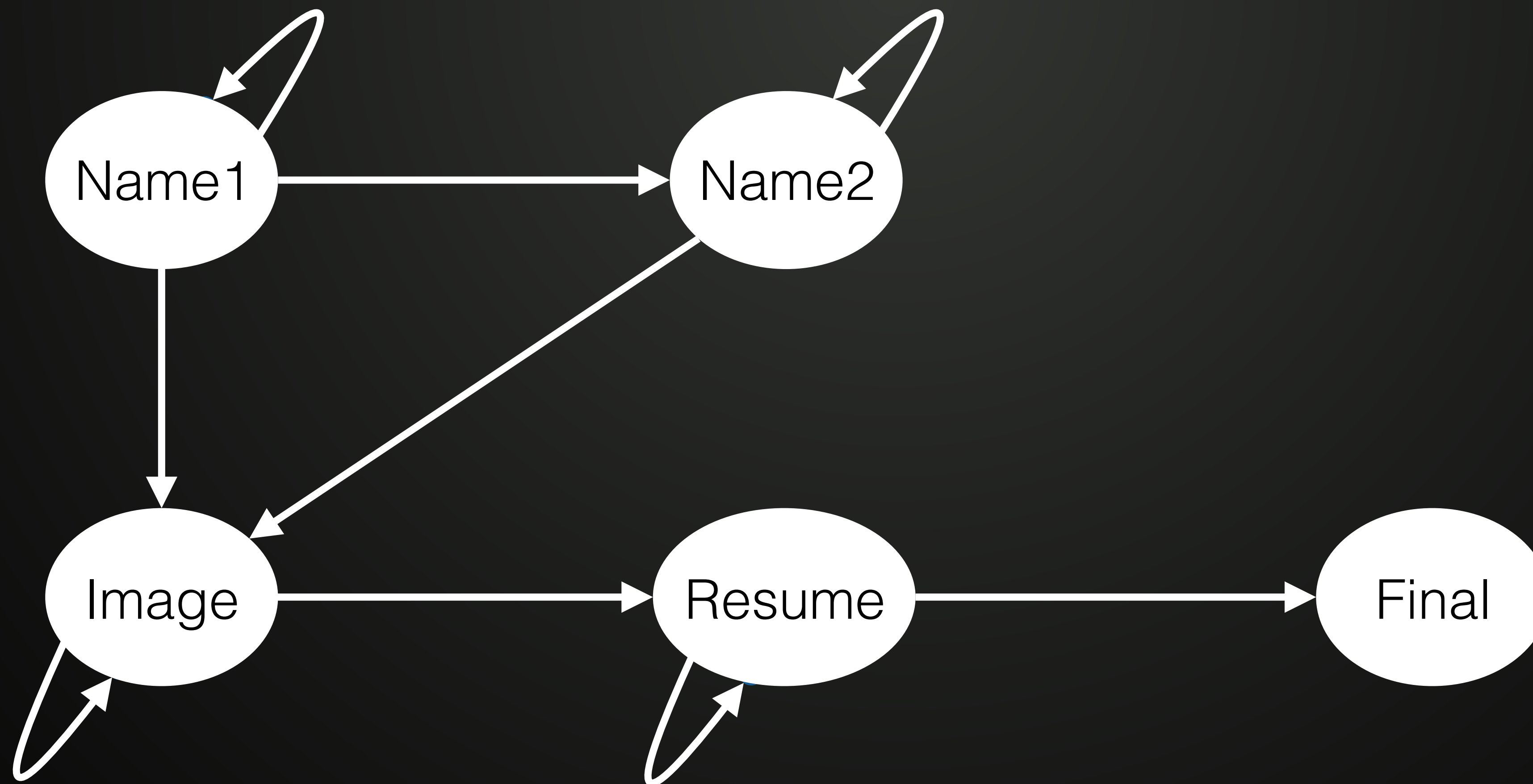
```php
class Worker
{
    // Call daily
    public function sendReminders()
    {
        $stateMachines = ...;// Fetch from database

        /** @var ProfileReminder $profileReminder */
        foreach ($stateMachines as $stateMachine) {
            $ended = $stateMachine->start($this->emailService);
            if ($ended === true) {
                // Remove $profileReminder from database
            }
        }
    }
}
```



@tobiasnyholm

```php
class CompleteYourProfileReminderStateMachine {
    private $user; /** @var User */
    private $state; /** @var ProfileReminderState */

    public function __construct(User $user) {
        $this->user = $user;
        $this->state = new AddYourNameFirst();
    }

    /**
     * @param AnyEmailService $emailService
     *
     * @return bool true if this state machine has come to an end.
     */
    public function start(AnyEmailService $emailService) {
        while (true !== $this->state->send($this, $emailService)) {
            // Looping through states.
        }

        return $this->state instanceof FinalState;
    }

    public function getUser(){
        return $this->user;
    }

    public function setState(ProfileReminderState $state) {
        $this->state = $state;
    }
}
```

```php
<?php

namespace AppBundle\StatePattern\Email;

interface ProfileReminderState
{
    /**
     * @param ProfileReminder $profileReminder
     * @param AnyEmailService $emailService
     *
     * @return bool true if we should stop execution of this state machine for now.
     */
    public function send(
        CompleteYourProfileReminderStateMachine $profileReminder,
        AnyEmailService $emailService
    );
}
```

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```
class NameStep implements ProfileReminderState
{
    private $createdAt;
    public function __construct() {
        $this->createdAt = new \DateTime();
    }

    public function send(Compl…StateMachine $stateMachine, $emailService)
    {
        // If [precondition] send to other state.
        if ($stateMachine->getUser()->hasName()) {
            $stateMachine->setState(new AddYourImage());
            return false;
        }

        // If we have been at this step for less than seven days. Do nothing
        if ($this->createdAt > new \DateTime('-7days')) {
            return true;
        }

        // Send email and set next state
        $emailService->send(
           'Mail\AddYourNameFirst.html.twig',
           ['user' => $stateMachine->getUser()]
        );
        $stateMachine->setState(new AddYourNameSecondReminder));
        return false;
    }
}
```

src/AppBundle/StatePattern/
- Worker.php
- Email/
  - AddYourImage.php
  - AddYourNameFirstReminder.php
  - AddYourNameSecondReminder.php
  - AddYourResume.php
  - CompleteYourProfileReminderStateMachine.php
  - FinalState.php
  - ProfileReminderState.php

```
class FinalState implements ProfileReminderState
{
    public function send(Compl…StateMachine $stateMachine, $emailService)
    {
        // Always stop the execution
        return true;
    }
}
```

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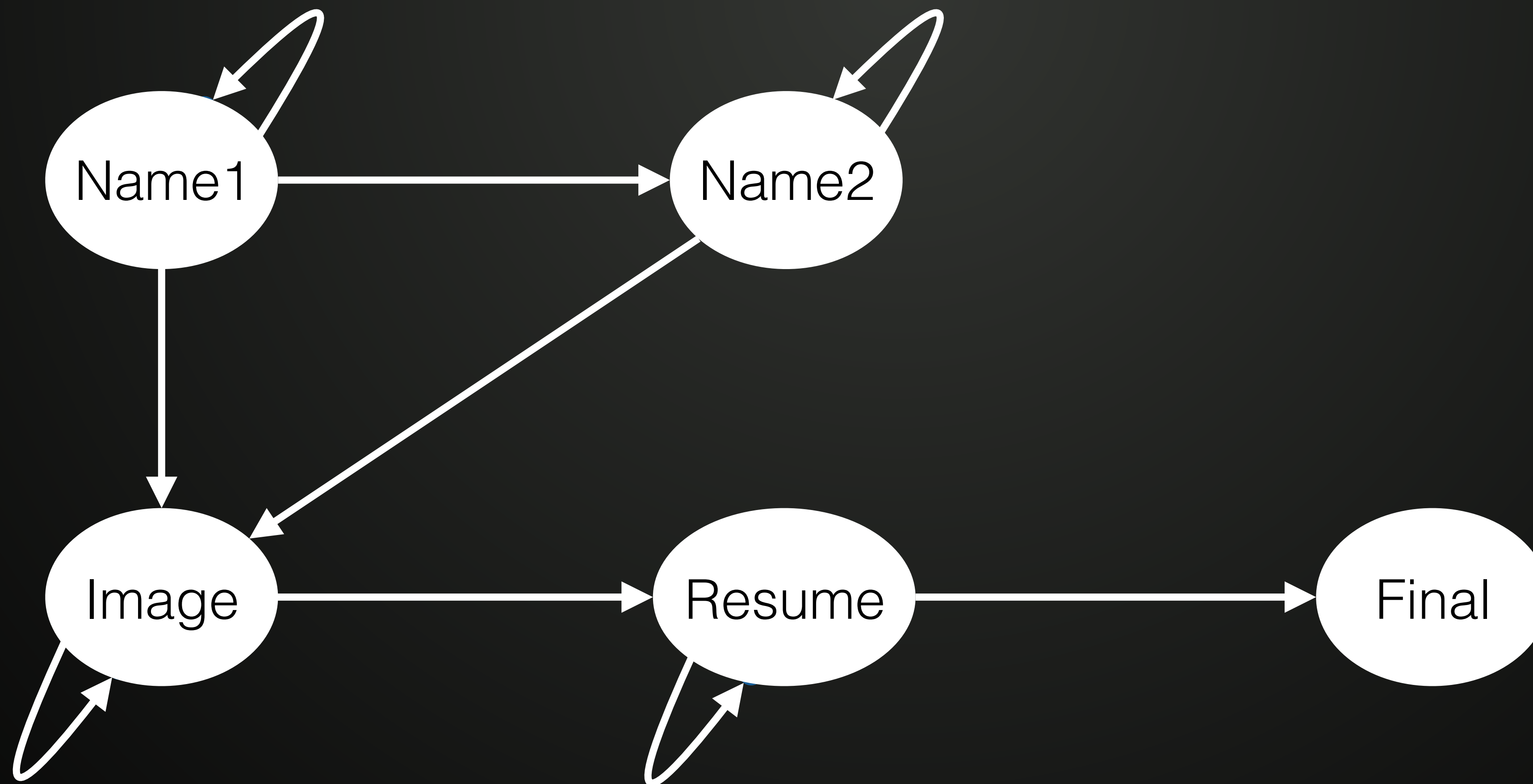
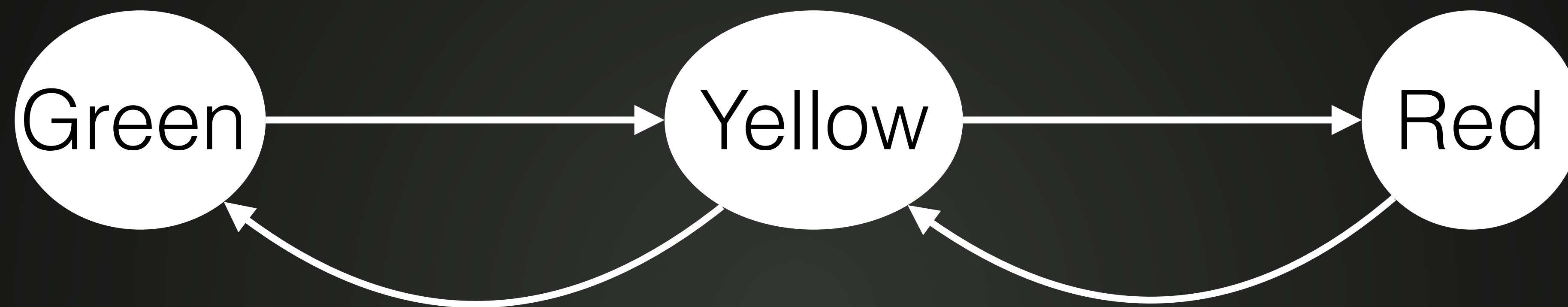
```php
class Worker
{
    // Call daily
    public function sendReminders()
    {
        $stateMachines = ...;// Fetch from database

        /** @var ProfileReminder $profileReminder */
        foreach ($stateMachines as $stateMachine) {
            $ended = $stateMachine->start($this->emailService);
            if ($ended === true) {
                // Remove $profileReminder from database
            }
        }
    }
}
```



Mealy State Machine

Traffic Light



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```php
<?php

namespace App;

class StateMachine
{
    const STATE_GREEN = 0;
    const STATE_YELLOW = 1;
    const STATE_RED = 2;

    private $state;

    public function can($transition) {
        switch ($this->state) {
            case self::STATE_GREEN:
                return ($transition === 'to_yellow');
            case self::STATE_YELLOW:
                return ($transition === 'to_green' || $transition === 'to_red');
            case self::STATE_RED:
                return ($transition === 'to_yellow');
            default:
                return false;
        }
    }


    // ..

}
```

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```php
<?php

namespace App;

class StateMachine
{
    // ..

    public function apply($transition) {
        if (!$this->can($transition)) {
            throw new \InvalidArgumentException('Invalid transition');
        }

        switch ($this->state) {
            case self::STATE_GREEN && ($transition === 'to_yellow'):
                $this->state = self::STATE_YELLOW;
                break;
            case self::STATE_YELLOW && ($transition === 'to_green'):
                $this->state = self::STATE_GREEN;
                break;
            case self::STATE_YELLOW && ($transition === 'to_red'):
                $this->state = self::STATE_RED;
                break;
            case self::STATE_RED && ($transition === 'to_yellow'):
                $this->state = self::STATE_YELLOW;
                break;
        }
    }
}
```

@tobiasnyholm

```php
<?php

namespace App;

class StateMachine
{
    const STATE_GREEN = 0;
    const STATE_YELLOW = 1;
    const STATE_RED = 2;

    public function can(TrafficLight $trafficLight, $transition) {
        $state = $trafficLight->getCurrentState();

        switch ($state) {
            case self::STATE_GREEN:
                return ($transition === 'to_yellow');
            case self::STATE_YELLOW:
                return ($transition === 'to_green' || $transition === 'to_red');
            case self::STATE_RED:
                return ($transition === 'to_yellow');
            default:
                return false;
        }
    }

    // ..
}
```

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```php
<?php

namespace App;

class StateMachine
{
    // ..

    public function apply(TrafficLight $trafficLight, $transition) {
        if (!$this->can($trafficLight, $transition)) {
            throw new \InvalidArgumentException('Invalid transition');
        }

        $state = $trafficLight->getCurrentState();

        switch ($state) {
            case self::STATE_GREEN && ($transition === 'to_yellow'):
                $trafficLight->setState(self::STATE_YELLOW);
                break;
            case self::STATE_YELLOW && ($transition === 'to_green'):
                $trafficLight->setState(self::STATE_GREEN);
                break;
            case self::STATE_YELLOW && ($transition === 'to_red'):
                $trafficLight->setState(self::STATE_RED);
                break;
            case self::STATE_RED && ($transition === 'to_yellow'):
                $trafficLight->setState(self::STATE_YELLOW);
                break;
        }
    }
}
```

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```php
<?php

namespace App;

class StateMachine
{

    // ...

    public function allowTraffic(TrafficLight $trafficLight)
    {
        if ($this->can($trafficLight, 'to_green')) {
            $this->apply($trafficLight, 'to_green');
        } elseif ($this->can($trafficLight, 'to_yellow')) {
            $this->apply($trafficLight, 'to_yellow');
        }
    }

    public function stopTraffic(TrafficLight $trafficLight)
    {
        if ($this->can($trafficLight, 'to_red')) {
            $this->apply($trafficLight, 'to_red');
        } elseif ($this->can($trafficLight, 'to_yellow')) {
            $this->apply($trafficLight, 'to_yellow');
        }
    }
}
```

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```php
<?php

namespace App;

class StateMachine
{

    // ...

    public function allowTraffic(TrafficLight $trafficLight)
    {
        if ($this->can($trafficLight, 'to_green')) {
            $this->apply($trafficLight, 'to_green');
        } elseif ($this->can($trafficLight, 'to_yellow')) {
            $this->apply($trafficLight, 'to_yellow');
        }
    }

    public function stopTraffic(TrafficLight $trafficLight)
    {
        if ($this->can($trafficLight, 'to_red')) {
            $this->apply($trafficLight, 'to_red');
        } elseif ($this->can($trafficLight, 'to_yellow')) {
            $this->apply($trafficLight, 'to_yellow');
        }
    }
}
```

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```php
class StateMachine{
    const STATE_GREEN = 0;
    const STATE_YELLOW = 1;
    const STATE_RED = 2;
    private $states = [
        self::STATE_GREEN => [
            'to_yellow' =>  self::STATE_YELLOW,
        ],
        self::STATE_YELLOW => [
            'to_green' => self::STATE_GREEN,
            'to_red' => self::STATE_RED,
        ],
        self::STATE_RED => [
            'to_yellow' =>  self::STATE_YELLOW,
        ],
    ];

    public function can(TrafficLight $trafficLight, $transition) {
        $state = $trafficLight->getCurrentState();

        return isset($this->states[$state][$transition]);
    }

    public function apply(TrafficLight $trafficLight, $transition) {
        if (!$this->can($trafficLight, $transition)) {
            throw new \InvalidArgumentException('Invalid transition');
        }

        $state = $trafficLight->getCurrentState();
        $newState = $this->states[$state][$transition];
        $trafficLight->setState($newState);
    }
}
```

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```php
class StateMachine{

    private $states;

    public function __construct(array $states) {
        $this->states = $states;
    }

    public function can(TrafficLight $trafficLight, $transition) {
        $state = $trafficLight->getCurrentState();

        return isset($this->states[$state][$transition]);
    }

    public function apply(TrafficLight $trafficLight, $transition) {
        if (!$this->can($trafficLight, $transition)) {
            throw new \InvalidArgumentException('Invalid transition');
        }

        $state = $trafficLight->getCurrentState();
        $newState = $this->states[$state][$transition];
        $trafficLight->setState($newState);
    }

    // ...

}
```

```php
class StateMachine{

    private $states;

    public function __construct(array $states) {
        $this->states = $states;
    }

    public function can(StateAwareInterface $object, $transition) {
        $state = $object->getCurrentState();

        return isset($this->states[$state][$transition]);
    }

    public function apply(StateAwareInterface $object, $transition) {
        if (!$this->can($object, $transition)) {
            throw new \InvalidArgumentException('Invalid transition');
        }

        $state = $trafficLight->getCurrentState();
        $newState = $this->states[$state][$transition];
        $trafficLight->setState($newState);
    }

    // ...

}
```

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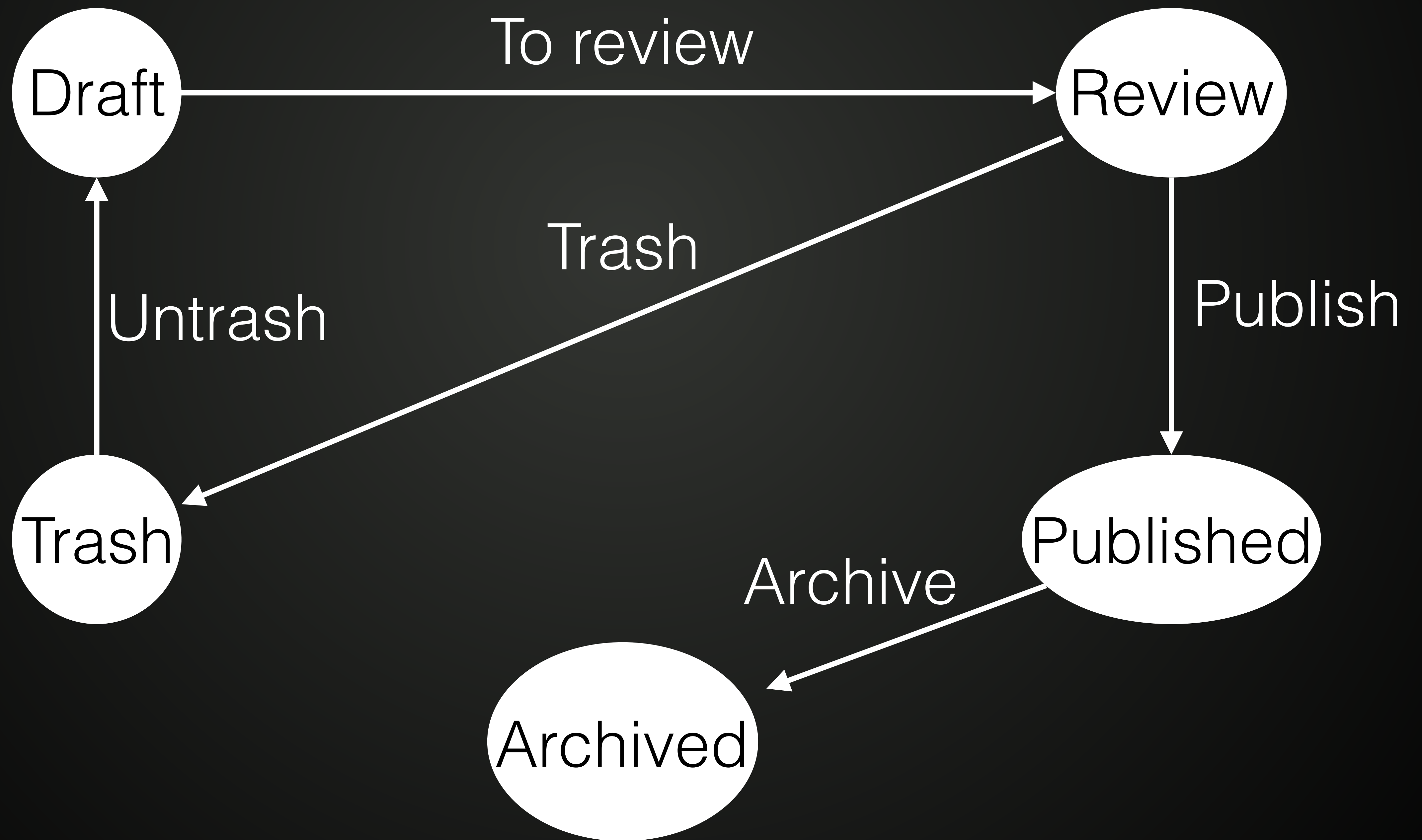
A good state machine

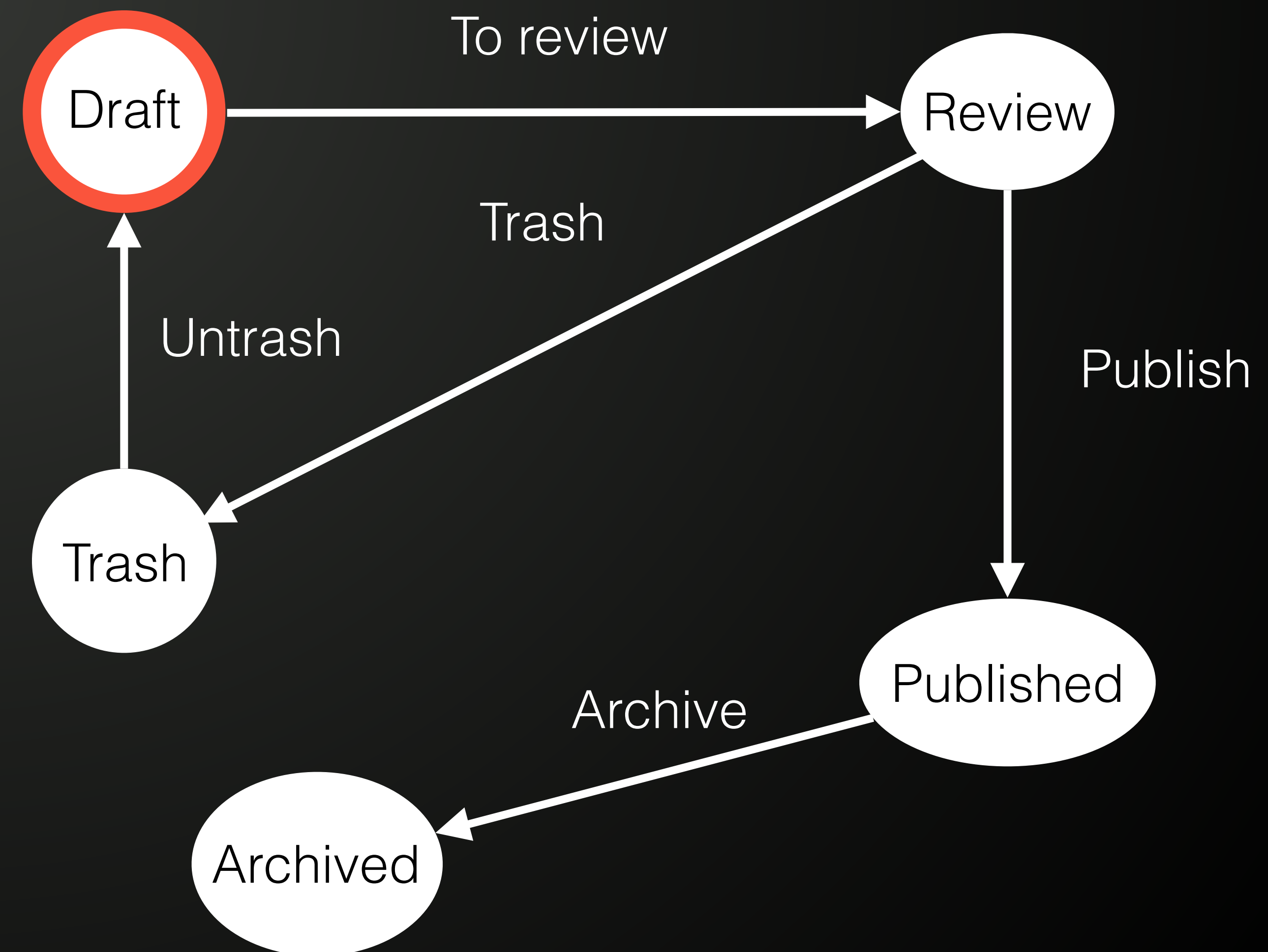
Functions

- Can we do [transition]?
- Apply [transition]
- What state are we in?
- Which are my valid transitions?

Job advert



Examples



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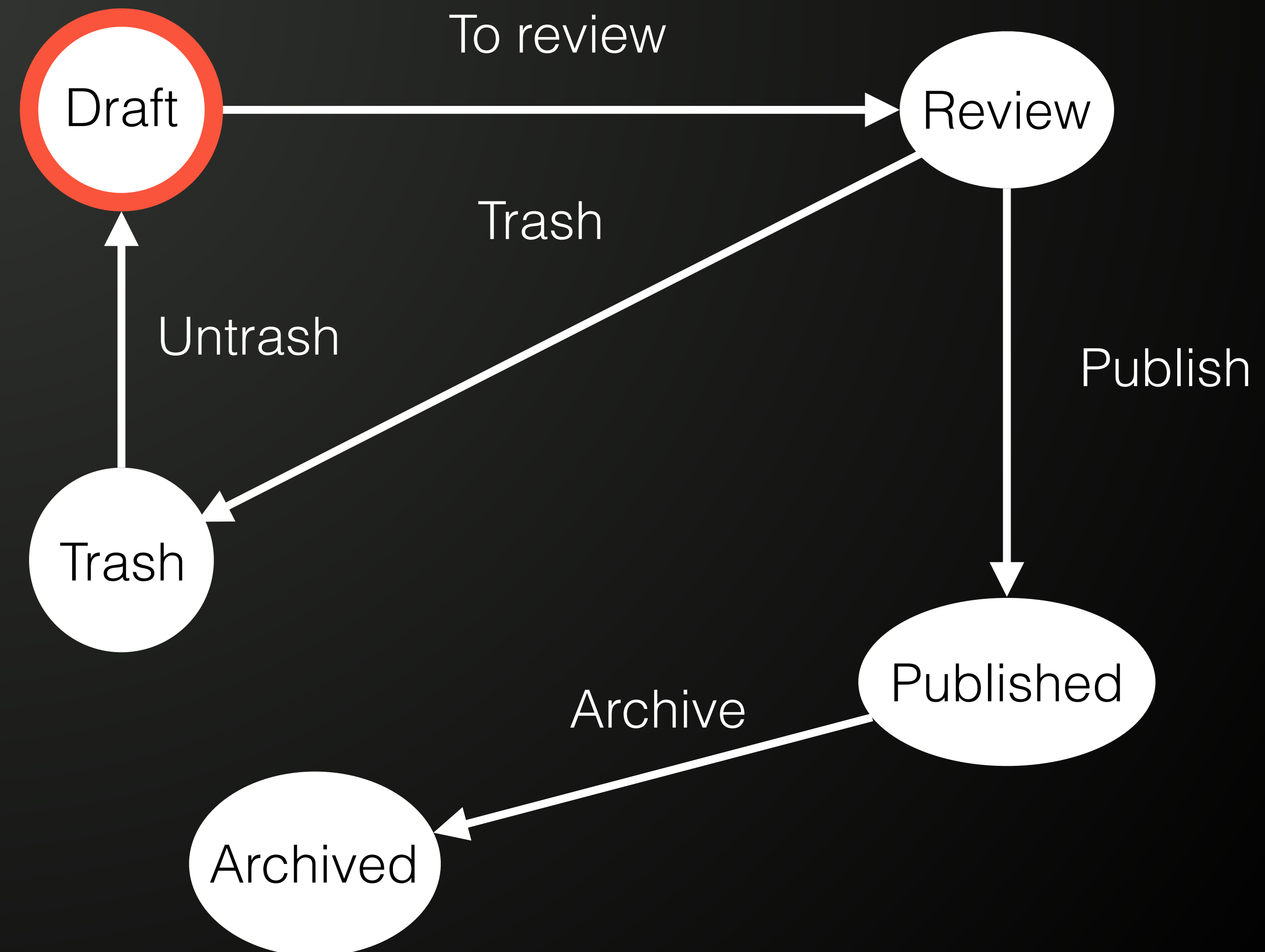
Examples

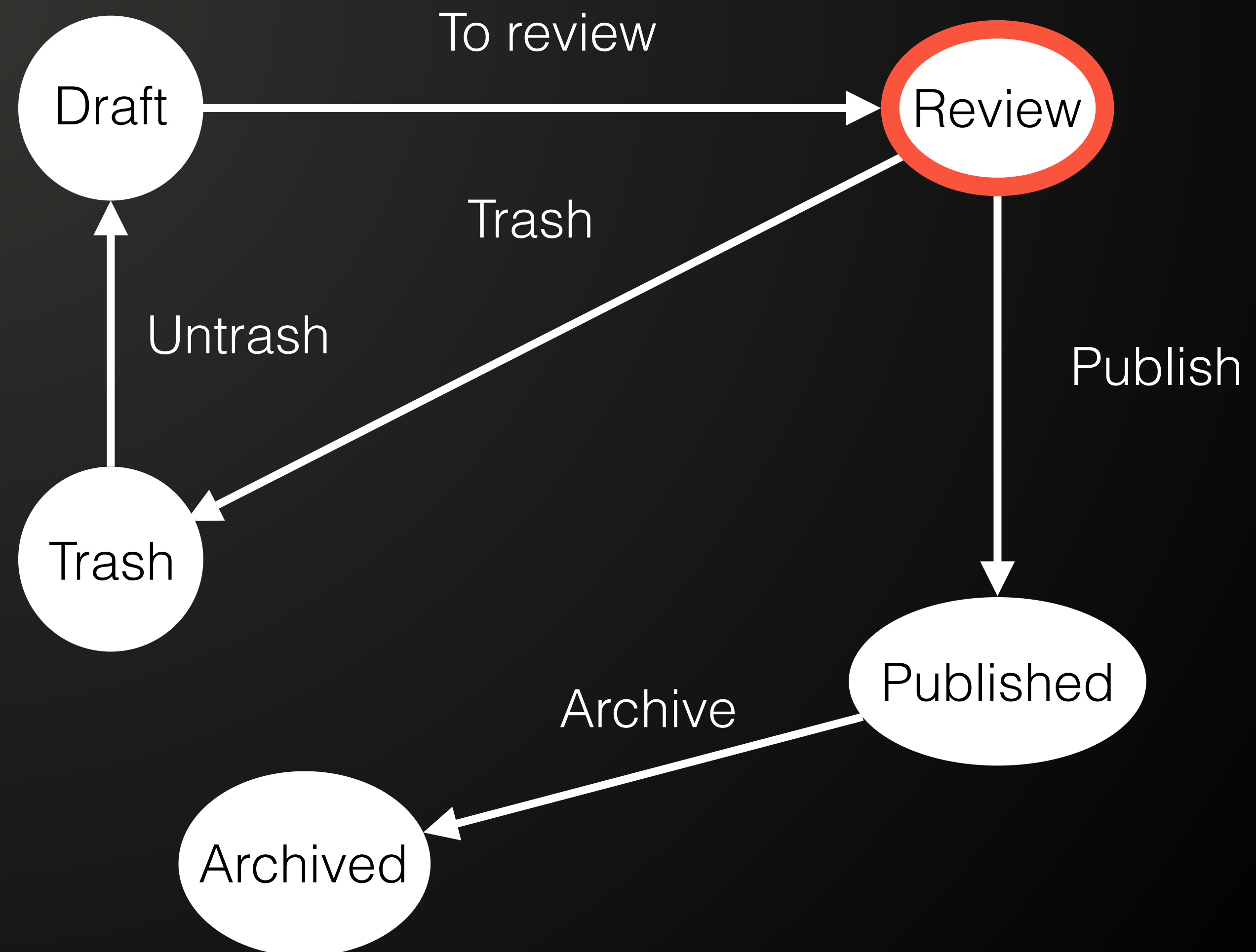
```
$stateMachine = $this->get('state_machine.job_advert');
```

```
$stateMachine->can($advert, 'publish'); // false
$stateMachine->can($advert, 'to_review'); // true
$stateMachine->apply($advert, 'to_review');
```



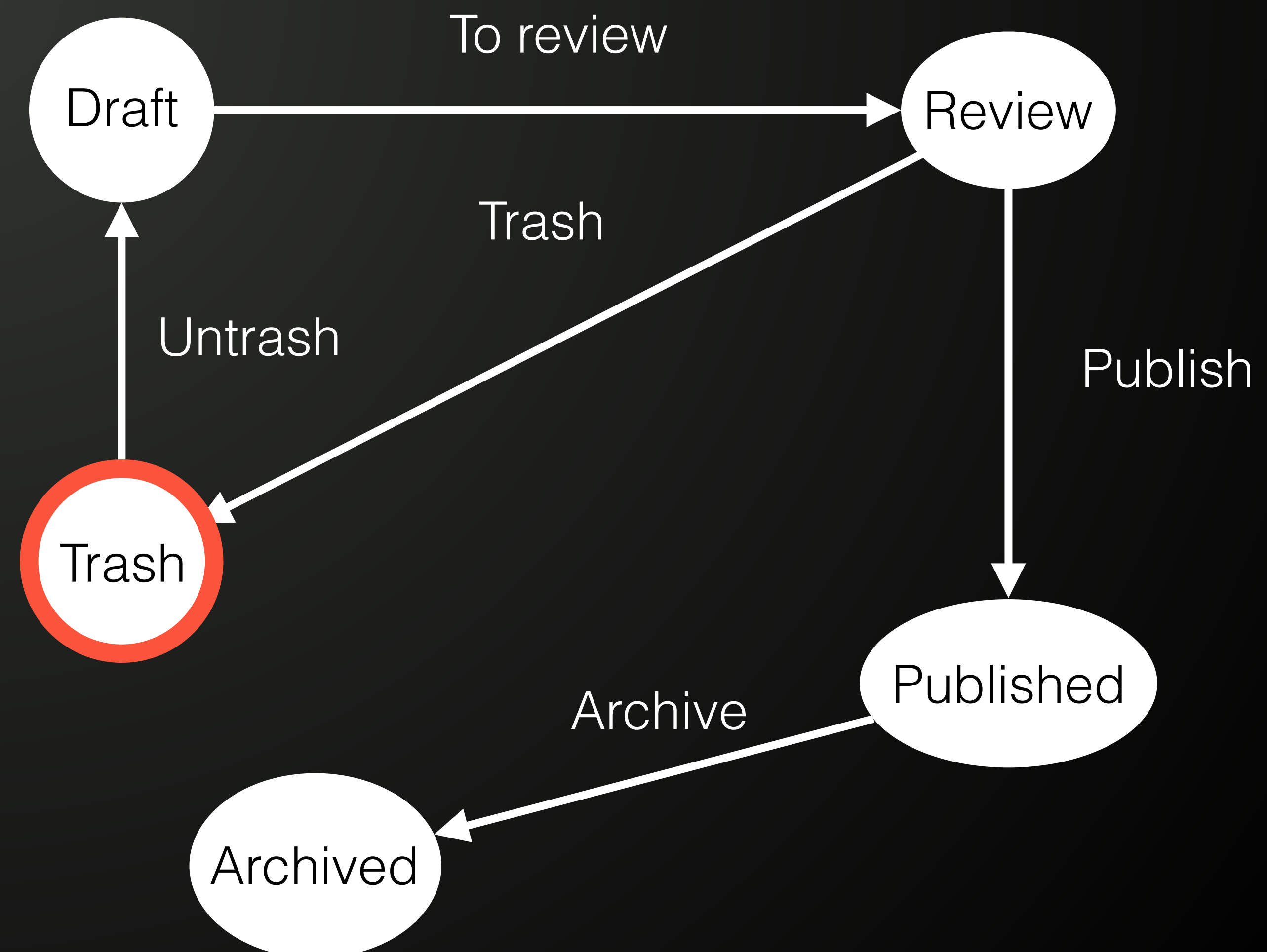
Examples

```
$stateMachine->can($advert, 'publish'); // false
$stateMachine->can($advert, 'to_review'); // true

$stateMachine->apply($advert, 'to_review');
```



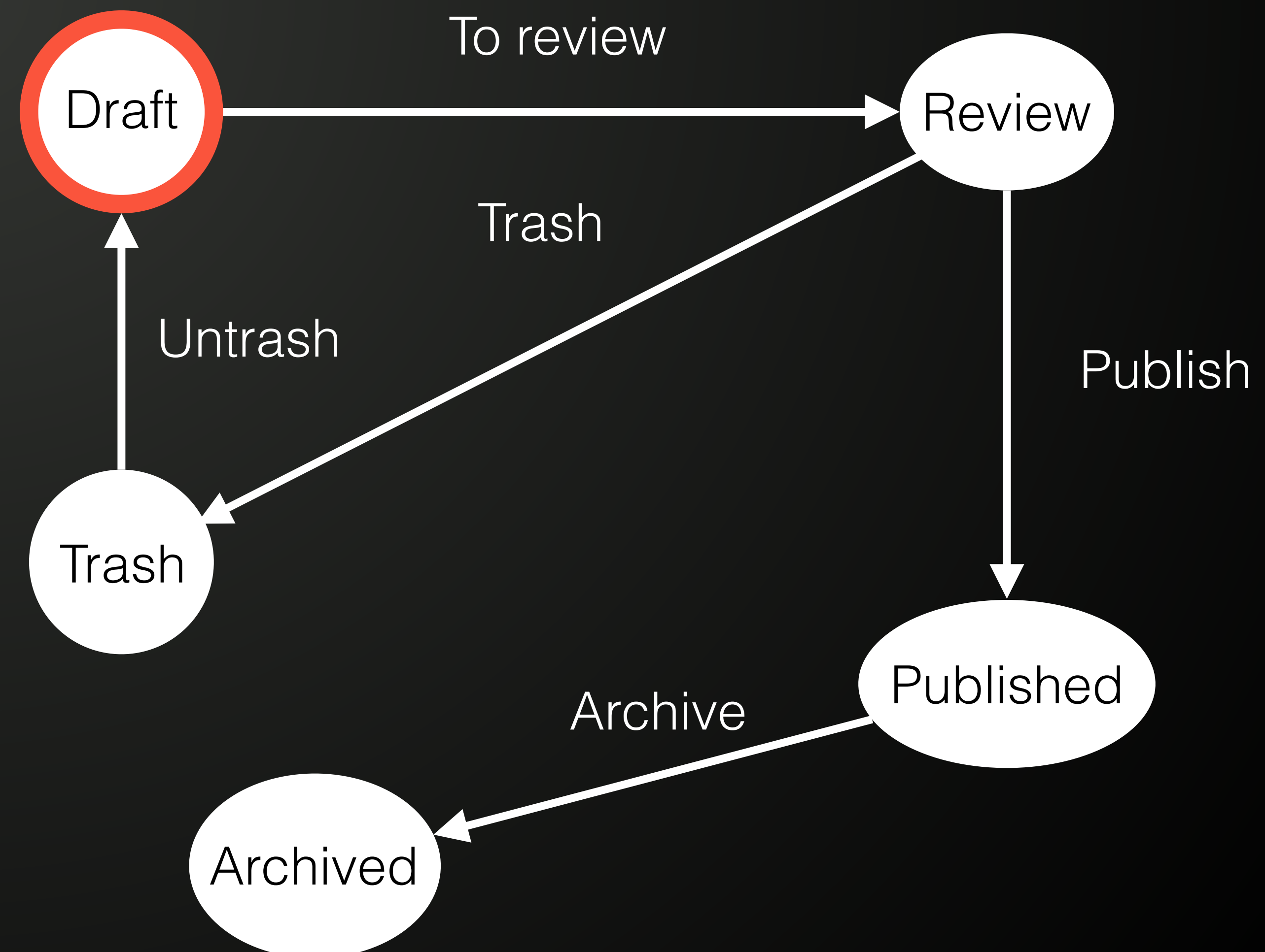
Examples

```
$stateMachine->can($advert, 'publish'); // false
$stateMachine->can($advert, 'to_review'); // true

$stateMachine->apply($advert, 'to_review');

$stateMachine->apply($advert, 'trash');
```



Examples

```
$stateMachine->can($advert, 'publish'); // false
$stateMachine->can($advert, 'to_review'); // true

$stateMachine->apply($advert, 'to_review');
$stateMachine->apply($advert, 'trash');
$stateMachine->apply($advert, 'untrash');
```



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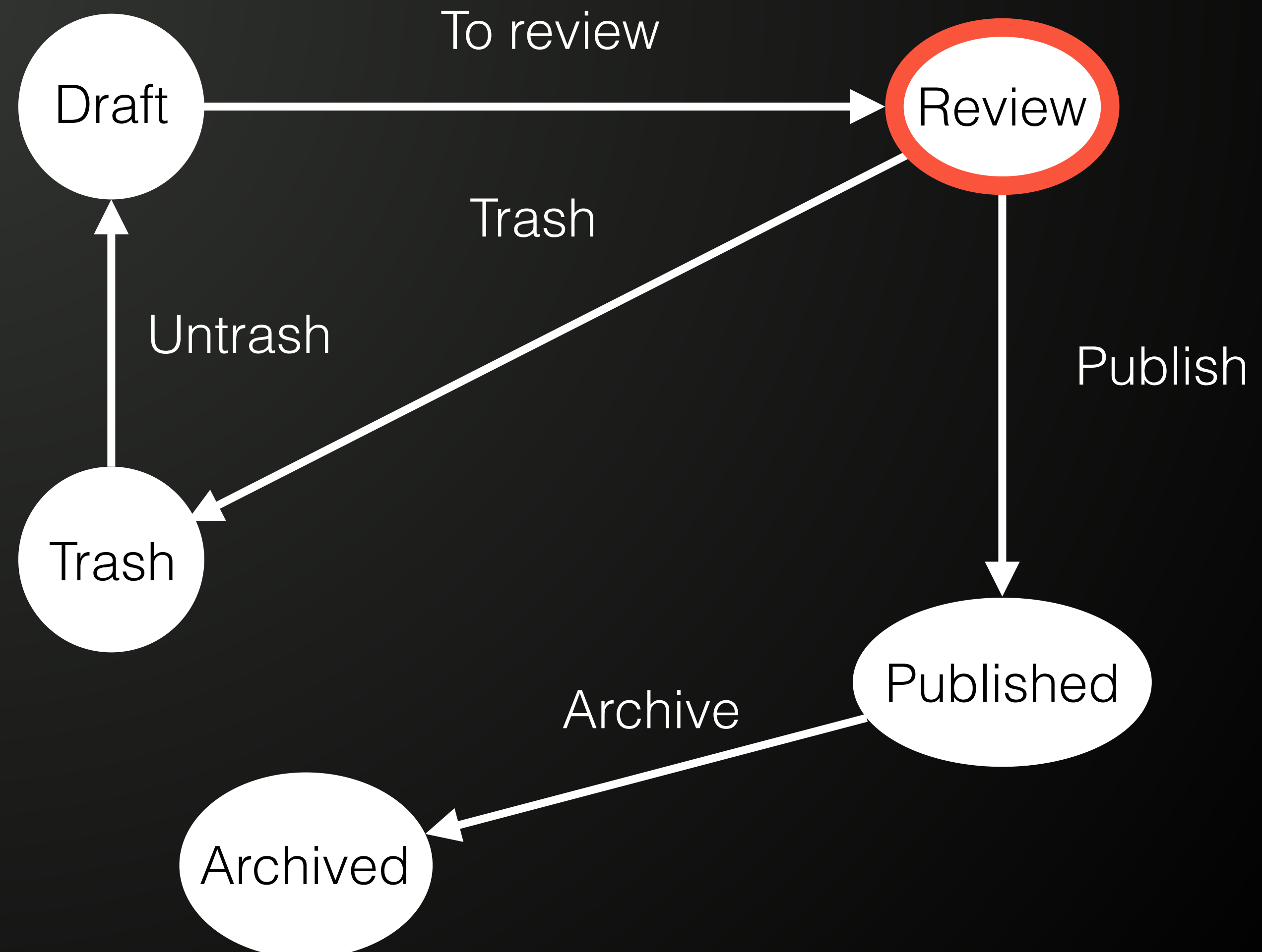
Examples

```php
$stateMachine->can($advert, 'publish'); // false
$stateMachine->can($advert, 'to_review'); // true

$stateMachine->apply($advert, 'to_review');
$stateMachine->apply($advert, 'trash');
$stateMachine->apply($advert, 'untrash');
$stateMachine->apply($advert, 'to_review');

$transitions = $stateMachine->getEnabledTransitions($advert);
foreach ($transitions as $transition) {
  echo $transition->getName();
}

// publish
// trash
```



Front end examples

```
<h4>Sidebar actions</h4>
{% if workflow_can(advert, 'to_review') %}
    <a href="{{ path('advert_to_review', {id:advert.id}) }}”>
      Send to review</a><br>
{% endif %}

{% if workflow_can(advert, 'publish') %}
    <a href="{{ path('advert_publish', {id:advert.id}) }}”>
      Publish advert</a><br>
{% endif %}

{% if workflow_can(advert, 'archive') %}
    <a href="{{ path('advert_archive', {id:advert.id}) }}”>
      Archive</a><br>
{% endif %}

{% if workflow_can(advert, 'trash') %}
    <a href="{{ path('advert_trash', {id:advert.id}) }}”>
      Trash</a><br>
{% endif %}

{% if workflow_can(advert, 'untrash') %}
    <a href="{{ path('advert_untrash', {id:advert.id}) }}”>
      Restore for trash</a><br>
{% endif %}
```

Front end examples

Sidebar actions

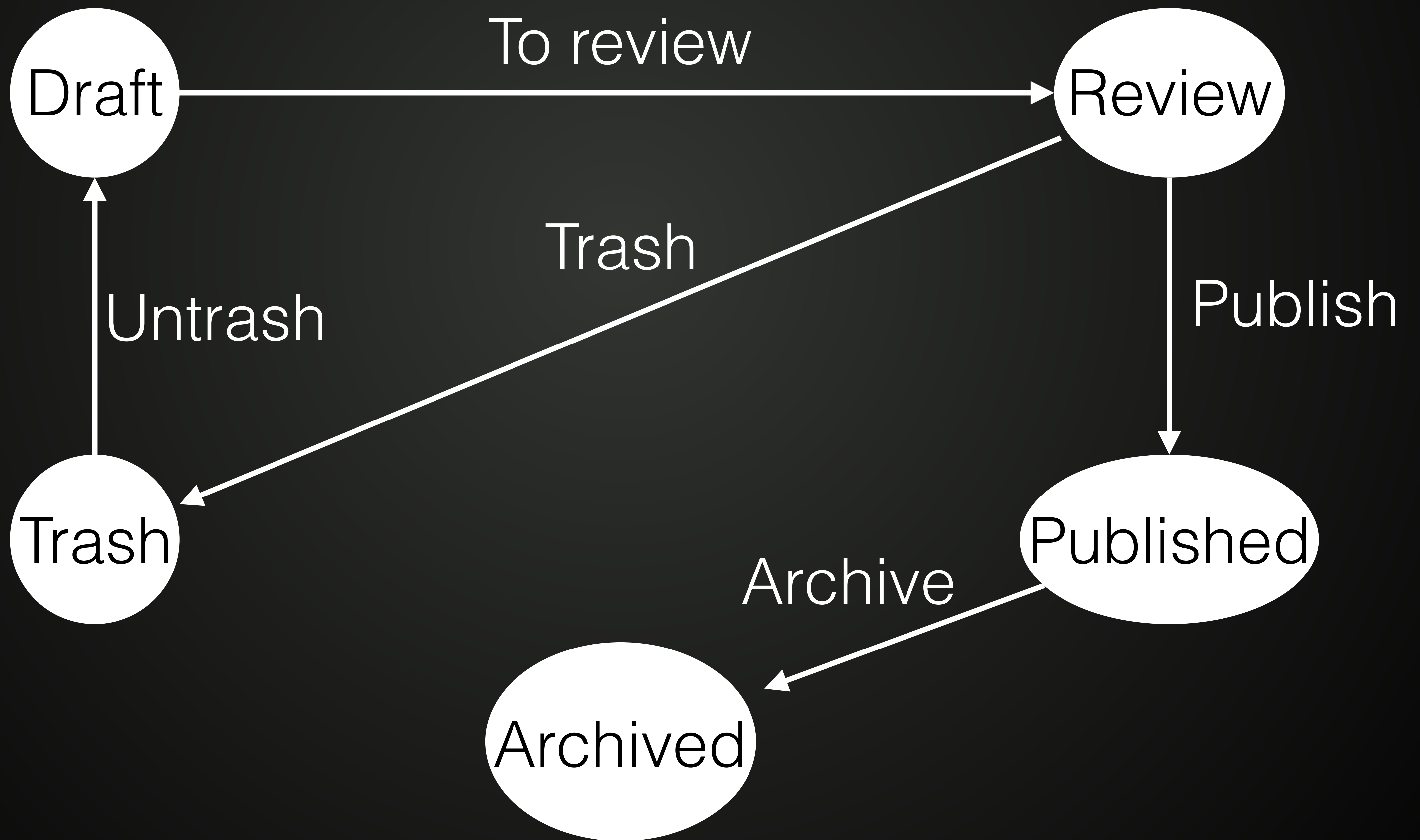
Send to review

Sidebar actions

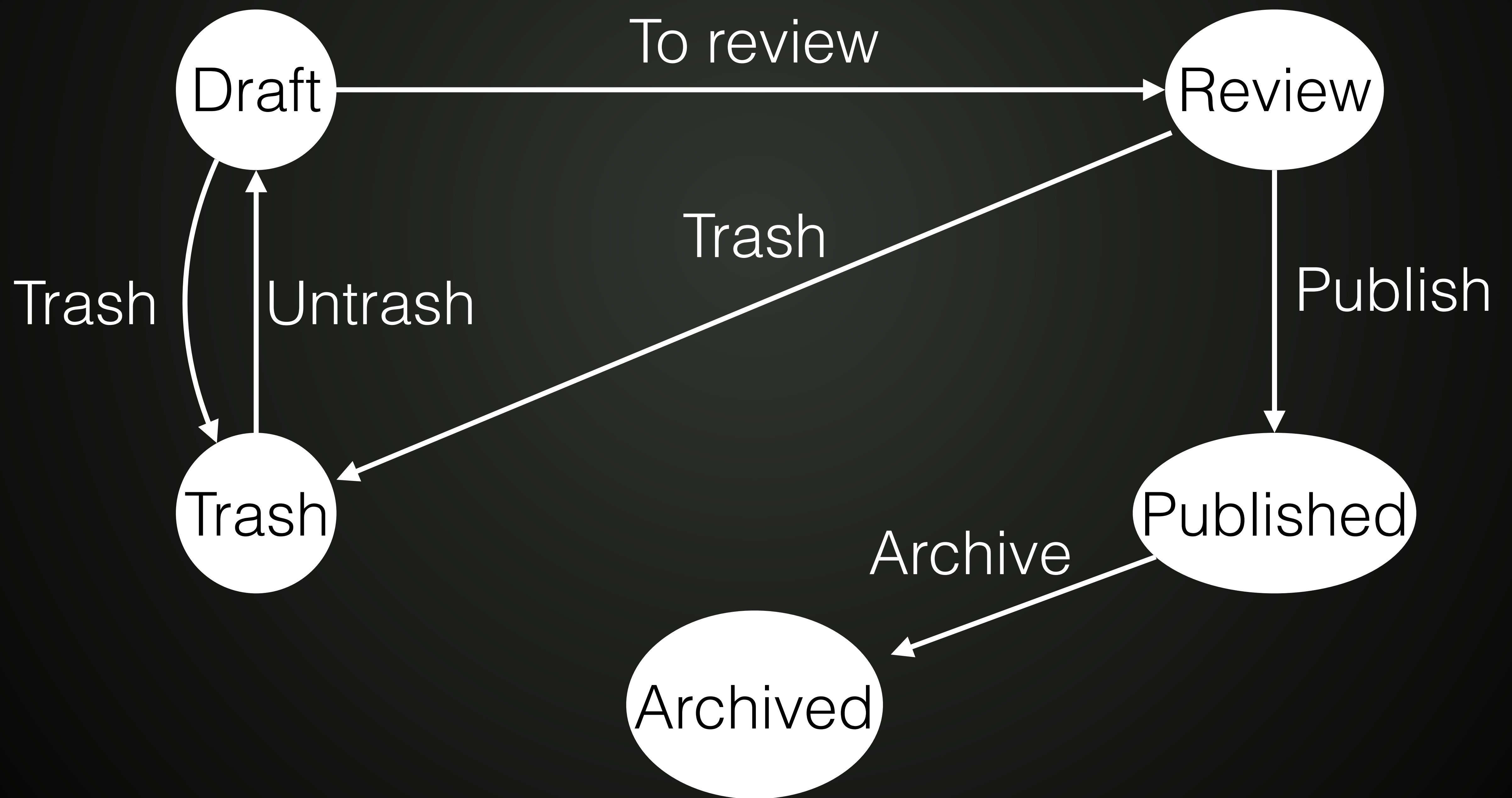
Publish advert

Trash

Job advert



Job advert



Configuration

```yaml
framework:
    workflows:
        job_advert:
            type: 'state_machine'
            supports:
                - AppBundle\Entity\Advert
            places:
                - draft
                - review
                - published
                - trash
                - archived
            transitions:
                to_review:
                    from: draft
                    to: review
                publish:
                    from: review
                    to: published
                trash:
                    from: [draft, review]
                    to: trash
                archive:
                    from: published
                    to: archived
                untrash:
                    from: trash
                    to: draft
```

Events

statemachine.leave
statemachine.[*job_advert*].leave
statemachine.[*job_advert*].leave.[*draft*]

statemachine.transition
statemachine.[*job_advert*].transition
statemachine.[*job_advert*].transition.[*to_review*]

statemachine.enter
statemachine.[*job_advert*].enter
statemachine.[*job_advert*].enter.[*review*]

statemachine.[*job_advert*].announce.[*publish*]
statemachine.[*job_advert*].announce.[*trash*]

Guard

```php
use Symfony\Component\EventDispatcher\EventSubscriberInterface;
use Symfony\Component\Security\Core\Authorization\AuthorizationCheckerInterface;
use Symfony\Component\Workflow\Event\GuardEvent;

class GuardListener implements EventSubscriberInterface
{
    public function __construct(AuthorizationCheckerInterface $checker)
    {
        $this->checker = $checker;
    }

    public function guardPublish(GuardEvent $event)
    {
        if (!$this->checker->isGranted('ROLE_PUBLISHER')) {
            $event->setBlocked(true);
        }
    }

    public static function getSubscribedEvents()
    {
        return array(
            'statemachine.job_advert.guard.publish' => 'guardPublish',
        );
    }
}
```

@tobiasnyholm

```php
use Psr\Log\LoggerInterface;
use Symfony\Component\EventDispatcher\EventSubscriberInterface;
use Symfony\Component\Workflow\Event\Event;

class WorkflowLogger implements EventSubscriberInterface
{
    public function __construct(LoggerInterface $logger)
    {
        $this->logger = $logger;
    }

    public function onLeave(Event $event)
    {
        $this->logger->alert(sprintf(
            'Advert (id: "%s") preformed transaction "%s" form "%s" to "%s"',
            $event->getSubject()->getId(),
            $event->getTransition()->getName(),
            implode(', ', array_keys($event->getMarking()->getPlaces())),
            implode(', ', $event->getTransition()->getTos())
        ));
    }

    public static function getSubscribedEvents()
    {
        return array(
            'statemachine.job_advert.leave' => 'onLeave',
        );
    }
}
```

Events

```php
use AppBundle\Service\EmailService;
use Symfony\Component\EventDispatcher\EventSubscriberInterface;
use Symfony\Component\Workflow\Event\Event;

class PublishListener implements EventSubscriberInterface
{
    public function __construct(EmailService $mailer)
    {
        $this->mailer = $mailer;
    }

    public function onPublished(Event $event)
    {
        $this->mailer->emailAllUsers($event->getSubject());
    }

    public static function getSubscribedEvents()
    {
        return array(
            'statemachine.job_advert.enter.published' => 'onPublished',
        );
    }
}
```

STATE MACHINES ARE GREAT
TO BAD I CANT APPLY THEM
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Identify state machines

```
class Quotation
{
  const STATUS_SENT = 0;
  const STATUS_NEGOTIATION = 1;
  const STATUS_WON = 2;
  const STATUS_LOST = 3;

  /**
   * @var int status
   *
   * @ORM\Column(type="integer")
   * @Assert\NotBlank()
   */
  private $status;

  // ...
}
```

Search: id IN 62,63,99,585

id	position_id	active	ended	closed	createdAt	u
62	119	0	1	1	2014-07-28 16:01:55	2
63	120	0	1	1	2014-07-28 16:02:17	2
99	204	0	1	1	2014-08-06 13:42:27	2
585	597	0	1	1	2015-03-19 09:51:49	2
586	386	0	1	1	2015-03-19 11:41:27	2
587	389	0	1	1	2015-03-19 11:42:22	2
614	82	0	1	1	2015-04-03 07:44:26	2
620	134	0	1	1	2015-04-04 13:36:20	2
880	1006	0	1	1	2015-07-03 14:47:19	2
4343	8968	0	1	1	2016-06-22 09:28:50	2
4344	23740	0	1	1	2016-06-22 09:35:33	2

a way of thinking