Pgcrypto Avast!

A study in Django's password hashers

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I’m Drew Engelson.

Hello

Intro.

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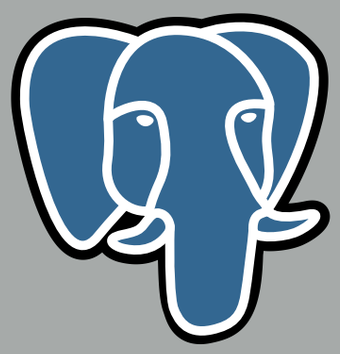
Chief Technologist

Why are we here?

Things I hope to touch on today.



django

Some background…

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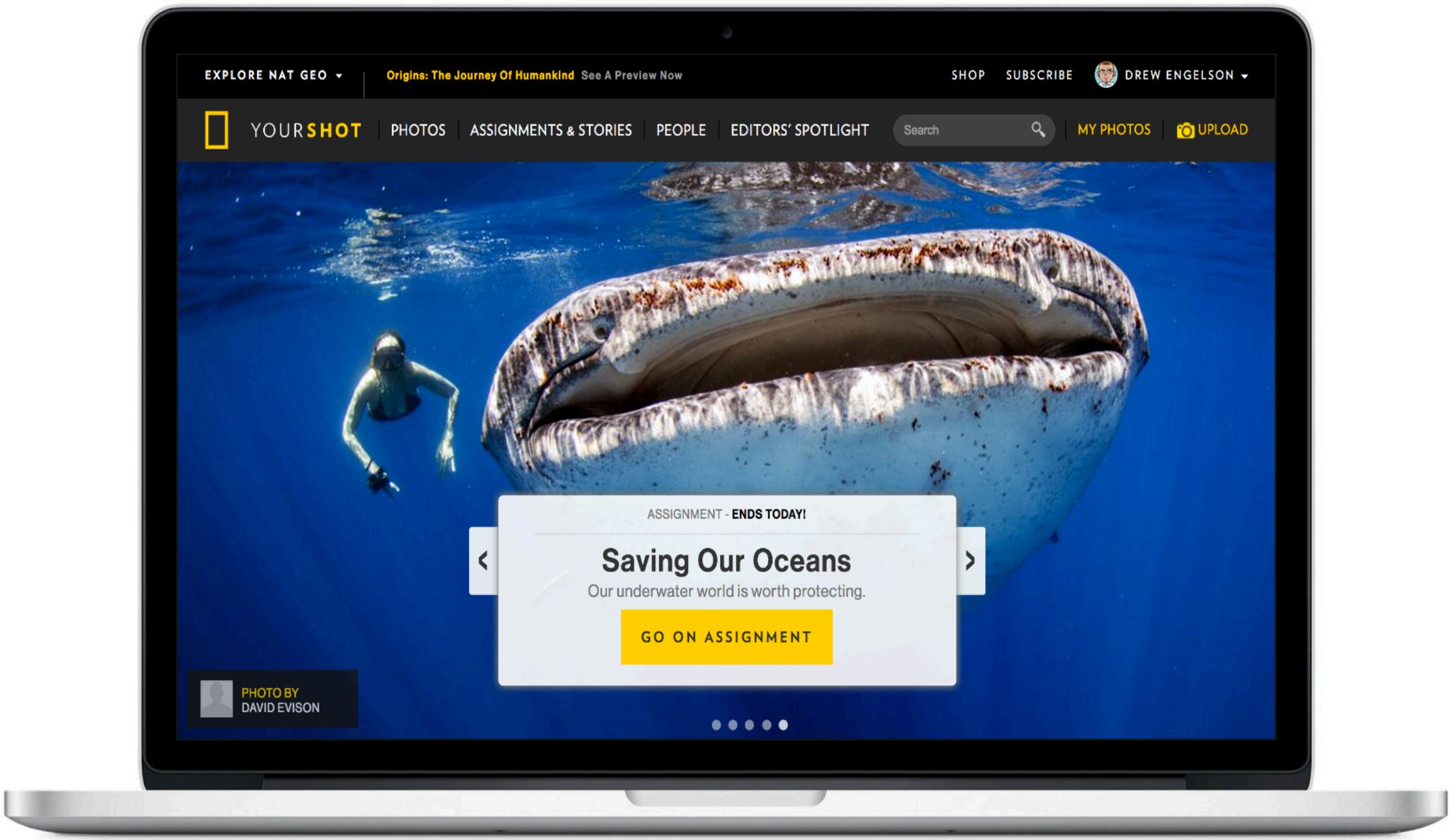
YOUR SHOT

national geographic



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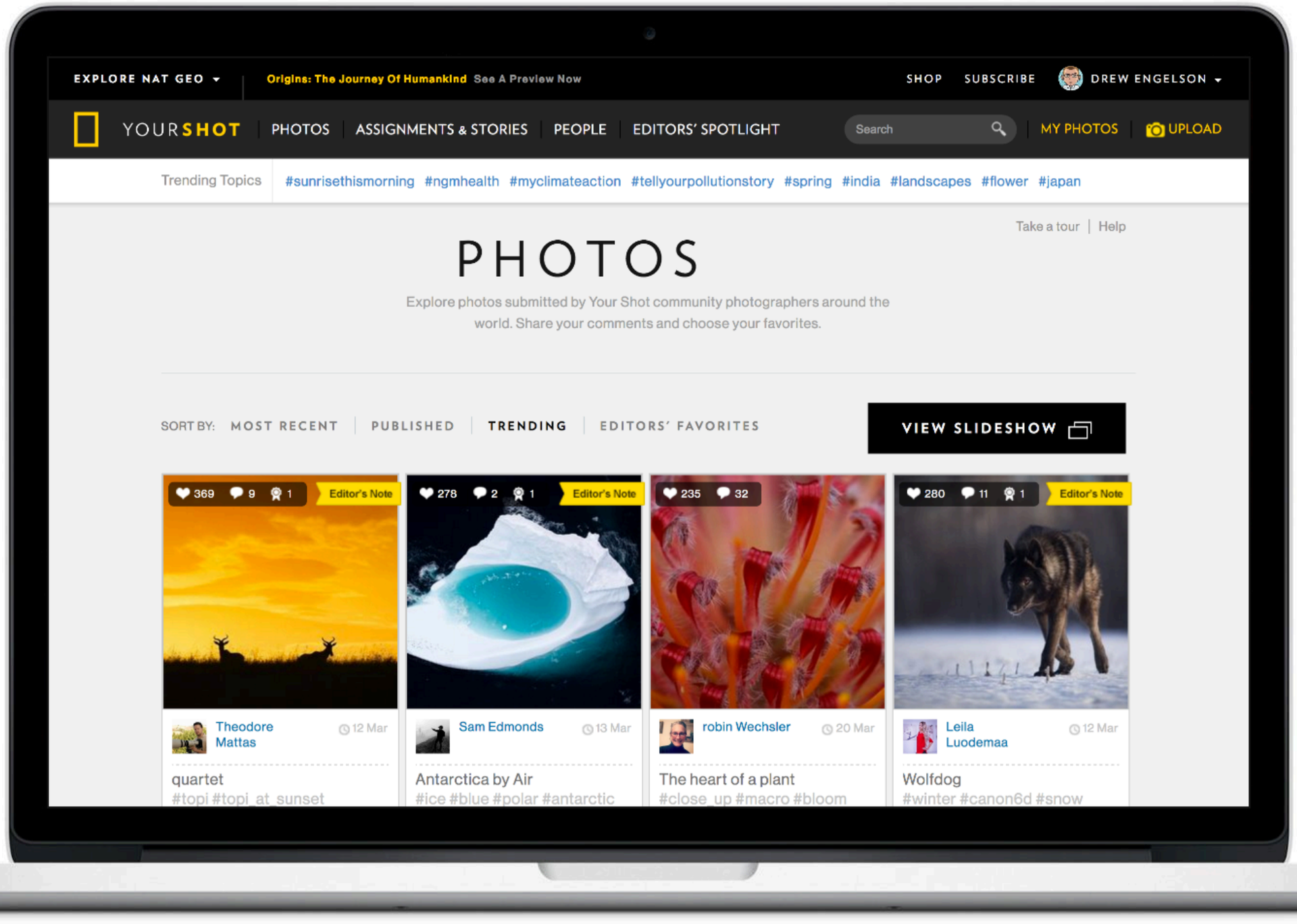
YOUR SHOT

national geographic



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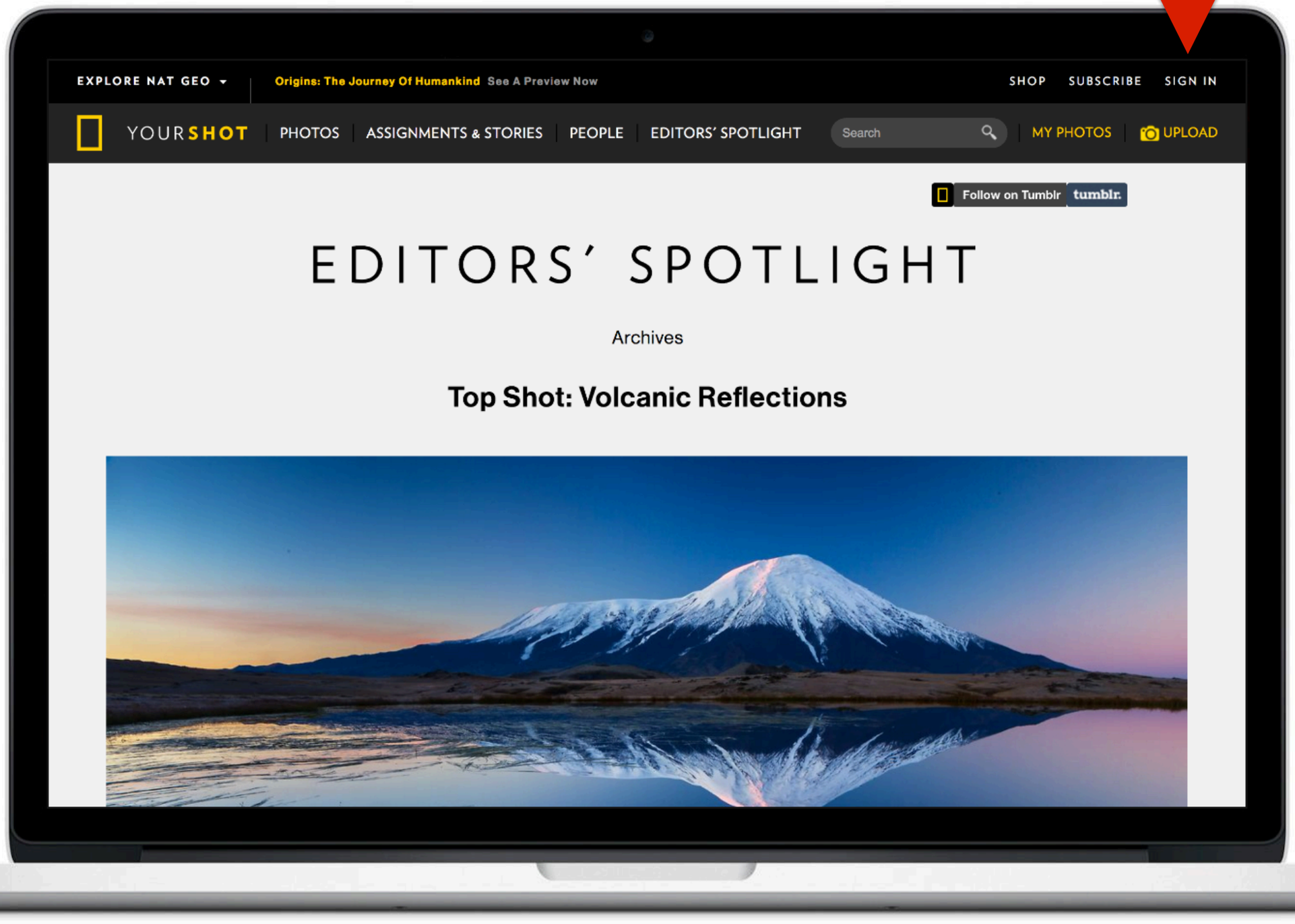
YOUR SHOT

national geographic



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Single Sign On

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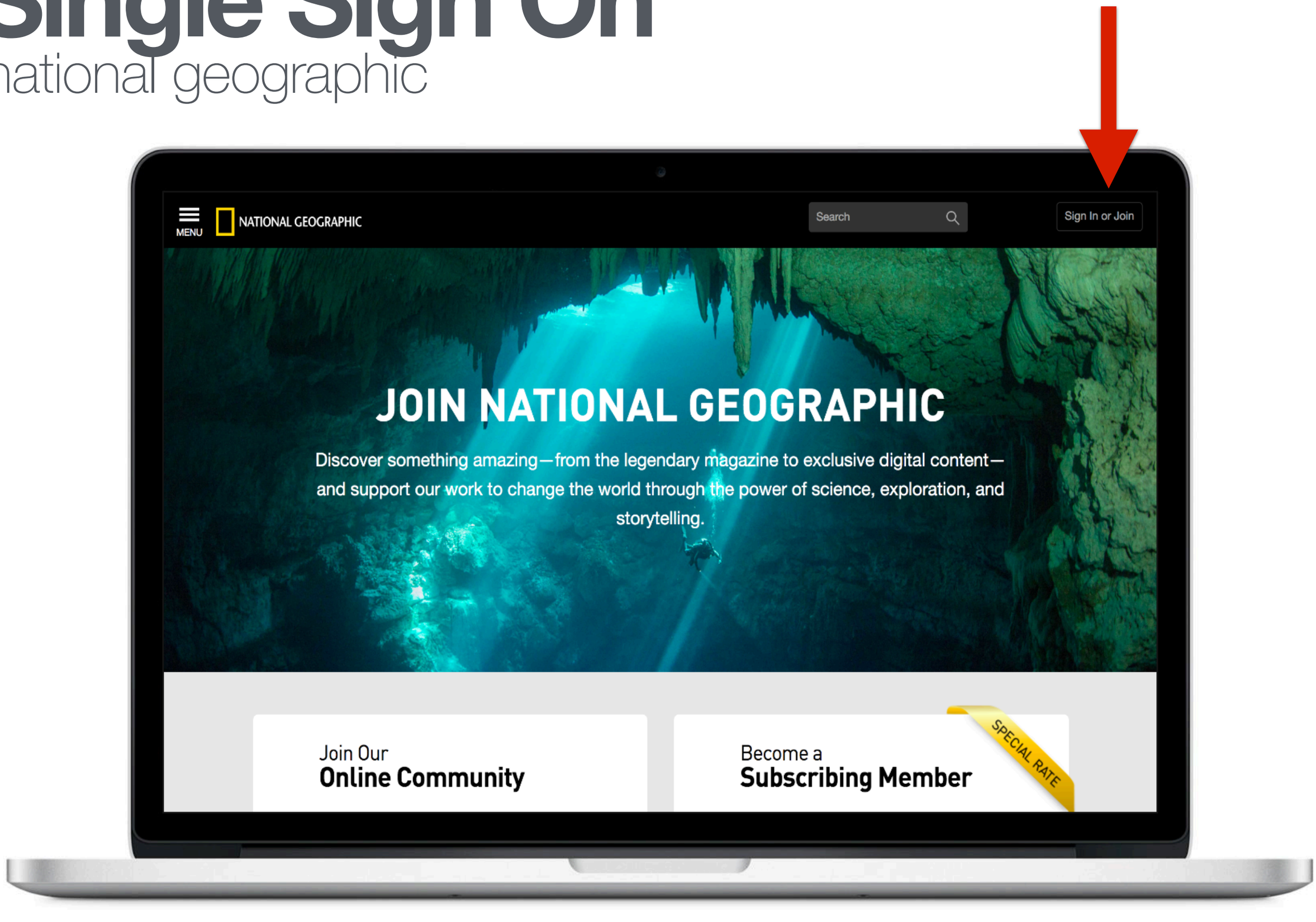


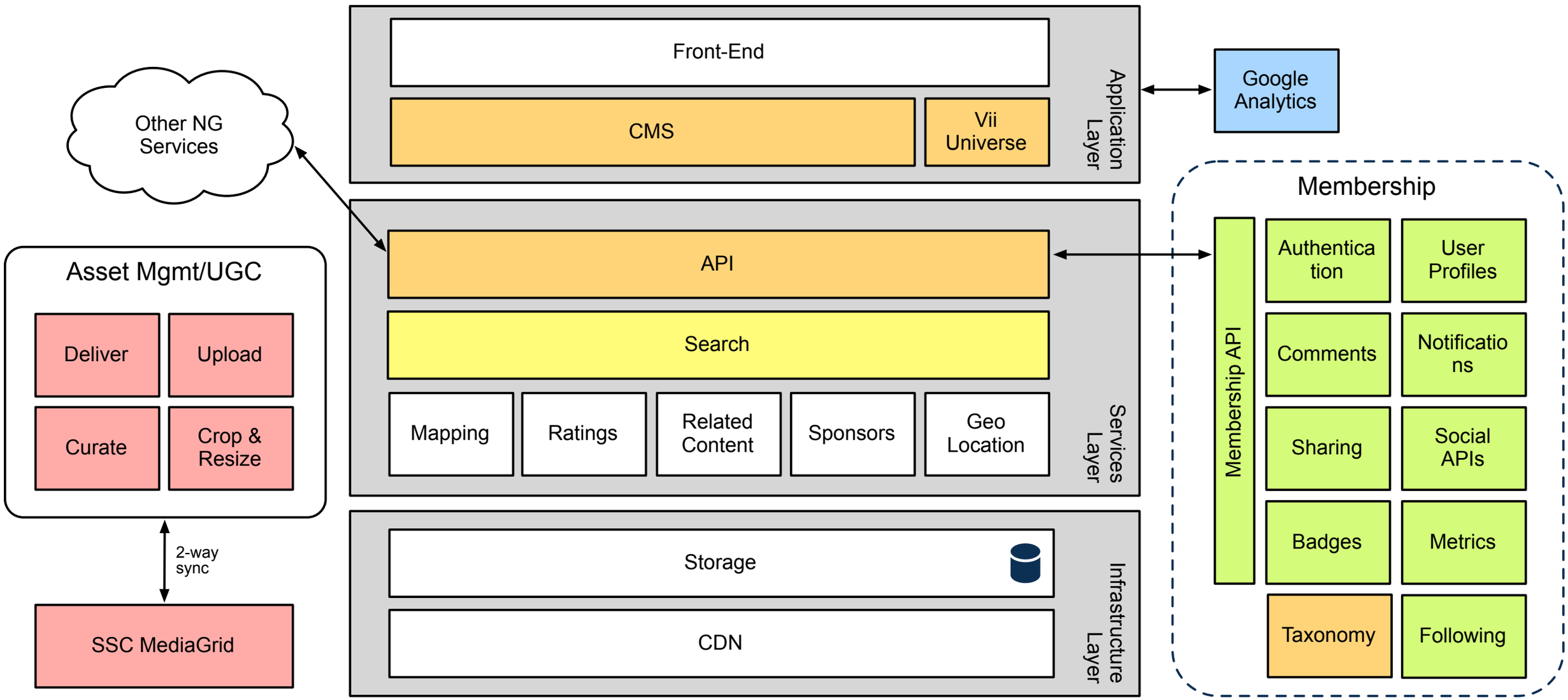
Architecture

national geographic yourshot

- Python 2.7
- Django
- Postgres
- Elasticsearch
- RabbitMQ
- Memcached
- Akamai
- Psycopg2
- Pillow
- Celery
- Haystack
- Gigya
- Mapbox

Architecture

national geographic yourshot



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Challenge: Migrate 356k user logins, invisibly.

Starting points.

Legacy users database.

```
myshot=# select * from users;
  username   |                password
-------------+-------------------------------
 kingdiamond | $1$AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1
 kingbuzzo   | $1$Pop9WeOo$2XqJ67vVoIh74Ybk6gSqK1
 ...
(354,992 rows)
```

- It's a Postgres database!
- Password is encrypted.
- Follows a format: **1_____$_____**

Starting out.

Found this Perl script.

```
#!/usr/bin/perl

...

my $db = “dbi:Pg:dbname=${db_name};host=${db_host}";

...

my $sth = $dbh->prepare("INSERT INTO users (username, password)
                         VALUES (?, CRYPT(?, GEN_SALT('md5')));");

my $result = $sth->execute($username, $password);
```

Approach #1.

Crack the passwords.

Approach #1.

Crack the passwords.

- Sweet. This sounds fun!
- How is this done?
  - Brute force.
  - Identify encryption algorithm.
  - Encrypt **every possible password** with same algorithm.
  - Find matches.

575e22bc356137a41abdef379b776dba

What we know about…

575e22bc356137a41abdef379b776dba

- It's a raw md5, one-way hash.
- To keep it simple today…
  - Password length is 4 characters.
  - Character set alphanumeric (a-z, A-Z, 0-9).
  - 62^4 = **14,776,336 possible passwords**.

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Crack password.

Raw md5 hash in Python.

```
import hashlib, itertools, string, sys, time

hash = sys.argv[1]

# All 14,776,336 4 character passwords (alphanumeric only!)
char_set = string.ascii_letters + string.digits
all_passwords = map(''.join, itertools.product(char_set, repeat=4))

start = time.time()
for attempt in all_passwords:
    if ciphertext == hashlib.md5(attempt.encode('utf-8')).hexdigest():
        elapsed = (time.time()-start)
        print('Cracked in', elapsed, 'seconds. Password is:', attempt)
        break
else:
    elapsed = (time.time()-start)
    print('Can\'t crack password.', elapsed, 'seconds elapsed.')
```

Crack password.

Cracked md5 hash in Python.

```
$ python crack.py 575e22bc356137a41abdef379b776dba
Cracked in 5.562524080276489 seconds. Your password is: thor
```

- Password is **thor**.
- Cracked in 5.5 seconds.
- Single threaded.
- But…
  - Short password.
  - Limited character set.

Crack password.

md5 hash with John the Ripper.

- Fast password cracker
- Detects weak Unix passwords
- http://www.openwall.com/john/


```
$ john --format=Raw-MD5 hash.txt
Loaded 1 password hash (Raw-MD5 [MD5 128/128 SSSE3 20x])
Press 'q' or Ctrl-C to abort, almost any other key for status
thor             (?)
1g 0:00:00:03 DONE 3/3 (2017-03-26 16:23) 0.2512g/s 509086p/s 509086c/s
509086C/s than..thio
Use the "--show" option to display all of the cracked passwords reliably
Session completed
```

Crack password.

Speed considerations.

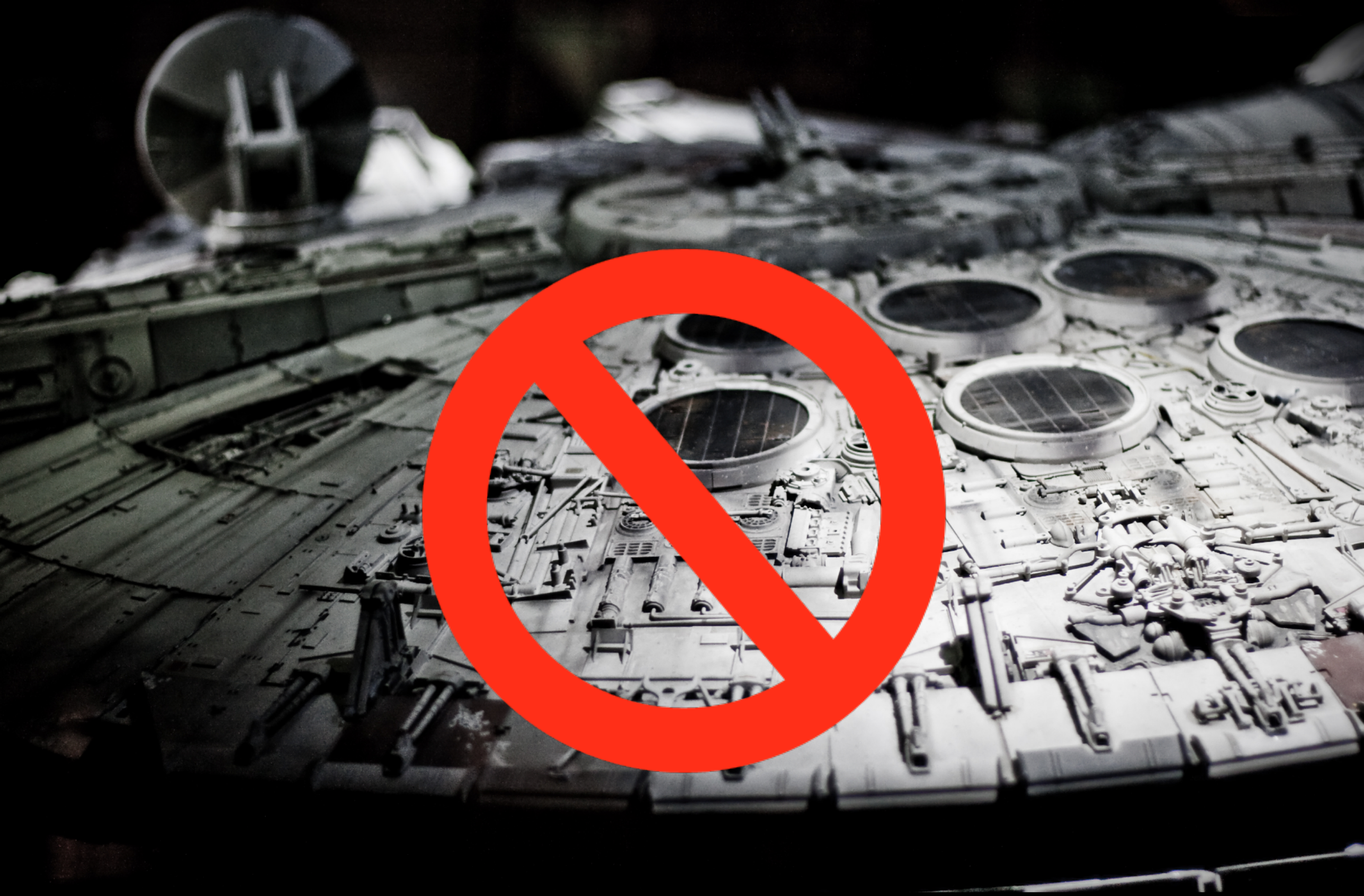
- 14,776,336 attempts in ~17.9 seconds.
- Or ~0.000001 seconds per attempt.
- This is just 4 character passwords.
- For 8-12 character passwords…

3,279,156,377,874,257,103,616 possibilities.

Crack the password.

Speed considerations.

- Remember, ~0.000001 seconds per attempt,
- Times 3,279,156,377,874,257,103,616 possibilities,
- Equals 3,965,458,719,643,761 seconds.
- That's **125,743,871 years!**



12 parsecs!

Photo: Adam Selwood (CC)

Crack password.

Speeding it up.

- Delegate some computing to a GPU.
- Parallel processing.
- Use a supercomputer.
- Use “the cloud”.
- Cheat.

Google

575e22bc356137a41abdef379b776dba

All Maps Videos Images Shopping More Settings Tools

About 170 results (0.51 seconds)

thor MD5: 575e22bc356137a41abdef379b776dba decrypted ...

md5decoder.org/575e22bc356137a41abdef379b776dba

Decrypted MD5: **575e22bc356137a41abdef379b776dba** is thor, other hashes: SHA1: 14051859736dd70525af7cbbbadfb687c175ca12, SHA2, RIPEMD, CRC, ...

Descifrado de 575e22bc356137a41abdef379b776dba

descodificar.claveycontraseña.es/575e22bc356137a41abdef379b77... - Translate this page

Descodificación y descifrado de **575e22bc356137a41abdef379b776dba**.

THOR - Description, name and nickname generator for THOR

https://nickfinder.com/THOR

Profile link, Site title and description. airlineforums.com/user/17061-thor/. Air Travel Flying. airsoft-forums.co.uk/index.php/user/1983-thor/. AF-UK Airsoft.

HashDecryption.com - Passwords Recovery Online

https://hashdecryption.com/h/plain/thor

md2('thor'), 7e1f33dabad688df108fc4ca5a42a6ab. md4('thor'), c320ec9188c003d75ab15c2b2e6a1b6b. md5('thor'), **575e22bc356137a41abdef379b776dba**.

68916 - Requested MD5 Hash queue

www.md5this.com/list.php?page=68916&key=1&author=ToXiC...city...

Mar 27, 2011 - 50 posts

Added: Sun 27th Mar,2011 11:11 am, Hash: **575e22bc356137a41abdef379b776dba**, Plain: thor. Added:

MD5decoder.org

thor MD5: 575e22bc356137a41abdef379b776dba hashes

MD5 to decode, or a word to encode... search

Put MD5 or a word

thor

Phrase: "thor" hashed with MD5 is: **575e22bc356137a41abdef379b776dba**

Other hashes

Below You can find all supported hashes for the phrase: "thor"

md2 ('thor') 7e1f33dabad688df108fc4ca5a42a6ab	**md4 ('thor')** c320ec9188c003d75ab15c2b2e6a1b6b
md5 ('thor') 575e22bc356137a41abdef379b776dba	**sha1 ('thor')** 14051859736dd70525af7cbbbadfb687c175ca12

Rainbow tables.

What are they?

- Precomputed table for reversing cryptographic hash functions, usually for cracking password hashes.
- RainbowCrack

```
736ff6a958d6b1c54b897be957323698 thom
88a2a07910827e18acb9a179be5fd798 thon
87cce92f7e96e2795d23e3655ce4c1f0 thoo
36049489e88e3ad83898d13799dae5c6 thop
8527fbb29fa42593243c4f7479be219d thoq
575e22bc356137a41abdef379b776dba thor
71140632a1cdac9f05998b786dd1850d thos
10e03f5f31c2dc5fd5e659e88fd7d087 thot
d39f3967327daee70fac2431efa0d93d thou
a0eb8790c45e7f8470db70332df0c480 thov
e339c57f6f97365e01c6ef59ca33ca6c thow
```

Rainbow tables.

Defending against rainbow cracks.

- Salt it! `hash(password + salt)`
- Stretch it! `hash(hash(hash(hash(password))))`
- Strengthen it! `len(password) > 16`

```
# Salt
hashlib.md5((password + salt).encode(‘utf-8')).hexdigest()

# Stretch
for _ in range(10000):
    hashed = hashlib.md5(hashed.encode('utf-8')).hexdigest()
```

What about our passwords?

Can we crack ‘em?

- Password format: **1_____$_____**
  - **$1** indicates the algorithm (md5crypt).
  - **$_____** is the salt.
  - **$_____** is the hashed password.
- `CRYPT(‘password’, GEN_SALT(‘md5’))`

These are salted, md5crypt hashes generated by the pgcrypto extension.

Google

1AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1

All Maps Shopping Images News More Settings Tools

Your search - **1AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1** - did not match any documents.

Suggestions:

- Make sure all words are spelled correctly.
- Try different keywords.
- Try more general keywords.
- Try fewer keywords.

What about our passwords?

Still brute forceable, but slow.

hashes/pgcrypto.txt

```
$1$AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1
```

Let's crack it with John the Ripper.

```
$ john –format=md5crypt hashes/pgcrypto.txt
Loaded 1 password hash (md5crypt, crypt(3) $1$ [MD5 128/128 SSSE3 20x])
Press 'q' or Ctrl-C to abort, almost any other key for status
thor             (?)
1g 0:00:01:37 DONE 3/3 (2017-03-27 16:38) 0.01024g/s 20766p/s 20766c/s
20766C/s than..thio
Use the "--show" option to display all of the cracked passwords
reliably
Session completed
```

Approach #2.
Django auth backend.

Django auth backend.

Using the legacy database.

- Django tries auth backend in sequence.
- A custom auth backend requires just 2 methods.
  - `get_user(user_id)`
  - `authenticate(**credentials)`
- Let's authenticate against the legacy users table.

```
AUTHENTICATION_BACKENDS = [
    'django.contrib.auth.backends.ModelBackend',
    'pgcrypto_avast.auth.backends.LegacyAuthBackend',
]
```

Django auth backend.

Get user.

- Getting the user is simple.
- After a user is authenticated, we need ensure a Django user is created.

```
from django.contrib.auth.models import User

class LegacyAuthBackend(object):

    def get_user(self, user_id):
        try:
            return User.objects.get(pk=user_id)
        except User.DoesNotExist:
            return None
```

Django auth backend.

Authenticate.

- Expects a username and password.
- Validates against the legacy database using the `pgcrypto.crypt()` method.
- Salt is extracted from hashed password.

```
SELECT 1 FROM legacy_users WHERE username=%s
    AND password=CRYPT(%s, password)
```

Django auth backend.

Authenticate.

```
class LegacyAuthBackend(object):

    def authenticate(self, username=None, password=None):
        with connection.cursor() as cursor:
            cursor.execute("SELECT 1 FROM legacy_users WHERE username=%s AND \
                           password=CRYPT(%s, password)",
                           [username, password])
        row = cursor.fetchone()
    if row:
        try:
            user = User.objects.get(username=username)
        except User.DoesNotExist:
            # Create a new user. Set an unusable password because only the
            # legacy_users password is checked.
            user = User(username=username)
            user.set_unusable_password()
            user.save()
        return user
    return None
```

Django auth backend.

Demo.

```
pgcrypto_avast=# \dt
                  List of relations
 Schema |            Name             | Type  |   Owner
--------+-----------------------------+-------+-----------
 ...
 public | auth_user                   | table | dengelson
 public | legacy_users                | table | dengelson
 ...
(11 rows)


pgcrypto_avast=# SELECT * FROM legacy_users;
  username   |                password
-------------+-----------------------------------
 kingdiamond | $1$AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1
 kingbuzzo   | $1$Pop9WeOo$2XqJ67vVoIh74Ybk6gSqK1
(2 rows)
```

Select user to change

ADD USER +

Search

Action: --------- Go 0 of 1 selected

	USERNAME	EMAIL ADDRESS	FIRST NAME	LAST NAME	STAFF STATUS
☐	drew	drew@engelson.net	Drew	Engelson	✓

1 user

FILTER

By staff status

All
Yes
No

By superuser status

All
Yes
No

By active

All
Yes
No

Django administration

Username:

kingbuzzo

Password:

••••

Log in

Change user

HISTORY

Username: kingbuzzo

Required. 150 characters or fewer. Letters, digits and @/./+/-/_ only.

Password: **No password set.**

Raw passwords are not stored, so there is no way to see this user's password, but you can change the password using this form.

Personal info

First name: King

Last name: Buzzo

Email address: kingbuzzo@example.com

Permissions

☑ Active

Designates whether this user should be treated as active. Unselect this instead of deleting accounts.

☑ Staff status

Designates whether the user can log into this admin site.

☑ Superuser status

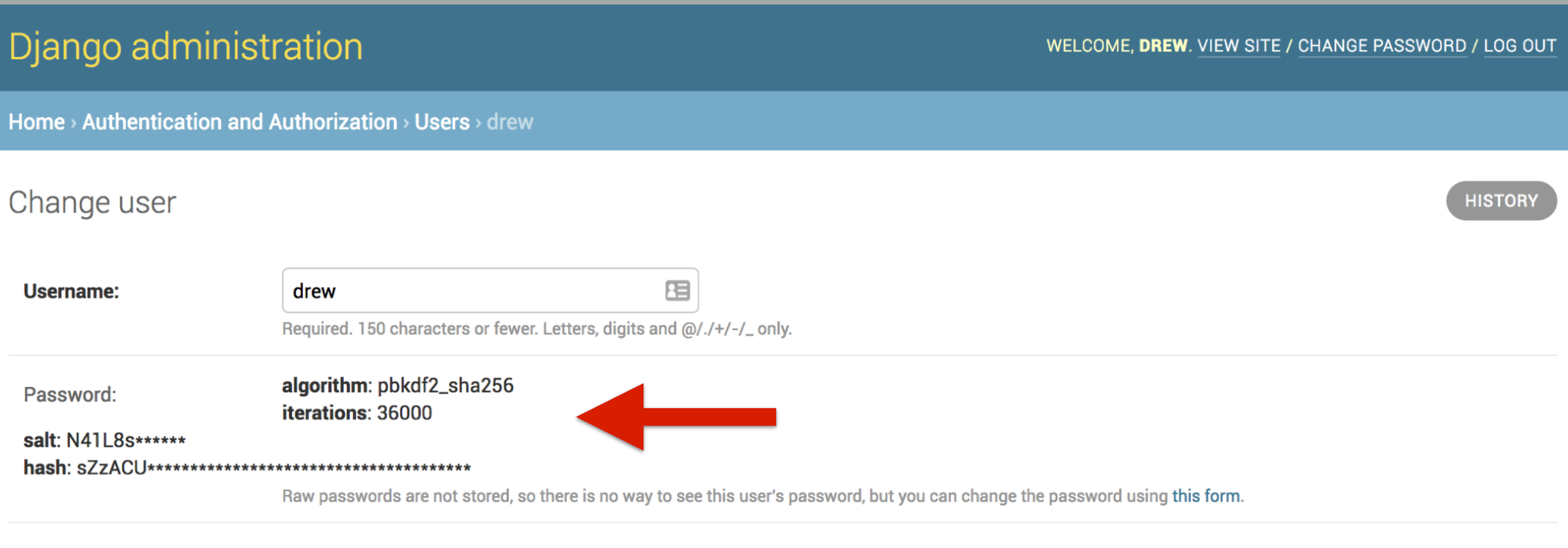
Designates that this user has all permissions without explicitly assigning them.

Approach #3.
Django password hasher.

Password hashers.

How Django stores passwords.

- By default, **PBKDF2** algorithm with a **SHA256 hash.**
- Password stretching - 36,000 iterations. (Django 1.11)
- And a random salt.



Password hashers.

How Django stores passwords.

<algorithm>$<iterations>$<salt>$<hash>

```
>>> user.password
'pbkdf2_sha256$36000$N41L8srmtbwm$sZzACUVNArYmNGV9ZYdqO7KeCd2VXnpE+MXh7tZzwKg='
```

Default password hashers

```
>>> settings.PASSWORD_HASHERS
[
    'django.contrib.auth.hashers.PBKDF2PasswordHasher',
    'django.contrib.auth.hashers.PBKDF2SHA1PasswordHasher',
    'django.contrib.auth.hashers.Argon2PasswordHasher',
    'django.contrib.auth.hashers.BCryptSHA256PasswordHasher',
    'django.contrib.auth.hashers.BCryptPasswordHasher',
]
```

Password hasher.

Custom password hasher.

- Subclass `django.contrib.auth.hashers.BasePasswordHasher`
- When creating your own hasher, you must override…
  - `algorithm`
  - `verify()`
  - `encode()`
  - `safe_summary()`
- Other methods.
  - `salt()`
  - `must_upgrade()`
  - `harden_runtime()`

Password hasher.

Custom password hasher.

```
class LegacyPasswordHasher(BasePasswordHasher):

    algorithm = 'pgcrypto'

    def salt(self):
        with connection.cursor() as cursor:
            cursor.execute("SELECT gen_salt('md5')")
            _salt = cursor.fetchall()[0][0]
            return _salt

    def encode(self, password, salt=None):
        assert password
        if not salt:
            salt = self.salt()
        with connection.cursor() as cursor:
            cursor.execute("SELECT crypt(%s, %s)", [password, salt])
            pghash = cursor.fetchall()[0][0]
            return "%s$%s" % (self.algorithm, pghash)
```

Password hasher.

Custom password hasher.

```
class LegacyPasswordHasher(BasePasswordHasher):
    ...
    def verify(self, password, encoded):
        algorithm, pghash = encoded.split('$', 1)
        assert algorithm == self.algorithm
        encoded_2 = self.encode(password, pghash)
        return constant_time_compare(encoded, encoded_2)

    def safe_summary(self, encoded):
        algorithm, pghash = encoded.split('$', 1)
        assert algorithm == self.algorithm
        return OrderedDict([
            (_('algorithm'), algorithm),
            (_('hash'), mask_hash(pghash)),
        ])

    def harden_runtime(self, password, encoded):
        pass
```

Password hashers.

Demo.

Create a new user, then give custom password hash.

```
pgcrypto_avast=# UPDATE auth_user
pgcrypto_avast=# SET password='pgcrypto$$1$AEm9NDkI$z9YLtNHjckjz5ZMmsNUrX1'
pgcrypto_avast=# WHERE username='kingdiamond';
UPDATE 1
```

Django administration

WELCOME, **DREW**. VIEW SITE / CHANGE PASSWORD / LOG OUT

Home › Authentication and Authorization › Users › kingdiamond

Change user

HISTORY

Username: kingdiamond

Required. 150 characters or fewer. Letters, digits and @/./+/-/_ only.

Password:

algorithm: pgcrypto
hash: 1AEm**********

Raw passwords are not stored, so there is no way to see this user's password, but you can change the password using this form.

Django administration

Username:

kingdiamond

Password:

••••

Log in

Change user

HISTORY

Username: kingdiamond

Required. 150 characters or fewer. Letters, digits and @/./+/-/_ only.

Password:

algorithm: pbkdf2_sha256
iterations: 36000

salt: QLCQJE******
hash: UHs93B**********

Raw passwords are not stored, so there is no way to see this user's password, but you can change the password using this form.

Personal info

First name: King

Last name: Diamond

Email address: kingdiamond@example.com

Permissions

☑ Active

Designates whether this user should be treated as active. Unselect this instead of deleting accounts.

☑ Staff status

Designates whether the user can log into this admin site.

Thank you!

Links and examples

https://github.com/tomatohater/pgcrypto-avast

Slides

http://tomatohater.com

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