

Collecting Data with Serverless Applications

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Tutorial Agenda

- Goal: learn about serverless computing through a sample application (data collection)
- What is (all) the FaaS (Function-as-a-Service aka Serverless)?
- Introduction to Apache OpenWhisk / IBM Cloud Functions
- Simple application to collect data
- Hands-on exercises

Quick Intro



Masters in distributed systems

PhD in computer architecture

Intern at Intel Research Labs and IBM Research



Joined 2012 as Research Staff Member

Runtimes for heterogeneous computing

programming languages, compilers, runtimes, GPUs, FPGAs

Infrastructure for cloud computing

OpenWhisk/FaaS/Serverless, open source, research to product

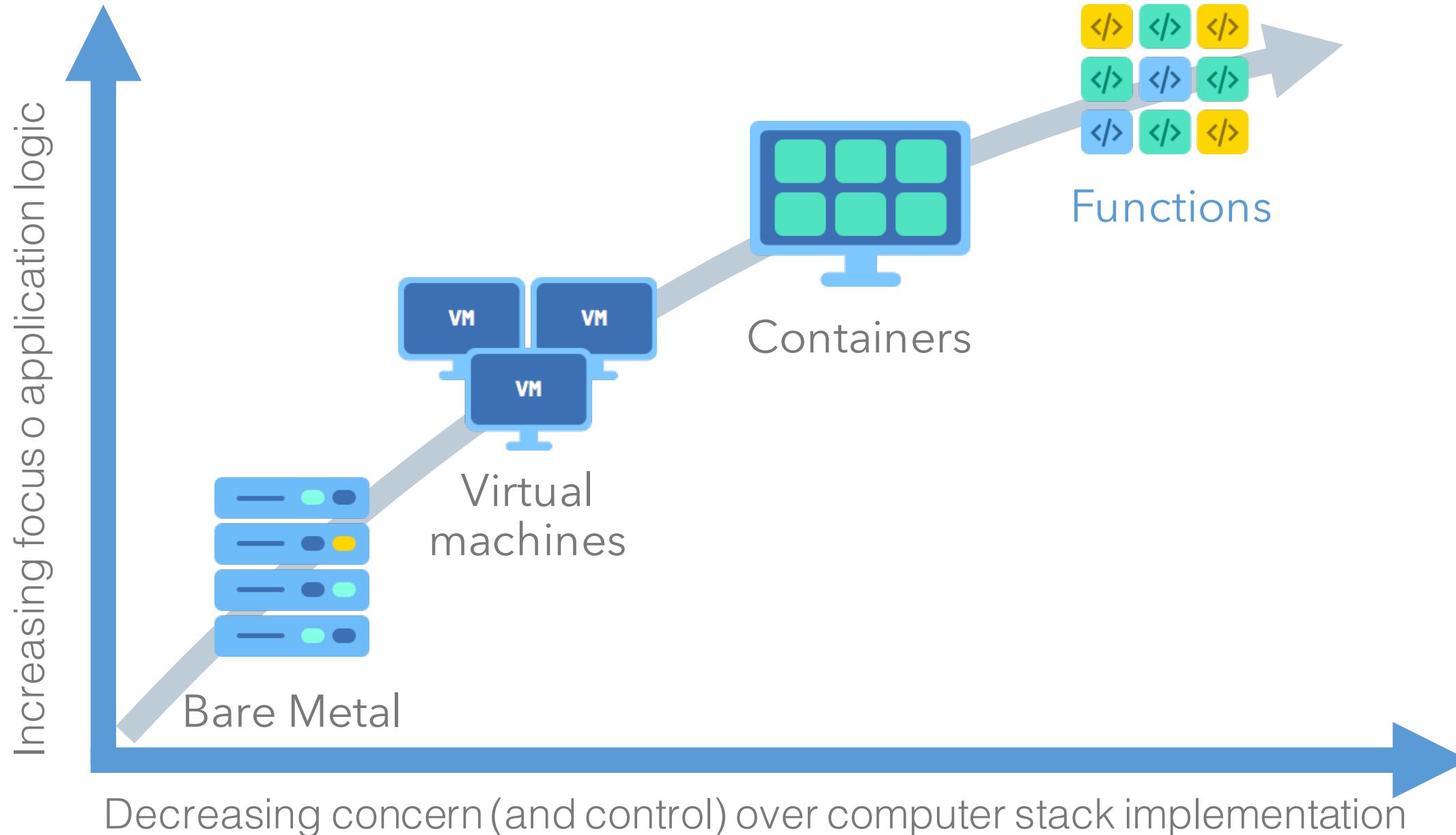
Science for social good

IBM Research AI

Intersection between machine learning/AI and cloud infrastructure/services

What is (all) the FaaS (Function-as-a-Service aka Serverless) Introduction to Serverless Computing aka Function-as-a-Service

The evolution of cloud computing (mostly wrong)



A close-up photograph of a server rack. The front panel features a grid of drive bays with blue indicator lights. Two drives are clearly visible with labels: '000 SAS FINE' and '000000 7000'. The background is dark, showing more of the server's internal structure and other bays.

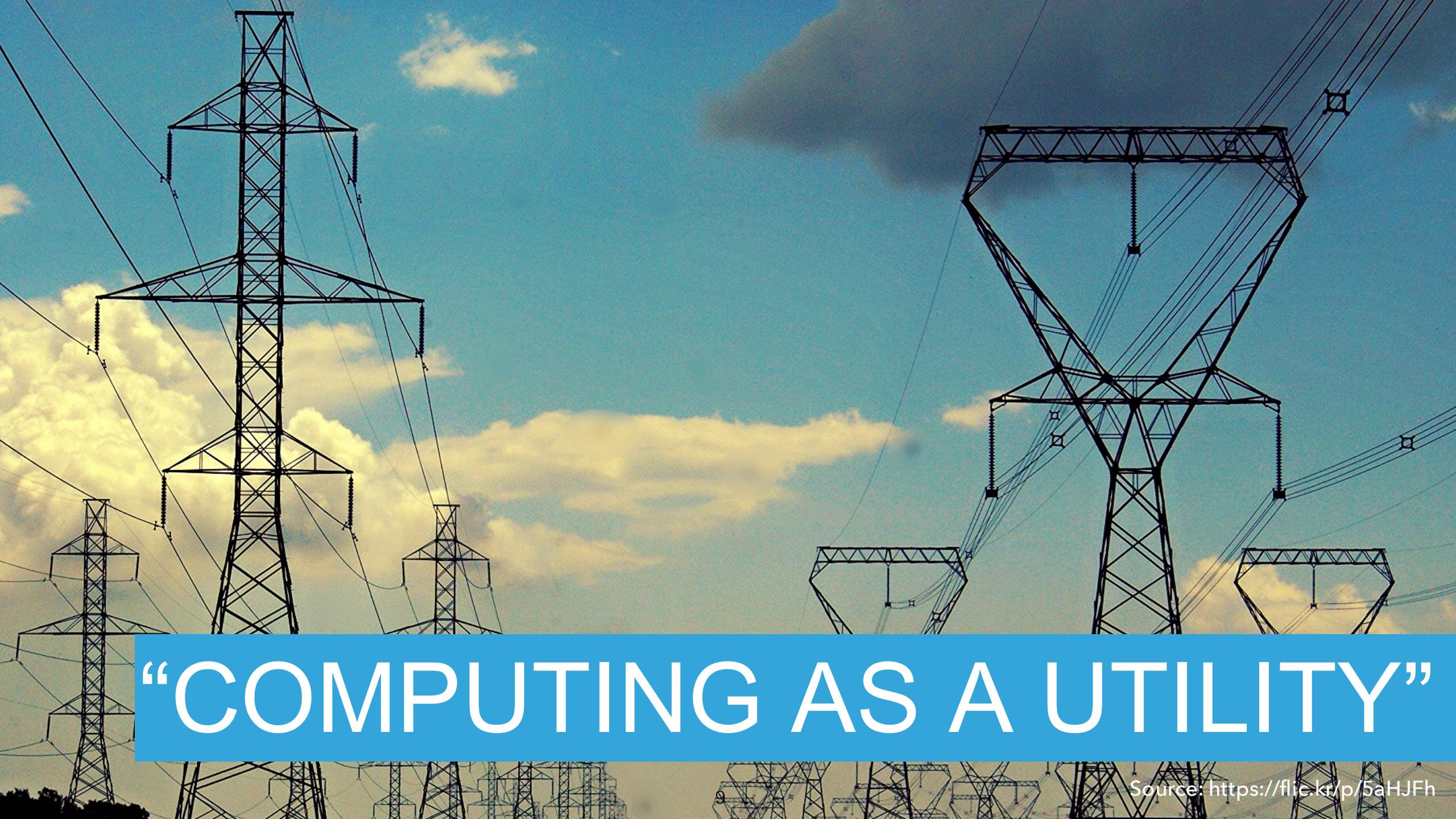
SPOILER:

THERE'S STILL SERVERS

WHY IS THIS DIFFERENT?

COMPLEXITY

flickr photo by: Bitterjug <https://flickr.com/photos/bitterjug/7670055210> CC (BY) license



“COMPUTING AS A UTILITY”

Source: <https://flic.kr/p/5aHJFh>

SEATTLE--(BUSINESS WIRE)--Nov. 13, 2014-- Today at AWS re:Invent, Amazon Web Services, Inc. (AWS), an Amazon.com company (NASDAQ: AMZN), announced

“RUNS CODE IN RESPONSE TO EVENTS, MANAGES COMPUTE RESOURCES”

compute time required to run their code. AWS Lambda charges for compute time in increments of 100 milliseconds, making it cost-effective and easy to scale apps to

...WHY IS THIS DIFFERENT?

Today, customers have many use cases where applications need compute cycles in

$f(x)$

FUNCTION-AS-A-SERVICE

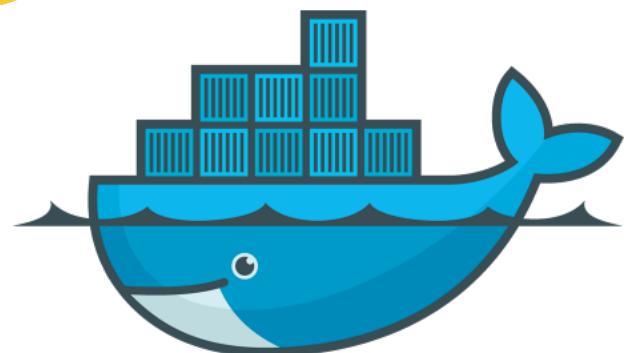


SCALING: 0 to N

PAY-AS-YOU-GO



flickr photo by a !oves dc <https://flickr.com/photos/alovesdc/3466740007> CC (BY) license



KEEP
CALM
AND
BE A
POLYGLOT

WHAT IS SERVERLESS (FaaS)

$$f(x) =$$

CLOUD NATIVE PLATFORM

for

short-running, stateless computation

and

event-driven applications

which

scales instantly, automatically, and transparently

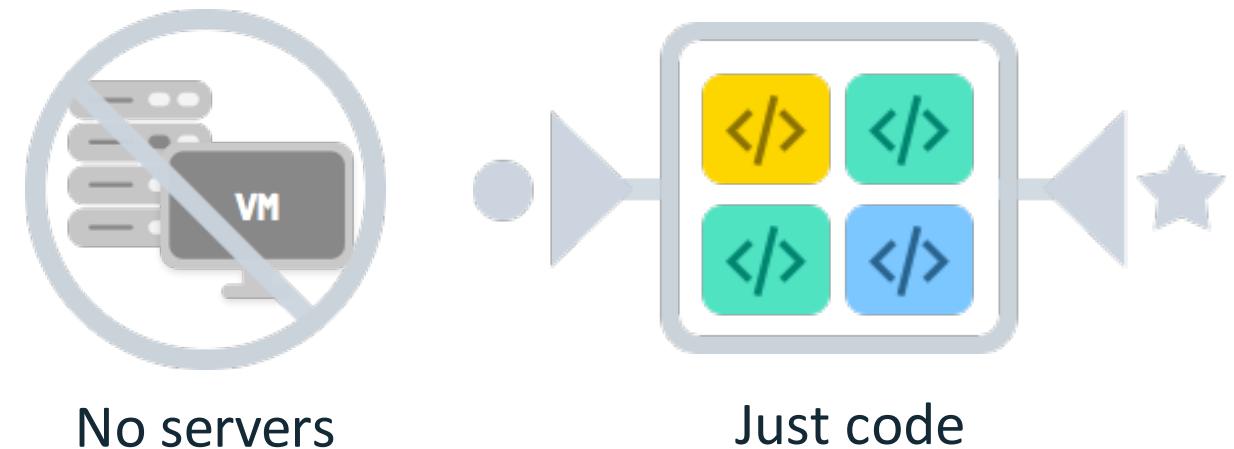
and

charges at a millisecond granularity

Serverless = Worry-less about servers

Runs code **only** on-demand on a per-request basis

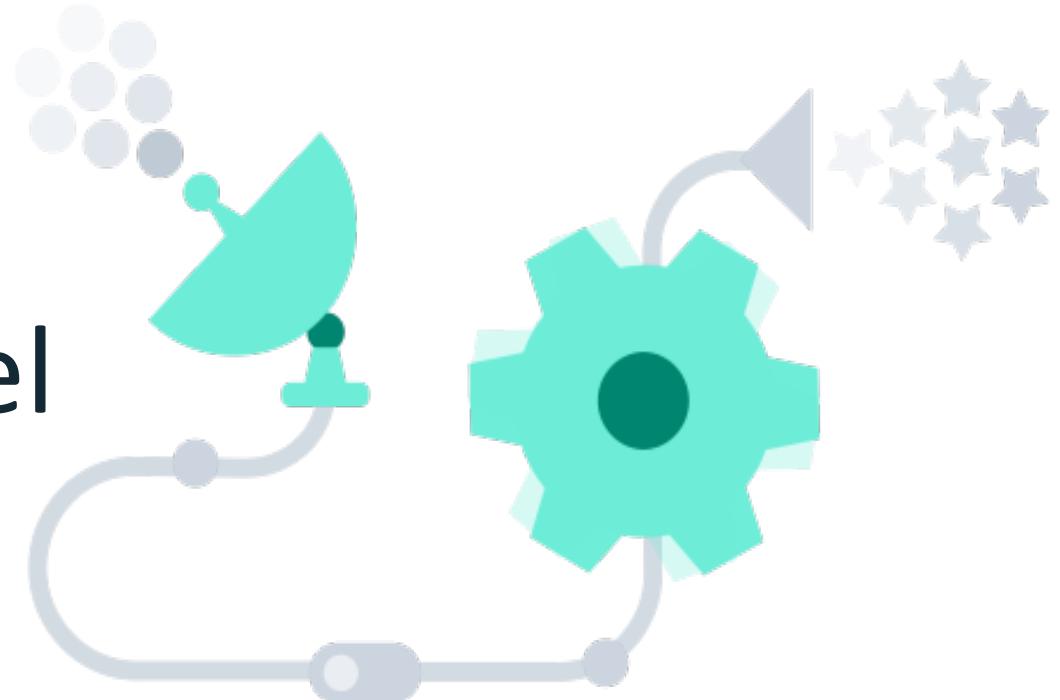
Serverless deployment & operations model



What triggers code execution?

Runs code **in response** to events

Event-programming model

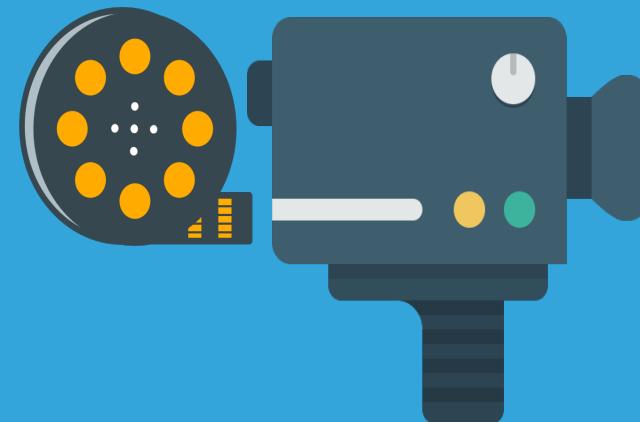


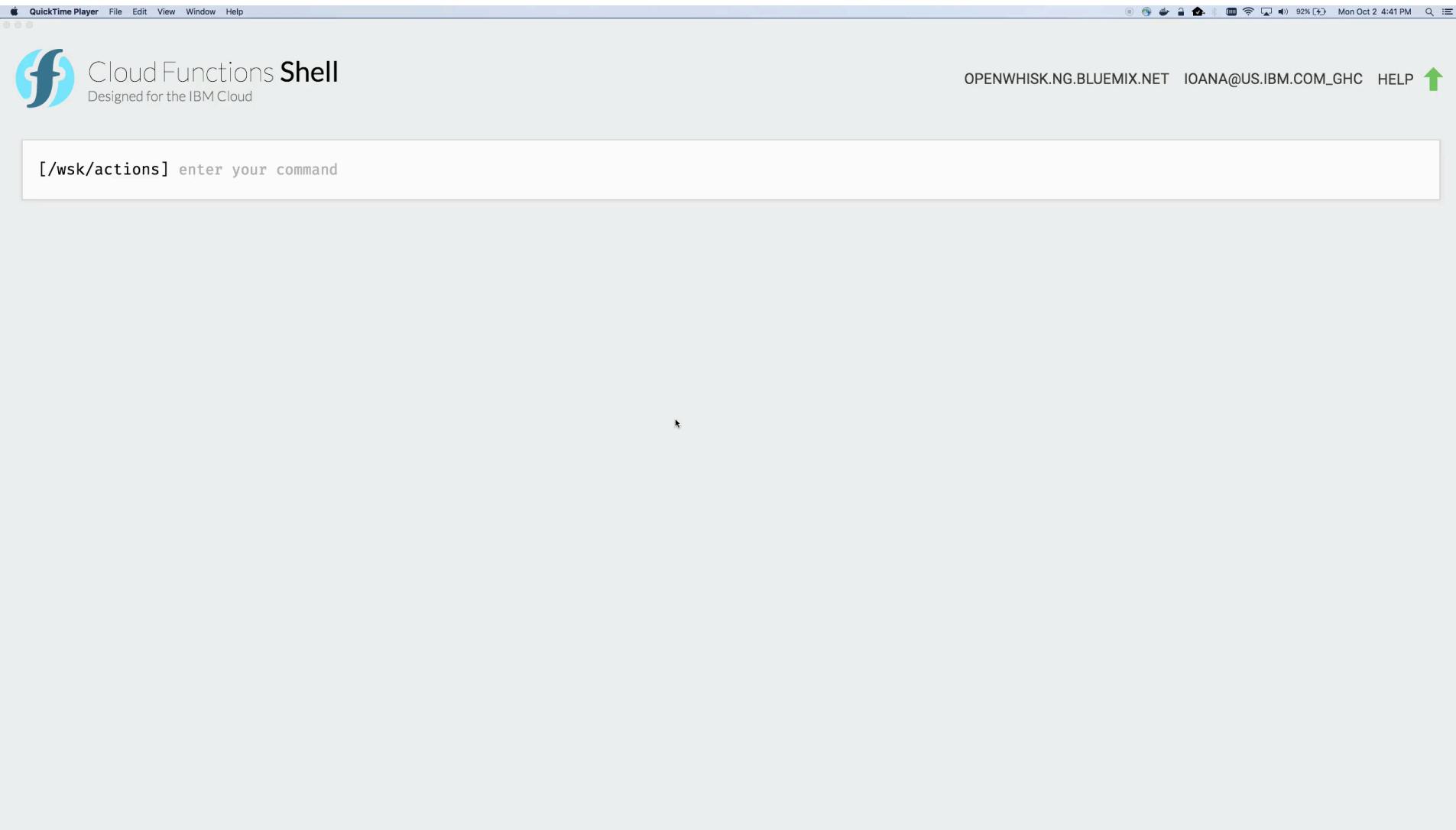
Why is Serverless attractive?

App development & ops dramatically faster, cheaper, easier

Infrastructure cost savings

DEMO: SERVERLESS HELLO WORLD





To FaaS or not to FaaS

Serverless is **good** for



*short-running
stateless
event-driven*



Microservices



Mobile Backends



Bots, ML Inferencing



IoT



Modest Stream Processing



Service integration

Serverless is **not good** for



*long-running
stateful
number crunching*



Databases



Deep Learning Training



Heavy-Duty Stream Analytics



Spark/Hadoop Analytics



Numerical Simulation



Video Streaming

Data processing



<http://ecc.ibm.com/case-study/us-en/ECCF-CDC12387USEN>

**10x faster
90% less cost**

MediaSpirit

Name elephant* Tag

Category	Count
Sukau NP	15
Berggebied, ook Gouden Driehoek	4
in gebruik	4

Captions from images:

- THAILAND-CHIANGMAI ELEPHANT CONSERVATION CENTRE (4)
- BALONG ELEPHANT (2)
- BORNEO PYGMY ELEPHANT, SUKAU (1) (2)
- BORNEO PYGMY ELEPHANT, SUKAU (15) (2)
- BORNEO PYGMY ELEPHANT, SUKAU (6) (2)
- SUKAU ELEPHANT CROSSING (4)
- BORNEO PYGMY ELEPHANT, SUKAU (14) (2)
- BORNEO PYGMY ELEPHANT, SUKAU (9) (2)
- BORNEO PYGMY ELEPHANT, SUKAU (17) (16)
- ELEPHANT PASS 2 (5)

(Some) Serverless Providers



IBM Cloud Functions



AWS Lambda



Kubernetes



Oracle



Azure Functions



Red-Hat



Google Functions

Apache OpenWhisk / IBM Functions

Introduction to serverless programming concepts



APACHE OPENWHISK

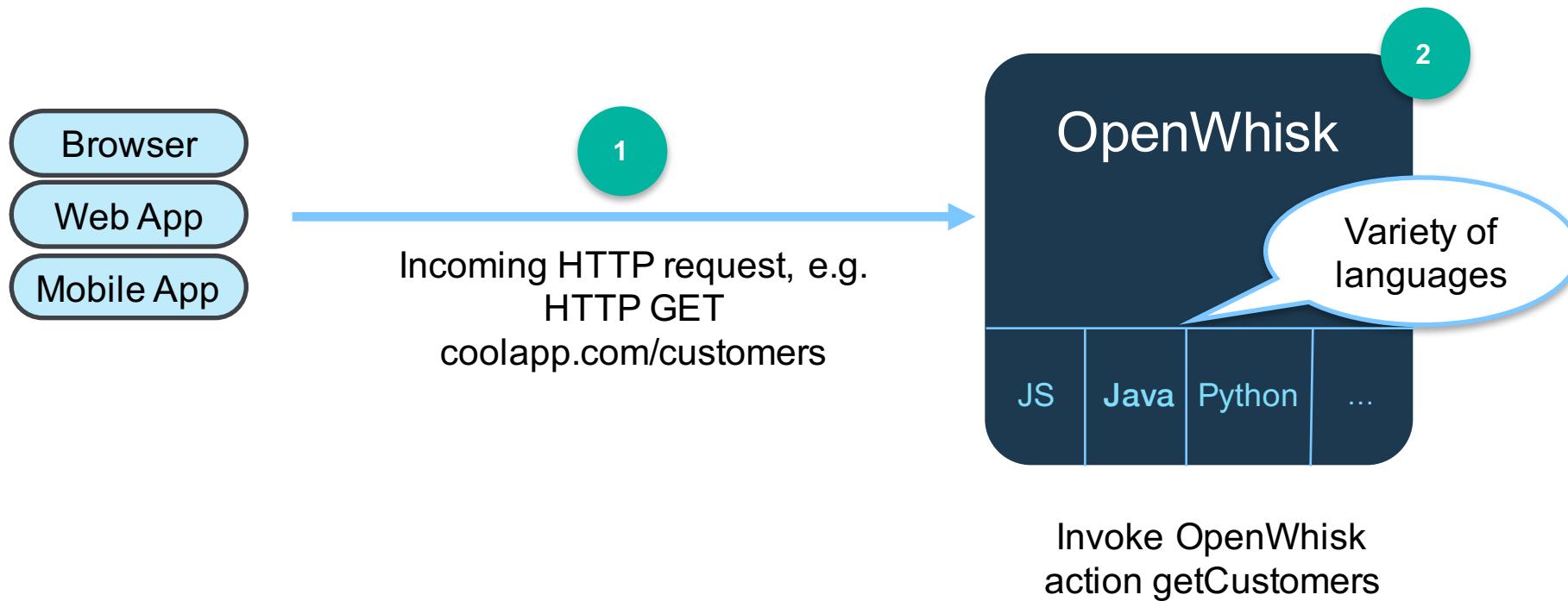
<https://openwhisk.incubator.apache.org/>



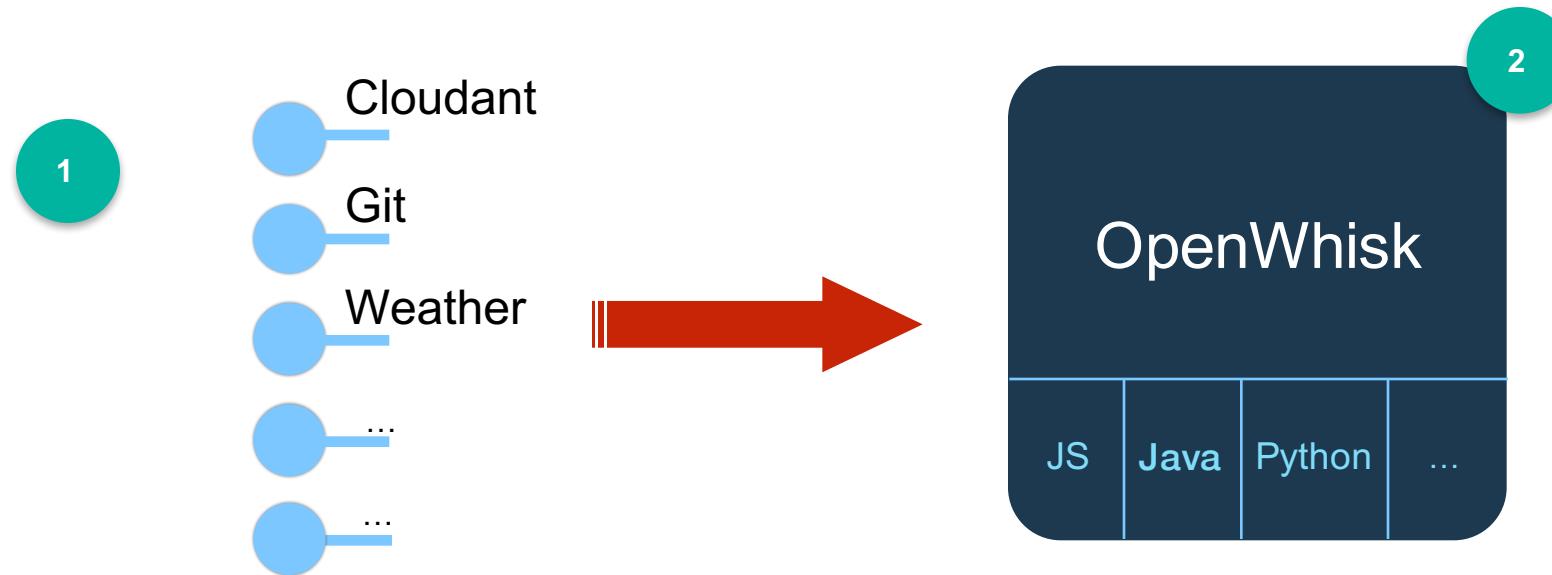
IBM CLOUD FUNCTIONS

<https://console.bluemix.net/openwhisk>

Apache OpenWhisk: How does it work?



Apache OpenWhisk: How does it work?



Data event occurs, e.g. commit on a Git repository, CRUD operation on Cloudant

Apache OpenWhisk: High Level Programming

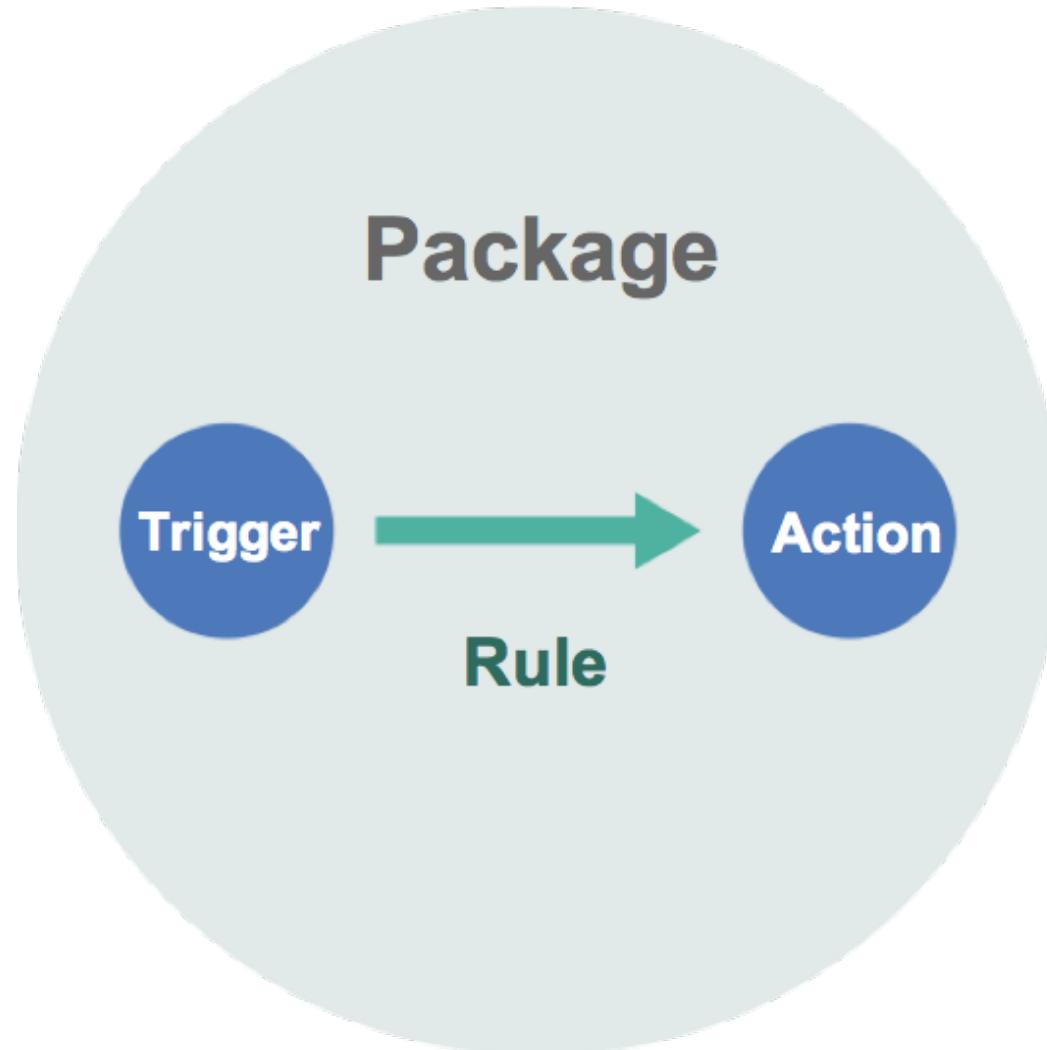
Services define the events they emit as **triggers**,
and developers associate the **actions** to handle the events via **rules**



The Serverless Trilemma: Function Composition for Serverless Computing – SPLASH'17

Ioana Baldini, Perry Cheng, Stephen J Fink, Nick Mitchell, Vinod Muthusamy, Rodric Rabbah, Philippe Suter, Olivier Tardieu

Apache OpenWhisk: High Level Programming



language support to
encapsulate, share, extend code

first-class functions
compose via sequences

Trigger

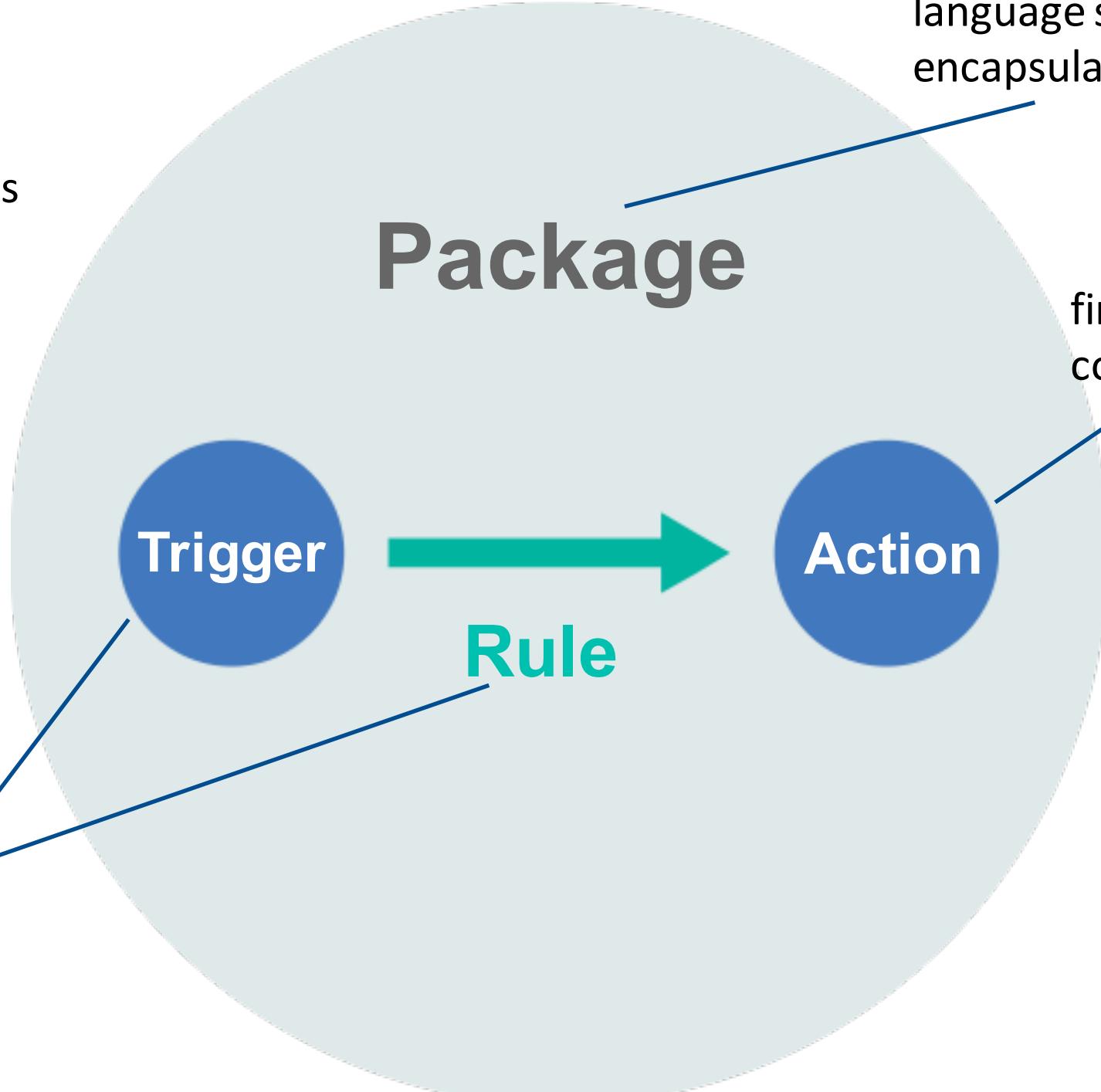
Action

Rule

first-class
event-driven
programming
constructs

all constructs first-class

Package





A

Action: a stateless function
(event handler)

A

Action: javascript



```
function main(params) {  
    console.log("Hello " + params.name);  
    return { msg: "Hello " + params.name };  
}
```

Sequences of actions

A

Can be composed to create sequences
that increase flexibility and foster reuse

$$\begin{aligned} A_A &:= A_1 + A_2 + A_3 \\ A_B &:= A_4 + A_A \\ A_C &:= A_A + A_A + A_B \end{aligned}$$

Web Actions

```
function main(params) {  
    console.log("Hello " + params.name);  
    return { body: "Hello " + params.name };  
}
```

AskNature AI Data Training

Follow the instructions in [our guide](#) and fill in the requested information for the following papers.

Name

Full name

Email

Email address

PaperID

28153982

Paper Id

Paper Title

Diel rhythms and sex differences in the locomotor activity of hawkmoths.

Authors

GT Broadhead,T Basu,M von Arx,RA Raguso

Abstract

Circadian patterns of activity are considered ubiquitous and adaptive, and are often invoked as a mechanism for temporal niche partitioning. Yet, comparisons of rhythmic behavior in related animal species are uncommon. This is particularly true of Lepidoptera (butterflies and moths), in which studies of whole-animal patterns of behavior are far outweighed by examinations of tissue-specific molecular clocks. Here, we used a comparative approach to examine the circadian patterns of flight behavior in *Manduca sexta* and *Hyles lineata*, two distantly related species of hawkmoth (Sphingidae). By filming isolated, individual animals we were able to examine rhythmic locomotor (flight) activity at the species level as well as at the level of the individual sexes, and in the absence of interference from social interaction. Our results confirm classic descriptions of strictly nocturnal behavior in *M. sexta* and demonstrate a dramatically different activity pattern in *H. lineata*. Furthermore, we show distinct species and sex-specific differences in the maintenance of the endogenous rhythm under conditions of constant darkness. In both species, female activity peaks in advance of males, whereas male activity coincides with periods of female sexual receptivity. This suggests a role for circadian patterns of locomotor activity in synchronizing periods of sexual receptivity between the sexes.

Do you think the paper may be relevant to AskNature?

- No
 Yes

Does the paper refer to a living system?

- No
 Yes

Paste the word from the abstract that identifies the living system

Paste the word from the abstract that identifies the living system.

Select the best label that characterizes a function of the living system discussed in the paper

Paste the phrase from the abstract that identifies the function

Paste the phrase from the abstract that describes the mechanism that performs the function above (if present in the text)

Optional: In your own words, summarize how the living system achieves the referenced function/s via the referenced mechanism/s

Optional: Add one more function

How confident are you in evaluating this paper?

- Very confident
 Somewhat confident
 Not confident

Explain your confidence level (optional)

Skip

Submit

Hands On Fun

Hands on fun

DSAA17 Tutorial

Paper Title

Relative colour cues improve colour constancy in birds.

Authors

P Olsson,A Kelber

Abstract

A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues - the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy - the ability to recognize colours in shifted illumination - has been studied in many animals, the use of relative colour cues is investigated more rarely. In a previous study on chickens, we measured how large a shift in illumination their colour constancy mechanisms tolerate without reliable relative colour cues. Here, we show that chickens remain colour constant over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.

Document ID

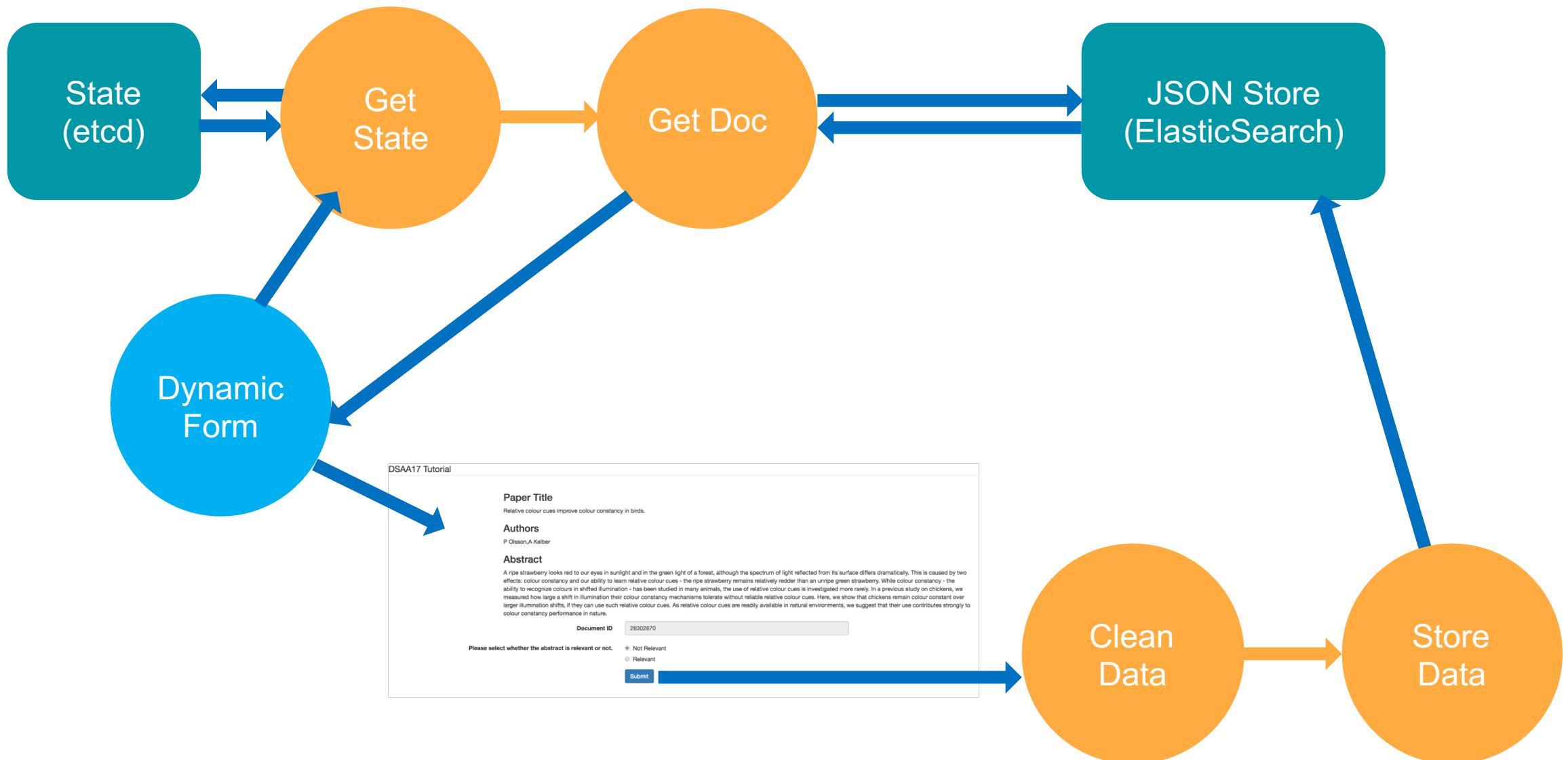
28302870

Please select whether the abstract is relevant or not.

- Not Relevant
 Relevant

Submit

Spoiler Alert...



Hands on fun

Hands on experience with Apache OpenWhisk / IBM Cloud Functions

Work through a series of simple examples

Final destination for today: collecting data the serverless way

Part 0: Account setup

Part 1: Actions and web actions

Part 2: Dynamic content

Part 3: Just a little bit of state

Part 4: Forms as web actions

Part 0

Account setup

Tutorial Setup

- To use IBM Cloud Functions proceed as follows: open a browser window and navigate to <https://console.ng.bluemix.net/openwhisk/>
- Log-in with your Bluemix account
 - Create one if you do not yet have one by clicking the sign-up link or by directly navigating to <https://console.ng.bluemix.net/registration/>
 - Region: US South, Organization: your email address, Space: DSAA
 - NOTE: You'll need to replace your email address everywhere where my email address shows up
- Code can be found here: <https://github.com/ioana-blue/dsaa17>

IBM Cloud Functions Setup

- To use IBM Cloud Functions proceed as follows: open a browser window and navigate to <https://console.ng.bluemix.net/openwhisk/>
- Click the Download CLI
 - Direct link <https://console.ng.bluemix.net/openwhisk/learn/cli>
- Follow steps 1 – 4
- For step 2: use your email address for the organization and DSAA for the space (make sure you created it from the Top Right Menu), e.g.:

```
bx login -a api.ng.bluemix.net -o ioana@us.ibm.com -s DSAA  
bx login -a api.ng.bluemix.net -o <organization> -s <space>
```

Requirements

bash

npm

zip

NOTE: for Windows users, zipped actions may not work

Adventurous?

Check out IBM Cloud Function Shell
Research lead tech preview

Install

```
npm install -g @ibm-functions/shell
```

Run

```
fsh shell
```

Part 1

Actions and Web Actions

Check Everything Is Working

List actions (there should be none)

```
bx wsk action list
```

List namespace

```
bx wsk namespace list
```

e.g.,

namespaces
ioana@us.ibm.com_DSAA

← **NAMESPACE**

Invoke a Public (Predefined) Action

Let's check everything is working

Invoke an action – bx wsk action invoke <action_name>

```
bx wsk action invoke /whisk.system/utils/echo -p message hello --result
```

Result:

```
{  
    "message": "hello"  
}
```

Hello Web Action

Create Hello World web action

```
bx wsk action update hello hello-world.js --web true
```

Invoke it

```
bx wsk action invoke hello -br
```

Web

https://openwhisk.ng.bluemix.net/api/v1/web/13a11094a0531bf9.com_DSMA/default/hello

Modify Hello Web Action: Hello DSAA17!

Modify hello-world.js to say “Hello DSAA17!”

```
bx wsk action update hello hello-dsaa17.js --web true
```

Invoke it

```
bx wsk action invoke hello -br
```

Web

https://openwhisk.ng.bluemix.net/api/v1/web/10a1194a83.1bf9.com_DSAA/default/hello

Actions with Parameter

Actions can take parameters – take a look at `hello-param.js`

```
function main(params) {
  if (params.name)
    return { body: 'Hello ' + params.name + '!' }
  return { body: 'Hello DSAA17!' }
}
```

```
bx wsk action update hello hello-param.js --web true
```

Invoke

```
bx wsk action invoke hello -p name Ioana -br
```

Web

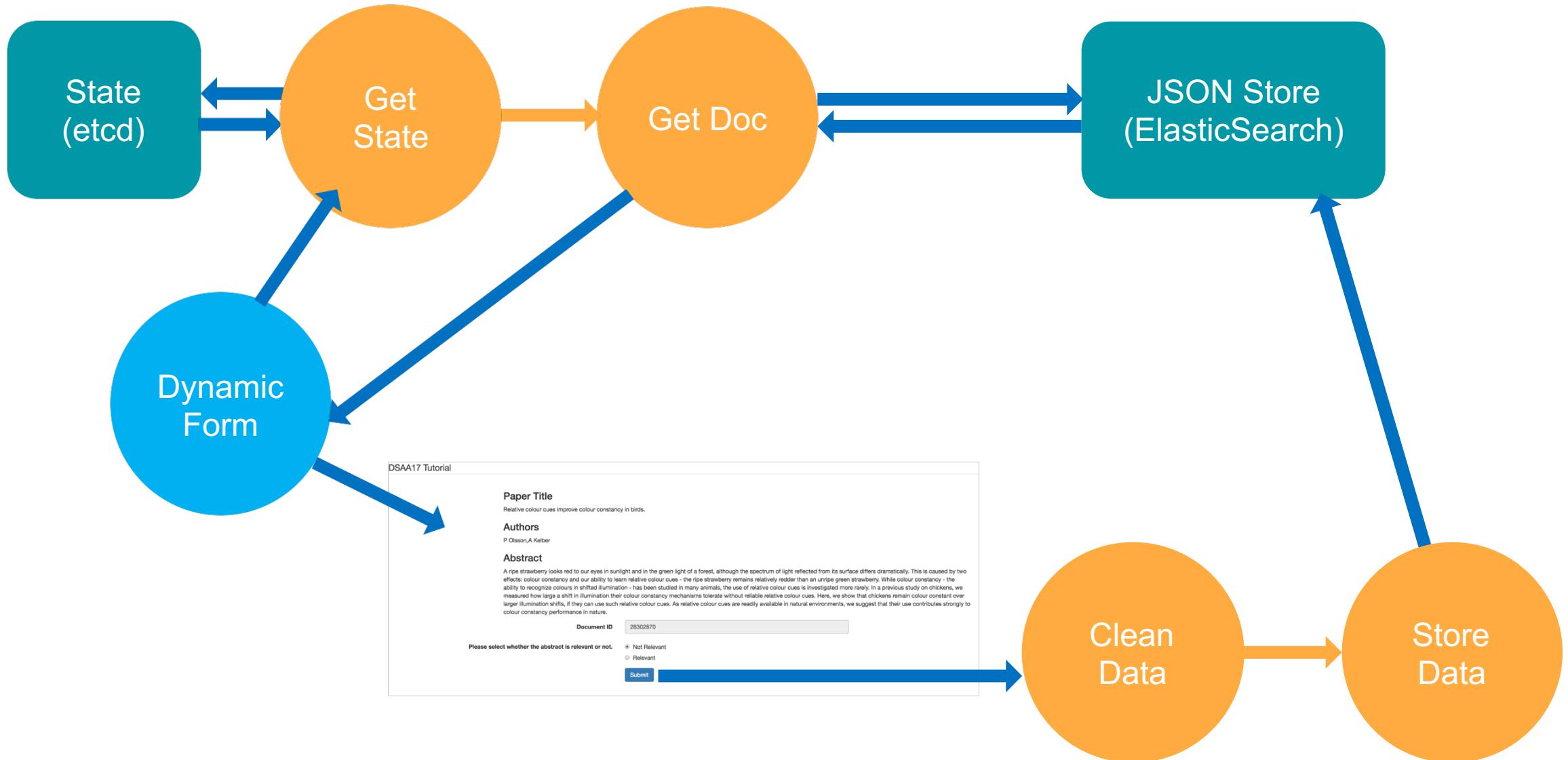
https://openwhisk.ng.bluemix.net/api/v1/web/ioana%40us.ibm.com_DSAA/default/hello

https://openwhisk.ng.bluemix.net/api/v1/web/ioana%40us.ibm.com_DSAA/default/hello?name=Ioana

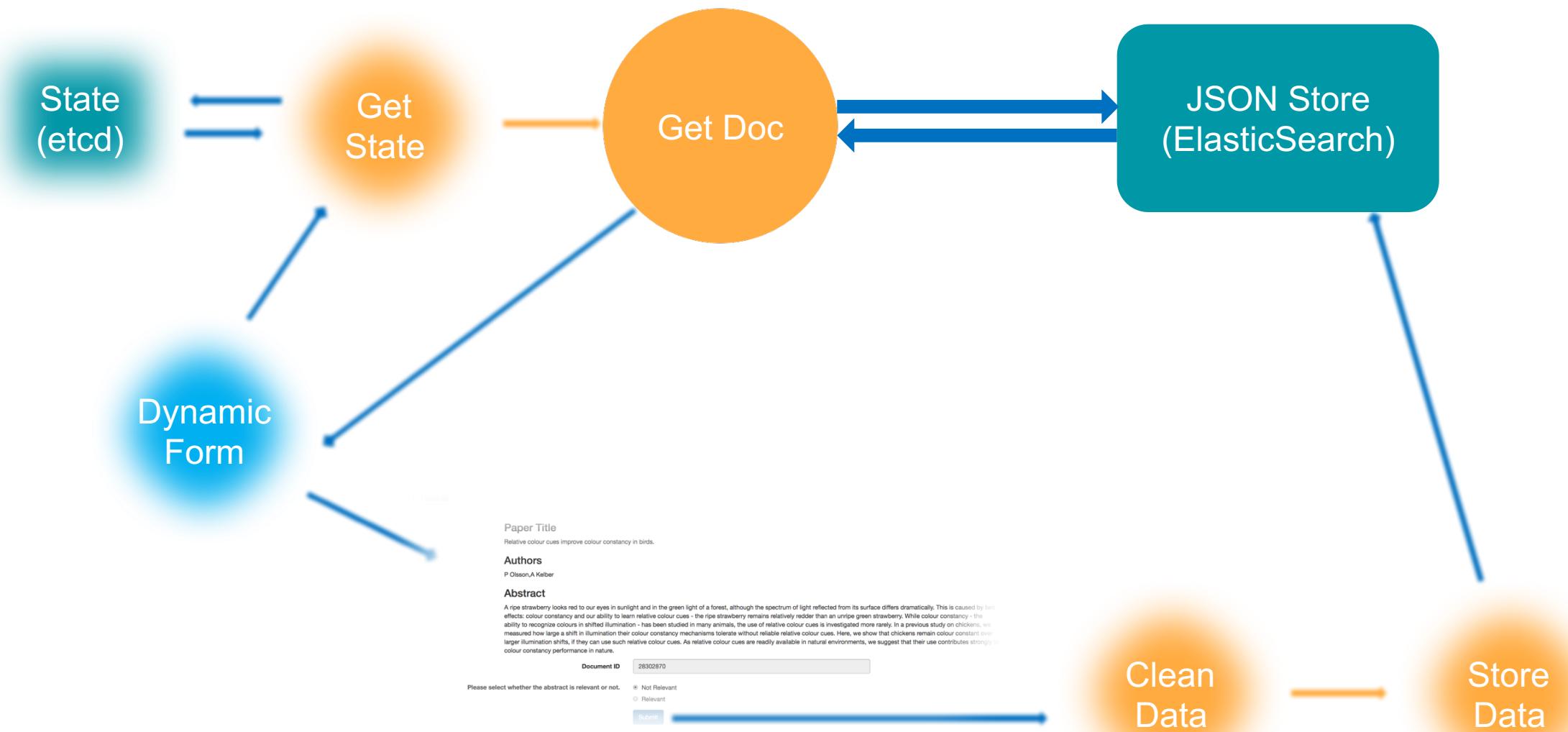
Part 2

Dynamic Content

Serverless Application



Get Doc from JSON Store



JSON Store: ElasticSearch

Let's check everything is working: ElasticSearch running in IBM BMX

Display documents in ElasticSearch

```
curl -u $ES_AUTH https://$ES_HOST/tutorial/data/_search?pretty
```

Result: 3 documents

Zipped Actions

Docs:

https://console.bluemix.net/docs/openwhisk/openwhisk_actions.html#openwhisk_actions

Package an action as a Node.js module

Code: actions/es-get-doc scripts/action-es-get-doc.sh

Zipped action: actions/es-get-doc.zip

Zipped action in one line:

action code, package.json, npm install, zip

Packages with Parameters

Packages – organize and share code

Parameters – default parameters shared with all actions within a package

```
# create package in default namespace with default parameters  
$WSK_CLI package update $PKG_NAME -p esHost $ES_HOST -p esAuth $ES_AUTH
```

Actions with Default Parameters

Default Parameter

overwrites parameter with same name from packages
overwritten by parameter with same name during invocation

```
# create action that reads doc from ES (in the default namespace)
ACTION=es-get-doc
PKG_NAME=es
INDEX=tutorial
TYPE=data

# default parameters for index and type
$WSK_CLI action update $PKG_NAME/$ACTION $ACTION.zip --kind nodejs:6 -t 300000 -p index $INDEX -p type $TYPE
```

Zipped Action: Get Doc from ES

Create the package and the zipped action

```
cd scripts; sh action-es-get-doc.sh
```

OR

Create the action from the zip file

```
# create action that reads doc from ES (in the default namespace)
ACTION=es-get-doc
PKG_NAME=es
INDEX=tutorial
TYPE=data

# default parameters for index and type
$WSK_CLI action update $PKG_NAME/$ACTION $ACTION.zip --kind nodejs:6 -t 300000 -p index $INDEX -p type $TYPE

# default parameters for index and type
bx wsk action update es/es-get-doc es-get-doc.zip --kind nodejs:6 -t 300000 -p index tutorial -p type data
```

Get Doc from ElasticSearch

Display documents in ElasticSearch

```
bx wsk action invoke es/es-get-doc -p id 1 -b -r
```

```
{  
    "_id": "1",  
    "_index": "tutorial",  
    "_source": {  
        "abstract": "A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues - the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy - the ability to recognize colours in shifted illumination - has been studied in many animals, the use of relative colour cues is investigated more rarely. In a previous study on chickens, we measured how large a shift in illumination their colour constancy mechanisms tolerate without reliable relative colour cues. Here, we show that chickens remain colour constant over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.",  
        "authors": "P Olsson,A Kelber",  
        "id": "28302870",  
        "title": "Relative colour cues improve colour constancy in birds."  
    },  
    "_type": "data",  
    "_version": 1,  
    "found": true  
}
```

Actions Calling Actions: Web Get ES Doc

web-es-doc.js

```
var openwhisk = require('openwhisk')

function main(parameters) {
    var id = 0
    if (parameters.id)
        id = parameters.id

    const name = 'es/es-get-doc'
    const params = {id: id}
    var ow = openwhisk()

    return ow.actions.invoke({name: name, blocking: true, params: params}).then(result => {
        console.log('here is the doc', result.response.result._source)
        return {body: result.response.result._source}
    }).catch(err => {
        console.error('failed to invoke action ', err)
        return {body: err}
    })
}
```

Actions Calling Actions: Web Get ES Doc

```
bx wsk action update web-es-doc web-es-doc.js -t 300000 --web true
```

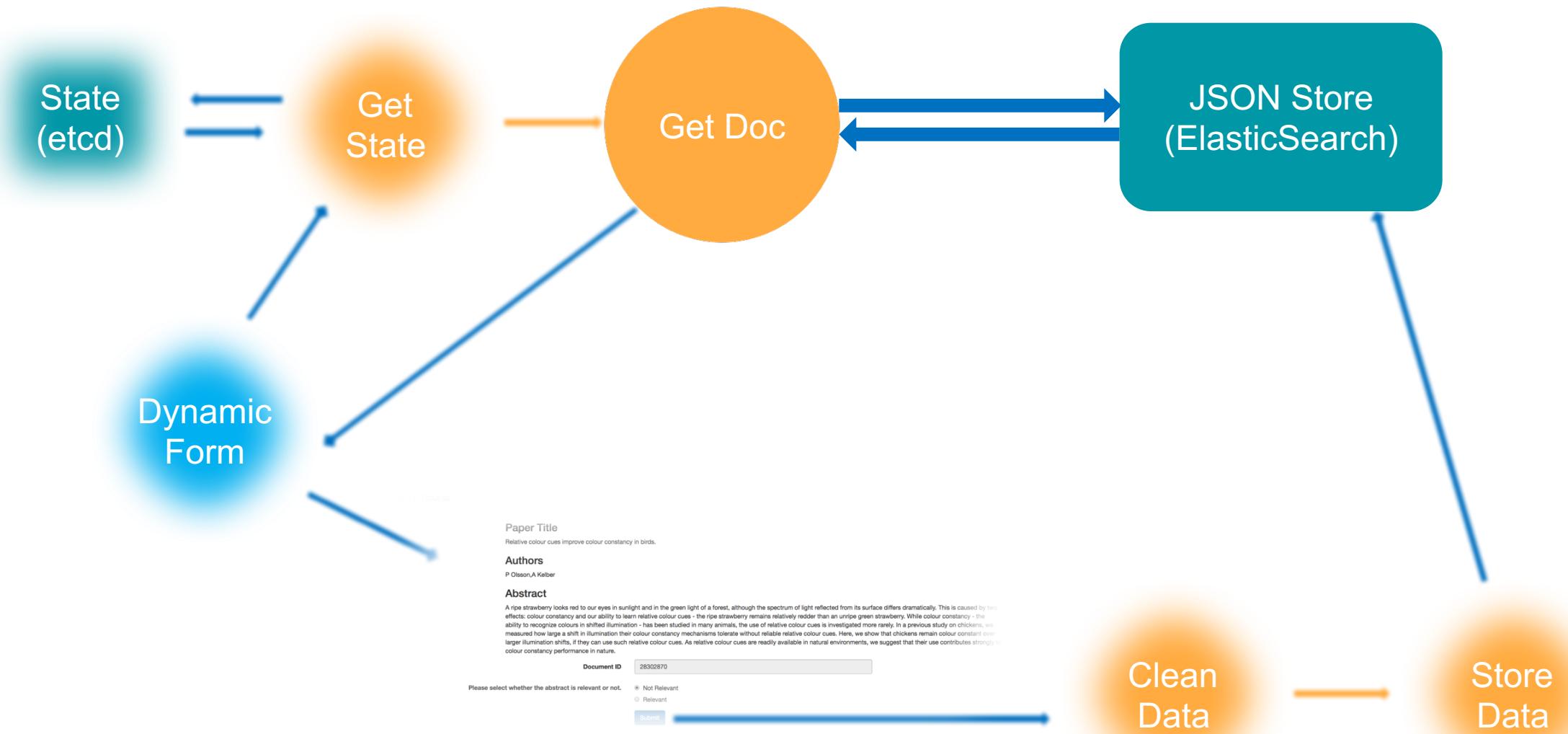
```
bx wsk action invoke web-es-doc -b -r -p id 2
```

```
https://openwhisk.ng.bluemix.net/api/v1/web/ioana%40us.ibm.com\_DSAA/default/web-es-doc?id=2
```

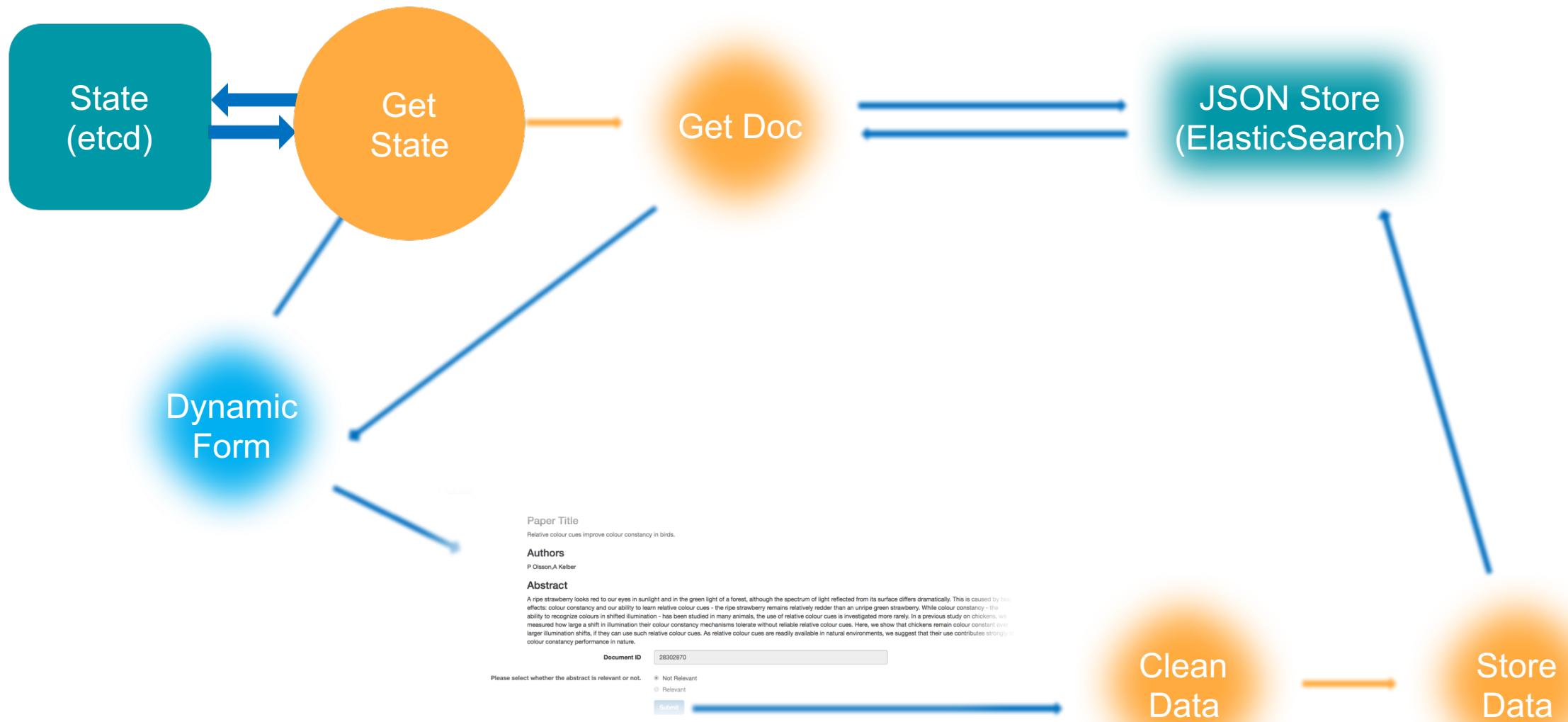
Part 3

Just a little bit of state

Serverless Application



Get and Update (External) State



ETCD - key/value store – running in IBM BMX

etcd-get-state.js

```
...
var etcd = new Etcd(hosts, opts)
var max = 3
if (params.max) max = params.max

get state
var crtId = etcd.getSync('/dsaa17/crtId')
var id = crtId.body.node.value
console.log(id)

update state
var newId = (id + 1) % max
etcd.setSync('dsaa17/crtId', newId)
console.log(newId)

return {id: id}
```

Zipped Actions

Docs:

https://console.bluemix.net/docs/openwhisk/openwhisk_actions.html#openwhisk_actions

Package an action as a Node.js module

Code: actions/etcdb-get-state scripts/action-etcdb-get-state.sh

Zipped action: actions/etcdb-get-etcdb.zip

Zipped action in one line:

action code, package.json, npm install, zip

ETCD Action

Create the package and the zipped action

```
cd scripts; sh action-etcd-get-state.sh
```

OR

Create the action from the zip file

```
WSK_CLI="bx wsk"
ACTION=etcd-get-state
PKG_NAME=etcd

# create package in default namespace with default parameters
# bx wsk package update etcd -p etcdHosts '$ETCD_HOSTS' -p etcdAuth '$ETCD_AUTH' -p etcdCa $ETCD_CA
$WSK_CLI package update $PKG_NAME -p etcdHosts '$ETCD_HOSTS' -p etcdAuth '$ETCD_AUTH' -p etcdCa $ETCD_CA

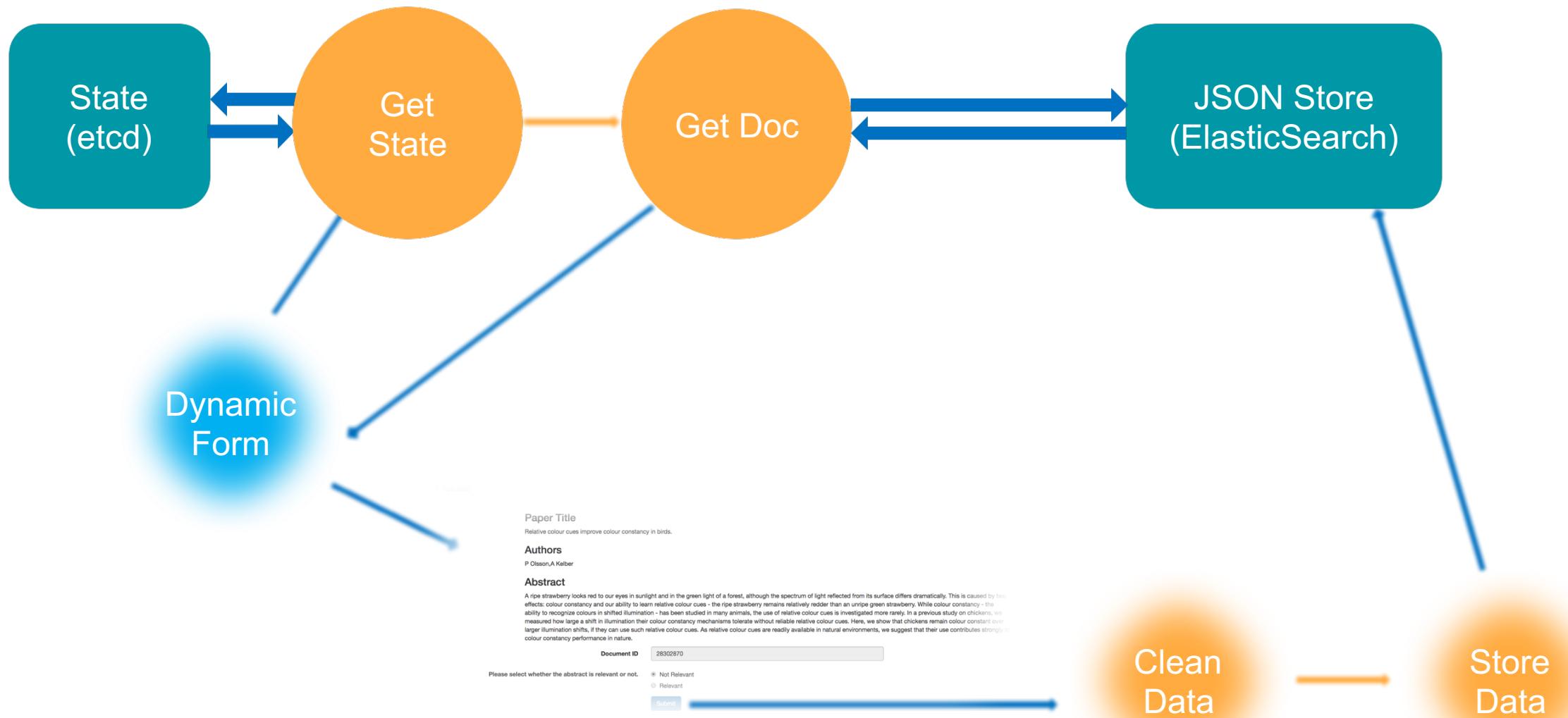
# create action that gets and updates state in ETCD
# bx wsk action update etcd/etcd-get-state $etcd-get-state.zip --kind nodejs:6 -t 300000
$WSK_CLI action update $PKG_NAME/$ACTION $ACTION.zip --kind nodejs:6 -t 300000
```

ETCD Action

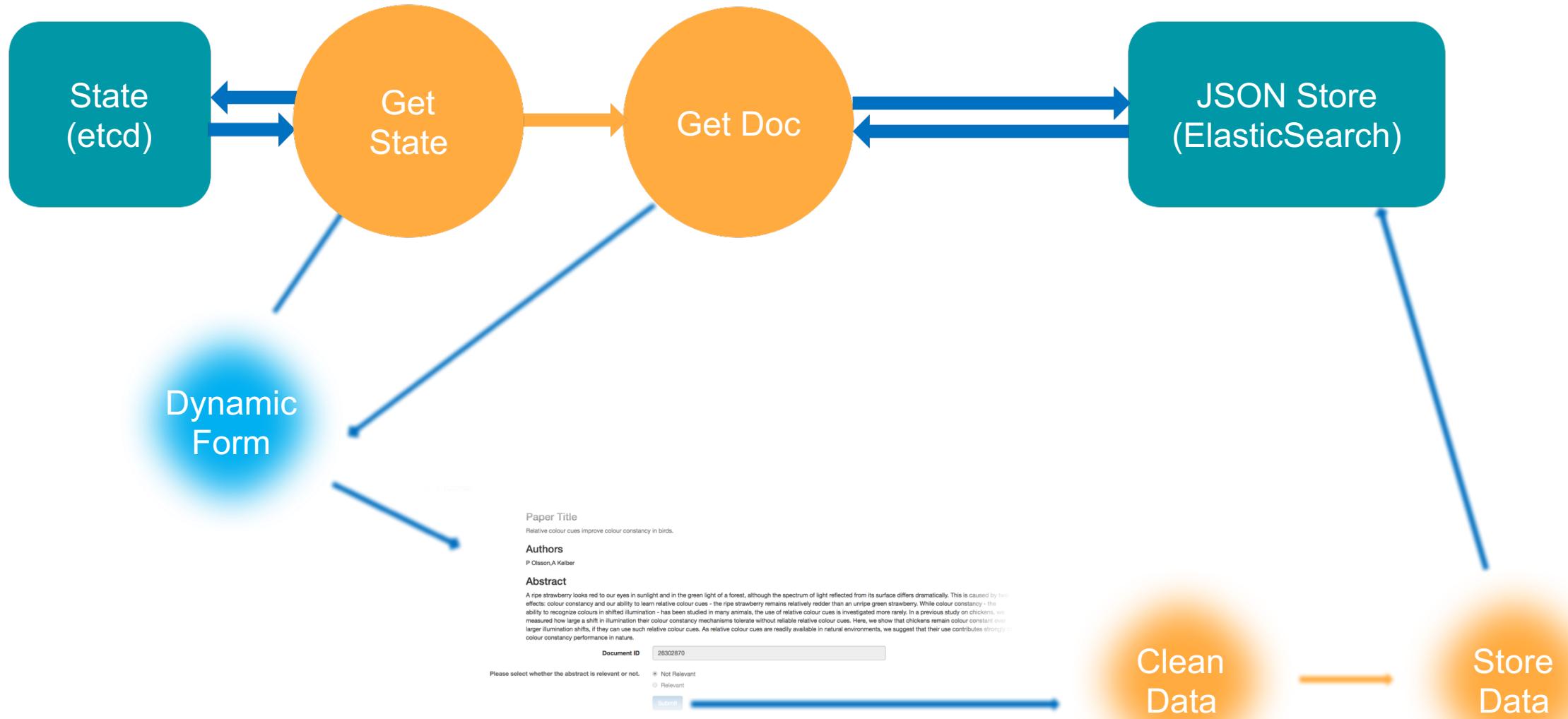
Invoke

```
bx wsk action invoke etcd/etcd-get-state -b -r
```

Serverless Application



Sequences



Sequence: ETCD => ES

Create sequence

```
bx wsk action update get-dynamic-doc --sequence etcd/etcd-get-state,es/es-get-doc
```

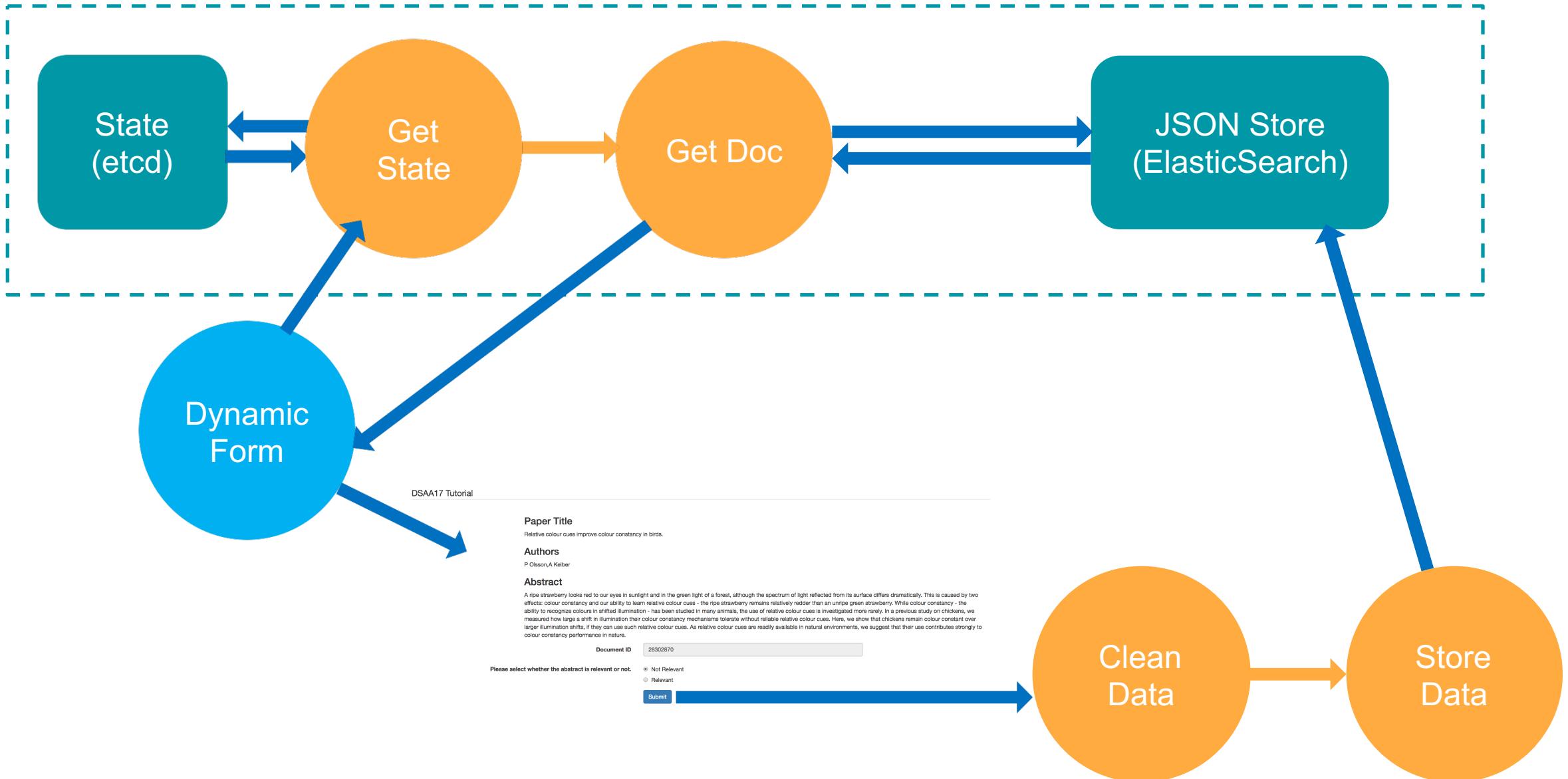
Invoke sequence just like any other action (and play with it)

```
bx wsk action invoke get-dynamic-doc -b -r
```

Part 4

Forms as web actions

Serverless Application



Hands on fun

DSAA17 Tutorial

Paper Title

Relative colour cues improve colour constancy in birds.

Authors

P Olsson, A Kelber

Abstract

A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues - the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy - the ability to recognize colours in shifted illumination - has been studied in many animals, the use of relative colour cues is investigated more rarely. In a previous study on chickens, we measured how large a shift in illumination their colour constancy mechanisms tolerate without reliable relative colour cues. Here, we show that chickens remain colour constant over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.

Document ID

28302870

Please select whether the abstract is relevant or not.

- Not Relevant
 Relevant

Submit

Dynamic Content

Form

HTML Forms

Free online tools you can play with

<https://bootsnipp.com/forms>

Generating HTML in a Web Action

DSAA17 Tutorial

Paper Title
Relative colour cues improve colour constancy in birds.

Authors
P Olsson,A Kelber

Abstract
A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues - the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy - the ability to recognize colours in shifted illumination - has been studied in many animals, the use of relative colour cues is investigated more rarely. In a previous study on chickens, we measured how large a shift in illumination their colour constancy mechanisms tolerate without reliable relative colour cues. Here, we show that chickens remain colour constant over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.

Dynamic Content

Document ID 28302870

Please select whether the abstract is relevant or not.

Not Relevant
 Relevant

Submit

Form

Generating HTML in a Web Action

DSAA17 Tutorial

Replace placeholders
with
dynamic content

get-dynamic-doc

Paper Title

TITLE_PLACEHOLDER

Authors

AUTHOR_PLACEHOLDER

Abstract

A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues – the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy – the ability to recognise colours shifted in illumination – has been studied in many animals, the use of relative colour cues is instead seen more rarely. In a previous study on chicks, we found no large a shift in illumination that colour constancy mechanisms operate without using relative colour cues. Here, we show that chicks' relative colour constancy over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.

ABSTRACT_PLACEHOLDER

Document ID

DOCID_PLACEHOLDER

Please select whether the abstract is relevant or not.

Not Relevant

Relevant

Submit

Dynamic Content

Form

On submit: clean data and save it to ElasticSearch

Sequence: Clean Data => Save Data to ES

Clean Data

```
bx wsk action update clean-data clean-data.js
```

```
function main(params) {  
    return { doc: {docid: params.docid, relevant: parseInt(params.relevant)} }  
}
```

Save Data to ES (Zipped Action)

Create the package and the zipped action (similar to getting doc from ES)

```
cd scripts; sh action-es-index-doc.sh
```

OR

Create the action from the zip file

```
# create action that reads doc from ES (in the default namespace)
ACTION=es-index-doc
PKG_NAME=es
INDEX=tutorial
TYPE=collected_data

# default parameters for index and type
$WSK_CLI action update $PKG_NAME/$ACTION $ACTION.zip --kind nodejs:6 -t 300000 -p index $INDEX -p type $TYPE

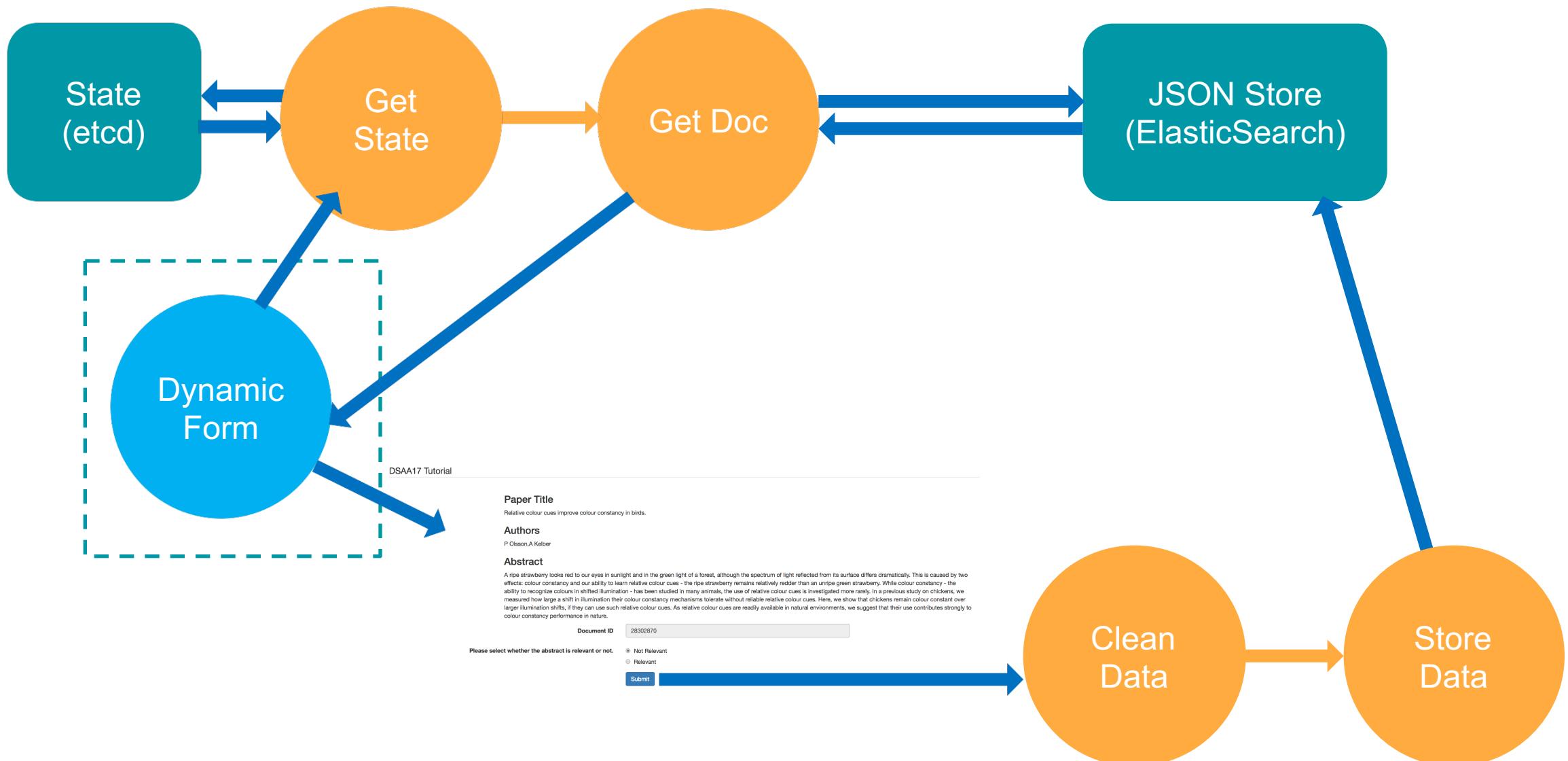
# default parameters for index and type
bx wsk action update es/es-index-doc es-index-doc.zip --kind nodejs:6 -t 300000 -p index tutorial -p type collected_data
```

Sequence: Clean Data => Save Data to ES

Create sequence to clean and save data

```
bx wsk action update clean-and-save --sequence clean-data,es/es-index-doc --web true
```

Serverless Application – Dynamic Form



Serverless Application – Dynamic Form

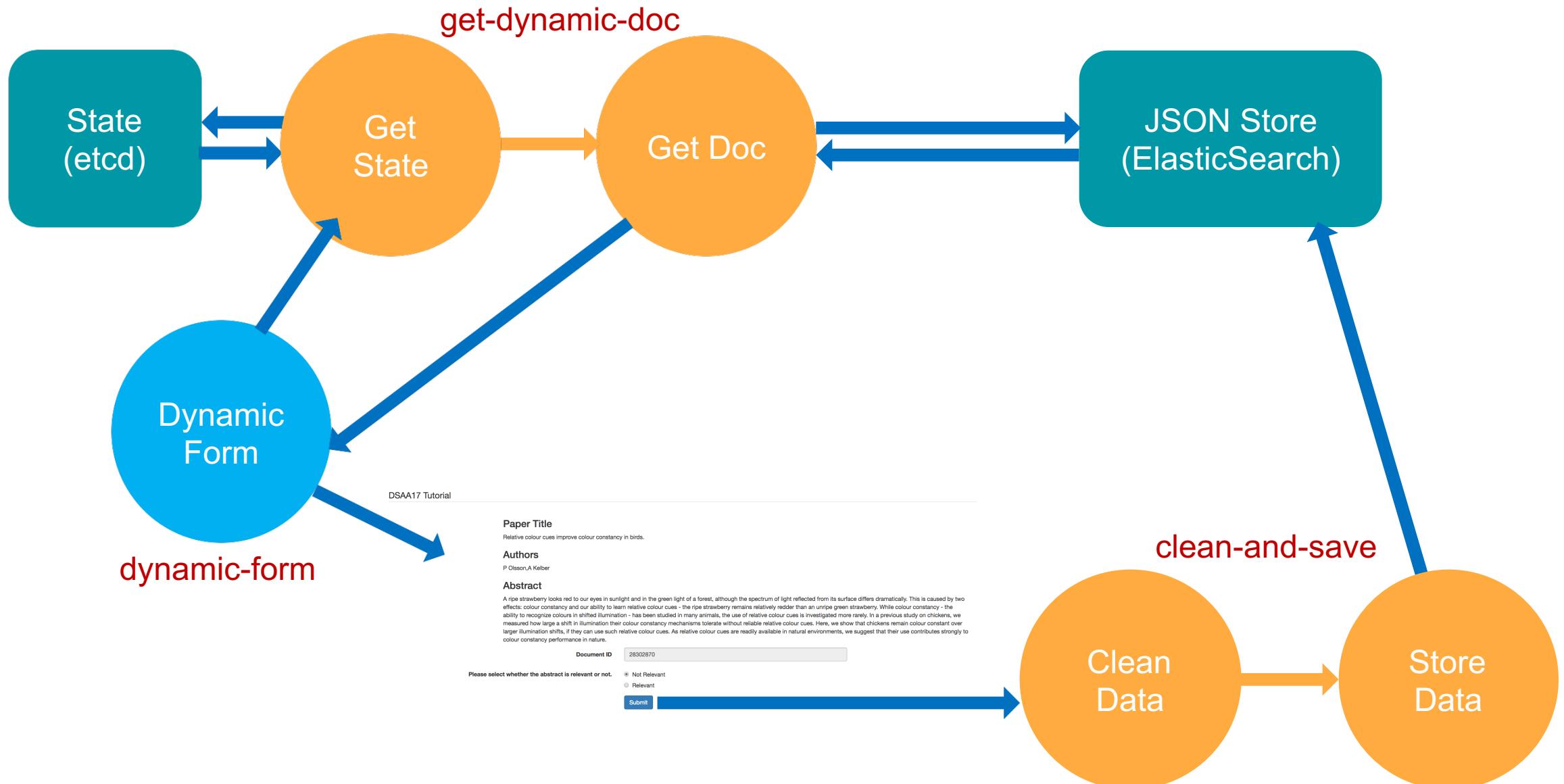
```
bx wsk action update dynamic-form dynamic-form.js --web true
```

```
https://openwhisk.ng.bluemix.net/api/v1/web/ioana@us.ibm.com_DSAA/default/dynamic-form
```

The diagram features a large blue circle containing the text "Dynamic Form". A dashed line extends from the bottom right of the circle to a screenshot of a web page. The screenshot is titled "DSAA17 Tutorial" and displays a form with the following fields:

- Paper Title**: Relative colour cues improve colour constancy in birds.
- Authors**: P Olsson, A Kelber
- Abstract**: A ripe strawberry looks red to our eyes in sunlight and in the green light of a forest, although the spectrum of light reflected from its surface differs dramatically. This is caused by two effects: colour constancy and our ability to learn relative colour cues - the ripe strawberry remains relatively redder than an unripe green strawberry. While colour constancy - the ability to recognize colours in shifted illumination - has been studied in many animals, the use of relative colour cues is investigated more rarely. In a previous study on chickens, we measured how large a shift in illumination their colour constancy mechanisms tolerate without reliable relative colour cues. Here, we show that chickens remain colour constant over larger illumination shifts, if they can use such relative colour cues. As relative colour cues are readily available in natural environments, we suggest that their use contributes strongly to colour constancy performance in nature.
- Document ID**: 28302870
- Please select whether the abstract is relevant or not.**:
• Not Relevant
• Relevant
- Submit**

Serverless Application – All Together Now



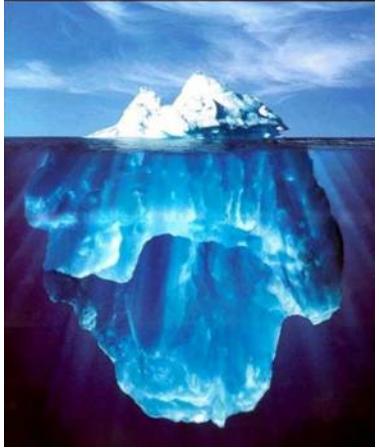
Now Play

Serverless app

https://openwhisk.ng.bluemix.net/api/v1/web/ioana@us.ibm.com_DSAA/default/dynamic-form
<http://tiny.cc/dsaa17-serverless>

Check collected data

```
curl -u $ES_AUTH https://$ES_HOST/tutorial/collected_data/_search?pretty
```



Collecting Data with Serverless Applications

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THANK YOU!

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