Open Policy Agent

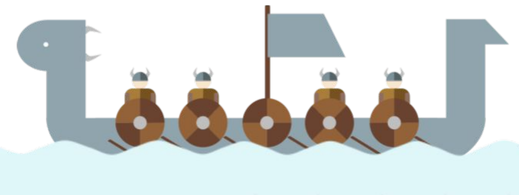
Language Introduction

Agenda

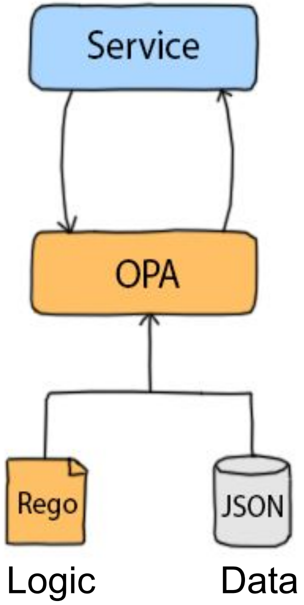
- How Policies are Invoked
- Policies with Data
- Policies with Search
- Additional Topics
    - Modularity
    - Negation
    - Any/All
    - Non-boolean Decisions

How Policies are Invoked

- Overview
- Example:
  - HTTP API Authorization



How Policies are Invoked



How Policies are Invoked

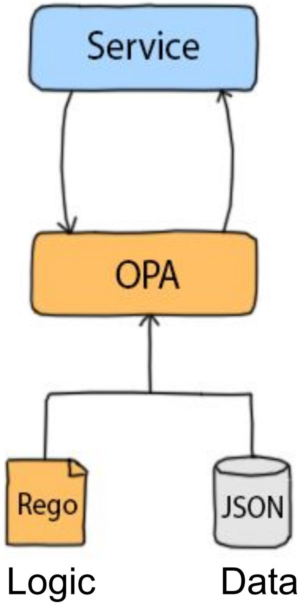
1. **Decision Request**

```
POST v1/data/<policy-name>

{"input": <JSON>}
```

Any JSON value:

- `"alice"`
- `["api", "v1", "cars"]`
- `{"headers": {...}}`



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How Policies are Invoked

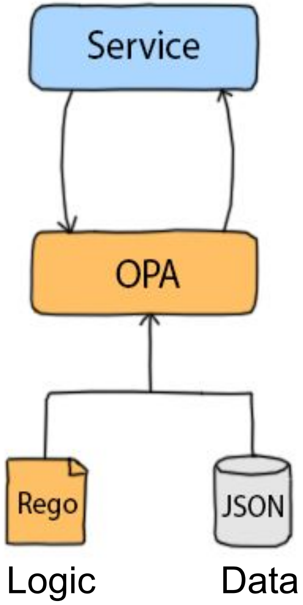
1. **Decision Request**

```
POST v1/data/<policy-name>

{“input”: <JSON>}
```

Any JSON value:

- `"alice"`
- `["api", "v1", "cars"]`
- `{"headers": {...}}`



2. **Decision Response**

```
200 OK

{“result”: <JSON>}
```

Any JSON value:

- `true, false`
- `"bob"`
- `{"servers": ["server-001", …]}`

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How Policies are Invoked

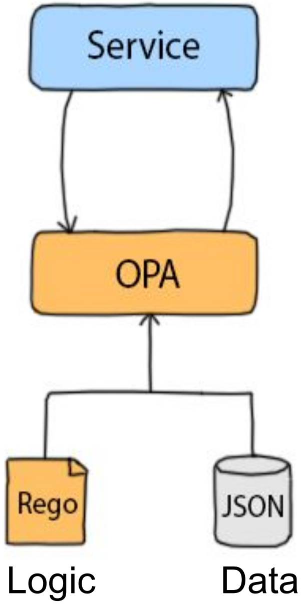
1. Decision Request

```
POST v1/data/<policy-name>

{“input”: <JSON>}
```

Any JSON value:

- `"alice"`
- `["api", "v1", "cars"]`
- `{"headers": {...}}`



2. Decision Response

```
200 OK

{“result”: <JSON>}
```

Any JSON value:

- `true, false`
- `"bob"`
- `{"servers": ["server-001", …]}`

Input is JSON. Policy decision is JSON.

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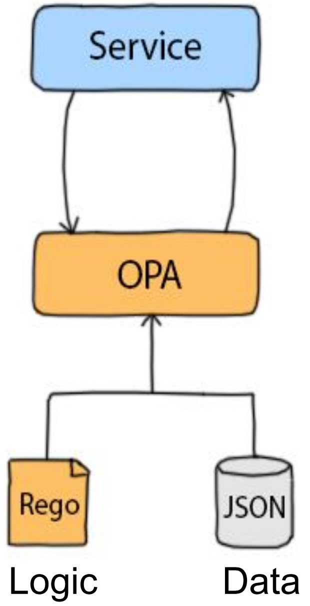
Example: HTTP API Authorization

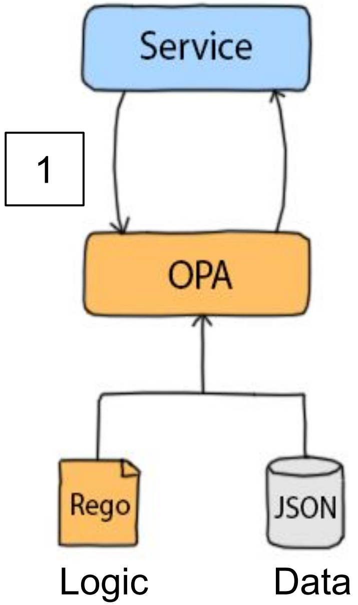


Example: HTTP API Authorization

1. Example Request to OPA

```
POST v1/data/http/authz/allow

{"input": {
    "method": "GET",
    "path":   ["finance", "salary", "alice"],
    "user":   "bob"}}
```



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Example: HTTP API Authorization

1. Example Request to OPA

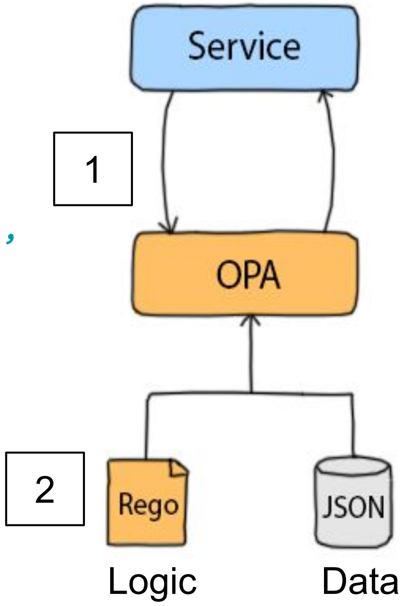
```
POST v1/data/http/authz/allow

{"input": {
    "method": "GET",
    "path":   ["finance", "salary", "alice"],
    "user":   "bob"}}
```

2. Example Policy in OPA

```
package http.authz

allow {
  input.user == “bob”
}
```



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Example: HTTP API Authorization

1. Example Request to OPA

```
POST v1/data/http/authz/allow

{"input": {
    "method": "GET",
    "path":   ["finance", "salary", "alice"],
    "user":   "bob"}}
```

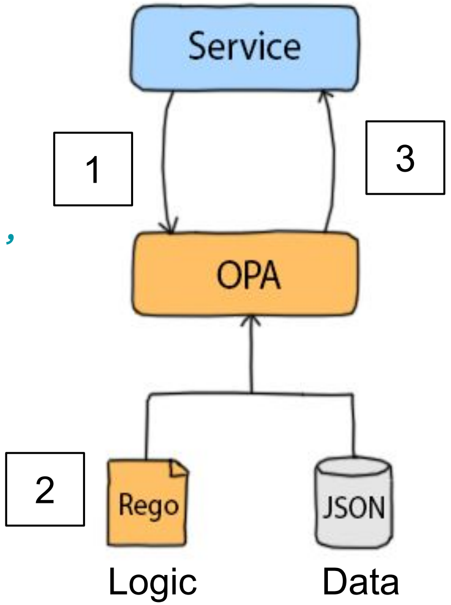
2. Example Policy in OPA

```
package http.authz

allow {
  input.user == “bob”
}
```

3. Example Response from OPA

```
{“result”: true}
```



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Agenda

- How Policies are Invoked
- **Policies with Data**
- Policies with Search
- Additional Topics
    - Modularity
    - Negation
    - Non-boolean Decisions

Policies With Data

- Lookup values
- Compare values
- Assign values
- Create rules
- Create functions
- Use context (data)

Lookup and Compare Values

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Lookup values.

```
input.method

input.path[0]
```

Lookup and Compare Values

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Lookup values. Compare values.

```
input.method == “GET”

input.path[0] == “finance”

input.user != input.method
```

Lookup and Compare Values

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Lookup values. Compare values.

```
input.method == “GET”

input.path[0] == “finance”

input.user != input.method

startswith(input.path[1], “sal”)

count(input.path) > 2
```

See 50+ operators documented at openpolicyagent.org/docs/language-reference.html

Assign Values to Variables

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Assign variables.

```
path := input.path
```

Use variables like input.

```
path[2] == "alice"
```

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow = true {
  input.method == "GET"
  input.user == "bob"
}
```

Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow = true {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Head

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow = true {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Head

Name	`allow`
Value	`true`

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Head

Name	allow
Value	true

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Body

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Body

Multiple statements
in rule body
are ANDed together.

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules have a Head and a Body.

```
allow {
  input.method == "GET"
  input.user == "bob"
}
```

Rule Body

Multiple statements
in rule body
are ANDed together.

`allow` is true IF
`input.method` equals "`GET`" AND
`input.user` equals "`bob`"

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Multiple rules with same name.

```
allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

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Create Rules

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Multiple rules with same name.

```
allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

Rule Head

Multiple statements
with same head
are ORed together.

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Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Rules can be undefined.

```
allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Different method.
"POST" instead of "GET"

Rules can be undefined.

```
allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

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Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Different method.
"POST" instead of "GET"

Rules can be undefined.

```
allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

Neither rule matches.
allow is undefined (*not false!*)

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Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Use default keyword.

```
default allow = false

allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

default <name> = <value>
If no rules match
default value is returned.

Use default keyword.

```
default allow = false

allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

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Create Rules

Input

```
{
  "method": "POST",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

default <name> = <value>
If no rules match
default value is returned.

at most one default per rule set

Use default keyword.

```
default allow = false

allow {
  input.method == "GET"
  input.user == "bob"
}

allow {
  input.method == "GET"
  input.user == input.path[2]
}
```

Summary

Lookup values	input.path[1]
Compare values	"bob" == input.user
Assign values	user := input.user
Rules	<head> { <body> }
Rule Head	<name> = <value> { … } or <name> { … }
Rule Body	<statement-1>; <statement-2>; … (ANDed)
Multiple Rules *with same name*	<rule-1> OR <rule-2> OR ...
Default Rule Value	default <name> = <value>

Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Path is a string now.

Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Path is a string now.

Example rule

```
default allow = false

allow {
  trimmed := trim(input.path, "/")
  path := split(trimmed, "/")
  path = ["finance", "salary", user]
  input.user == user
}
```

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Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Path is a string now.

Avoid duplicating common logic like string manipulation

Example rule

```
default allow = false

allow {
  trimmed := trim(input.path, "/")
  path := split(trimmed, "/")
  path = ["finance", "salary", user]
  input.user == user
}
```

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Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Path is a string now.

Avoid duplicating common logic like string manipulation

Put common logic into functions

```
default allow = false

allow {
  path := split_path(input.path)
  path = ["finance", "salary", user]
  input.user == user
}

split_path(str) = parts {
  trimmed := trim(str, "/")
  parts := split(trimmed, "/")
}
```

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Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Functions are Rules with arguments.

```
read_method(str) = true {
  str == "GET"
}

read_method(str) = true {
  str == "HEAD"
}
```

Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Functions are Rules with arguments.

```
read_method(str) = true {
  str == "GET"
}

read_method(str) = true {
  str == "HEAD"
}
```

"Function" Head

Multiple statements
with same head
are ORed together.

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Create Functions

Input

```
{
  "method": "GET",
  "path":   "/finance/salary/alice",
  "user":   "bob"
}
```

Functions are Rules with arguments.

```
read_method(str) {
  str == "GET"
}

read_method(str) {
  str == "HEAD"
}
```

"Function" Head

Multiple statements
with same head
are ORed together.

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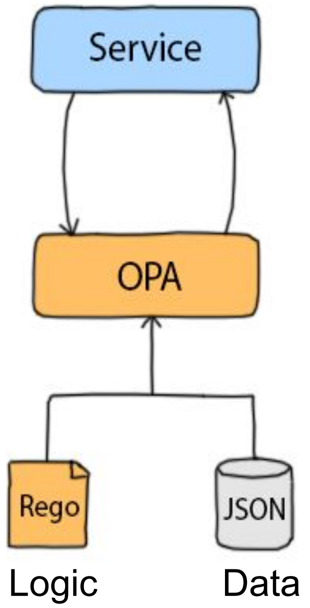
Policies can use Context from Outside World

Load Context/Data Into OPA

```
PUT v1/data/<path> HTTP/1.1
Content-Type: application/json

<JSON>
```



Policies Use Context

Input

```
{
  "method": "GET",
  "path":   ["finance", "salary", "alice"],
  "user":   "bob"
}
```

Data (context)

```
{
  "users": {
     "alice": {"department": "legal"},
     "bob":   {"department": "hr"},
     "janet": {"department": "r&d"}
  }
}
```

Policy

```
allow {
    # Users can access their own salary
    input.path = ["finance", "salary", user]
    input.user = user
}

allow {
    # HR can access any salary
    user = data.users[input.user]
    user.department = "hr"
}
```

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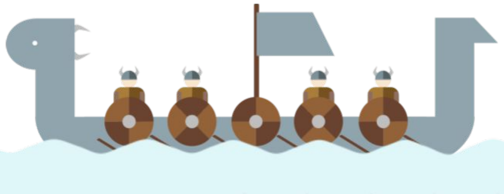
Policies With Search

- Iteration
- Variable assignments
- Filtering



How do Policies Handle Arrays?

Input

```
{
  "method": "GET",
  "path":   ["resources", "54cf10"],
  "user":   "alice"
}
```

Data

Different schema.
Array instead of map.

```
{
  "resources": [
    {"id": "54cf10", "owner": "alice"},
    {"id": "3df429": "owner": "bob"}
    ...
  ],
  ...
}
```

Not sure where resource is in array

```
allow {
    resource_name := input.path[1]
    data.resources[0].id == resource_name
    input.user == data.resources[0].owner
}

allow {
    resource_name := input.path[1]
    data.resources[1].id == resource_name
    input.user == data.resources[1].owner
}
...
```

How do Policies Handle Arrays?

Input

```
{
  "method": "GET",
  "path":   ["resources", "54cf10"],
  "user":   "alice"
}
```

Data

```
{
  "resources": [
    {"id": "54cf10", "owner": "alice"},
    {"id": "3df429": "owner": "bob"}
    ...
  ],
  ...
}
```

Different schema.
Array instead of map.

Not sure where resource is in array

```
allow {
    resource_name := input.path[1]
    data.resources[0].id == resource_name
    input.user == data.resources[0].owner
}

allow {
    resource_name := input.path[1]
    data.resources[1].id == resource_name
    input.user == data.resources[1].owner
}
...
```

<u>Problem:</u> Unknown number of elements.
Cannot write allow for every index.

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Policies Iterate over Arrays

Input

```
{
  "method": "GET",
  "path":   ["resources", "54cf10"],
  "user":   "alice"
}
```

Data

Different schema.
Array instead of map.

```
{
  "resources": [
    {"id": "54cf10", "owner": "alice"},
    {"id": "3df429": "owner": "bob"}
    ...
  ],
  ...
}
```

Not sure where resource is in array

```
allow {
    resource_name := input.path[1];
    data.resources[index].id == resource_name;
    input.user == data.resources[index].owner
}
```

Solution:

- **`allow`** is true if SOME value for **`index`** makes the rule body true.
- OPA automatically iterates over values for **`index`**.
- allow is true for **`index`** `= 0`

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Policies Iterate over Everything

Input

```
{
  "method": "GET",
  "path":   ["resources", "54cf10"],
  "user":   "bob"
}
```

Data

```
{
  "resources": [
    {"id": "54cf10", "owner": "alice"},
    {"id": "3df429": "owner": "bob"}
  ],
  "users": {
    "alice":   {"admin": false},
    "bob":     {"admin": true},
    "charlie": {"admin": true},
  }
}
```

Iterate over arrays/dictionaries (whether input or data)

```
# Iterate over array indexes/values
resource_obj := data.resources[index]

# Iterate over dictionary key/values
user_obj := data.users[name]

# Doesn't matter whether input or data
value := input[key]

# Use _ to ignore variable name
# Iterate over just the array values
resource_obj := data.resources[_]
```

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Policies Iterate to Search for Data

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  },
  “orgs”: {
    “00”: {“name”: “HR”},
    “11”: {“name”: “Legal”},
    “22”: {“name”: “Research”},
    “33”: {“name”: “IT”},
    “44”: {“name”: “Accounting”},
  }
}
```

Search for the data you need

```
# Find admin users and their organization
user_obj := data.users[user_name];
user_obj.admin == true;
org_name := data.orgs[user_obj.org_code].name
```

Variable assignments that satisfy search criteria

user_obj	user_name	org_name
{"admin": true, ...}	bob	Research
{"admin": true, ...}	charlie	IT

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Policies Give Names to Search Results

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  },
  “orgs”: {
    “00”: {“name”: “HR”},
    “11”: {“name”: “Legal”},
    “22”: {“name”: “Research”},
    “33”: {“name”: “IT”},
    “44”: {“name”: “Accounting”},
  }
}
```

Name the search results

```
admins[[org_name, user_name]] {
  user_obj := data.users[user_name]
  user_obj.admin == true
  org_name := data.orgs[user_obj.org_code].name
}
```

admins is a set that contains all of the **[org_name, user_name]** pairs that make the body true.

```
admins == {
  ["Research", "bob"],
  ["IT", "charlie"],
}
```

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Policies Apply Search Results to Make Decisions

Input

```
{
  "method": "GET",
  "path":   ["resources", "54cf10"],
  "user":   "bob"
}
```

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  },
  “orgs”: {
    “00”: {“name”: “HR”},
    “11”: {“name”: “Legal”},
    “22”: {“name”: “Research”},
  ...
```

Apply the search results

```
allow {
  # allow admins to do everything
  admins[[_, input.user]]
}

admins[[org_name, user_name]] {
  user_obj := data.users[user_name]
  user_obj.admin == true
  org_name := data.orgs[user_obj.org_code].name
}
```

Check if bob is an admin	`admins[[_, “bob”]]`
Lookup IT admins	`admins[[“IT”, name]]`
Iterate over all pairs	`admins[x]`

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- Policies with Data
- Policies with Search
- **Additional Topics**
  - **Modularity**
  - **Negation**
  - **Any/All**
  - **Non-boolean Decisions**

People can Create Multiple Policies and Delegate

Entry point policy

```
package http.authz
import data.http.service_graph
import data.http.org_chart

allow {
   org_chart.allow
   service_graph.allow
}
```

Service graph policy

```
package http.service_graph
allow {
   input.source == “frontend”
   input.destination == “finance”
}
...
```

Organization chart policy

```
package http.org_chart
allow {
   admin[user.input]
}
...
```

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Policies can use Negation

Entry point policy

```
package http.authz
import data.http.service_graph
import data.http.org_chart

allow {
   org_chart.allow
   not service_graph.deny
   not deny
}
deny { ... }
```

Service graph policy

```
package http.service_graph
deny {
   input.source == “frontend”
   input.destination == “finance”
}
...
```

Organization chart policy

```
package http.org_chart
allow {
   admin[user.input]
}
```

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Any vs. All

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  }
}
```

Check if all users are admins.

```
all_admins = true {
  data.users[user_name].admin == true
}
```

Any vs. All

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  }
}
```

Check if all users are admins.

```
all_admins = true {
  data.users[user_name].admin == true
}
```

Problem: `all_admins` is `true` if ANY users are admins.

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Any vs. All

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  }
}
```

Check if all users are admins.

```
all_admins = true {
  not any_non_admins
}

any_non_admins = true {
  user := data.users[user_name]
  not user.admin
}
```

Solution:

1. Check if any users are NOT admins
2. Complement (1)

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Any vs. All

Data

```
{
  “users”: {
    "alice":   {"admin": false, “org_code”: “11”},
    "bob":     {"admin": true,  “org_code”: “22”},
    "charlie": {"admin": true,  “org_code”: “33”}
  }
}
```

Check if all users are admins.

```
all_admins = true {
  not any_non_admins
}

any_non_admins = true {
  user := data.users[user_name]
  not user.admin
}
```

<u>**Solution**</u>:

1. Check if any users are NOT admins

2. Complement (1)

allow/deny are NOT special. Decisions are JSON

1. **Example Request**

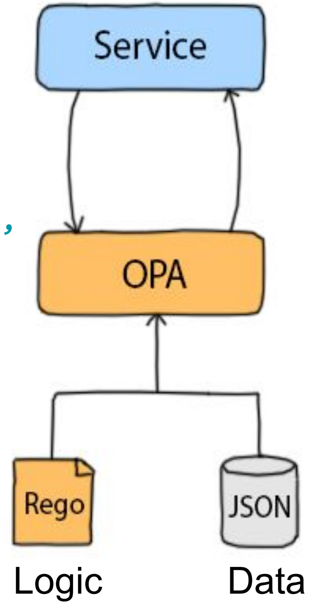
```
POST v1/data/http/authz/admin
{"input": {
    "method": "GET",
    "path":   ["finance", "salary", "alice"],
    "user":   "bob"}}
```

2. **Example Policy**

```
package http.authz
import data.http.service_graph
import data.http.org_chart

admin[x] {
   org_chart.admin[x]
}
admin[x] {
   service_graph.admin[x]
}
```

Sets defined with multiple rules are unioned together.



3. **Example Response**

```
{“result”: [“bob”, “charlie”]}
```

Policy decision can be any JSON data: boolean, number, string, null, array, or dictionary.

Sets are serialized to JSON arrays.

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Thank You!

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github.com/open-policy-agent/opa