US 20250258757A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0258757 A1**

KAWAZOE (43) **Pub. Date: Aug. 14, 2025**

(54) **INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND COMPUTER PROGRAM PRODUCT**

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(21) Appl. No.: **19/042,994**

(22) Filed: **Jan. 31, 2025**

(30) **Foreign Application Priority Data**

Feb. 8, 2024 (JP) 2024-017691

Publication Classification

(51) **Int. Cl.**
G06F 11/3668 (2025.01)

(52) **U.S. Cl.**
CPC ***G06F 11/3684*** (2013.01); ***G06F 11/3688*** (2013.01)

(57) **ABSTRACT**

According to an embodiment, an information processing apparatus includes a communication interface, and a processor. The communication interface is configured to transmit an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receive a response indicating the method of calling the API included in the API specification from the specification interpretation device. The processor is configured to determine whether or not the method of calling the API indicated by the response is correct, and generate a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.

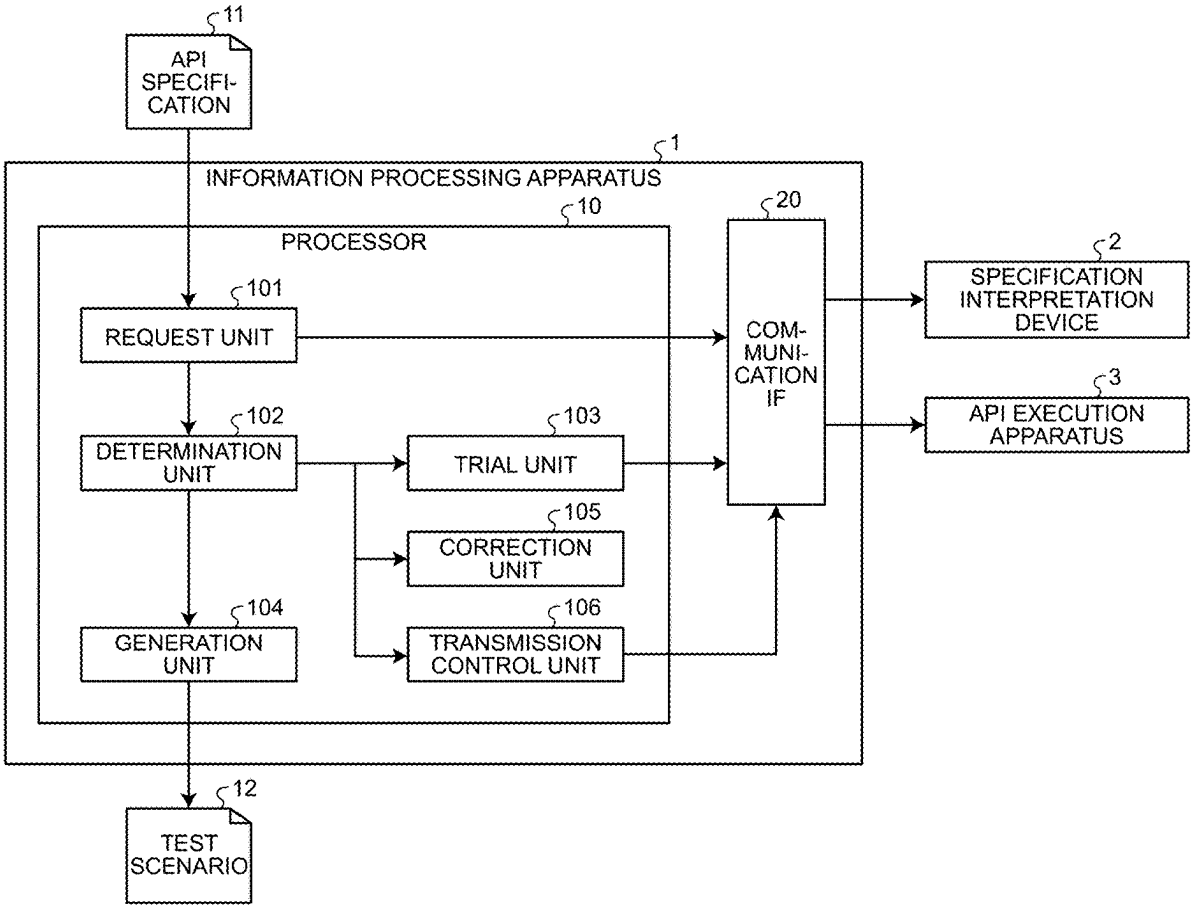


FIG.1

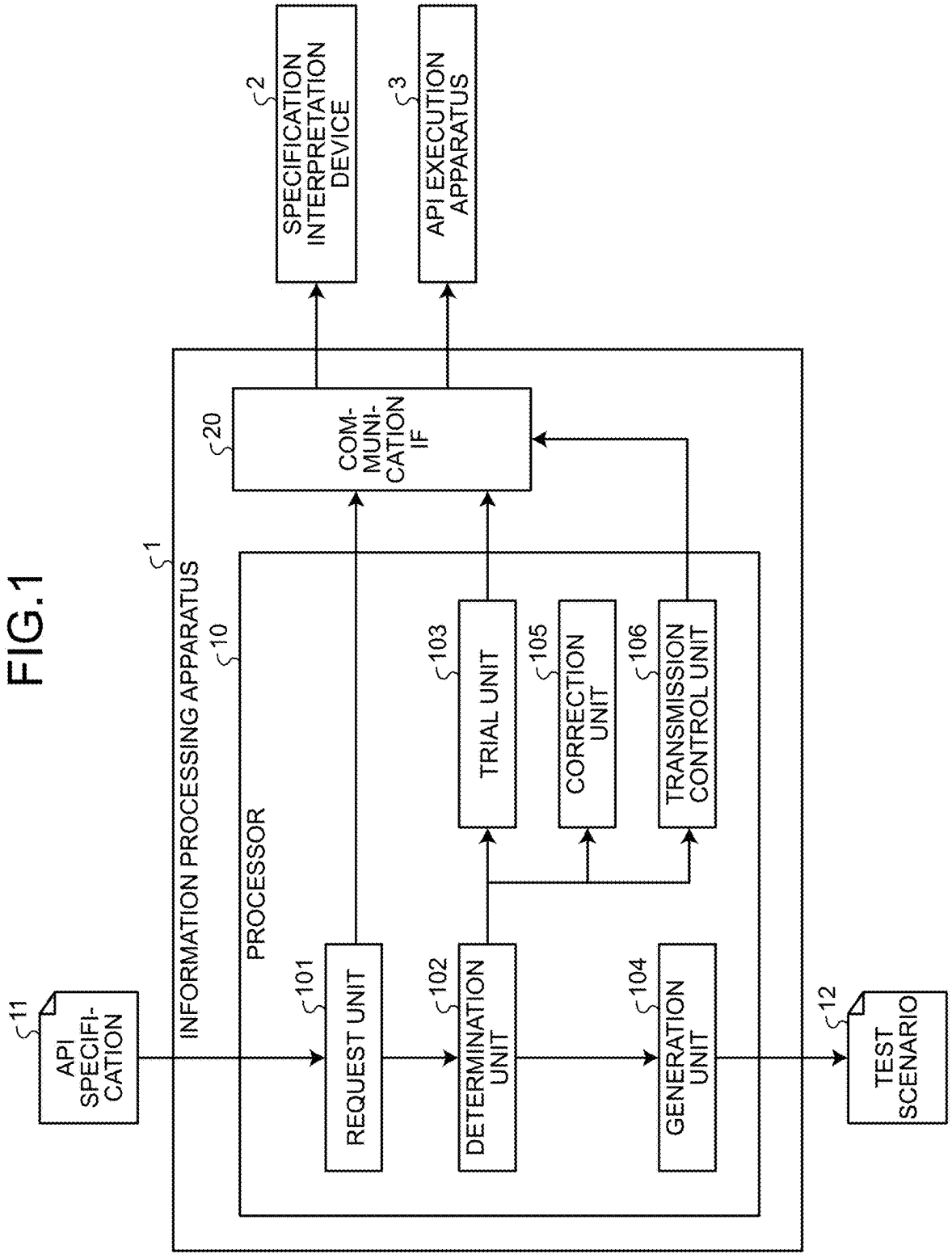

2
SPECIFICATION INTERPRETATION DEVICE
3
API EXECUTION APPARATUS
1
INFORMATION PROCESSING APPARATUS
20
COM-MUNI-CATION IF
10
PROCESSOR
103
TRIAL UNIT
105
CORRECTION UNIT
106
TRANSMISSION CONTROL UNIT
11
API SPECIFI-CATION
101
REQUEST UNIT
102
DETERMINATION UNIT
104
GENERATION UNIT
12
TEST SCENARIO

FIG.2

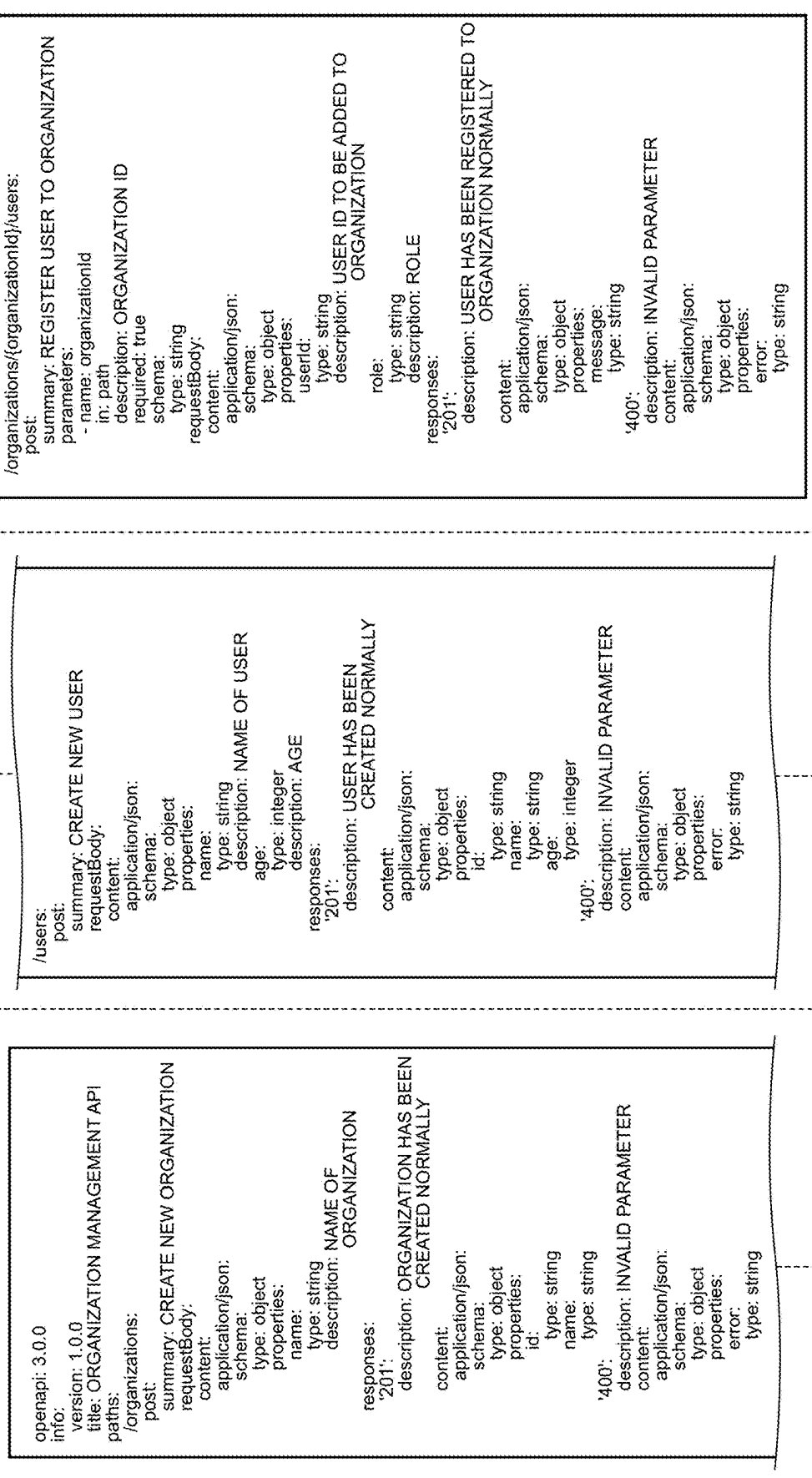
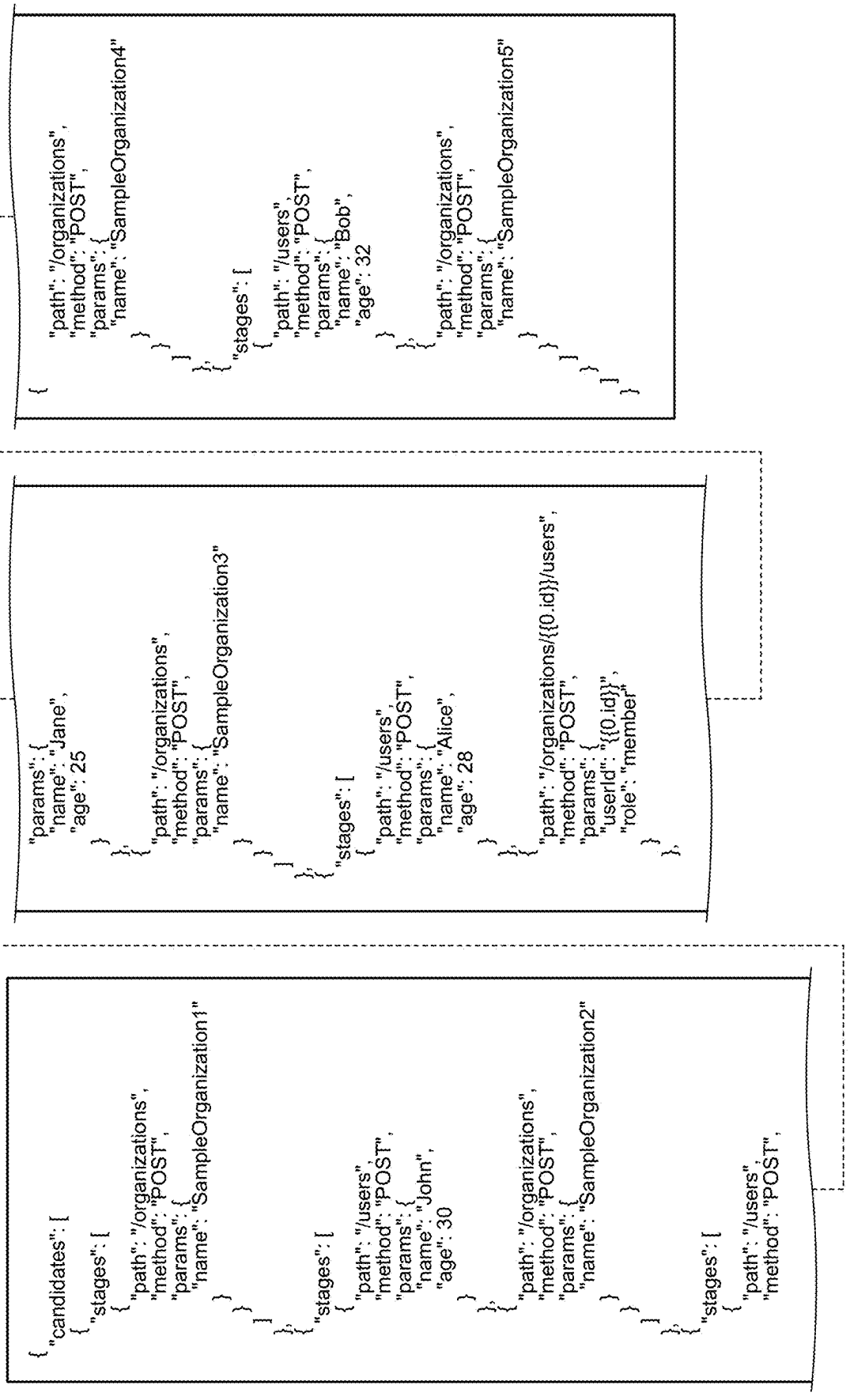

openapi: 3.0.0
info:
version: 1.0.0
title: ORGANIZATION MANAGEMENT API
paths:
/organizations:
post:
summary: CREATE NEW ORGANIZATION
requestBody:
content:
application/json:
schema:
type: object
properties:
name:
type: string
description: NAME OF ORGANIZATION
responses:
'201':
description: ORGANIZATION HAS BEEN CREATED NORMALLY
content:
application/json:
schema:
type: object
properties:
id:
type: string
name:
type: string
'400':
description: INVALID PARAMETER
content:
application/json:
schema:
type: object
properties:
error:
type: string
/users:
post:
summary: CREATE NEW USER
requestBody:
content:
application/json:
schema:
type: object
properties:
name:
type: string
description: NAME OF USER
age:
type: integer
description: AGE
responses:
'201':
description: USER HAS BEEN CREATED NORMALLY
content:
application/json:
schema:
type: object
properties:
id:
type: string
name:
type: string
age:
type: integer
'400':
description: INVALID PARAMETER
content:
application/json:
schema:
type: object
properties:
error:
type: string
/organizations/{organizationId}/users:
post:
summary: REGISTER USER TO ORGANIZATION
parameters:
- name: organizationId
in: path
description: ORGANIZATION ID
required: true
schema:
type: string
requestBody:
content:
application/json:
schema:
type: object
properties:
userId:
type: string
description: USER ID TO BE ADDED TO ORGANIZATION
role:
type: string
description: ROLE
responses:
'201':
description: USER HAS BEEN REGISTERED TO ORGANIZATION NORMALLY
content:
application/json:
schema:
type: object
properties:
message:
type: string
'400':
description: INVALID PARAMETER
content:
application/json:
schema:
type: object
properties:
error:
type: string

FIG.3


{
"candidates": [
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "SampleOrganization1"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "John",
"age": 30
}
},
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "SampleOrganization2"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "Jane",
"age": 25
}
},
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "SampleOrganization3"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "Alice",
"age": 28
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{0.id}}",
"role": "member"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "Bob",
"age": 32
}
},
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "SampleOrganization5"
}
}
]
},
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "SampleOrganization4"
}
}
]
}

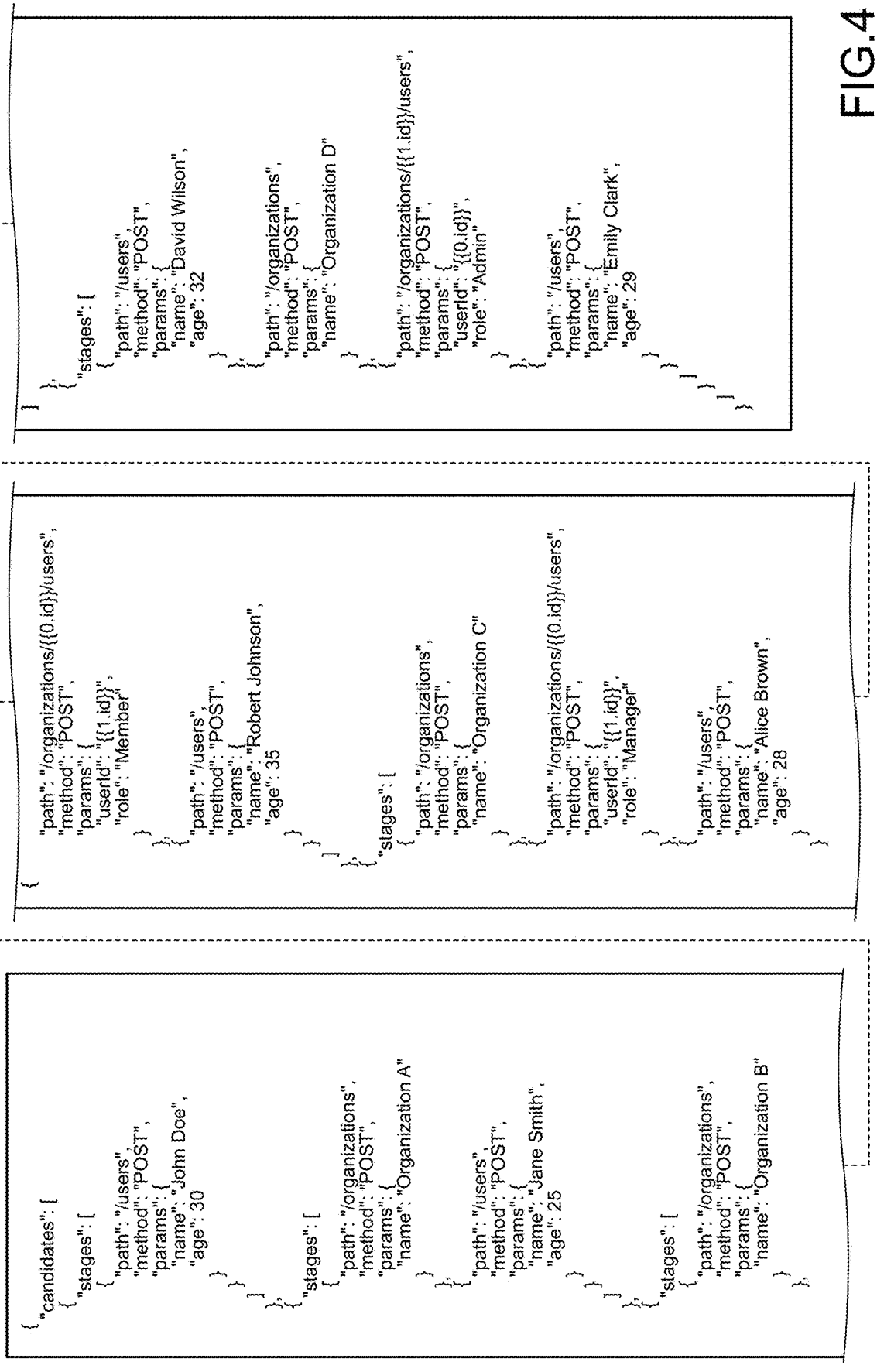

{
"candidates": [
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "John Doe",
"age": 30
}
}
]
},
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Organization A"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "Jane Smith",
"age": 25
}
}
]
},
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Organization B"
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{1.id}}",
"role": "Member"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "Robert Johnson",
"age": 35
}
}
]
},
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Organization C"
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{1.id}}",
"role": "Manager"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "Alice Brown",
"age": 28
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "David Wilson",
"age": 32
}
},
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Organization D"
}
},
{
"path": "/organizations/{{1.id}}/users",
"method": "POST",
"params": {
"userId": "{{0.id}}",
"role": "Admin"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "Emily Clark",
"age": 29
}
}
]
}
]
}

FIG.4

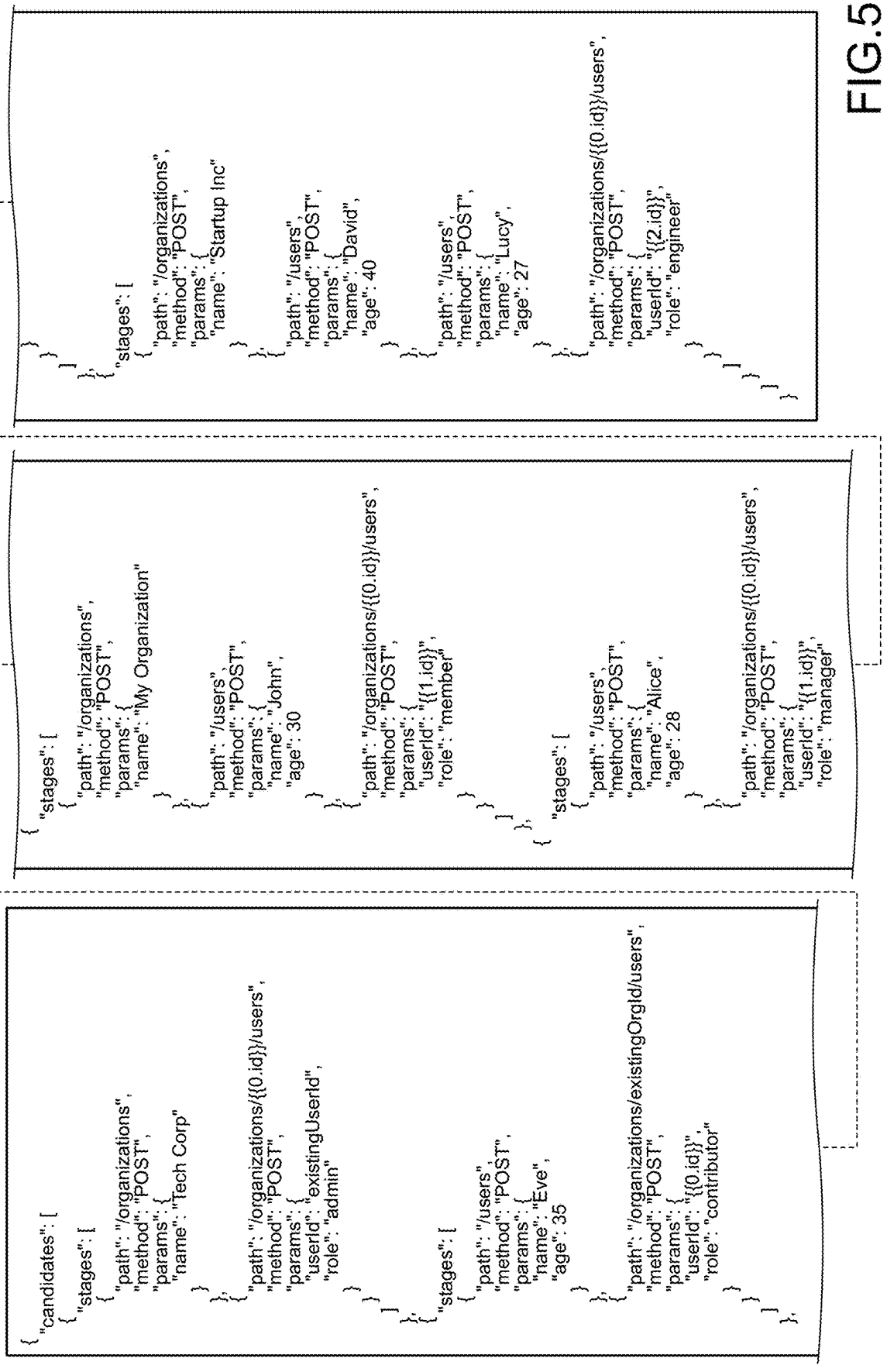

{
"candidates": [
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Tech Corp"
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "existingUserId",
"role": "admin"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "Eve",
"age": 35
}
},
{
"path": "/organizations/existingOrgId/users",
"method": "POST",
"params": {
"userId": "{{0.id}}",
"role": "contributor"
}
}
]
},
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "My Organization"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "John",
"age": 30
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{1.id}}",
"role": "member"
}
}
]
},
{
"stages": [
{
"path": "/users",
"method": "POST",
"params": {
"name": "Alice",
"age": 28
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{1.id}}",
"role": "manager"
}
}
]
},
{
"stages": [
{
"path": "/organizations",
"method": "POST",
"params": {
"name": "Startup Inc"
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "David",
"age": 40
}
},
{
"path": "/users",
"method": "POST",
"params": {
"name": "Lucy",
"age": 27
}
},
{
"path": "/organizations/{{0.id}}/users",
"method": "POST",
"params": {
"userId": "{{2.id}}",
"role": "engineer"
}
}
]
}
]
}

FIG.5

FIG.6A

```
POST /organizations HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko)
Chrome/58.0.3029.110 Safari/537
Accept: application/json
Content-Type: application/json
Content-Length: 34

{
   "name": "SampleOrganization1"
}
```

FIG.6B

```
HTTP/1.1 201 Created
Date: Mon, 23 May 2022 22:38:34 GMT
Server: Apache/2.4.1 (Unix)
Content-Length: 52
Content-Type: application/json

{
   "id": "abc123",
   "name": "SampleOrganization1"
}
```

FIG.7

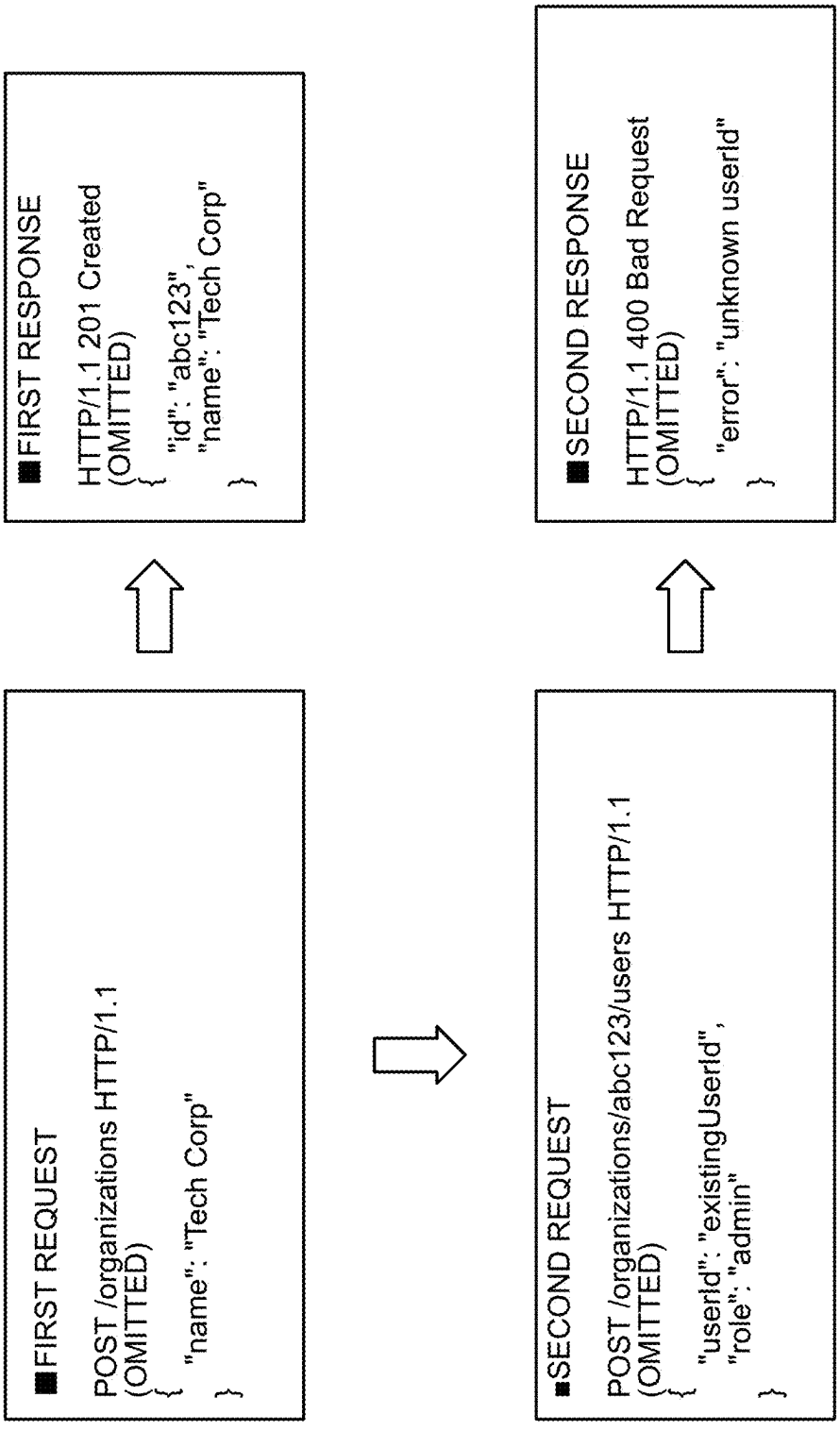

■FIRST REQUEST
POST /organizations HTTP/1.1
(OMITTED)
{
"name": "Tech Corp"
}
■FIRST RESPONSE
HTTP/1.1 201 Created
(OMITTED)
{
"id": "abc123",
"name": "Tech Corp"
}
■SECOND REQUEST
POST /organizations/abc123/users HTTP/1.1
(OMITTED)
{
"userId": "existingUserId",
"role": "admin"
}
■SECOND RESPONSE
HTTP/1.1 400 Bad Request
(OMITTED)
{
"error": "unknown userId"
}

FIG.8

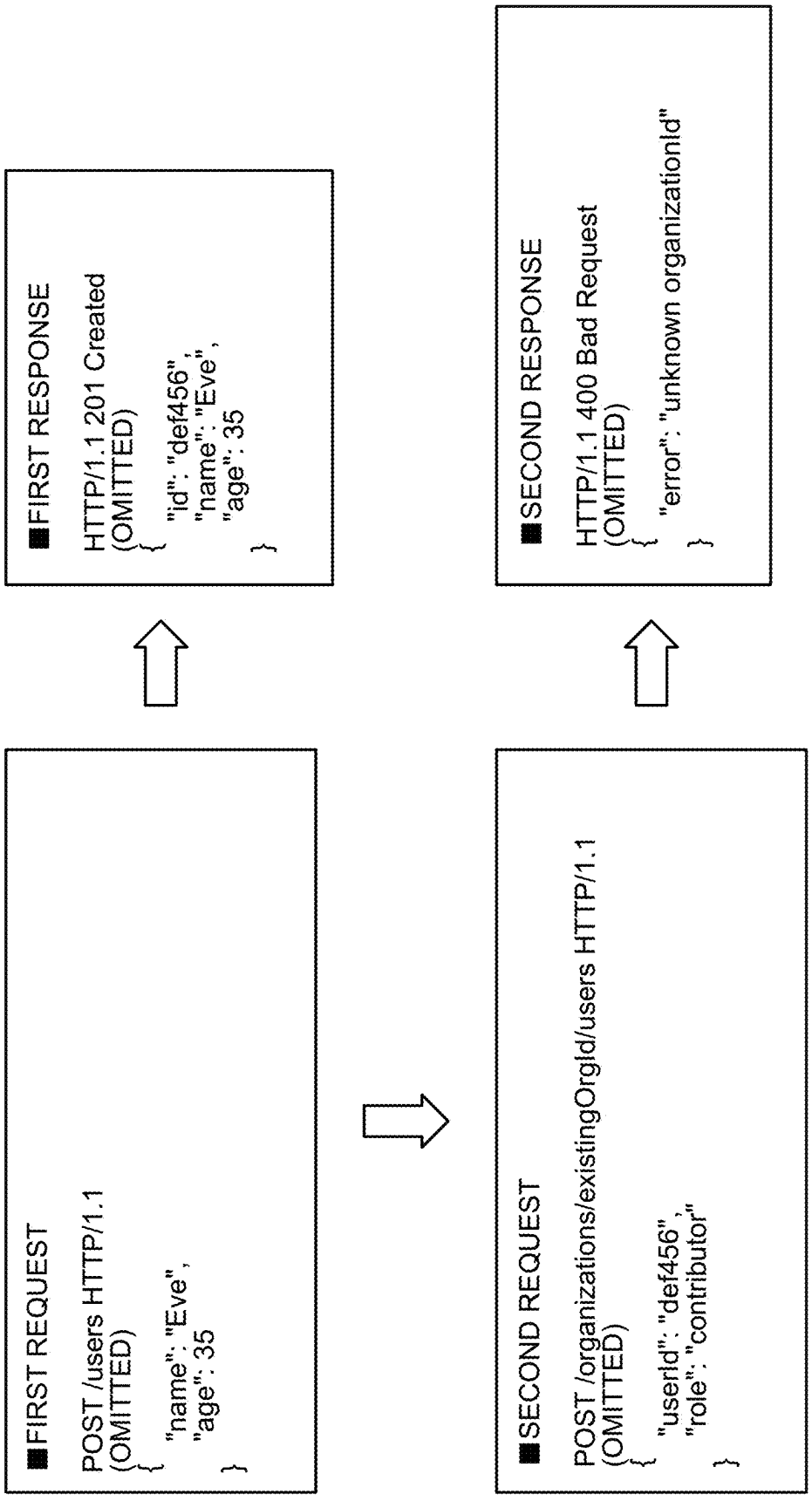

■FIRST REQUEST
POST /users HTTP/1.1
(OMITTED)
{
"name": "Eve",
"age": 35
}
■FIRST RESPONSE
HTTP/1.1 201 Created
(OMITTED)
{
"id": "def456",
"name": "Eve",
"age": 35
}
■SECOND REQUEST
POST /organizations/existingOrgId/users HTTP/1.1
(OMITTED)
{
"userId": "def456",
"role": "contributor"
}
■SECOND RESPONSE
HTTP/1.1 400 Bad Request
(OMITTED)
{
"error": "unknown organizationId"
}

FIG.9

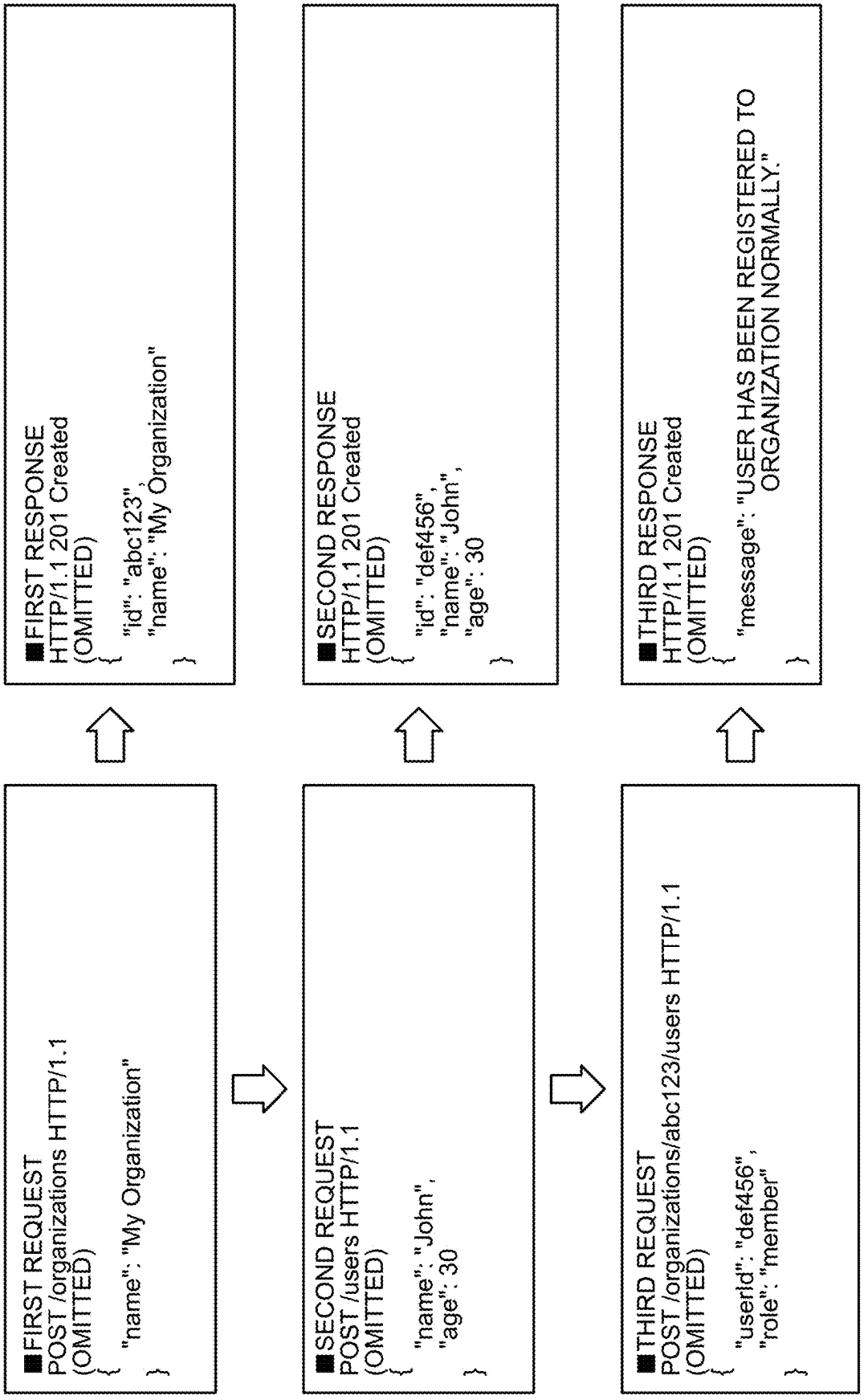

■FIRST REQUEST
POST /organizations HTTP/1.1
(OMITTED)
{
"name": "My Organization"
}
■FIRST RESPONSE
HTTP/1.1 201 Created
(OMITTED)
{
"id": "abc123",
"name": "My Organization"
}
■SECOND REQUEST
POST /users HTTP/1.1
(OMITTED)
{
"name": "John",
"age": 30
}
■SECOND RESPONSE
HTTP/1.1 201 Created
(OMITTED)
{
"id": "def456",
"name": "John",
"age": 30
}
■THIRD REQUEST
POST /organizations/abc123/users HTTP/1.1
(OMITTED)
{
"userId": "def456",
"role": "member"
}
■THIRD RESPONSE
HTTP/1.1 201 Created
(OMITTED)
{
"message": "USER HAS BEEN REGISTERED TO ORGANIZATION NORMALLY."
}

FIG.10A

(1) POST/organizations

```
{
  "stages": [
    {
      "path": "/organizations",
      "method": "POST",
      "params": {
        "name": "SampleOrganization1"
      }
    }
  ]
}
```

FIG.10B

(2) POST/users

```
{
  "stages": [
    {
      "path": "/users",
      "method": "POST",
      "params": {
        "name": "John Doe",
        "age": 30
      }
    }
  ]
}
```

FIG.10C

(3) POST/organizations/{organizationId}/users

```
{
  "stages": [
    {
      "path": "/organizations",
      "method": "POST",
      "params": {
        "name": "My Organization"
      }
    },
    {
      "path": "/users",
      "method": "POST",
      "params": {
        "name": "John",
        "age": 30
      }
    },
    {
      "path": "/organizations/{{0.id}}/users",
      "method": "POST",
      "params": {
        "userId": "{{1.id}}",
        "role": "member"
      }
    }
  ]
}
```

FIG.11A

```
test_name: REQUIRED PARAMETER name NOT SPECIFIED
stages:
  - name: CREATION OF ORGANIZATION
    request:
      url: https://localhost/organizations
      method: POST
      json:
response:
      status_code: 400
```

FIG.11B

```
test_name: SPECIFY INVALID TYPE IN name
stages:
  - name: CREATION OF ORGANIZATION
    request:
      url: https://localhost/organizations
      method: POST
      json:
        name: 1
    response:
      status_code: 400
```

FIG.12A

```
test_name: REQUIRED PARAMETER role NOT SPECIFIED
stages:
  - name: CREATION OF ORGANIZATION
    request:
      url: https://localhost/organizations
      method: POST
      json:
        name: "My Organization"
    response:
      status_code: 201
      save:
        json:
          organization_id: id
  - name: CREATION OF USER
    request:
      url: https://localhost/users
      method: POST
      json:
        name: "John"
        age: 30
    response:
      status_code: 201
      save:
        json:
          user_id: id
  - name: REGISTRATION OF USER TO ORGANIZATION
    request:
      url: https://localhost/organizations/{organization_id}/users
      method: POST
      json:
        user_id: "{user_id}"
response:
      status_code: 400
```

FIG.12B

```
test_name: SPECIFY INVALID TYPE IN role
stages:
  - name: CREATION OF ORGANIZATION
    request:
      url: https://localhost/organizations
      method: POST
      json:
        name: "My Organization"
    response:
      status_code: 201
      save:
        json:
          organization_id: id
  - name: CREATION OF USER
    request:
      url: https://localhost/users
      method: POST
      json:
        name: "John"
        age: 30
    response:
      status_code: 201
      save:
        json:
          user_id: id
  - name: REGISTRATION OF USER TO ORGANIZATION
    request:
      url: https://localhost/organizations/{organization_id}/users
      method: POST
      json:
        user_id: "{user_id}"
        role: 1
    response:
      status_code: 400
```

FIG.13

```
openapi: 3.0.0
info:
  version: 1.0.0
  title: ORGANIZATION MANAGEMENT API
paths:
  /organizations:
    get:
      summary: SEARCH FOR ORGANIZATION
      parameters:
        - name: name
          in: query
          schema:
            type: string
          required: true
          description: |-
          FILTER BY NAME.
          IF ENCLOSED IN DOUBLE QUOTATION MARKS,
          VALUE NARROWS DOWN TO THOSE THAT MATCH VALUE EXACTLY.
          IF ENCLOSED IN SLASHES, VALUE NARROWS DOWN TO
          THOSE THAT MATCH REGULAR EXPRESSION (POSIX ERE).
        - name: count
          in: query
          schema:
            type: integer
          description: NUMBER OF ACQUISITIONS
      responses:
        '200':
          description: ORGANIZATION SEARCH IS SUCCESSFUL
          content:
            application/json:
              schema:
                type: array
                properties:
                  organizations:
                    type: object
                    properties:
                      id:
                        type: string
                      name:
                        type: string
        '400':
          description: INVALID PARAMETER
          content:
            application/json:
              schema:
                type: object
                properties:
                  error:
                    type: string
```

FIG.14


```
{
  "candidates": [
    {
      "stages": [
        {
          "path": "/organizations",
          "method": "GET",
          "params": {
            "name": "¥"SpecificOrgName¥""
          }
        }
      ]
    },
    {
      "stages": [
        {
          "path": "/organizations",
          "method": "GET",
          "params": {
            "name": "/OrgPattern/"
          }
        }
      ]
    },
    {
      "stages": [
        {
          "path": "/organizations",
          "method": "GET",
          "params": {
            "name": "¥"AnyOrgName¥"",
            "count": 10
          }
        }
      ]
    },
    {
      "stages": [
        {
          "path": "/organizations",
          "method": "GET",
          "params": {
            "name": "¥"SpecificOrgName¥"",
            "count": 5
          }
        }
      ]
    },
    {
      "stages": [
        {
          "path": "/organizations",
          "method": "GET",
          "params": {
            "name": "/OrgPattern/",
            "count": 3
          }
        }
      ]
    }
  ]
}
```

FIG.15

```
test_name: SPECIFY INVALID TYPE IN count
stages:
  - name: SEARCH FOR ORGANIZATION
    request:
      url: https://localhost/organizations
      method: POST
      params:
        count: "x"
    response:
      status_code: 400
```

FIG.16

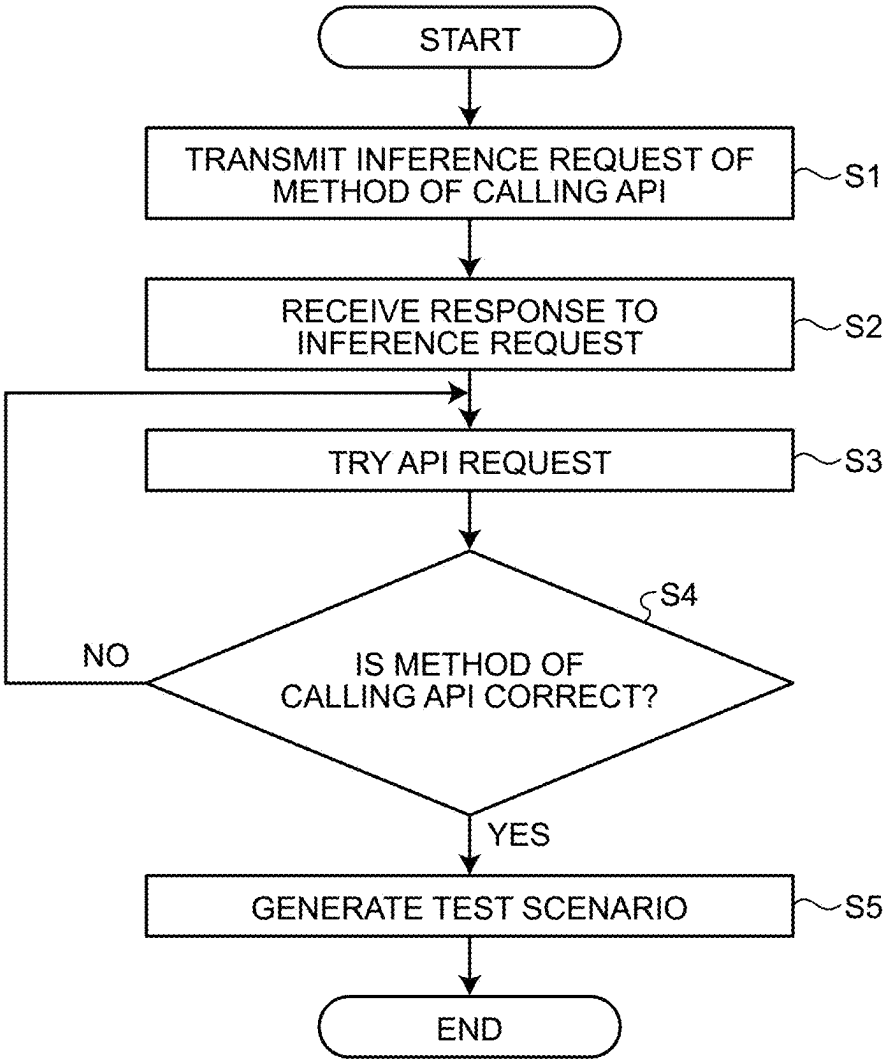

START
TRANSMIT INFERENCE REQUEST OF METHOD OF CALLING API
S1
RECEIVE RESPONSE TO INFERENCE REQUEST
S2
TRY API REQUEST
S3
S4
IS METHOD OF CALLING API CORRECT?
NO
YES
GENERATE TEST SCENARIO
S5
END

FIG.17

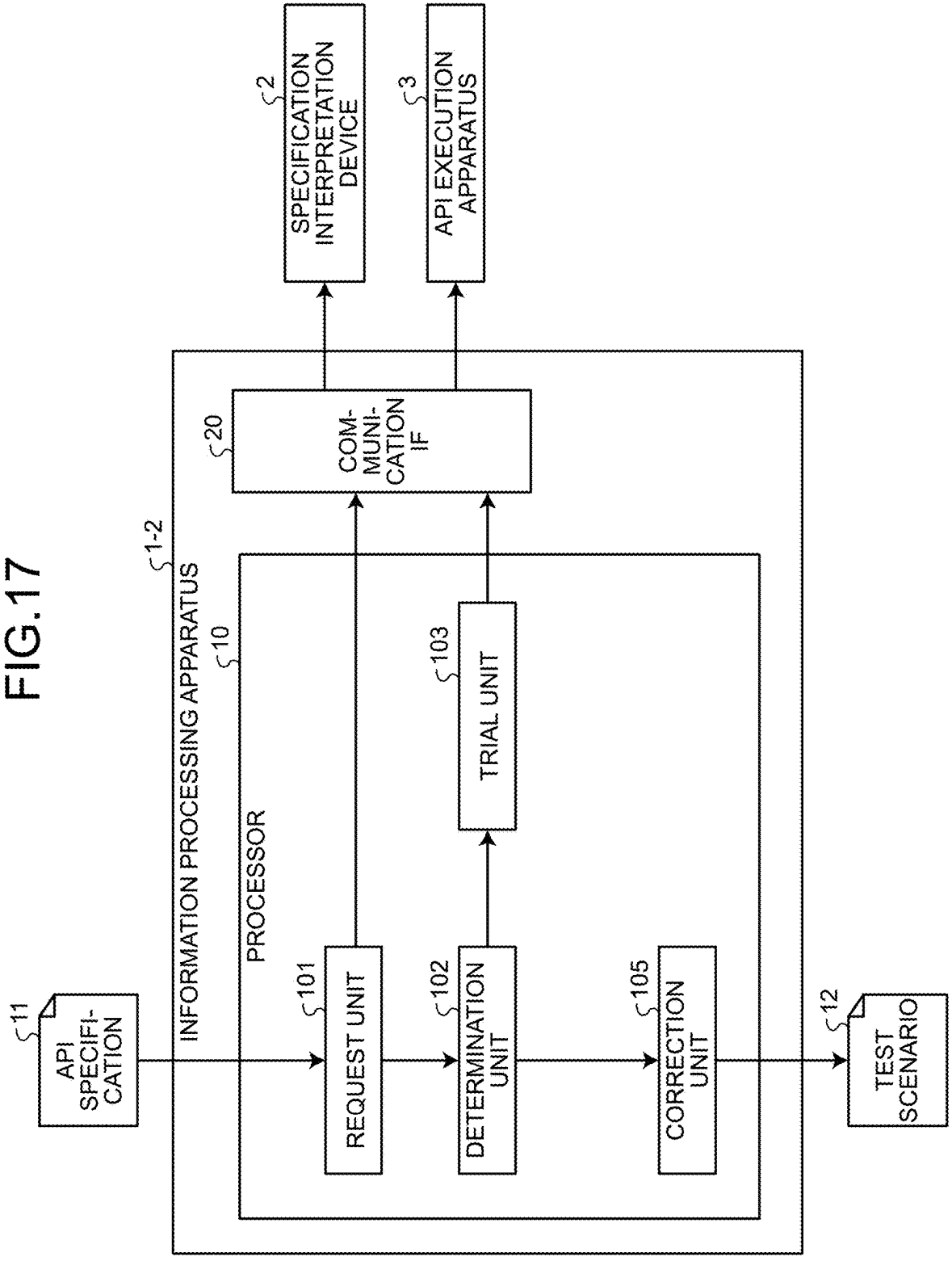

2
SPECIFICATION INTERPRETATION DEVICE
3
API EXECUTION APPARATUS
20
COM-MUNI-CATION IF
1-2
INFORMATION PROCESSING APPARATUS
10
PROCESSOR
103
TRIAL UNIT
11
API SPECIFI-CATION
101
REQUEST UNIT
102
DETERMINATION UNIT
105
CORRECTION UNIT
12
TEST SCENARIO

FIG.18

```
openapi: 3.0.0
info:
  version: 1.0.0
  title: DEVICE MANAGEMENT API
servers:
  - url: 'https://api.example.com/'
paths:
  /devices:
    post:
      summary: CREATE NEW DEVICE
      requestBody:
        content:
          application/json:
            schema:
              type: object
              properties:
                name:
                  type: string
                  description: NAME OF DEVICE
                  required: true
                  minLength: 1
                  maxLength: 256
                model_number:
                  type: string
                  description: MODEL NUMBER
                  minLength: 1
                  maxLength: 128
  responses:
        '201':
          description: DEVICE HAS BEEN CREATED NORMALLY
          content:
            application/json:
              schema:
                type: object
                properties:
                  id:
                    type: string
                  name:
                    type: string
                  model_number:
                    type: string
        '400':
          description: INVALID PARAMETER
          content:
            application/json:
              schema:
                type: object
                properties:
                  error:
                    type: string
                    enum:
                      - invalid_name
                      - invalid_model_number
```

FIG.19A

```
# This is a Tavern test scenario file
# for the provided Web API specification

---

test_name: Create device success test
stages:
  - name: Test successful device creation
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: "Device1"
        model_number: "MN1234"
    response:
      status_code: 201
      json:
        id: "{uuid}"
        name: "Device1"
        model_number: "MN1234"

---

test_name: Create device with invalid parameter types
stages:
  - name: Test invalid name type
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: 123
        model_number: "MN1234"
    response:
      status_code: 400
      json:
        error: "invalid_name"
  - name: Test invalid model_number type
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: "Device1"
        model_number: 1234
    response:
      status_code: 400
      json:
        error: "invalid_model_number"

---

test_name: Create device with missing required parameters
stages:
  - name: Test missing name
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        model_number: "MN1234"
    response:
      status_code: 400
      json:
        error: "invalid_name"

---
```

FIG.19B

```
test_name: Create device with string length constraints
stages:
  - name: Test name with length exceeding maximum
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: "a" * 257  # Exceeds maxLength of 256
        model_number: "MN1234"
    response:
      status_code: 400
      json:
        error: "invalid_name"

  - name: Test name with length below minimum
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: ""  # Below minLength of 1
        model_number: "MN1234"
    response:
      status_code: 400
      json:
        error: "invalid_name"
  - name: Test model_number with length exceeding maximum
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: "Device1"
        model_number: "m" * 129  # Exceeds maxLength of 128
    response:
      status_code: 400
      json:
        error: "invalid_model_number"

  - name: Test model_number with length below minimum
    request:
      url: "https://api.example.com/devices"
      method: POST
      json:
        name: "Device1"
        model_number: ""  # Below minLength of 1
    response:
      status_code: 400
      json:
        error: "invalid_model_number"
```

FIG.20

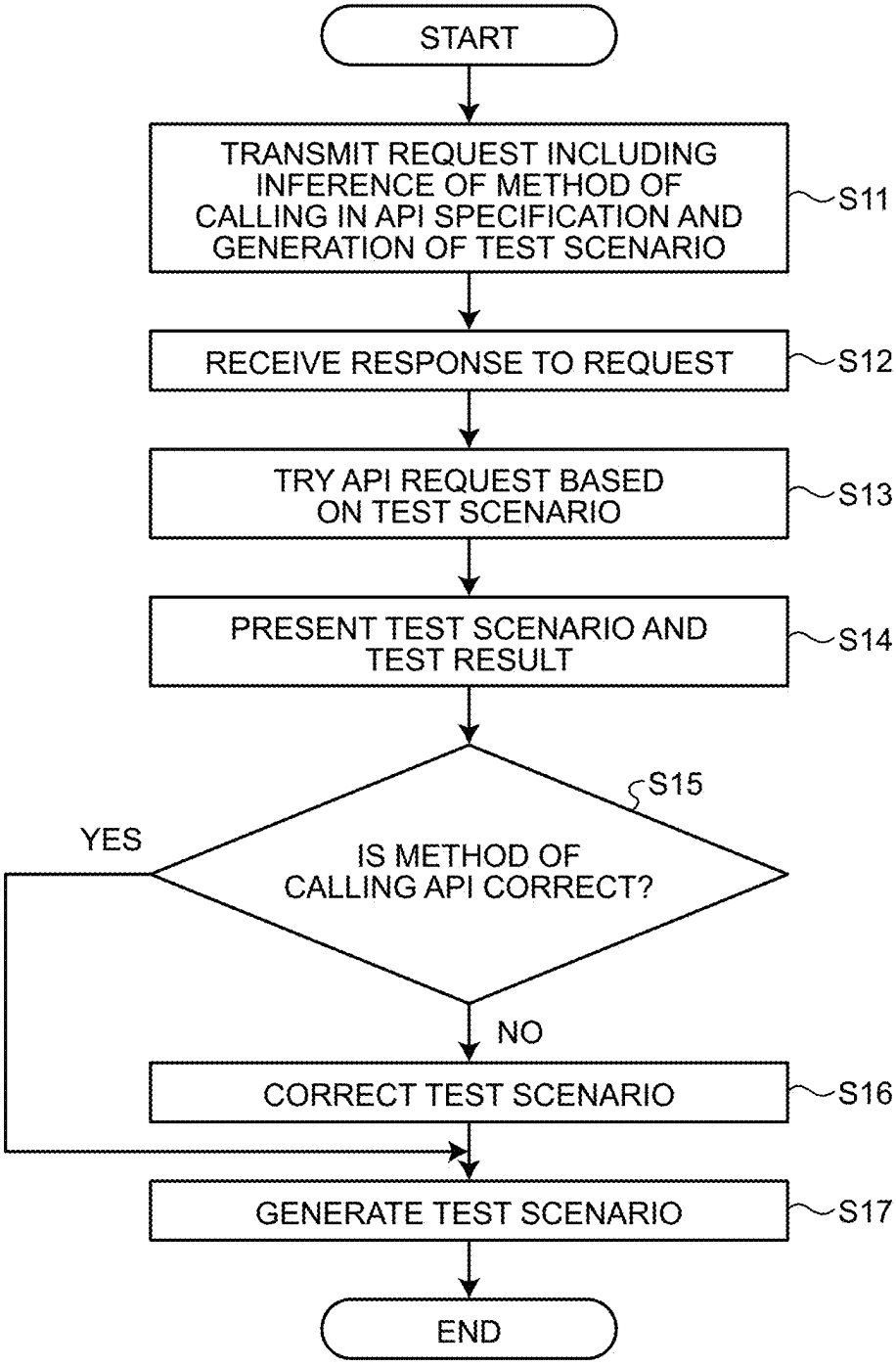
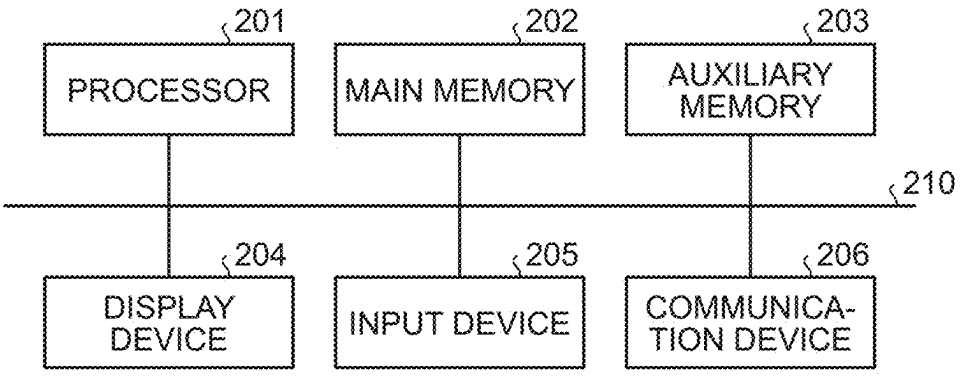

START
TRANSMIT REQUEST INCLUDING INFERENCE OF METHOD OF CALLING IN API SPECIFICATION AND GENERATION OF TEST SCENARIO
S11
RECEIVE RESPONSE TO REQUEST
S12
TRY API REQUEST BASED ON TEST SCENARIO
S13
PRESENT TEST SCENARIO AND TEST RESULT
S14
S15
IS METHOD OF CALLING API CORRECT?
YES
NO
CORRECT TEST SCENARIO
S16
GENERATE TEST SCENARIO
S17
END

FIG.21


201
PROCESSOR
202
MAIN MEMORY
203
AUXILIARY MEMORY
210
204
DISPLAY DEVICE
205
INPUT DEVICE
206
COMMUNICA-TION DEVICE

INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND COMPUTER PROGRAM PRODUCT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2024-017691, filed on Feb. 8, 2024; the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to an information processing apparatus, an information processing method, and a computer program product.

BACKGROUND

[0003] Recently, in application programming interface (API) development, importance of a technique for automatically generating a test scenario is increasing. The test scenario is a series of procedures and test cases for checking whether the API functions as expected. When a test scenario is manually created, there is a case where completeness, accuracy, and the like are insufficient due to human judgment, mistake, omission, or the like. In particular, in a case where a large-scale API or a specification changes frequently, manual updating is very laborious, and thus, needs for automation are increasing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a diagram illustrating an example of a functional configuration of an information processing apparatus according to a first embodiment;
[0005] FIG. **2** is a diagram illustrating Example 1 of an API specification according to the first embodiment;
[0006] FIG. **3** is a diagram illustrating Example 1 of a response to a prompt according to the first embodiment;
[0007] FIG. **4** is a diagram illustrating Example 2 of a response to a prompt according to the first embodiment;
[0008] FIG. **5** is a diagram illustrating Example 3 of a response to a prompt according to the first embodiment;
[0009] FIG. **6**A is a diagram illustrating an example of an HTTP request according to the first embodiment;
[0010] FIG. **6**B is a diagram illustrating an example of a response to the HTTP request in FIG. **6**A;
[0011] FIG. **7** is a diagram illustrating Example 1 of a series of HTTP requests and responses according to the first embodiment;
[0012] FIG. **8** is a diagram illustrating Example 2 of a series of HTTP requests and responses according to the first embodiment;
[0013] FIG. **9** is a diagram illustrating Example 3 of a series of HTTP requests and responses according to the first embodiment;
[0014] FIG. **10**A is a diagram illustrating Example 1 of a method of calling an API to be a normal system according to the first embodiment;
[0015] FIG. **10**B is a diagram illustrating Example 2 of a method of calling an API to be a normal system according to the first embodiment;
[0016] FIG. **10**C is a diagram illustrating Example 3 of a method of calling an API to be a normal system according to the first embodiment;
[0017] FIG. **11**A is a diagram illustrating Example 1 of a test scenario of an abnormal system according to the first embodiment;
[0018] FIG. **11**B is a diagram illustrating Example 2 of a test scenario of an abnormal system according to the first embodiment;
[0019] FIG. **12**A is a diagram illustrating Example 3 of a test scenario of an abnormal system according to the first embodiment;
[0020] FIG. **12**B is a diagram illustrating Example 4 of a test scenario of an abnormal system according to the first embodiment;
[0021] FIG. **13** is a diagram illustrating Example 2 of an API specification according to the first embodiment;
[0022] FIG. **14** is a diagram illustrating Example 4 of a response to a prompt according to the first embodiment;
[0023] FIG. **15** is a diagram illustrating Example 5 of a test scenario of an abnormal system according to the first embodiment;
[0024] FIG. **16** is a flowchart illustrating an example of an information processing method according to the first embodiment;
[0025] FIG. **17** is a diagram illustrating an example of a functional configuration of an information processing apparatus according to a second embodiment;
[0026] FIG. **18** is a diagram illustrating an example of an API specification according to the second embodiment;
[0027] FIG. **19**A is a diagram illustrating an example of a response to a prompt according to the second embodiment;
[0028] FIG. **19**B is a diagram illustrating an example of a response to a prompt according to the second embodiment;
[0029] FIG. **20** is a flowchart illustrating an example of an information processing method according to the first embodiment; and
[0030] FIG. **21** is a diagram illustrating an example of a hardware configuration of an information processing apparatus according to the first and second embodiments.

DETAILED DESCRIPTION

[0031] According to an embodiment, an information processing apparatus includes a communication interface, and a processor. The communication interface is configured to transmit an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receive a response indicating the method of calling the API included in the API specification from the specification interpretation device. The processor is configured to determine whether or not the method of calling the API indicated by the response is correct, and generates a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.
[0032] Hereinafter, embodiments of an information processing apparatus, an information processing method, and a program will be described in detail with reference to the accompanying drawings.
[0033] Recently, in particular, a description specification of an API specification called OpenAPI (formerly Swagger) has become widespread, and details such as an API endpoint, a parameter, and a response can be structured and described. This structured information is well suited as a basis for automated test case generation.

[0034] On the other hand, there is a specification that cannot be expressed by the expressive power of OpenAPI. For example, examples include dependency between a plurality of API (for example, a response of API-A is used for input of API-B), a complicated parameter specification method, and the like. These specifications may be freely described in the OpenAPI description column, or the reader may have to imagine from the endpoint name, parameter name, or the like.

[0035] Therein, the incorporation of a natural language processing technology represented by generative AI such as ChatGPT (registered trademark) is becoming a field of view. It can be expected to analyze the content of the free description and specify an API specification that cannot be expressed by OpenAPI. Furthermore, generative AI is expected to be able to interpret API specifications based on current best practices and conventions for API design.

First Embodiment

[0036] In the first embodiment, an information processing apparatus that automatically generates a test scenario from description contents of an API specification and inputs and executes test patterns of various normal systems and abnormal systems to an API execution apparatus under development to improve API quality will be described.

[0037] The first embodiment is an example of generating a test scenario for checking whether or not a response when various inputs are given is appropriate for an API execution apparatus that has been developed by a user (for example, API developers) and at least correctly implemented normal system processing. In the first embodiment, the processing of the normal system can be performed even in a stage where the processing of the normal system is implemented and the processing of the abnormal system is not yet implemented.

[0038] In the test using the test scenario of the first embodiment, it is checked that a status code indicating success or failure is returned. In the test of the processing of the normal system, it is checked that a status code indicating success is returned. In the test of the processing of the abnormal system, it is checked that a status code indicating failure is returned.

Example of Functional Configuration

[0039] FIG. **1** is a diagram illustrating an example of a functional configuration of an information processing apparatus **1** according to a first embodiment. The information processing apparatus **1** according to the first embodiment includes a processor **10** and a communication interface (IF) **20**.

[0040] The processor **10** generates a test scenario **12** based on, for example, an input of an API specification **11** from a user of an organization that creates the API.

[0041] The processor **10** is implemented by at least one processing device, and executes processing of the information processing apparatus **1**. This processing device includes, for example, a control device and an arithmetic device, and is implemented by an analog or digital circuit or the like. The processing device may be a central processing unit (CPU), or may be a general-purpose processor, a microprocessor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a combination thereof.

[0042] The processor **10** includes a request unit **101**, a determination unit **102**, a trial unit **103**, a generation unit **104**, a correction unit **105**, and a transmission control unit **106**.

[0043] The request unit **101** receives an input of the API specification **11**, and requests a specification interpretation device **2** via the communication IF **20** to perform inference of the method of calling the API included in the specification of each API. The inference of the method of calling the API in the first embodiment means that "the method of calling a series of APIs from which a success status code is obtained" is inferred in each API. The inference request of the method of calling the API included in the API specification may include a presentation request of a plurality of candidates indicating the method of calling the API. Whether or not the method of calling the API obtained by the inference by the specification interpretation device **2** is correct is determined by the determination unit **102**.

[0044] The determination unit **102** determines whether the method of calling the API obtained by the inference by the specification interpretation device **2** is correct. For example, in a case where a successful status code is included in the response to the API request, the determination unit **102** determines that the method of calling the API is correct.

[0045] The trial unit **103** tries the API request by transmitting the API request to an API execution apparatus **3** via the communication IF **20**.

[0046] The generation unit **104** generates a test scenario **12** based on the method of calling the API determined to be correct by the determination unit **102**.

[0047] The correction unit **105** corrects the method of calling the API based on an instruction from the user. For example, the correction unit **105** displays information indicating the method of calling the API determined to be correct on the display device, and corrects the method of calling the API based on the correction information input by the user.

[0048] The transmission control unit **106** transmits learning data including information indicating the method of calling the API determined to be correct to the specification interpretation device **2** via the communication IF **20**.

[0049] The communication IF **20** communicates with other devices such as the specification interpretation device **2** and the API execution apparatus **3**. For example, the communication IF **20** receives a response to the inference request of the method of calling the API included in the API specification from the specification interpretation device **2**, and transmits at least one API request to the API execution apparatus **3** based on the method of calling the API indicated by the response.

[0050] The specification interpretation device **2** analyzes the contents of the API specification **11** and infers the method of calling the API. In the first embodiment, the specification interpretation device **2** is, for example, a server device of ChatGPT (registered trademark).

[0051] The API execution apparatus **3** is a server device developed by the user (for example, API developers) of the first embodiment based on the API specification **11**. Based on the input of the request, an output is generated and returned as a response. It is assumed that at least the normal system processing is correctly implemented in the API execution apparatus **3**.

[0052] Next, processing performed by the information processing apparatus **1** according to the first embodiment

will be described. The request unit **101** receives an input of the API specification **11** in response to an operation input by the user.

[0053] FIG. **2** is a diagram illustrating Example 1 of the API specification **11** according to the first embodiment. In the example of FIG. **2**, the following information is written as a specification in the OpenAPI format for three APIs.

Specification Example

```
1. Create new organization
endpoint: /organizations
method: POST
request body:
name (character string): The name of the organization.
response:
status:
201 Created
400 Bad Request
body:
id (character string): Unique identifier of the
organization.
name (character string): The name of the organization.
2. Create new user
Endpoint: /users
method: POST
request body:
title (character string): User's name.
age (integer): age.
response:
status:
201 Created
400 Bad Request
body:
id (character string): Unique identifier of the user.
name (character string): User's name.
age (integer): age.
3. Register a user to an organization
endpoint: /organizations/{organizationId}/users
method: POST
parameters:
organizationId (character string-path): ID of the
organization to which the user is added.
request body:
userId (character string): ID of the user to be added
to the organization.
response:
status:
201 Created
400 Bad Request
------------
```

[0054] Next, the usage intended by the creator of the API specification is as follows.

Usage Example

[0055] A first API (left in FIG. **2**) is an API for creating a new organization./organizations sends a request to the endpoint by a POST method. In the request body, the name of the organization to be newly created is specified as name in the JSON format.

Request Example

```
{
"name": "Sales department"
}
```

[0056] When the processing is normally performed, information of the newly created organization is returned as a response together with a status code **201**.

Response Example

```
{
"id": "abc123",
"name": "Sales department"
}
```

[0057] If an inappropriate parameter is specified, a status code **400** is returned.

[0058] A second API (center in FIG. **2**) is an API for creating a new user./users sends a request to the endpoint by a POST method. In the request body, the name of the user to be newly created is specified as name, and the age is specified as age in the JSON format.

Request Example

```
{
"name": "John Smith",
"age": 30
}
```

[0059] When the processing is normally performed, information of the newly created user is returned as a response together with the status code **201**.

Response Example

```
{
"id": "def456",
"name": "John Smith",
"age": 30
}
```

[0060] If an inappropriate parameter is specified, the status code **400** is returned.

[0061] A third API (right in FIG. **2**) is an API for registering a user in an organization.

[0062] /organizations/{organizationId}/users sends a request to the endpoint by a POST method. Here, {organizationId} specifies an ID of an organization to which the user is desired to be added. In the request body, the ID of the user to be added to the organization is specified as userId, and the role of the user in the organization is specified as role.

Example

```
{
"userId": "def456",
"role": "manager",
}
```

[0063] When processed normally, the status code **201** is returned.

Response Example

```
{
  "message": "The user has been registered with the
organization normally.  "
}
```

[0064] If an inappropriate parameter is specified, the status code **400** is returned.

[0065] When receiving the API specification **11** as an input, the processor **10** generates the test scenario **12** by the following procedure. In the test scenario **12**, various inputs are given to the parameters of each API, and it is checked that an appropriate status code is obtained.

[0066] First, the request unit **101** analyzes the API specification **11** and extracts an endpoint, a parameter, a response, and the like of each API defined in the API specification **11**. Next, when performing the API test, the request unit **101** requests the specification interpretation device **2** to infer the method of calling the API in order to grasp what value should be designated for each parameter in order to perform the normal system test.

[0067] The following is an example of a prompt generated by the request unit **101**. This prompt is a prompt asking the test scenario **12** of the normal system (the method of calling the API from which the success status code is obtained) for the first API (POST/organizations) among the three examples of FIG. **2**.

Example of Prompt

[0068] The following is a specification of Web API described in OpenAPI format. Regarding the following API of interest, estimate at least five methods of "the method of calling a series of APIs" by which a status code of success can be obtained from this API, and output them strictly following the following constraint conditions.

```
# API of interest
POST /organizations
# constraint condition
- never output any text other than JSON.
- output in JSON format according to the following
JSON schema.
- the last element of each stages corresponds to a
call of the API of interest.
{
"$schema": "http://json-schema.org/draft-04/schema#",
"type": "object",
"properties": {
"candidates": {
"type": "array",
"items": (
{
"type": "object",
"properties": {
"stages": {
"type": "array",
"items": (
{
"type": "object",
"properties": {
"path": {
"type": "string"
},
"method": {
"type": "string"
},
```

-continued

```
"params": {
"type": "object"
}
},
"required": (
"path",
"method",
"params"
)
}
)
}
},
"required": (
"stages"
)
}
)
}
},
"required": (
"candidates"
)
}
- In stages, specify "the method of calling a series
of APIs". "the method of calling a series of APIs" is an
array of "API calls". "API call" corresponds to
transmission of a request to the API and reception of a
response, and includes a path (path), a method (method),
and a parameter (param). By calling the APIs in the order
specified in "the method of calling a series of APIs", it
is expected that the API call of the API of interest
returns a success status code.
- If it is presumed that the API of interest needs to
call some other API in advance in order to return a status
code of success, describe such an API call in an array of
stages. When the API is called in order from the top of
the array stages, it is expected that the last API call
returns a status code of success. The last element of the
stages must be a call of the API of interest.
- In a case where it is estimated that the next API
call needs to be performed using the content of the
response to the API call called in advance, write the
dependency in the response. When making a request for API
call of the second element of the stages by using the
element foo of the response to API call of the first
element of the stages, write {{0.foo}} in params.
- In candidates, specify a plurality of patterns of
API call method candidates for which a status code of
success will be obtained. Priority will be given to those
with a small number of API calls and a high possibility of
obtaining a status code of success at the beginning.
Simple guesses may not provide a status code of success, so
please also mention complex patterns involving multiple API
calls.
# Web API Specification
openapi: 3.0.0
info:
```

[0069] The specification interpretation device **2** returns a response to the above prompt asking a test scenario **12** of the normal system (the method of calling an API from which a status code of success is obtained) to the first API (POST/organizations) in FIG. **2**. An example of the response is illustrated in FIG. **3**.

[0070] FIG. **3** is a diagram illustrating Example 1 of a response to a prompt according to the first embodiment. In the example of FIG. **3**, a plurality of candidates for calling a series of APIs are illustrated. Note that, in a case where the response in FIG. **3** is not as expected, the request unit **101** may perform a part or all of the request again.

[0071] The request unit **101** creates a similar prompt for other APIs (center and right in FIG. **2**) and requests the

specification interpretation device **2** to do the same. FIG. **4** illustrates a response to the second API (POST/users) in FIG. **2**, and FIG. **5** illustrates a response to the third API (POST/organizations/{organizationId}/users) in FIG. **2**.

[0072] FIG. **4** is a diagram illustrating Example 2 of a response to a prompt according to the first embodiment. FIG. **4** illustrates an example of a response to the above prompt asking the test scenario **12** of the normal system (the method of calling the API from which the status code of success is obtained) with respect to the second API (POST/users) in FIG. **2**. In the example of FIG. **4**, a plurality of candidates for calling a series of APIs are illustrated.

[0073] FIG. **5** is a diagram illustrating Example 3 of a response to a prompt according to the first embodiment. FIG. **5** illustrates an example of a response to the above prompt asking the test scenario **12** of the normal system (the method of calling the API from which the status code of success is obtained) with respect to the third API (POST/organizations/{organizationId}/users) in FIG. **2**. In the example of FIG. **5**, a plurality of candidates for calling a series of APIs are illustrated.

[0074] Note that, in the first embodiment, an individual prompt is created for each API and transmitted to the specification interpretation device **2**, but an inference request of a method of calling for all APIs may be written in a single prompt and requested to the specification interpretation device **2** only once.

[0075] The request unit **101** transmits the obtained API call method (JSON format) to the determination unit **102**, and requests the determination unit to determine whether or not the API call method is a correct API call method. For each API, the determination unit **102** tries candidates for calling a series of APIs in order from the top. For example, in the case of the first API (POST/organizations) in FIG. **2**, the first candidate (candidates) is to make the following API call according to FIG. **3**.

```
•Method: POST
•Path: /organizations
•Parameters:
{
"name": "SampleOrganization1"
}
```

[0076] The determination unit **102** requests the trial unit **103** to create and transmit an HTTP request. The trial unit **103** creates an HTTP request in response to the request from the determination unit **102** and sends the HTTP request to the API execution apparatus **3**. The API execution apparatus **3** processes the request and returns an HTTP response. Examples of the request and the response are illustrated in FIGS. **6**A and **6**B.

[0077] FIG. **6**A is a diagram illustrating an example of an HTTP request according to the first embodiment. FIG. **6**B is a diagram illustrating an example of a response to the HTTP request in FIG. **6**A. In the case of FIGS. **6**A and **6**B, the request is successful, and the status code **201** and the details of the resource generated in the response body are returned. The determination unit **102** determines that FIG. **6**A is the normal-system API call method based on the fact that the status code of success is obtained. The determination of the specification related to the first API in FIG. **2** ends.

[0078] The determination unit **102** also determines the specification of the second API in FIG. **2**. Also for the second API, a status code of success is obtained by making the first API call of the candidates in FIG. **4**. Therefore, the determination unit **102** determines that the first API call of the candidates in FIG. **4** is a normal-system API call method.

```
•Method: POST
•Path: /users
•Parameters:
{
"name": "John Doe",
"age": 30
}
```

[0079] Note that, in a case where the status code of success has not been obtained (for example, the status code **400** or the like), the determination unit **102** continues to call the API of the next element of candidates and checks whether or not the status code of success is obtained.

[0080] The determination unit **102** also determines the specification of the third API in FIG. **2**. According to FIG. **5**, the first candidate consists of the following two API calls.

```
•First time
•Method: POST
•Path: /organizations
•Parameters:
{
"name": "Tech Corp"
}
•Second time
•Method: POST
•Path: /organizations/{{0.id}/users
•Parameters:
{
"userId": "existingUserId",
"role": "admin"
}
```

[0081] In the second API call, the content of the first response is used as instructed in the prompt. That is, the id portion of the first response is used as the {{0.id}} portion of the path. The determination unit **102** constructs a body part of the second HTTP request from the first response. An example of a series of requests and responses is as illustrated in FIG. **7**.

[0082] FIG. **7** is a diagram illustrating Example 1 of a series of HTTP requests and responses according to the first embodiment. In the second request, the actual id value (abc123) is used for the {{0.id}} portion of the path. However, the second request fails with a status code **400**. The reason is that the character string "existingUserId" specified as the identifier of the user is an identifier that does not exist in the actual system. From this, the determination unit **102** determines that the request in FIG. **7** is not a normal-system API call method, and tries the next candidate in FIG. **5**. The next candidate consists of the following two API calls:

```
•First time
•Method: POST
•Path: /users
•Parameters:
{
"name": "Eve",
"age": 35
```

-continued

```
}
•Second time
•Method: POST
•Path: organizations/existingOrgId/users
•Parameters:
{
"userId": "{{0.id}}",
"role": "contributor"
}
```

[0083] As in the case of the first candidate, the content of the first response is used for the second API call. An example of a series of requests and responses is as illustrated in FIG. **8**.

[0084] FIG. **8** is a diagram illustrating Example 2 of a series of HTTP requests and responses according to the first embodiment. The second request fails with a status code **400**. The reason is that the character string "existingOrgId" specified as the identifier of the organization is an identifier that does not exist in the actual system. From this, the determination unit **102** determines that the request in FIG. **8** is not a normal-system API call method, and tries the next candidate in FIG. **5**. The next candidate consists of the following three API calls:

```
•First time
•Method: POST
•Path: /organizations
•Parameters:
{
"name": "My Organization"
}
•Second time
•Method: POST
•Path: /users
•Parameters:
{
"name": "John",
"age": 30,
}
•Third time
•Method: POST
•Path: /organizations/{{0.id}/users
•Parameters:
{
"userId": "{{1.id}}",
"role": "member"
}
```

[0085] In the third API call, the contents of the first response and the second response are used as instructed in the prompt. The id portion of the first response is used as the {{0.id}} portion of the path. The id portion of the second response is used as the {{1.id}} portion of the parameter. The determination unit **102** constructs a body part of the third HTTP request from the first response and the second response. An example of a series of requests and responses is as illustrated in FIG. **9**.

[0086] FIG. **9** is a diagram illustrating Example 3 of a series of HTTP requests and responses according to the first embodiment. The last (third) request succeeds with the status code **201**. The determination unit **102** determines that FIG. **9** is the normal-system API call method based on the fact that the status code of success is obtained. The determination of the specification related to the third API ends.

[0087] The determination unit **102** passes, to the correction unit **105**, the specifications determined in the above procedure (the method of calling the API to become a normal system: FIGS. **10**A to **10**C).

[0088] FIG. **10**A is a diagram illustrating Example 1 of a method of calling an API to be a normal system according to the first embodiment. FIG. **10**B is a diagram illustrating Example 2 of a method of calling an API to be a normal system according to the first embodiment. FIG. **10**C is a diagram illustrating Example 3 of a method of calling an API to be a normal system according to the first embodiment. The correction unit **105** displays the specification determined by the determination unit **102** (for example, FIGS. **10**A to **10**C) on a display device or the like, and causes a user (for example, an API developer) of the information processing apparatus **1** to check whether or not the specification determined by the determination unit **102** has content as expected. When the user inputs the correction information via the input device or the like in a case where the specification is different from the expectation, the specification determined by the determination unit **102** is corrected by the correction information.

[0089] Next, the determination unit **102** passes the specification finally specified by the above procedure to the transmission control unit **106**, and requests transmission of the learning data. The transmission control unit **106** transmits the learning data to the specification interpretation device **2** via the communication IF **20**.

[0090] The specification interpretation device **2** trains which candidate is a correct API call method by using the learning data, and uses it for accuracy improvement in the next and subsequent times.

[0091] The determination unit **102** inputs the specifications determined in the above procedure (the method of calling the API to become a normal system: FIGS. **10**A to **10**C) to the generation unit **104** and requests generation of the test scenario **12**.

[0092] The generation unit **104** generates the test scenario **12** based on the specification determined by the determination unit **102**. The generation unit **104** generates, as a test scenario of the normal system, a method of calling an API request in which a status code of success is included in a response to the API request. Then, the generation unit **104** generates a test scenario of an abnormal system based on the test scenario of the normal system. The scenario of the abnormal system test includes a test for verifying that incorrect parameter input is performed in various patterns for each parameter and a status code of failure is returned.

[0093] The test scenario **12** of the abnormal system includes, for example, the following tests.

[0094] It is checked that the status code **400** is obtained when the API is called without specifying the required parameter.

[0095] It is checked that the status code **400** is obtained when an invalid type is designated for the parameter and the API is called.

[0096] Each test scenario **12** is generated by rewriting designation of a specific parameter based on the call of the API of the normal system specified by the determination unit **102** (FIGS. **10**A to **10**C). FIGS. **11**A and **11**B illustrate examples of generation of scenarios of the two tests of the abnormal system in the first API (POST/organizations) in FIG. **2**.

[0097] FIG. **11**A is a diagram illustrating Example 1 of the test scenario **12** of an abnormal system according to the first embodiment. FIG. **11**B is a diagram illustrating Example 2

of the test scenario **12** of an abnormal system according to the first embodiment. In the examples of FIGS. **11**A and **11**B, the test scenario **12** of the abnormal system is described in the format of tavern, which is a pytest-based test tool. In the test scenario **12** of FIG. **11**A, it is checked that the status code **400** is returned when the API is called without specifying the required parameter name. In the test scenario **12** of FIG. **11**B, it is confirmed that the status code **400** is returned when an invalid type (a numerical value type is designated where a character string type should be designated) is designated and the API is called.

[0098] Also, FIGS. **12**A and **12**B illustrate examples of generation in the third API (POST/organizations/{organizationId}/users) in FIG. **2**.

[0099] FIG. **12**A is a diagram illustrating Example 3 of the test scenario **12** of an abnormal system according to the first embodiment. FIG. **12**B is a diagram illustrating Example 4 of the test scenario **12** of an abnormal system according to the first embodiment. The examples of FIGS. **12**A and **12**B are test scenarios **12** for a purpose similar to that of the first API in FIG. **2**. In FIGS. **12**A and **12**B, the manner of designating the parameter role is variously changed based on the content of FIG. **10**C.

[0100] In the first embodiment, the two methods above for generating the test scenario **12** have been described. In addition, the test scenario **12** of the abnormal system described below may be generated.

[0101] Omission of authentication header including specification of password for enabling only specific user

[0102] Format (email, etc.) violation

[0103] Value other than option for enum

[0104] Invalid ID character string

[0105] Boundary value test for numerical parameters

[0106] Specify null value

[0107] Length boundary value test for character string parameters with length lower/upper limit

[0108] The generation unit **104** allows the user to download the generated test scenario **12** as a file. For example, the API developer can download the test scenario **12**, execute a test tool (tavern in the first embodiment) on a terminal at hand, and execute a test according to the test scenario **12**. The API developer can detect a defective operation of the API execution apparatus **3** under development by referring to the test result.

[0109] Note that there is a method of using the test scenario **12** other than causing the user to download. For example, the system may further include a test execution unit, and the processor **10** may pass the test scenario **12** to the test execution unit and request the test execution. Also in this case, the test execution unit presents the test execution result to the API developer as a report, so that the API developer can detect the defect of the API execution apparatus **3**.

[0110] In the first embodiment, the test scenario **12** is automatically generated using the specification determined by the determination unit **102**, but the determined specification may be used for other purposes. For example, the generation unit **104** may automatically generate a sample code indicating a use example of each API. By widely disclosing this sample code together with the API specification **11**, it can be expected that the user of the API smoothly understands and learns the API use procedure. In addition, for example, the generation unit **104** may automatically generate a Try It Out page. The Try It Out page is an HTML page on which the API can be used for a trial. By configuring the page according to the determined specification, it is possible to encourage the user of the API to smoothly understand the usage procedure. Alternatively, the generation unit **104** may process the information corresponding to FIGS. **10**A to **10**C into a document in an HTML format and use the document as a manual of the API usage method. Then, the manual may be presented by a display device or the like.

[0111] An operation example when another API specification **11** different from that in FIG. **2** is input will be described below.

[0112] FIG. **13** is a diagram illustrating Example 2 of the API specification **11** according to the first embodiment. FIG. **14** illustrates a response example when a similar prompt regarding the API specification **11** of FIG. **13** is requested to the specification interpretation device **2**.

[0113] FIG. **14** is a diagram illustrating Example 4 of a response to a prompt according to the first embodiment. When the request unit **101** inputs the response of FIG. **14** to the trial unit **103** and the trial unit **103** makes a trial, a status code of success in the first candidate is obtained in the case of FIG. **14**.

```
•Method: GET
•Path: /organizations
•Parameters:
{
"name": "\"SpecificOrgName\""
}
```

[0114] As a result, the method of calling the API that becomes the normal system is specified. The generation unit **104** generates the test scenario **12** of the abnormal system based on the method of calling the API to be the normal system. For example, the test scenario **12** when an invalid type is designated for the parameter count is as illustrated in FIG. **15**.

[0115] FIG. **15** is a diagram illustrating Example 5 of the test scenario **12** of an abnormal system according to the first embodiment. In the test scenario **12** of FIG. **15**, it is checked that the status code **400** is returned when an invalid type is designated for the parameter count and the API is called.

Example of Information Processing Method

[0116] FIG. **16** is a flowchart illustrating an example of an information processing method according to the first embodiment. First, the communication IF **20** transmits an inference request of the method of calling the API included in the API specification **11** to the specification interpretation device **2** that interprets the API specification **11** by natural language processing (Step S**1**). Next, the communication IF **20** receives a response indicating the method of calling the API included in the API specification **11** from the specification interpretation device **2** (Step S**2**). Next, the processor **10** tries the API request by transmitting at least one API request to the API execution apparatus **3** based on the API call method candidate indicated by the response received in Step S**2** (Step S**3**).

[0117] Next, the processor **10** determines whether the method of calling the API is correct based on the trial result of Step S**3** (Step S**4**). For example, in a case where a status code of success is included in the response to the API

request, the processor **10** determines that the method of calling the API indicated by the response in Step S**2** is correct.

[0118] In a case where the method of calling the API is not correct (Step S**4**, No), the processing returns to Step S**3**, and an API request based on a next API call method candidate included in the response received in Step S**2** is tried.

[0119] In a case where the API call method is correct (Step S**4**, Yes), the processor **10** generates the test scenario **12** based on the method of calling the API determined to be correct (Step S**5**). Note that the processor **2** may present to the user the method of calling the API determined to be correct, and may receive the correction information from the user as necessary before generating the test scenario **12**.

[0120] As described above, in the information processing apparatus **1** of the first embodiment, the communication IF **20** transmits the inference request of the method of calling the API included in the API specification **11** to the specification interpretation device **2** that interprets the API specification **11** by natural language processing, and receives the response indicating the method of calling the API included in the API specification **11** from the specification interpretation device **2**. Then, the processor **10** determines whether or not the method of calling the API indicated by the response is correct, and generates the test scenario **12** based on the method of calling the API indicated by the response in a case where the method of calling the API indicated by the response is correct.

[0121] As a result, according to the information processing apparatus **1** of the first embodiment, the test scenario **12** can be automatically generated more accurately from the API specification **11** using the natural language processing. Specifically, although there is a problem of uncertainty in utilizing the natural language processing technology, it is possible to generate the test scenario **12** (proper test scenario **12**) as expected even if there is a possibility that a method of calling the API different from the intention of the creator of the API specification is inferred. As a result, for example, the API quality can be improved with less effort.

[0122] For example, the processor **10** can also specify a test item for checking an item not described in the API specification based on the response to the API request. As a result, the test scenario of the first embodiment can also include a test item for checking an item not described in the API specification.

Second Embodiment

[0123] Next, a second embodiment will be described. In the description of the second embodiment, the description similar to that of the first embodiment will be omitted, and portions different from those of the first embodiment will be described.

[0124] In the second embodiment, as in the first embodiment, an example of generating a test scenario **12** for checking whether responses when various inputs are given are appropriate will be described. In the test scenario **12** of the second embodiment, it is checked that the API returns a status code of success when a valid input is made and returns a status code of failure when an invalid input is made. Further, at the time of failure, it is checked whether the content of the response body is as expected.

[0125] The second embodiment is different from the first embodiment in that generation of the test scenario **12** based on the method of calling the API obtained by inference is requested to the specification interpretation device **2** by a prompt, and a final test scenario **12** is generated after correction as necessary.

Example of Functional Configuration

[0126] FIG. **17** is a diagram illustrating an example of a functional configuration of an information processing apparatus **1-2** according to the second embodiment. The information processing apparatus **1-2** according to the second embodiment includes a processor **10** and a communication IF **20**. The processor **10** includes a request unit **101**, a determination unit **102**, a trial unit **103**, and a correction unit **105**.

[0127] The request unit **101** receives an input of the API specification **11**, and requests the specification interpretation device **2** to infer the method of calling each API via the communication IF **20**.

[0128] FIG. **18** is a diagram illustrating an example of the API specification **11** according to the second embodiment. In the example of FIG. **18**, the following information is described as a specification in the OpenAPI format.

Specification Example

```
•Create new device
endpoint: /devices
method: POST
request body:
name (character string): The name of the device.
model_number (character string): model number.
response:
status:
201 Created
400 Bad Request
body (when succeeded):
id (character string): Unique identifier of the
organization.
name (character string): The name of the organization.
model_number (character string): model number.
body (when failed):
error (character string): error content. invalid_name
or invalid_model_number.
```

[0129] Next, the usage intended by the creator of the API specification is as follows.

Usage Example

[0130] The API is an API for creating a new device./devices sends a request to the endpoint by a POST method. In the request body, a name and a model number of a newly created device are specified as name and model number in a JSON format.

Request Example

```
{
"name": "Air conditioner 1",
"model_number": "RAS-N221"
}
```

[0131] When the processing is normally performed, information of the newly created organization is returned as a response together with a status code **201**.

Response Example

```
{
"id": "abc123",
"name": "Air conditioner 1",
"model_number": "RAS-N221"
}
```

[0132] If an inappropriate parameter is specified, an error content is returned along with a status code **400**. In the error content, invalid_name is written when an inappropriate value is specified for name, and invalid_model_number is written when an inappropriate value is specified for model_number.

```
{
"error": "invalid_name"
}
```

[0133] When receiving the API specification **11** as an input, the processor **10** generates the test scenario **12** by the following procedure. First, the request unit **101** passes the API specification **11** to the specification interpretation device **2** and requests the specification interpretation device **2** to infer the method of calling the API. The following is an example of a prompt generated by the request unit **101**.

Example of Prompt

[0134] The following is a specification of Web API described in OpenAPI format. Generate a scenario file of tavern for testing the API execution apparatus implemented according to the use of the API. Generate tests indicated by the following test items. Output in strict compliance with the constraint conditions.

```
# test item
- Test for checking that a status code of success is obtained.
- Test for checking that an error occurs when an invalid type is specified for each parameter of the API.
- Test for checking that an error occurs when each parameter to which the required flag is added is not specified.
- Test for checking that an error occurs when a character string having a length exceeding the upper limit is specified for each parameter in which the upper limit and the lower limit of the character string length are specified. Test for checking that an error occurs when a character string having a length less than the lower limit is specified.
# constraint condition
- Never output text other than the scenario file of tavern.
- In the test for checking that an error occurs, further checking that the status code and the body content of the response are as expected.
# Web API Specification
openapi: 3.0.0
info:
(The following is omitted since it is the same content as that in Fig. 18.)
```

[0135] The specification interpretation device **2** returns the test scenario **12** based on the method of calling the API as a response to the prompt. Examples of the response are illustrated in FIGS. **19**A and **19**B.

[0136] FIGS. **19**A and **19**B are diagrams illustrating examples of responses to a prompt according to the second embodiment. In the test scenario **12** of FIGS. **19**A and **19**B, a test of an abnormal system is also described in addition to a test of a normal system.

[0137] In the abnormal system test, it is checked that the status code **400** is obtained when an invalid value of various patterns (instructed by a prompt) is specified for each parameter, and that error content of a response body includes a name of a parameter. That the error content of the response body includes the name of the parameter means that, for example, when an invalid value is designated for name, error of the response body becomes invalid name.

[0138] The content of the response body of the abnormal system test is not directly described in the API specification **11**, and the specification interpretation device **2** infers this point from the API specification **11** and includes the content of the response body of the abnormal system test in the test scenario **12**.

[0139] Referring back to FIG. **17**, the request unit **101** requests the determination unit **102** to determine the method of calling the API by inputting the test scenario **12** (tavern format) obtained by the response from the specification interpretation device **2**.

[0140] The determination unit **102** determines that the specification interpretation indicated by the test scenario **12** input from the request unit **101** is a correct API call method when the test scenario **12** is actually executed and the test is successful. Specifically, the determination unit **102** passes the test scenario **12** to the trial unit **103** and requests execution of a test. The trial unit **103** performs a test and generates a test result report by transmitting an API request to the API execution apparatus **3** according to the test scenario **12**.

[0141] When the test ends, the determination unit **102** passes the test scenario **12** and the test result report generated by the trial unit **103** to the correction unit **105**.

[0142] The correction unit **105** displays the test scenario **12** and the test result report on a display device or the like, and causes the user (for example, an API developer) of the information processing apparatus **1**-**2** to check whether the determined specification has contents as expected. In particular, for the test scenario **12** in which the actual test execution result was a failure, the user checks whether the content of the test scenario **12** is as intended, and if it is different from the intention, inputs the correction content of the test scenario **12**.

[0143] When the checking by the user ends, the correction unit **105** outputs the final test scenario **12**, and the processing of the processor **10** ends.

Example of Information Processing Method

[0144] FIG. **20** is a flowchart illustrating an example of an information processing method according to the second embodiment. First, the communication IF **20** transmits a request including the inference of the method of calling the API included in the API specification **11** and the generation of the test scenario to the specification interpretation device **2** (Step S**11**). Next, the communication IF **20** receives a response including a test scenario based on the method of calling the API included in the API specification **11** from the specification interpretation device **2** (Step S**12**). Next, the processor **10** tries the API request by transmitting at least

one API request to the API execution apparatus **3** based on the test scenario indicated by the response received in Step S**12** (Step S**13**).

[0145] Next, the correction unit **105** presents the test scenario and the test result to the user by a display device or the like (Step S**14**).

[0146] Next, the processor **10** determines whether the method of calling the API (test scenario based on the method of calling the API obtained as the inference result) is correct based on the trial result of Step S**13** (Step S**15**). For example, in a case where the test is successful, that is, in a case where an expected result is obtained in the test of the normal system or the abnormal system, the processor **10** determines that the method of calling the API indicated by the response in Step S**12** is correct.

[0147] In a case where the method of calling the API is not correct (Step S**15**, No), the processor **10** receives an input of correction information for correcting the test scenario from the user via the input device (Step S**16**).

[0148] In a case where the method of calling the API is correct (Step S**15**, Yes), the processor **10** generates the final test scenario **12** by performing conversion into a predetermined data format or the like (Step S**17**).

[0149] Note that the correction of the test scenario may be performed not only in a case where the method of calling the API is incorrect, but also in a test scenario in which the method of calling the API is determined to be correct. For example, for the test scenario in which the method of calling the API is determined to be correct, a correction such as further increasing the variation (for example, a test item for testing a range of parameter values (such as an upper limit and a lower limit)) of the test item may be performed.

[0150] Finally, an example of a hardware configuration of the information processing apparatus **1** (**1-2**) according to the first and second embodiments will be described.

Example of Hardware Configuration

[0151] FIG. **21** is a diagram illustrating an example of a hardware configuration of the information processing apparatus **1** (**1-2**) according to the first and second embodiments. The information processing apparatus **1** (**1-2**) according to the first and second embodiments includes a processor **201**, a main memory **202**, an auxiliary memory **203**, a display device **204**, an input device **205**, and a communication device **206**. The processor **201**, the main memory **202**, the auxiliary memory **203**, the display device **204**, the input device **205**, and the communication device **206** are connected via a bus **210**.

[0152] Note that the information processing apparatus **1** (**1-2**) may not include a part of the above configuration. For example, in a case where the information processing apparatus **1** (**1-2**) can use an input function and a display function of an external device, the information processing apparatus **1** (**1-2**) may not include the display device **204** and the input device **205**.

[0153] The processor **201** executes a program read from the auxiliary memory **203** to the main memory **202**. The main memory **202** is a memory such as a ROM and a RAM. The auxiliary memory **203** is a hard disk drive (HDD), a memory card, or the like.

[0154] The display device **204** is, for example, a liquid crystal display or the like. The input device **205** is an interface for operating the information processing apparatus **1**. Note that the display device **204** and the input device **205** may be implemented by a touch panel or the like having a display function and an input function. The communication device **206** is an interface for communicating with other devices.

[0155] For example, the program executed by the information processing apparatus **1** (**1-2**) is a file in an installable format or an executable format, is recorded in a computer-readable storage medium such as a memory card, a hard disk, a CD-RW, a CD-ROM, a CD-R, a DVD-RAM, and a DVD-R, and is provided as a computer program product.

[0156] Furthermore, for example, the program executed by the information processing apparatus **1** (**1-2**) may be stored on a computer connected to a network such as the Internet and provided by being downloaded via the network.

[0157] Furthermore, for example, the program executed by the information processing apparatus **1** (**1-2**) may be provided via a network such as the Internet without being downloaded. Specifically, the information processing may be executed by a so-called application service provider (ASP) type service that implements a processing function only by an execution instruction and result acquisition without transferring the program from the server computer.

[0158] Furthermore, for example, the program of the information processing apparatus **1** (**1-2**) may be provided by being incorporated in a ROM or the like in advance.

[0159] The program executed by the information processing apparatus **1** (**1-2**) has a module configuration including functions that can be implemented by the program among the above-described functional configurations. As actual hardware, the processor **201** reads a program from a storage medium and executes the program, whereby the functional blocks are loaded on the main memory **202**. That is, the functional blocks are generated on the main memory **202**.

[0160] Note that some or all of the above-described functions may not be implemented by software but may be implemented by hardware such as an integrated circuit (IC).

[0161] In addition, each function may be implemented using a plurality of processors **201**, and in this case, each processor **201** may implement one of the functions or may implement two or more of the functions.

[0162] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Supplement

[0163] The above embodiments may be summarized into the following Technical Ideas.

Technical Idea 1

[0164] An information processing apparatus including:

[0165] a communication interface configured to transmit an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural

language processing, and receive a response indicating the method of calling the API included in the API specification from the specification interpretation device; and

[0166] a processor configured to determine whether or not the method of calling the API indicated by the response is correct, and generate a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.

Technical Idea 2

[0167] The information processing apparatus according to Technical Idea 1, in which

[0168] the communication interface is configured to transmit at least one API request to an API execution apparatus, based on the method of calling the API indicated by the response, and

[0169] the processor is configured to determine that the method of calling the API indicated by the response is correct if a status code of success is included in the response of the API request.

Technical Idea 3

[0170] The information processing apparatus according to Technical Idea 2, in which

[0171] the processor is configured to generate, as the test scenario of the normal system, a method of calling the API request in which a status code of success is included in a response of the API request, and generate the test scenario of the abnormal system based on the test scenario of the normal system.

Technical Idea 4

[0172] The information processing apparatus according to Technical Idea 2, in which

[0173] the processor is configured to also specify a test item for checking an item not described in the API specification, based on the response to the API request, and

[0174] the test scenario includes a test item for checking an item not described in the API specification.

Technical Idea 5

[0175] The information processing apparatus according to any one of Technical Ideas 1 to 4, in which

[0176] the inference request includes a presentation request of a plurality of candidates indicating the method of calling the API.

Technical Idea 6

[0177] The information processing apparatus according to any one of Technical Ideas 1 to 4, in which

[0178] the processor is configured to display, on a display device, information indicating the method of calling the API determined to be correct, and correct the method of calling the API, based on correction information input by a user.

Technical Idea 7

[0179] The information processing apparatus according to any one of Technical Ideas 1 to 4, in which

[0180] the communication interface is configured to transmit, to the specification interpretation device, learning data including information indicating the method of calling the API determined to be correct.

Technical Idea 8

[0181] An information processing method including:

[0182] transmitting an inference request of a method of calling an application programming interface (API) included in API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receiving a response indicating the method of calling the API included in the API specification from the specification interpretation device, by an information processing apparatus; and

[0183] determining whether or not the method of calling the API indicated by the response is correct, and generating a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct, by the information processing apparatus.

Technical Idea 9

[0184] A computer program product comprising a non-transitory computer-readable medium including programmed instructions, the instructions causing a computer to execute:

[0185] transmitting an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receiving a response indicating the method of calling the API included in the API specification from the specification interpretation device; and

[0186] determining whether or not the method of calling the API indicated by the response is correct, and generating a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.

What is claimed is:

1. An information processing apparatus comprising:

a communication interface configured to transmit an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receive a response indicating the method of calling the API included in the API specification from the specification interpretation device; and

a processor configured to determine whether or not the method of calling the API indicated by the response is correct, and generate a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.

2. The apparatus according to claim 1, wherein
the communication interface is configured to transmit at least one API request to an API execution apparatus, based on the method of calling the API indicated by the response, and
the processor is configured to determine that the method of calling the API indicated by the response is correct if a status code of success is included in the response of the API request.

3. The apparatus according to claim 2, wherein
the processor is configured to generate, as the test scenario of the normal system, a method of calling the API request in which a status code of success is included in a response of the API request, and generate the test scenario of the abnormal system based on the test scenario of the normal system.

4. The apparatus according to claim 2, wherein
the processor is configured to also specify a test item for checking an item not described in the API specification, based on the response to the API request, and
the test scenario includes a test item for checking an item not described in the API specification.

5. The apparatus according to claim 1, wherein
the inference request includes a presentation request of a plurality of candidates indicating the method of calling the API.

6. The apparatus according to claim 1, wherein
the processor is configured to display, on a display device, information indicating the method of calling the API determined to be correct, and correct the method of calling the API, based on correction information input by a user.

7. The apparatus according to claim 1, wherein
the communication interface is configured to transmit, to the specification interpretation device, learning data including information indicating the method of calling the API determined to be correct.

8. An information processing method comprising:
transmitting an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receiving a response indicating the method of calling the API included in the API specification from the specification interpretation device, by an information processing apparatus; and
determining whether or not the method of calling the API indicated by the response is correct, and generating a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct, by the information processing apparatus.

9. A computer program product comprising a non-transitory computer-readable medium including programmed instructions, the instructions causing a computer to execute:
transmitting an inference request of a method of calling an application programming interface (API) included in an API specification, to a specification interpretation device that interprets the API specification by natural language processing, and receiving a response indicating the method of calling the API included in the API specification from the specification interpretation device; and
determining whether or not the method of calling the API indicated by the response is correct, and generating a test scenario based on the method of calling the API indicated by the response if the method of calling the API indicated by the response is correct.

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