

 opspec v.0.1.5

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Introduction

opspec is a specification for defining, distributing, and controlling operations.

Characteristics

- distributed (peer to peer)
- fault-tolerant
- scalable

Scope

- operation definition
- operation distribution
- operation control

Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#)

Packages

A [package](#) is the distributable definition of an [op](#).

Packages are:

- composable
- stateless
- self-describing

Packages **MUST** contain an `op.yml` file declaring the inputs, outputs, and call graph (consisting of container, [op](#), parallel, and serial calls) of the operation.

Packages **MAY** contain files/dirs the operation depends on

op.yml

Constraints:

- **MUST** be named (case sensitive) `op.yml`
- **MUST** be valid [v1.2 yaml](#)
- **MUST** validate against the [op.yml json schema](#)

op.yml JSON schema

[open in schema visualizer](#)

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "id": "https://opspec.io/0.1.5/op.yml.schema.json",
  "title": "op.yml",
  "description": "Defines an op",
  "properties": {
    "name": {
      "description": "Name of the op",
      "type": "string"
    },
    "description": {
      "description": "Description of the op",
      "type": "string"
    },
    "inputs": {
      "$ref": "#/definitions/param"
    },
    "outputs": {
      "$ref": "#/definitions/param"
    },
    "run": {
      "$ref": "#/definitions/scg"
    },
    "version": {
```

```
    "description": "Version of the op",
    "$ref": "#/definitions/semVer"
  }
},
"required": [
  "name"
],
"additionalProperties": false,
"definitions": {
  "arrayParam": {
    "title": "arrayParam",
    "description": "Array parameter of an op",
    "type": "object",
    "properties": {
      "array": {
        "properties": {
          "description": {
            "type": "string"
          },
          "default": {
            "type": "array"
          },
          "isSecret": {
            "description": "If the array is secret",
            "type": "boolean"
          },
          "constraints": {
            "$ref": "#/definitions/arrayConstraints"
          }
        }
      },
      "additionalProperties": false
    }
  },
  "arrayConstraints": {
    "title": "arrayConstraints",
    "type": "object",
    "properties": {
      "maxItems": {
        "description": "JSON Schema [maxItems keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.10)",
        "type": "integer",
        "minimum": 0
      },
      "minItems": {
        "description": "JSON Schema [minItems keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.11)",
        "type": "integer",
        "minimum": 0
      }
    }
  }
}
```

```
    },
    "items": {
      "description": "JSON Schema [items keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-01#section-6.9)",
      "oneOf": [
        {
          "$ref": "#/definitions/typeConstraints"
        },
        {
          "items": {
            "$ref": "#/definitions/typeConstraints"
          }
        }
      ]
    },
    "additionalItems": {
      "description": "JSON Schema [additionalItems keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-01#section-6.10)",
      "$ref": "#/definitions/typeConstraints"
    },
    "uniqueItems": {
      "description": "JSON Schema [uniqueItems keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-01#section-6.13)",
      "type": "boolean"
    }
  },
  "additionalProperties": false
},
"dirParam": {
  "title": "dirParam",
  "description": "Directory parameter of an op",
  "type": "object",
  "properties": {
    "dir": {
      "properties": {
        "description": {
          "type": "string"
        },
        "default": {
          "description": "Default value; an absolute path from root of pkg or relative path interpreted from the dir in which the op is run",
          "type": "string"
        },
        "isSecret": {
          "description": "If the directory is secret",
          "type": "boolean"
        }
      }
    },
    "additionalProperties": false
  }
},
"additionalProperties": false,
"required": [
```

```
    "dir"
  ]
},
"fileParam": {
  "title": "fileParam",
  "description": "File parameter of an op",
  "type": "object",
  "properties": {
    "file": {
      "properties": {
        "description": {
          "type": "string"
        },
        "default": {
          "description": "Default value; an absolute path from root of pkg or relative path interpreted from the dir in which the op is run",
          "type": "string"
        },
        "isSecret": {
          "description": "If the file is secret",
          "type": "boolean"
        }
      }
    },
    "additionalProperties": false
  }
},
"additionalProperties": false,
"required": [
  "file"
]
},
"pullCreds": {
  "type": "object",
  "description": "Credentials used during authentication with the source of an image or pkg",
  "properties": {
    "username": {
      "description": "expression coercible to string value",
      "$ref": "#/definitions/expression"
    },
    "password": {
      "description": "expression coercible to string value",
      "$ref": "#/definitions/expression"
    }
  },
  "required": [
    "username",
    "password"
  ],
  "additionalProperties": false
},
"numberConstraints": {
  "title": "numberConstraints",
```

```
    "type": "object",
    "properties": {
      "allOf": {
        "description": "JSON Schema [allOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.22)",
        "type": "array",
        "items": {
          "$ref": "#/definitions/numberConstraints"
        }
      },
      "anyOf": {
        "description": "JSON Schema [anyOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.23)",
        "type": "array",
        "items": {
          "$ref": "#/definitions/numberConstraints"
        }
      },
      "enum": {
        "description": "JSON Schema [enum keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.20)",
        "type": "array",
        "items": {
          "type": "number"
        }
      },
      "format": {
        "oneOf": [
          {
            "title": "integer",
            "description": "Requires the number be an integer",
            "type": "string",
            "enum": [
              "integer"
            ]
          }
        ]
      },
      "maximum": {
        "description": "JSON Schema [maximum keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.2)",
        "type": "number"
      },
      "minimum": {
        "description": "JSON Schema [minimum keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.4)",
        "type": "number"
      },
      "multipleOf": {
        "description": "JSON Schema [multipleOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.1)",
        "type": "number"
      },
    },
  },
}
```



```
    "not": {
      "description": "JSON Schema [not keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.25)",
      "$ref": "#/definitions/numberConstraints"
    },
    "oneOf": {
      "description": "JSON Schema [oneOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.24)",
      "type": "array",
      "items": {
        "$ref": "#/definitions/numberConstraints"
      }
    }
  },
  "additionalProperties": false
},
"numberParam": {
  "title": "numberParam",
  "description": "Number parameter of an op",
  "type": "object",
  "properties": {
    "number": {
      "properties": {
        "description": {
          "type": "string"
        },
        "default": {
          "type": "number"
        },
        "isSecret": {
          "description": "If the number is secret",
          "type": "boolean"
        },
        "constraints": {
          "$ref": "#/definitions/numberConstraints"
        }
      }
    },
    "additionalProperties": false
  }
},
"additionalProperties": false,
"required": [
  "number"
]
},
"objectConstraints": {
  "title": "objectConstraints",
  "type": "object",
  "properties": {
    "maxProperties": {
      "description": "JSON Schema [maxProperties keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.13)",
      "type": "integer",
```

```
    "minimum": 0
  },
  "minProperties": {
    "description": "JSON Schema [minProperties keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.14)",
    "type": "integer",
    "minimum": 0
  },
  "required": {
    "description": "JSON Schema [required keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.15)",
    "type": "array",
    "items": {
      "type": "string"
    }
  },
  "properties": {
    "description": "JSON Schema [properties keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.16)",
    "type": "object",
    "additionalProperties": {
      "$ref": "#/definitions/typeConstraints"
    }
  },
  "patternProperties": {
    "description": "JSON Schema [patternProperties keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.17)",
    "type": "object",
    "additionalProperties": {
      "$ref": "#/definitions/typeConstraints"
    }
  },
  "additionalProperties": {
    "description": "JSON Schema [additionalProperties keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.18)",
    "oneOf": [
      {
        "type": "boolean"
      },
      {
        "$ref": "#/definitions/typeConstraints"
      }
    ]
  },
  "dependencies": {
    "description": "JSON Schema [dependencies keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.19)",
    "oneOf": [
      {
        "$ref": "#/definitions/typeConstraints"
      },
      {
        "items": {
```

```
        "type": "string"
      }
    }
  ],
  "enum": {
    "description": "JSON Schema [enum keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.20)",
    "type": "array",
    "items": {
      "type": [
        "null",
        "object"
      ]
    }
  },
  "allOf": {
    "description": "JSON Schema [allOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.22)",
    "type": "array",
    "items": {
      "$ref": "#/definitions/objectConstraints"
    }
  },
  "anyOf": {
    "description": "JSON Schema [anyOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.23)",
    "type": "array",
    "items": {
      "$ref": "#/definitions/objectConstraints"
    }
  },
  "oneOf": {
    "description": "JSON Schema [oneOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.24)",
    "type": "array",
    "items": {
      "$ref": "#/definitions/objectConstraints"
    }
  },
  "not": {
    "description": "JSON Schema [not keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.25)",
    "$ref": "#/definitions/objectConstraints"
  }
},
"additionalProperties": false
},
"objectParam": {
  "title": "objectParam",
  "description": "Object parameter of an op",
  "type": "object",
  "properties": {
```

```
    "object": {
      "properties": {
        "description": {
          "type": "string"
        },
        "default": {
          "type": "object"
        },
        "isSecret": {
          "description": "If the object is secret",
          "type": "boolean"
        },
        "constraints": {
          "$ref": "#/definitions/objectConstraints"
        }
      },
      "additionalProperties": false
    },
    "additionalProperties": false,
    "required": [
      "object"
    ],
    "socketParam": {
      "title": "socketParam",
      "type": "object",
      "description": "Socket parameter of an op",
      "properties": {
        "socket": {
          "properties": {
            "description": {
              "type": "string"
            },
            "isSecret": {
              "description": "If the socket is secret",
              "type": "boolean"
            }
          }
        }
      },
      "additionalProperties": false
    },
    "additionalProperties": false,
    "required": [
      "socket"
    ],
    "stringConstraints": {
      "title": "stringConstraints",
      "type": "object",
      "properties": {
        "allOf": {
          "description": "JSON Schema [allOf keyword](https://tools.ietf.org/html/draft-w
```

```
right-json-schema-validation-00#section-5.22)",
  "type": "array",
  "items": {
    "$ref": "#/definitions/stringConstraints"
  }
},
"anyOf": {
  "description": "JSON Schema [anyOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.23)",
  "type": "array",
  "items": {
    "$ref": "#/definitions/stringConstraints"
  }
},
"enum": {
  "description": "JSON Schema [enum keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.20)",
  "type": "array",
  "items": {
    "type": "string"
  }
},
"format": {
  "description": "Superset of JSON Schema [format keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7)",
  "oneOf": [
    {
      "title": "date-time",
      "description": "JSON Schema [date-time format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.1)",
      "type": "string",
      "enum": [
        "date-time"
      ]
    },
    {
      "title": "docker-image-ref",
      "description": "A docker image reference as defined by [github.com/docker/distribution/reference](https://github.com/docker/distribution/tree/docker/1.13/reference)",
      "type": "string",
      "enum": [
        "docker-image-ref"
      ]
    }
  ],
  {
    "title": "email",
    "description": "JSON Schema [email format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.2)",
    "type": "string",
    "enum": [
      "email"
    ]
  }
]
```

```
    },
    {
      "title": "hostname",
      "description": "JSON Schema [hostname format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.3)",
      "type": "string",
      "enum": [
        "hostname"
      ]
    },
    {
      "title": "ipv4",
      "description": "JSON Schema [ipv4 format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.4)",
      "type": "string",
      "enum": [
        "ipv4"
      ]
    },
    {
      "title": "ipv6",
      "description": "JSON Schema [ipv6 format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.5)",
      "type": "string",
      "enum": [
        "ipv6"
      ]
    },
    {
      "title": "uri",
      "description": "JSON Schema [uri format](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-7.3.6)",
      "type": "string",
      "enum": [
        "uri"
      ]
    },
    {
      "title": "semver",
      "description": "A semantic version as defined by [semver.org](http://semver.org/)",
      "type": "string",
      "enum": [
        "semver"
      ]
    }
  ],
  "maxLength": {
    "description": "JSON Schema [maxLength keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.6)",
    "type": "integer",
    "minimum": 1
  }
}
```

```
    },
    "minLength": {
      "description": "JSON Schema [minLength keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.7)",
      "type": "integer",
      "minimum": 0,
      "default": 0
    },
    "not": {
      "description": "JSON Schema [not keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.25)",
      "$ref": "#/definitions/stringConstraints"
    },
    "oneOf": {
      "description": "JSON Schema [oneOf keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.24)",
      "type": "array",
      "items": {
        "$ref": "#/definitions/stringConstraints"
      }
    },
    "pattern": {
      "description": "JSON Schema [pattern keyword](https://tools.ietf.org/html/draft-wright-json-schema-validation-00#section-5.8)",
      "type": "string",
      "format": "regex"
    }
  },
  "additionalProperties": false
},
"stringParam": {
  "title": "stringParam",
  "type": "object",
  "description": "String parameter of an op",
  "properties": {
    "string": {
      "properties": {
        "description": {
          "type": "string"
        },
        "default": {
          "type": "string"
        },
        "isSecret": {
          "description": "If the string is secret",
          "type": "boolean"
        },
        "constraints": {
          "$ref": "#/definitions/stringConstraints"
        }
      }
    },
    "additionalProperties": false
  }
}
```

```
    },
    "additionalProperties": false,
    "required": [
      "string"
    ]
  },
  "param": {
    "description": "Parameter of an op",
    "type": "object",
    "patternProperties": {
      "[_\\.a-zA-Z0-9]+": {
        "oneOf": [
          {
            "$ref": "#/definitions/arrayParam"
          },
          {
            "$ref": "#/definitions/dirParam"
          },
          {
            "$ref": "#/definitions/fileParam"
          },
          {
            "$ref": "#/definitions/numberParam"
          },
          {
            "$ref": "#/definitions/objectParam"
          },
          {
            "$ref": "#/definitions/socketParam"
          },
          {
            "$ref": "#/definitions/stringParam"
          }
        ]
      }
    }
  },
  "additionalProperties": false
},
"typeConstraints": {
  "title": "typeConstraints",
  "description": "Parameter constraints",
  "oneOf": [
    {
      "$ref": "#/definitions/arrayConstraints"
    },
    {
      "$ref": "#/definitions/numberConstraints"
    },
    {
      "$ref": "#/definitions/objectConstraints"
    },
    {
      "$ref": "#/definitions/stringConstraints"
    }
  ]
}
```



```

    }
  ]
},
"scg": {
  "title": "scg",
  "description": "Static call graph of an op; see https://en.wikipedia.org/wiki/Call_
graph",
  "oneOf": [
    {
      "$ref": "#/definitions/containerCall"
    },
    {
      "$ref": "#/definitions/opCall"
    },
    {
      "$ref": "#/definitions/parallelCall"
    },
    {
      "$ref": "#/definitions/serialCall"
    }
  ]
},
"containerCall": {
  "title": "containerCall",
  "type": "object",
  "properties": {
    "container": {
      "properties": {
        "cmd": {
          "description": "Command run by a container; overrides any set at the image
level",
          "type": "array",
          "items": {
            "description": "expression coercible to string value",
            "$ref": "#/definitions/expression"
          }
        },
        "dirs": {
          "type": "object",
          "description": "Directories in the container",
          "patternProperties": {
            "^[a-zA-Z]:)?[-_\\.\\a-zA-Z0-9]+$": {
              "oneOf": [
                {
                  "description": "(will be bound to same path in pkg)",
                  "type": "null"
                },
                {
                  "description": "expression coercible to dir value &/or scope ref to
set upon exit",
                  "$ref": "#/definitions/expression"
                }
              ]
            }
          }
        }
      }
    }
  ]
}

```

```

    }
  },
  "additionalProperties": false
},
"envVars": {
  "type": "object",
  "description": "Environment variables in the container",
  "patternProperties": {
    "^[^=]+$": {
      "oneOf": [
        {
          "description": "(will be bound to in scope ref w/ same name)",
          "type": "null"
        },
        {
          "description": "expression coercible to string value",
          "$ref": "#/definitions/expression"
        }
      ]
    }
  }
},
"additionalProperties": false
},
"files": {
  "type": "object",
  "description": "Files in the container",
  "patternProperties": {
    "^[[a-zA-Z]:)?[-_\\.\\a-zA-Z0-9]+$": {
      "oneOf": [
        {
          "description": "(will be bound to same path in pkg)",
          "type": "null"
        },
        {
          "description": "expression coercible to file value &/or scope ref t
o set upon exit",
          "$ref": "#/definitions/expression"
        }
      ]
    }
  }
},
"additionalProperties": false
},
"image": {
  "type": "object",
  "properties": {
    "ref": {
      "description": "Reference to an image",
      "$ref": "#/definitions/expression"
    },
    "pullCreds": {
      "$ref": "#/definitions/pullCreds"
    }
  }
}

```

```
    },
    "required": [
      "ref"
    ],
    "additionalProperties": false
  },
  "name": {
    "description": "Name the container can be referenced by from other containe
rs",
    "type": "string"
  },
  "ports": {
    "description": "Ports bound from the container to the host",
    "type": "object",
    "patternProperties": {
      "[0-9]+(-[0-9]+)?(tcp|udp)?": {
        "description": "Host port(s) to bind to",
        "type": "string",
        "pattern": "[0-9]+(-[0-9]+)?"
      }
    },
    "additionalProperties": false
  },
  "sockets": {
    "type": "object",
    "patternProperties": {
      "[a-zA-Z0-9]+": {
        "description": "Container socket address mapped to a socket ref",
        "type": "string"
      }
    },
    "additionalProperties": false
  },
  "stderr": {
    "type": "object",
    "patternProperties": {
      "^.+$": {
        "description": "Container stderr prefix mapped to a string ref",
        "type": "string"
      }
    },
    "additionalProperties": false
  },
  "stdout": {
    "type": "object",
    "patternProperties": {
      "^.+$": {
        "description": "Container stdout prefix mapped to a string ref",
        "type": "string"
      }
    },
    "additionalProperties": false
  },
}
```

```
    "workDir": {
      "description": "Working directory path (overrides any defined by image)",
      "type": "string"
    }
  },
  "required": [
    "image"
  ],
  "additionalProperties": false
}
},
"required": [
  "container"
],
"additionalProperties": false
},
"opCall": {
  "title": "opCall",
  "type": "object",
  "properties": {
    "op": {
      "type": "object",
      "properties": {
        "pkg": {
          "type": "object",
          "properties": {
            "ref": {
              "description": "Reference to a pkg",
              "type": "string",
              "format": "uri-reference"
            },
            "pullCreds": {
              "$ref": "#/definitions/pullCreds"
            }
          }
        },
        "required": [
          "ref"
        ],
        "additionalProperties": false
      },
      "inputs": {
        "description": "Initializes INPUT_NAME from VALUE in format 'INPUT_NAME: VALUE'. If VALUE is null, it MUST be assumed VALUE = $(INPUT_NAME)",
        "type": "object",
        "patternProperties": {
          "[_\\.a-zA-Z0-9]+": {
            "oneOf": [
              {
                "type": "null"
              },
              {
                "$ref": "#/definitions/expression"
              }
            ]
          }
        }
      }
    }
  }
}
```

```
    ]
  }
},
"additionalProperties": false
},
"outputs": {
  "description": "Initializes NAME from OUTPUT_NAME in format 'NAME: OUTPUT_NAME'. If OUTPUT_NAME is null, it MUST be assumed NAME = $(OUTPUT_NAME)",
  "type": "object",
  "patternProperties": {
    "[_\\.a-zA-Z0-9]+": {
      "oneOf": [
        {
          "type": "null"
        },
        {
          "type": "string"
        }
      ]
    }
  }
},
"additionalProperties": false
}
},
"oneOf": [
  {
    "required": [
      "pkg"
    ]
  },
  {
    "required": [
      "ref"
    ]
  }
],
"additionalProperties": false
}
},
"required": [
  "op"
],
"additionalProperties": false
},
"parallelCall": {
  "title": "parallelCall",
  "type": "object",
  "properties": {
    "parallel": {
      "type": "array",
      "items": {
        "$ref": "#/definitions/scg"
      }
    }
  }
}
```

```
    }
  },
  "required": [
    "parallel"
  ],
  "additionalProperties": false
},
"serialCall": {
  "title": "serialCall",
  "type": "object",
  "properties": {
    "serial": {
      "type": "array",
      "items": {
        "$ref": "#/definitions/scg"
      }
    }
  }
},
"required": [
  "serial"
],
"additionalProperties": false
},
"expression": {
  "title": "expression",
  "description": "An array, number, object, or string. Strings MUST be interpolated at runtime, replacing $(REF) by the value of REF. REF MUST be a scope $(name) or pkg fs $(/path) ref. Nesting up to one level MUST be supported, i.e. $(/$(name))",
  "type": ["array", "number", "object", "string"]
},
"semVer": {
  "title": "semVer",
  "description": "v2.0.0 semantic version (see http://semver.org/spec/v2.0.0.html)",
  "type": "string",
  "pattern": "^(?:[0-9]+)\.(?:[0-9]+)\.(?:[0-9]+)(?:(-|~>)(?:[0-9A-Za-z-]+(?:\.[0-9A-Za-z-]+)*)?)?(?:\+[0-9A-Za-z-~\.\-\.]+)?$"
}
}
}
```

Ops

An **op** is an orchestration of (a) containerized process(es).

Ops SHOULD be deterministic i.e, assuming external state remains constant, calling the same **package** w/ the same input(s) SHOULD always result in the same output(s).

Nodes

Nodes distribute packages and run ops.

Nodes **MUST** implement the [node API](#)

API

Constraints:

- **MUST** validate against the [API spec](#)

API Spec

[open in swagger editor](#)

```
openapi: 3.0.0
servers: []
info:
  version: 0.1.5
  title: Node API
paths:
  /events/stream:
    get:
      summary: Get an event stream
      description: The connection will be upgraded to use the websocket protocol.
      parameters:
        - name: since
          in: query
          description: Filters events to those occurring on/after the provided instant
          required: false
          schema:
            type: string
            format: date-time
          explode: false
        - name: roots
          in: query
          description: Filters events to those w/ the provided root op ids
          required: false
          schema:
            type: array
            items:
              type: string
            explode: false
      tags:
        - events
      responses:
        '101':
          description: HTTP/1.1 ["Switching Protocols" response status code](https://tools.ietf.org/html/rfc7231#section-6.2.2)
```



```
headers:
  Upgrade:
    schema:
      type: string
      enum:
        - websocket
  Connection:
    schema:
      type: string
      enum:
        - Upgrade
content:
  application/json:
    schema:
      type: array
      items:
        $ref: '#/components/schemas/Event'
  '400':
    description: HTTP/1.1 ["Bad Request" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.1)
/liveness:
  get:
    summary: Get liveness of node
    tags:
      - liveness
    responses:
      '200':
        description: HTTP/1.1 ["OK" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.1)
      '500':
        description: HTTP/1.1 ["Internal Server Error" response status code](https://tools.ietf.org/html/rfc7231#section-6.6.1)
/ops/starts:
  post:
    summary: Starts an op
    tags:
      - ops
    responses:
      '201':
        description: HTTP/1.1 ["Created" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.2)
        content:
          application/json:
            schema:
              description: 'The id of the [started] op'
              type: string
          text/plain:
            schema:
              description: 'The id of the [started] op'
              type: string
      '400':
        description: HTTP/1.1 ["Bad Request" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.1)
```

```

    '500':
      description: HTTP/1.1 ["Internal Server Error" response status code](https://tools.ietf.org/html/rfc7231#section-6.6.1)
      requestBody:
        content:
          application/json:
            schema:
              required:
                - pkg
              properties:
                args:
                  type: object
                  description: arguments passed to the op to satisfy inputs
                  additionalProperties:
                    $ref: '#/components/schemas/Value'
                pkg:
                  required:
                    - ref
                  properties:
                    ref:
                      type: string
                      format: uri-reference
                      description: reference to a pkg
                    pullCreds:
                      description: credentials used during authentication with the source
of the package
                      required:
                        - username
                        - password
                    properties:
                      username:
                        type: string
                      password:
                        type: string
                    type: object
                  type: object
            required: true
      /ops/kills:
        post:
          summary: Kills an op
          tags:
            - ops
          responses:
            '204':
              description: HTTP/1.1 ["No Content" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.5)
            '400':
              description: HTTP/1.1 ["Bad Request" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.1)
            '500':
              description: HTTP/1.1 ["Internal Server Error" response status code](https://tools.ietf.org/html/rfc7231#section-6.6.1)

```

```
requestBody:
  content:
    application/json:
      schema:
        required:
          - opId
        properties:
          opId:
            type: string
        type: object
      required: true
'/pkgs/{ref}/contents':
  get:
    summary: Lists package contents
    tags:
      - pkgs
    parameters:
      - name: ref
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: HTTP/1.1 ["OK" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.1)
        headers:
          Content-Length:
            description: HTTP/1.1 ["Content-Length" header field](https://tools.ietf.org/html/rfc7230#section-3.3.2)
            schema:
              type: integer
        content:
          application/json:
            schema:
              items:
                properties:
                  path:
                    description: absolute path within pkg
                    type: string
                  size:
                    type: integer
                  mode:
                    description: golang [FileMode](https://golang.org/pkg/os/#FileMode)
                    type: integer
                type: array
      '400':
        description: HTTP/1.1 ["Bad Request" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.1)
      '401':
        description: HTTP/1.1 ["Unauthorized" response status code](https://tools.ietf.org/html/rfc7235#section-3.1)
      '403':
```

```
description: HTTP/1.1 ["Forbidden" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.3)
'404':
description: HTTP/1.1 ["Not Found" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.4)
'500':
description: HTTP/1.1 ["Internal Server Error" response status code](https://tools.ietf.org/html/rfc7231#section-6.6.1)
'/pkgs/{ref}/contents/{path}':
get:
summary: Gets pkg content at path
tags:
- pkgs
parameters:
- name: ref
in: path
required: true
schema:
type: string
- name: path
in: path
required: true
schema:
type: string
- name: Range
description: HTTP/1.1 ["Range" header field](https://tools.ietf.org/html/rfc7233#section-3.1)
in: header
required: false
schema:
type: string
responses:
'200':
description: HTTP/1.1 ["OK" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.1)
headers:
Accept-Ranges:
description: HTTP/1.1 ["Accept-Ranges" header field](https://tools.ietf.org/html/rfc7233#section-2.3)
schema:
type: string
enum:
- bytes
Content-Length:
description: HTTP/1.1 ["Content-Length" header field](https://tools.ietf.org/html/rfc7230#section-3.3.2)
schema:
type: integer
content:
application/octet-stream: {}
multipart/byteranges: {}
text/plain: {}
application/json: {}
```

```
'206':
  description: HTTP/1.1 ["Partial Content" response status code](https://tools.ie
tf.org/html/rfc7233#section-4.1)
  headers:
    Content-Length:
      description: HTTP/1.1 ["Content-Length" header field](https://tools.ietf.or
g/html/rfc7230#section-3.3.2)
      schema:
        type: integer
    Content-Range:
      description: HTTP/1.1 ["Content-Range" header field](https://tools.ietf.org
/html/rfc7233#section-4.2)
      schema:
        type: string
  content:
    application/octet-stream:
      schema:
        type: string
    multipart/byteranges:
      schema:
        type: string
    text/plain:
      schema:
        type: string
    application/json:
      schema:
        type: string
'401':
  description: HTTP/1.1 ["Unauthorized" response status code](https://tools.ietf.
org/html/rfc7235#section-3.1)
'403':
  description: HTTP/1.1 ["Forbidden" response status code](https://tools.ietf.org
/html/rfc7231#section-6.5.3)
'404':
  description: HTTP/1.1 ["Not Found" response status code](https://tools.ietf.org
/html/rfc7231#section-6.5.4)
'416':
  description: HTTP/1.1 ["Range Not Satisfiable" response status code](https://to
ols.ietf.org/html/rfc7233#section-4.4)
'500':
  description: HTTP/1.1 ["Internal Server Error" response status code](https://to
ols.ietf.org/html/rfc7231#section-6.6.1)
head:
  summary: Gets pkg content at path
  tags:
    - pkgs
  parameters:
    - name: ref
      in: path
      required: true
      schema:
        type: string
    - name: path
```

```
    in: path
    required: true
    schema:
      type: string
  - name: Range
    description: HTTP/1.1 ["Range" header field](https://tools.ietf.org/html/rfc7233#section-3.1)
    in: header
    required: false
    schema:
      type: string
  responses:
    '200':
      description: HTTP/1.1 ["OK" response status code](https://tools.ietf.org/html/rfc7231#section-6.3.1)
      headers:
        Accept-Ranges:
          description: HTTP/1.1 ["Accept-Ranges" header field](https://tools.ietf.org/html/rfc7233#section-2.3)
          schema:
            type: string
            enum:
              - bytes
        Content-Length:
          description: HTTP/1.1 ["Content-Length" header field](https://tools.ietf.org/html/rfc7230#section-3.3.2)
          schema:
            type: integer
    '206':
      description: HTTP/1.1 ["Partial Content" response status code](https://tools.ietf.org/html/rfc7233#section-4.1)
      headers:
        Content-Length:
          description: HTTP/1.1 ["Content-Length" header field](https://tools.ietf.org/html/rfc7230#section-3.3.2)
          schema:
            type: integer
        Content-Range:
          description: HTTP/1.1 ["Content-Range" header field](https://tools.ietf.org/html/rfc7233#section-4.2)
          schema:
            type: string
      content:
        application/octet-stream:
          schema:
            type: string
        multipart/byteranges:
          schema:
            type: string
        text/plain:
          schema:
            type: string
        application/json:
```

```
    schema:
      type: string
    '401':
      description: HTTP/1.1 ["Unauthorized" response status code](https://tools.ietf.org/html/rfc7235#section-3.1)
    '403':
      description: HTTP/1.1 ["Forbidden" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.3)
    '404':
      description: HTTP/1.1 ["Not Found" response status code](https://tools.ietf.org/html/rfc7231#section-6.5.4)
    '416':
      description: HTTP/1.1 ["Range Not Satisfiable" response status code](https://tools.ietf.org/html/rfc7233#section-4.4)
    '500':
      description: HTTP/1.1 ["Internal Server Error" response status code](https://tools.ietf.org/html/rfc7231#section-6.6.1)
  components:
    schemas:
      Value:
        description: a typed value
        oneOf:
          - properties:
              array:
                type: array
          - properties:
              dir:
                description: path
                type: string
          - properties:
              file:
                description: path
                type: string
          - properties:
              number:
                type: number
          - properties:
              object:
                type: object
          - properties:
              socket:
                description: socket address
                type: string
          - properties:
              string:
                type: string
        type: object
    Event:
      properties:
        timestamp:
          type: string
          format: dateTime
      oneOf:
```

```
- properties:
  containerExited:
    $ref: '#/components/schemas/ContainerExitedEvent'
- properties:
  containerStarted:
    $ref: '#/components/schemas/ContainerStartedEvent'
- properties:
  containerStdErrWrittenTo:
    $ref: '#/components/schemas/ContainerStdErrWrittenToEvent'
- properties:
  containerStdOutWrittenTo:
    $ref: '#/components/schemas/ContainerStdOutWrittenToEvent'
- properties:
  opEnded:
    $ref: '#/components/schemas/OpEndedEvent'
- properties:
  opStarted:
    $ref: '#/components/schemas/OpStartedEvent'
- properties:
  opErred:
    $ref: '#/components/schemas/OpErredEvent'
- properties:
  parallelCallEnded:
    $ref: '#/components/schemas/ParallelCallEndedEvent'
- properties:
  serialCallEnded:
    $ref: '#/components/schemas/SerialCallEndedEvent'
type: object
ContainerExitedEvent:
  properties:
    imageRef:
      type: string
    exitCode:
      type: integer
    rootOpId:
      type: string
    containerId:
      type: string
    pkgRef:
      type: string
    outputs:
      type: object
    additionalProperties:
      $ref: '#/components/schemas/Value'
type: object
ContainerStartedEvent:
  properties:
    imageRef:
      type: string
    rootOpId:
      type: string
    containerId:
      type: string
```



```
    pkgRef:
      type: string
  type: object
ContainerStdErrWrittenToEvent:
  properties:
    imageRef:
      type: string
    data:
      type: string
      format: binary
    rootOpId:
      type: string
    containerId:
      type: string
    pkgRef:
      type: string
  type: object
ContainerStdOutWrittenToEvent:
  properties:
    imageRef:
      type: string
    data:
      type: string
      format: binary
    rootOpId:
      type: string
    containerId:
      type: string
    pkgRef:
      type: string
  type: object
OpErredEvent:
  properties:
    rootOpId:
      type: string
    msg:
      type: string
    opId:
      type: string
    pkgRef:
      type: string
  type: object
OpEndedEvent:
  properties:
    rootOpId:
      type: string
    opId:
      type: string
    pkgRef:
      type: string
    outcome:
      enum:
        - SUCCEEDED
```

```
- FAILED
- KILLED
  type: string
  outputs:
    type: object
    additionalProperties:
      $ref: '#/components/schemas/Value'
  type: object
OpStartedEvent:
  properties:
    rootOpId:
      type: string
    opId:
      type: string
    pkgRef:
      type: string
  type: object
ParallelCallEndedEvent:
  properties:
    rootOpId:
      type: string
    callId:
      type: string
  type: object
SerialCallEndedEvent:
  properties:
    rootOpId:
      type: string
    callId:
      type: string
  outputs:
    type: object
    additionalProperties:
      $ref: '#/components/schemas/Value'
  type: object
```