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#4010 307

Which of these do you think represents an API?

$ curl https://api.nasa.gov/planetary/apod?api_key=DEMO_KEY

0%

>>> arr = np.array([[1, 2, 3], [4, 5, 6]])

0%

None of them

0%

Both of them

0%

I have no idea what "API" even stands for

0%

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0%

Web API

>>> arr = np.array([[1, 2, 3], [4, 5, 6]])

0%

Python Library API

None of them

0%

Both of them

0%

I have no idea what "API" even stands for

0%

In the context of this talk….

API == Python library API == Library == Package

Preferred term → **Library**

Understanding API dispatching

Dispatching??

Arriving Sunday

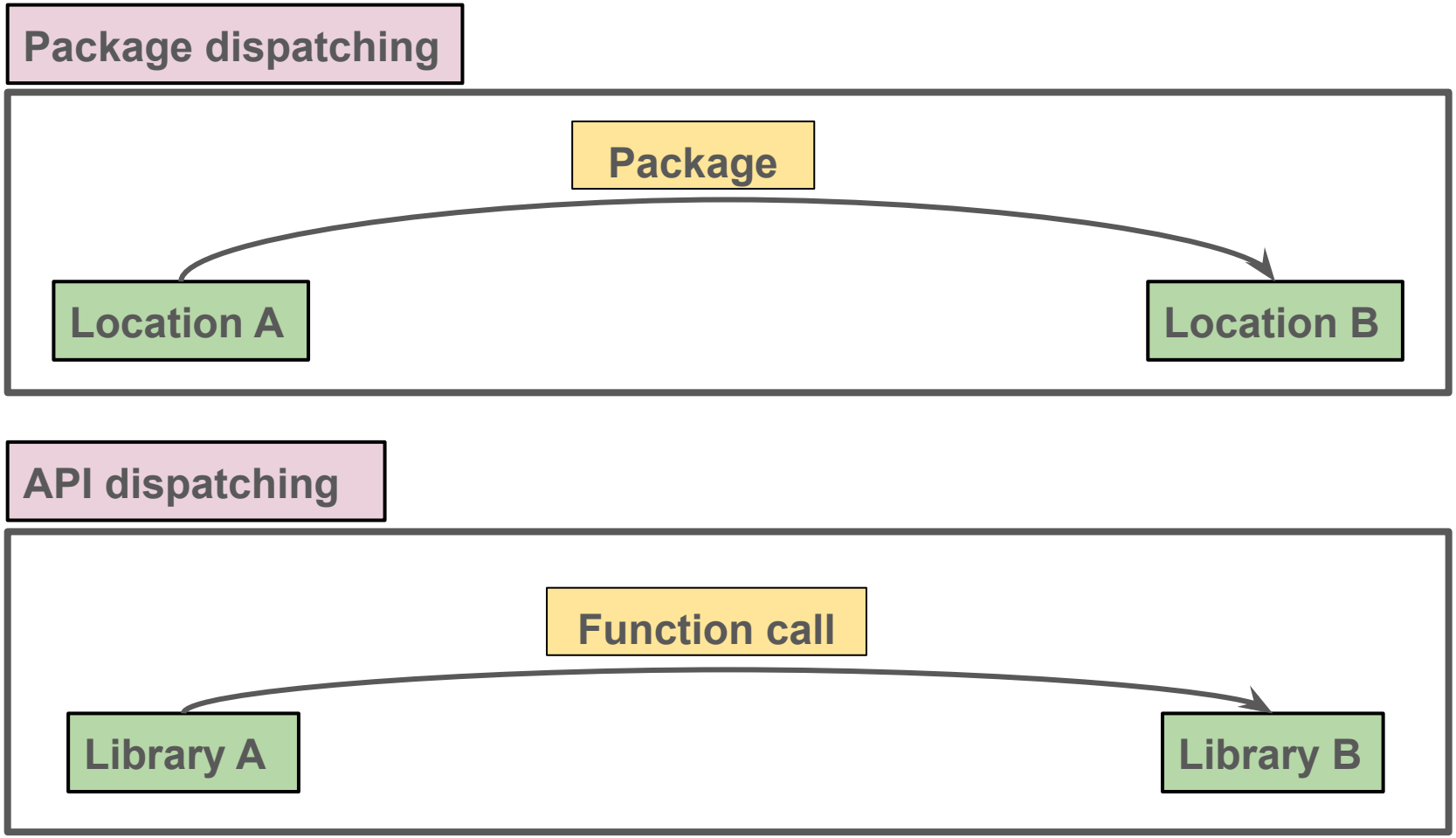
Dispatched

Apsara Dustless Chalks | 4x Longer Than Regular Chalks | Hypoallergenic Chalk for Safe Using | Non-dust Chalk for Clean Writing | Available in Vibrant Colors | Ideal for Schools Box of 100 Chalks.

Sold by: Cocoblu Retail

₹343.00

- Track package
- Request cancellation
- Return or replace items
- Share gift receipt
- Leave seller feedback
- Write a product review


Package dispatching
Package
Location A
Location B
API dispatching
Function call
Library A
Library B

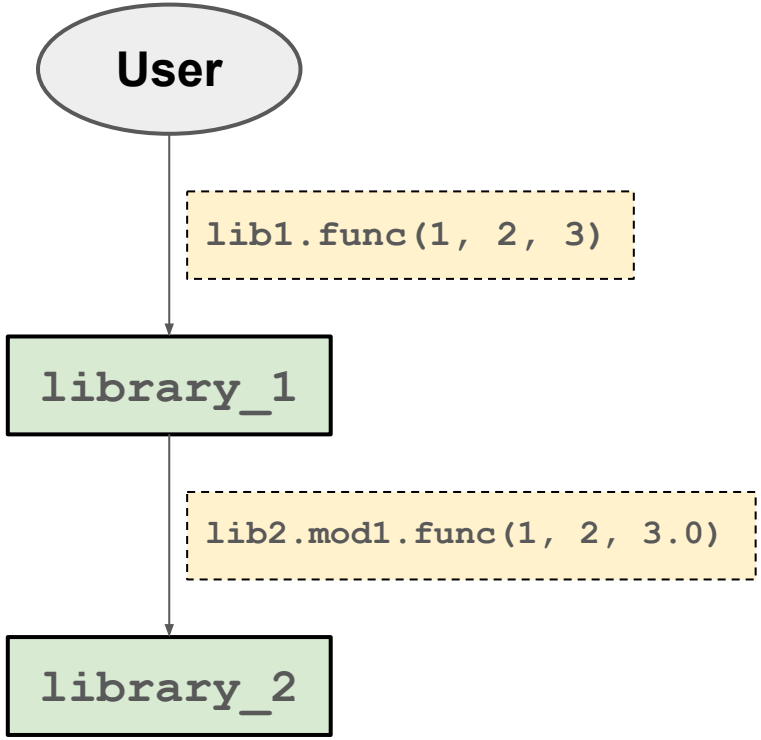
But… what does it *really* mean to dispatch a call from one library to another?

Dispatching is not Calling!

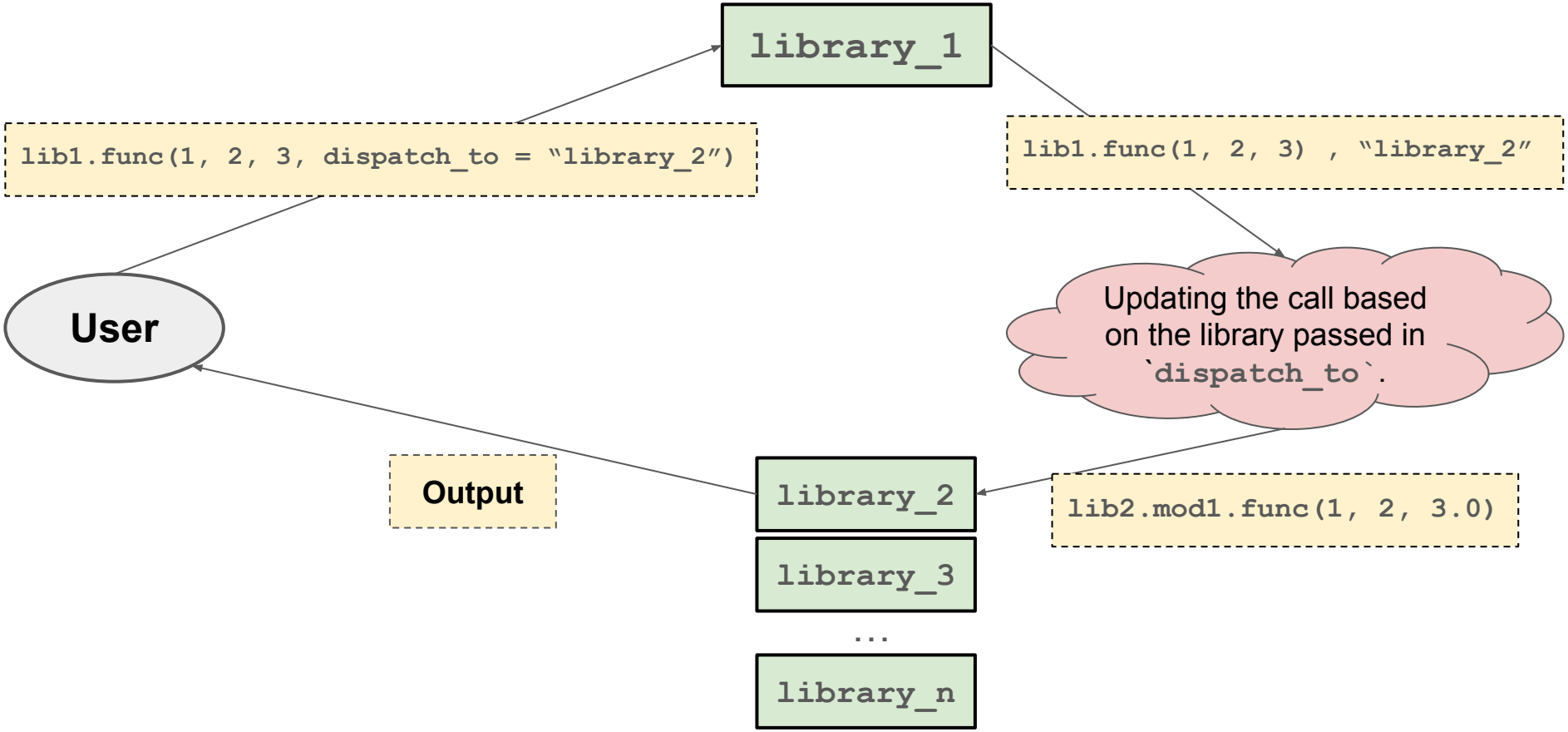
Calling

Inside `library_1`

```
def func(x, y, z, dispatch_to):
    if dispatch_to == "library_2":
        import library_2 as lib2
        z = float(z)
        return lib2.mod1.func(x, y, z)
    elif dispatch_to == "..." :
    ...
    ...
    else:
        return x + y + z
```



Dispatching



Dispatching

Inside `library_1`

```
@dispatch
def func(x, y, z):
    return x + y + z

...
...
```

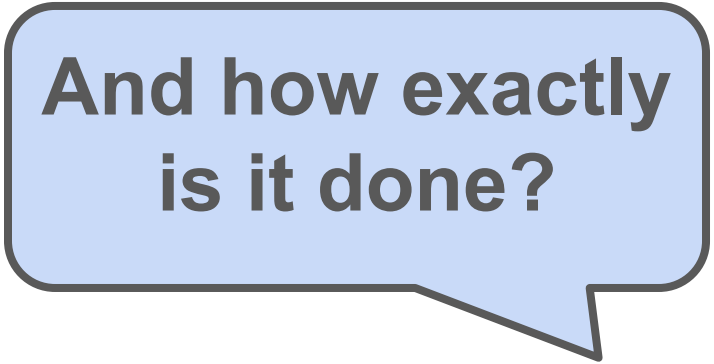
Updating the call based on the library passed in `dispatch_to`.

Calling is a part of this whole dispatching process.

Dispatching is a way to call a function in a given library, without hard-coding it all…

Wait… let’s take a step back


Why would I
want to dispatch
a call?


And how exactly
is it done?

Let’s understand API dispatching with the *NetworkX* library

What is NetworkX?

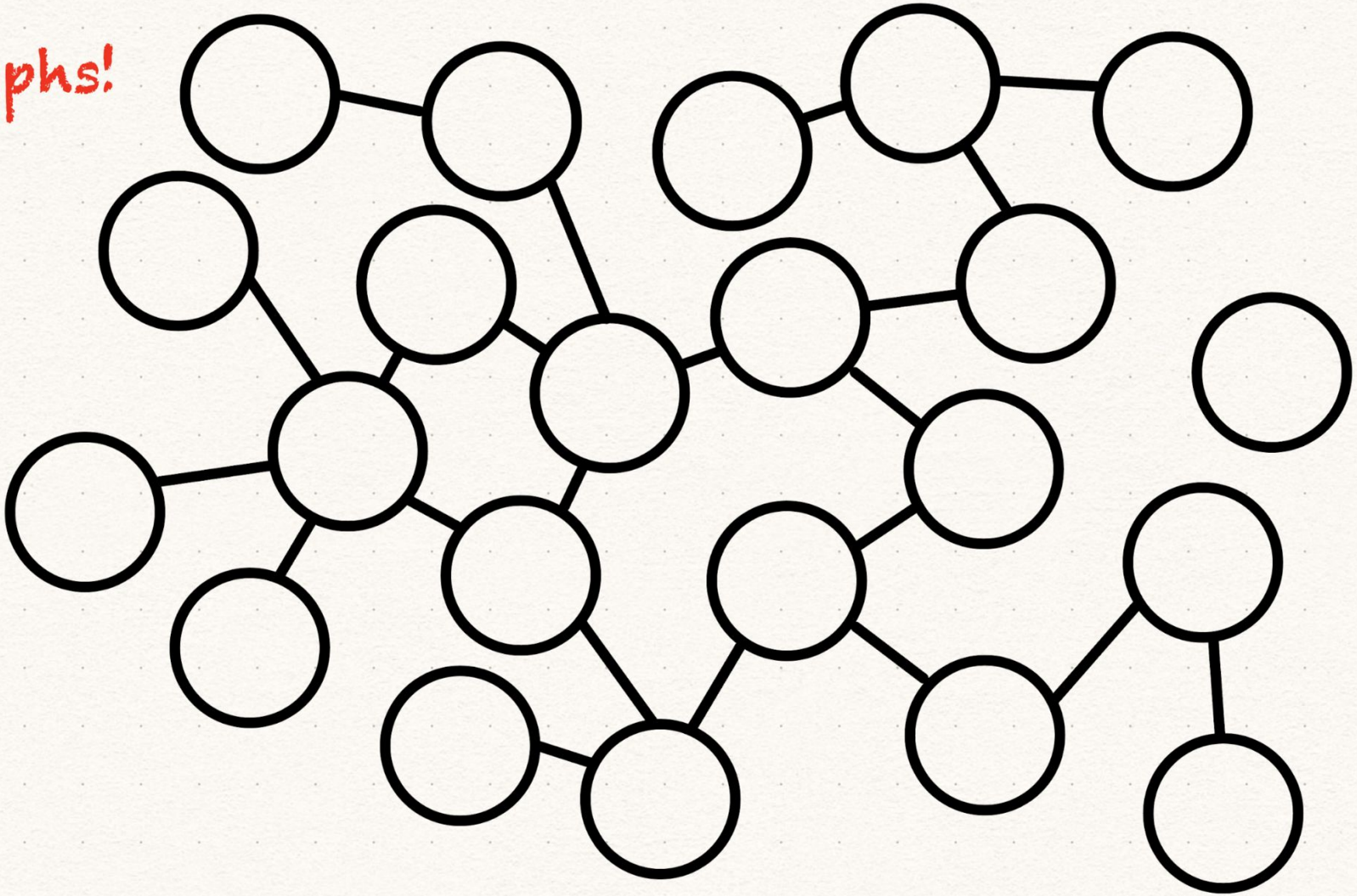
NetworkX is a graph (aka network) analysis Python library

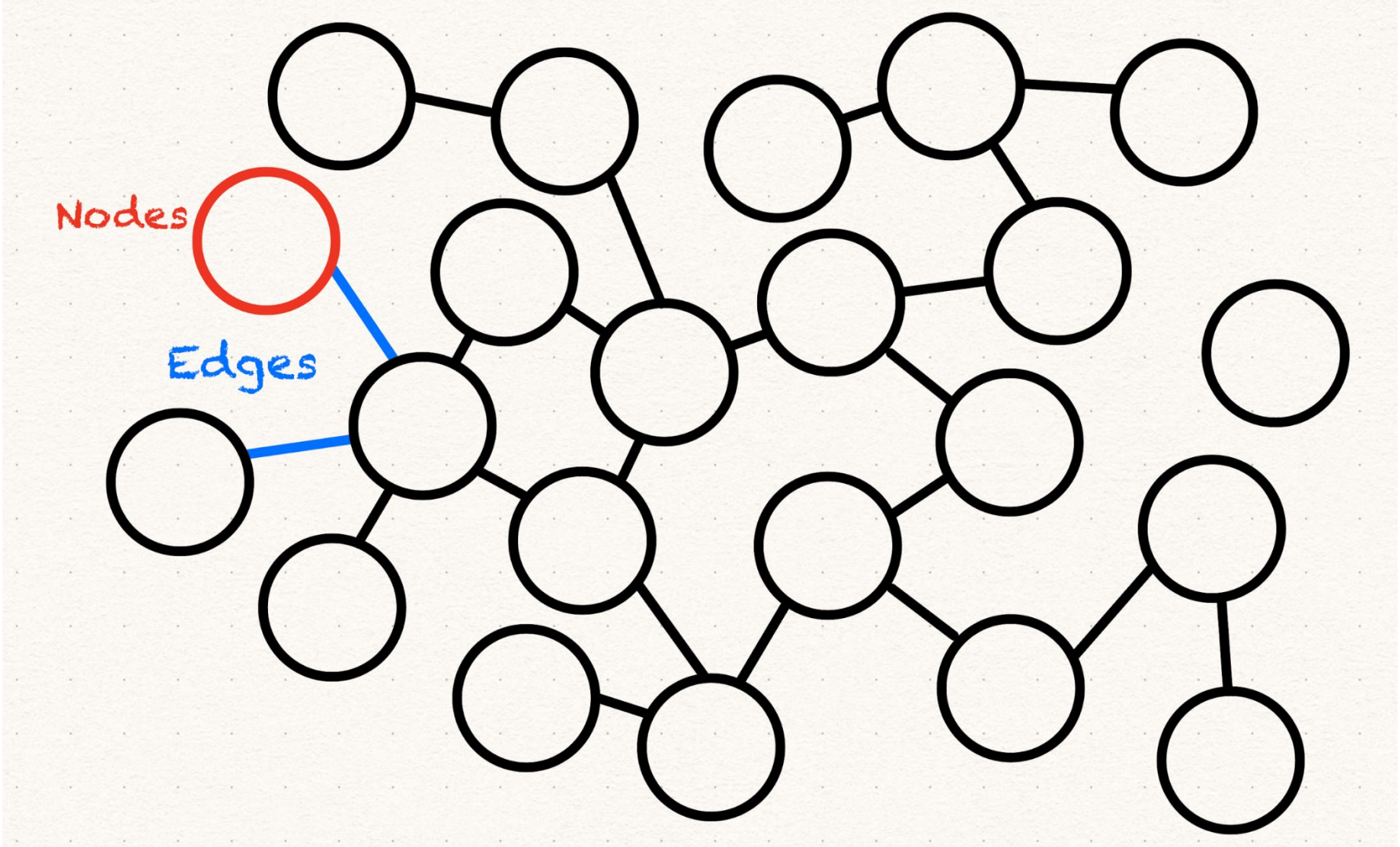
What is NetworkX?

NetworkX is a graph (aka network) analysis Python library

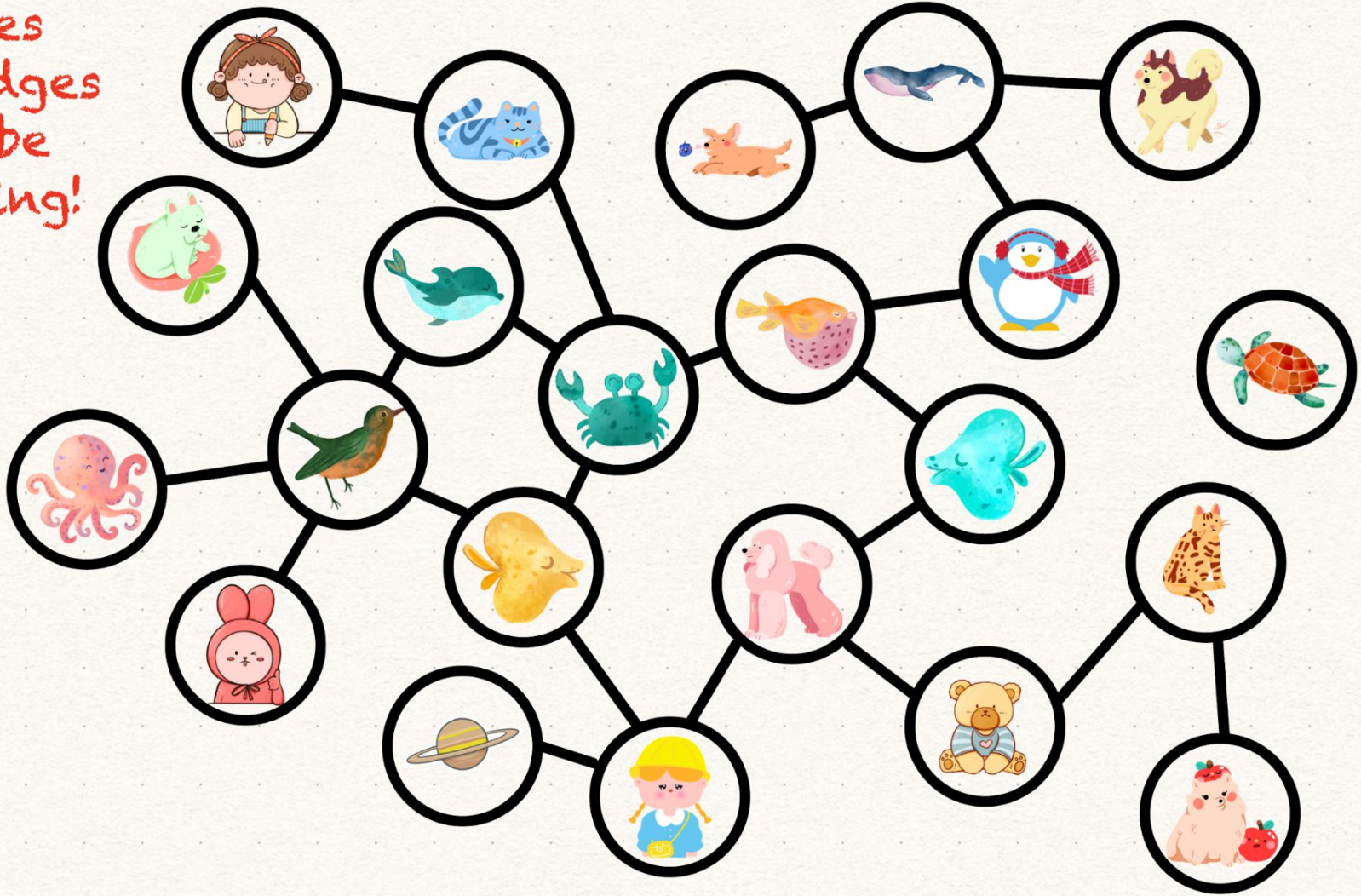
NOT these kind of graphs!

Graphs!



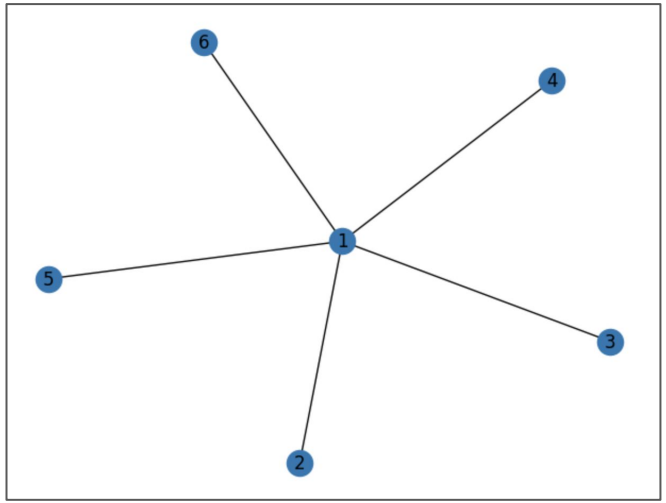

Nodes
Edges

Nodes and edges can be anything!



<NetworkX DEMO>

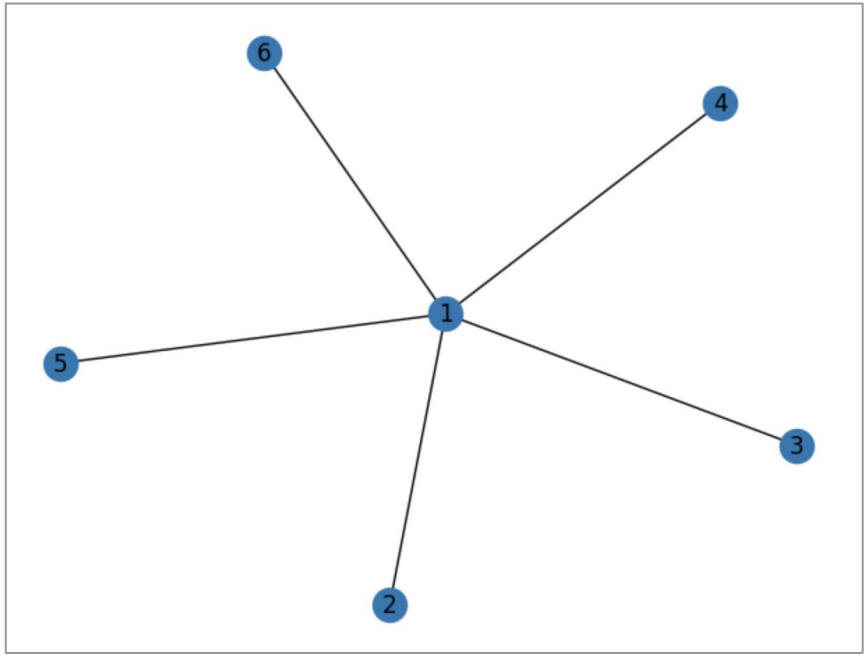
```
import networkx as nx


G = nx.Graph()
G.add_nodes_from([1, 2, 3, 4, 5, 6])
G.add_edges_from([(1, 2), (1, 3), (1, 4), (1, 5), (1, 6)])
nx.draw(G, with_labels=True)
```



Tells us how important a node is.

```
nx.betweenness_centrality(G)
```

```
{
1: 1.0,
2: 0.0,
3: 0.0,
4: 0.0,
5: 0.0,
6: 0.0
}
```



Problem

```
big_G = nx.fast_gnp_random_graph(1000000, 0.5)
nx.betweenness_centrality(big_G)
```

```
Takes forever.... Probably a few years
```

Problem

```
big_G = nx.fast_gnp_random_graph(1000000, 0.5)
nx.betweenness_centrality(big_G)
```

```
Takes forever.... Probably a few years
```

Reason?

- Written in pure Python.
- But that is also what makes NetworkX simple.
- NetworkX was not created with performance in mind, but rather simplicity.

Workarounds…

- Switch to a faster library
  - If cannot find one, then make one
  - Eg : graphblas, cugraphs, graph-tool, rustworkx, etc…

- Some issues - not as comprehensive and/or well-maintained as networkx or complex user-interface (**switching can be hard!**)

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- But, NetworkX's performance issue still persists…
  - cannot re-written to be fast… NetworkX is too big for that(500-600 algos)
  - Also some consistency needed

- **Is there a way to integrate these different faster libraries into networkx?**

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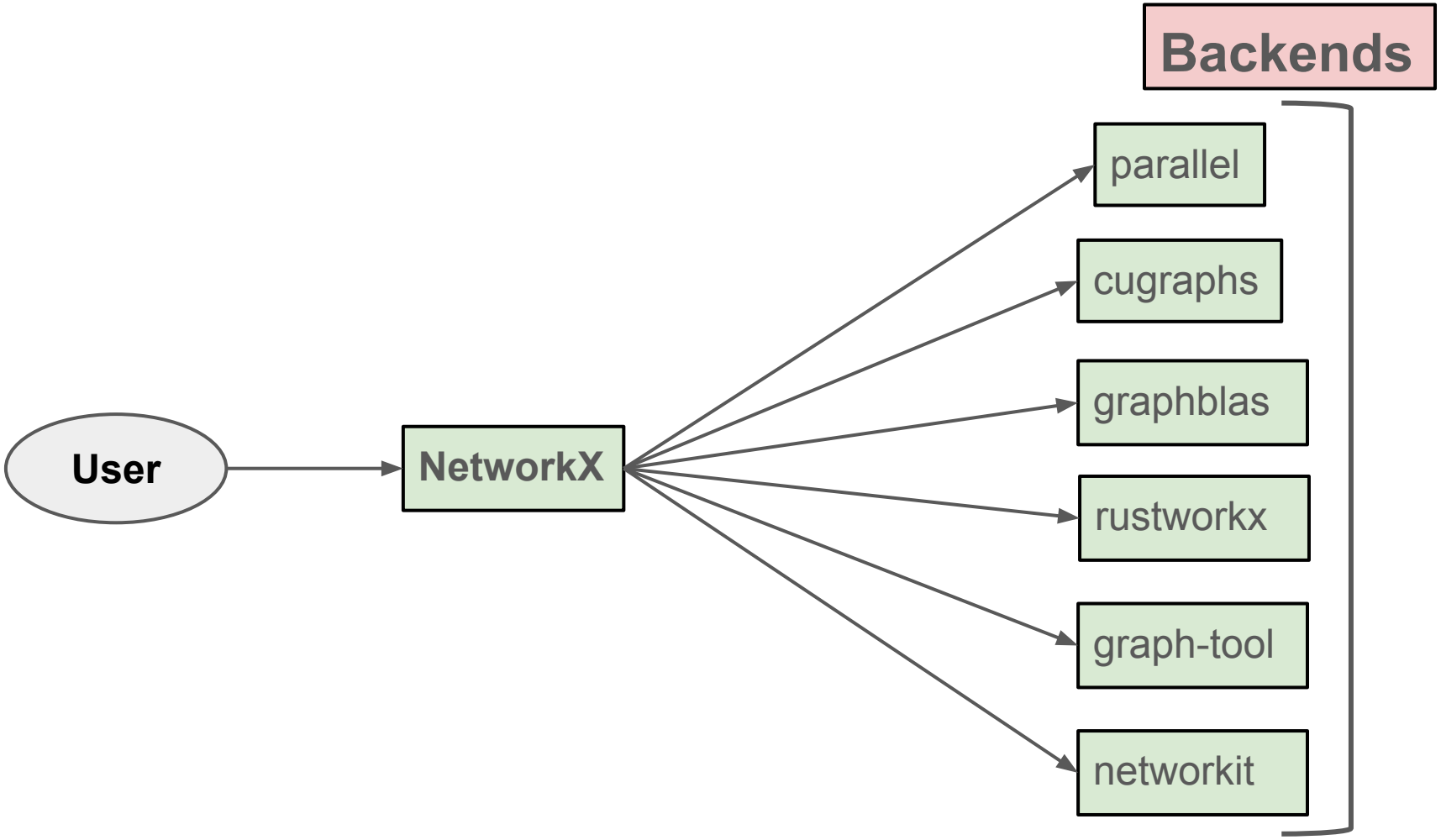
- **Is there a way to integrate these different faster libraries into networkx?**
  - **Dispatching!**


Backends
User
NetworkX
parallel
cugraphs
graphblas
rustworkx
graph-tool
networkit

Improving Performance

Why would I want to dispatch a call?

And how exactly is it done?

<DISPATCHING DEMO>

4 ways of dispatching in NetworkX

```
nx.betweenness_centrality(G,
backend = "parallel")
```

```
nx.betweenness_centrality(CuG)
```

```
with nx.config(backend_priority =
["cugraph", "graphblas"]):
    nx.betweenness_centrality(G)
```

```
$ NETWORKX_BACKEND_PRIORITY="graphblas"
$ python nx_code.py
```

Inside `networkx`

```
@_dispatchable
def betweenness_centrality(
    G, k, ... ,seed
):
    ...
    ...
```

nx-parallel

nx-cugraph

graphblas

2 Types of Dispatching

Type based dispatching:

- `nx.betweenness_centrality(CuG)`

Backend-name-based dispatching:

- `nx.betweenness_centrality(G, backend = “parallel”)`
- `with nx.config(backend_priority = [“cugraph”, “graphblas”]):`
- **$ NETWORKX_BACKEND_PRIORITY=”graphblas” && python nx_code.py**

Type-based dispatching and **backend-name-based dispatching** differences:

- For type-based dispatching,
  - we require each backend to have a unique type.
  - conversion of args and kwargs is not needed.

And how exactly is it done?

Python entry-points

used to extend the functionality of a project

Defined in the metadata files of a project

```
>>> from importlib.metadata import entry_points
>>> entry_points(group="networkx.backends")
(EntryPoint(name='parallel',
value='nx_parallel.interface:BackendInterface',
group='networkx.backends'),...)
```

Group

used by the networkx library to discover the backend libraries

In backend's pyproject.toml

```
[project.entry-points."networkx.backends"]
parallel = "nx_parallel.interface:BackendInterface"
```

Name

Backend Name

Object reference

BackendInterface namespace

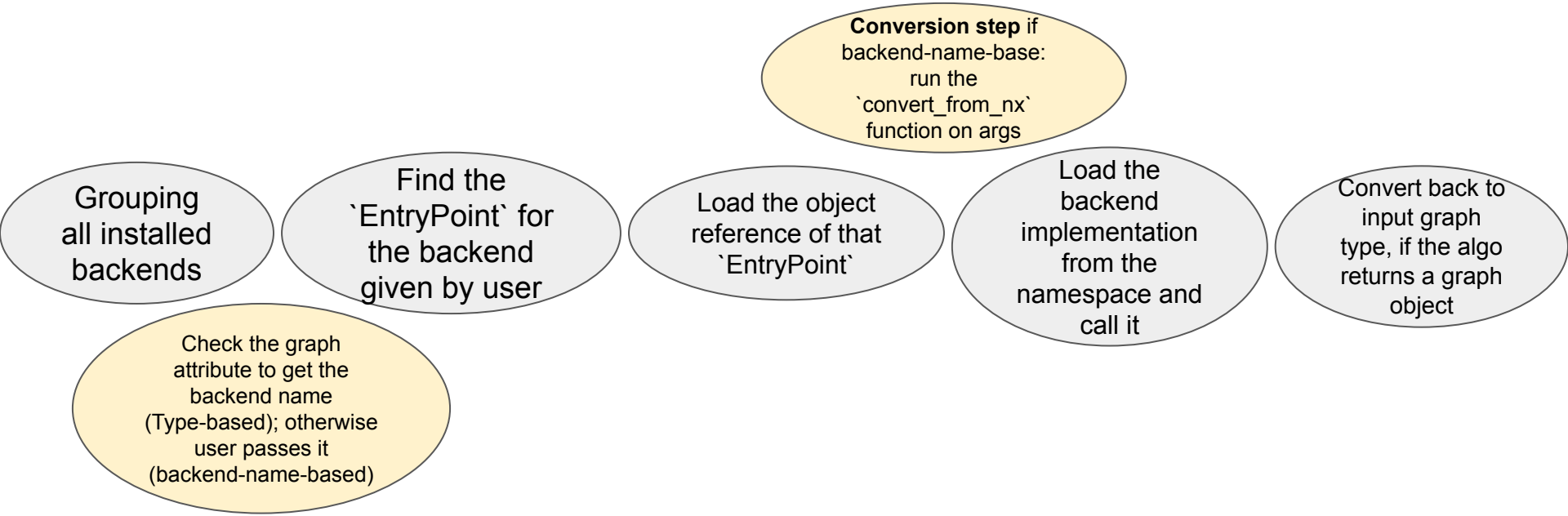
All the backend algorithms

`convert_from_nx

`convert_to_nx`

ref. https://packaging.python.org/en/latest/specifications/entry-points/

How does entry-point based dispatching work?



Some more dispatching-related stuff:

logging

Automatic testing

```
NETWORKX_TEST_BACKEND=parallel
NETWORKX_FALLBACK_TO_NX=True
pytest --pyargs networkx
```

Additional backend args

```
>>> nx.betweenness_centrality(G,
backend="parallel",
get_chunks=get_chunks)
```

2nd entry point

```
[project.entry-
points."networkx.backend_info"]
parallel = "_nx_parallel:get_info"
```

Additional backends implement this function

cugraph : ***GPU-accelerated backend.***

Negative cycles are not yet supported. `NotImplementedError` will be raised if there are negative edge weights. We plan to support negative edge weights soon. Also, callable `weight` argument is not supported.

Additional parameters:

dtype : ***dtype or None, optional***

The data type (np.float32, np.float64, or None) to use for the edge weights in the algorithm. If None, then dtype is determined by the edge values.

graphblas : ***OpenMP-enabled sparse linear algebra backend.***

Additional parameters:

chunksize : ***int or str, optional***

Split the computation into chunks; may specify size as string or number of rows. Default "10 MiB"

parallel : ***Parallel backend for NetworkX algorithms***

The parallel implementation first divides the nodes into chunks and then creates a generator to lazily compute shortest paths lengths for each node in `node_chunk`, and then employs joblib's `Parallel` function to execute these

source - https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.shortest_paths.weighted.all_pairs_bellman_ford_path_length.html

Configurations

```
nx.config.backends.parallel.n_jobs = 8
nx.config.backends.parallel.verbose = 10
```

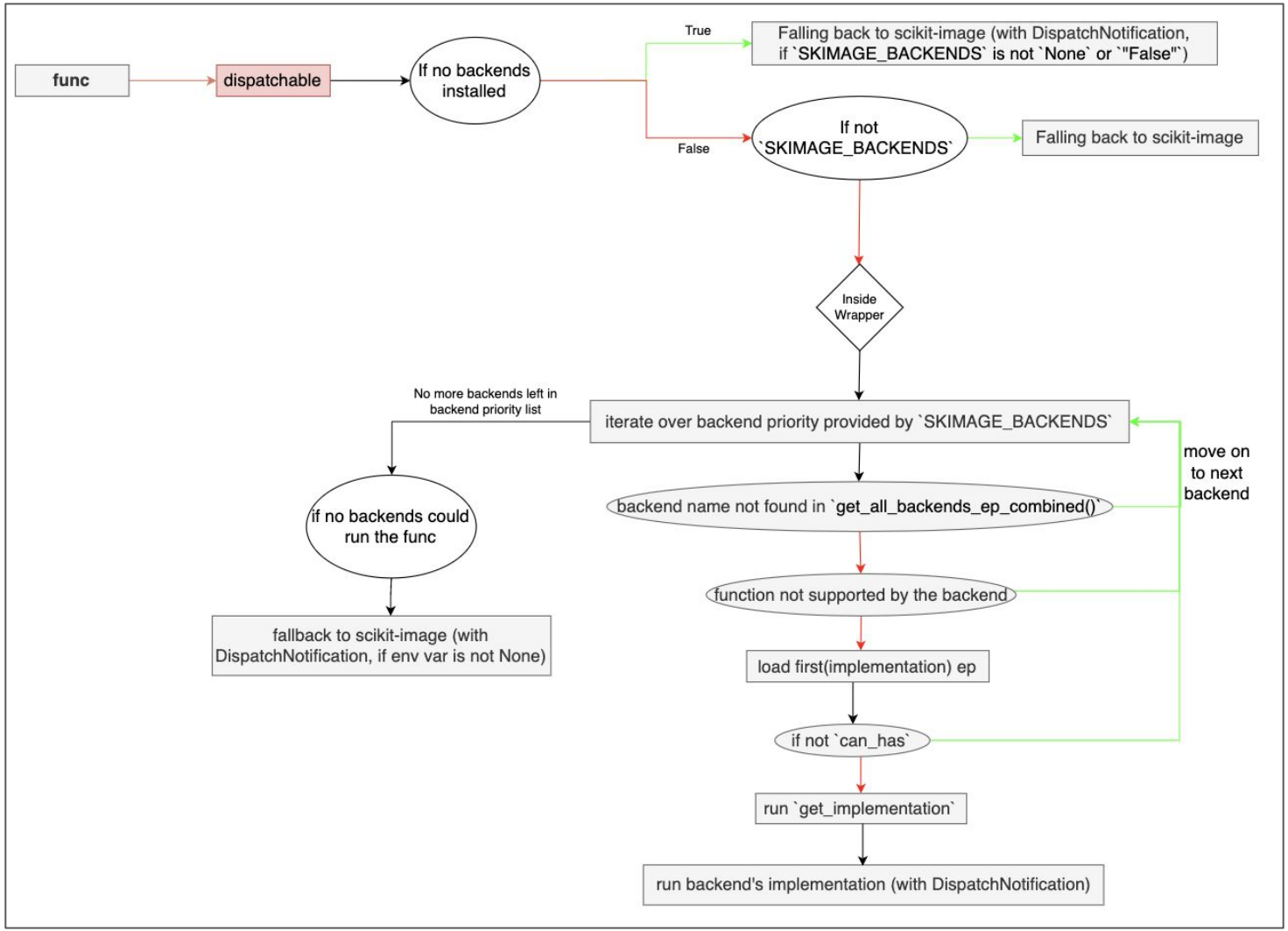
fallback option

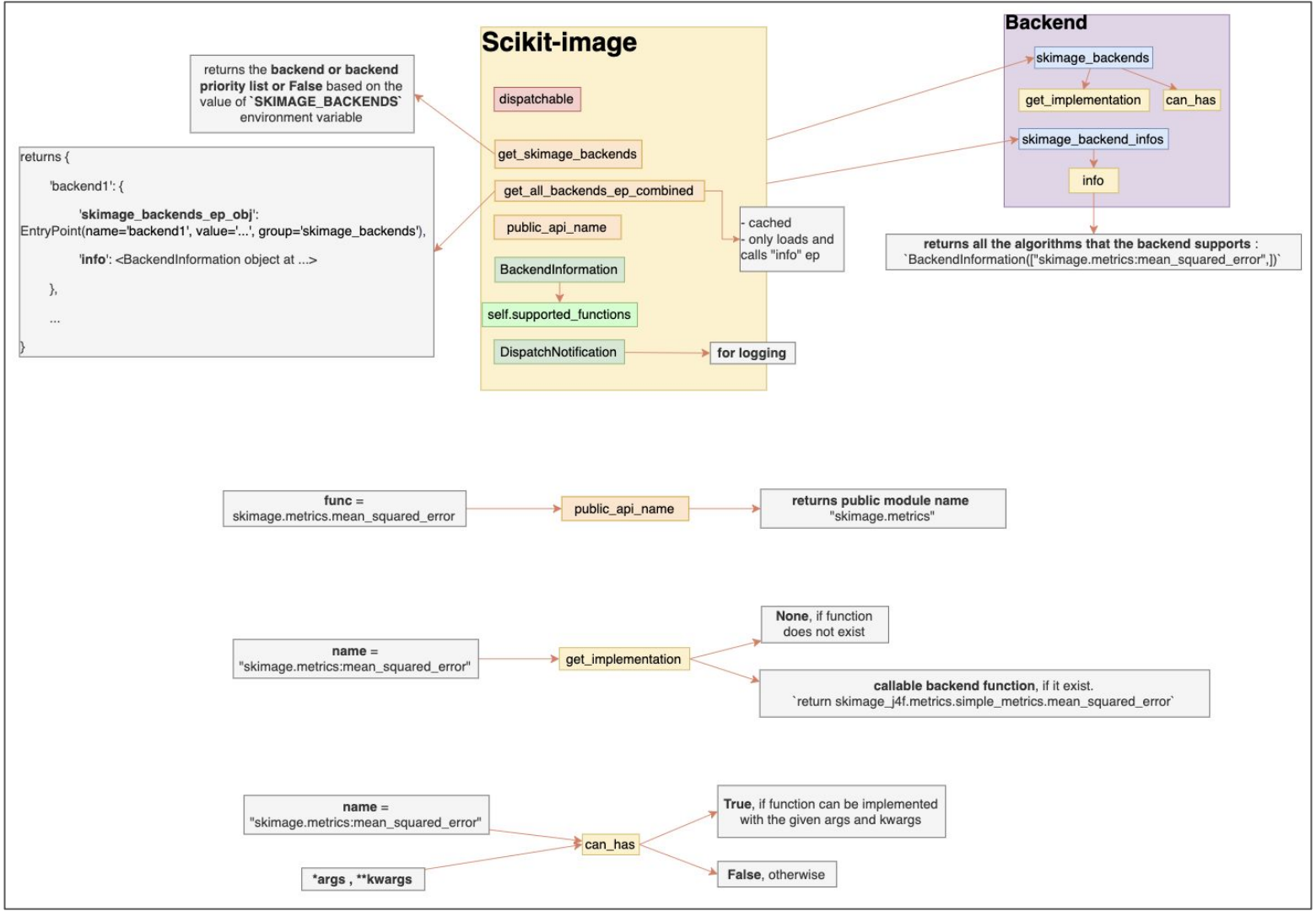
Caching conversion

Dispatching in scikit-image

How is it different?

- Image object (`numpy.ndarray`) instead of a `nx.Graph` object
- No type-based dispatching, only backend-name-based dispatching (but maybe we'll have it in future?) because we want to allow multiple backends to support same array types
- No array conversions right now!
- Some other trivial differences but it's entry-point based dispatching only!


func
dispatchable
If no backends installed
True
Falling back to scikit-image (with DispatchNotification, if `SKIMAGE_BACKENDS` is not `None` or `"False"`)
False
If not `SKIMAGE_BACKENDS`
Falling back to scikit-image
Inside Wrapper
No more backends left in backend priority list
iterate over backend priority provided by `SKIMAGE_BACKENDS`
move on to next backend
if no backends could run the func
backend name not found in `get_all_backends_ep_combined()`
function not supported by the backend
fallback to scikit-image (with DispatchNotification, if env var is not None)
load first(implementation) ep
if not `can_has`
run `get_implementation`
run backend's implementation (with DispatchNotification)


Scikit-image
dispatchable
get_skimage_backends
get_all_backends_ep_combined
public_api_name
BackendInformation
self.supported_functions
DispatchNotification
for logging
returns the backend or backend priority list or False based on the value of `SKIMAGE_BACKENDS` environment variable
returns {
'backend1': {
'skimage_backends_ep_obj': EntryPoint(name='backend1', value='...', group='skimage_backends'),
'info': <BackendInformation object at ...>
},
...
}
- cached
- only loads and calls "info" ep
Backend
skimage_backends
get_implementation
can_has
skimage_backend_infos
info
returns all the algorithms that the backend supports : `BackendInformation(["skimage.metrics:mean_squared_error",])`
func = skimage.metrics.mean_squared_error
public_api_name
returns public module name "skimage.metrics"
name = "skimage.metrics:mean_squared_error"
get_implementation
None, if function does not exist
callable backend function, if it exist. `return skimage_j4f.metrics.simple_metrics.mean_squared_error`
name = "skimage.metrics:mean_squared_error"
*args , **kwargs
can_has
True, if function can be implemented with the given args and kwargs
False, otherwise

Mini-ecosystem of NetworkX backends:

Well-maintained:

- nx-parallel : https://github.com/networkx/nx-parallel
- nx-cugraph : https://github.com/rapidsai/nx-cugraph
- nx-arangodb : https://github.com/arangodb/nx-arangodb
- graphblas-algorithms : https://github.com/python-graphblas/graphblas-algorithms

Experimental:

- nx-pandas : https://github.com/networkx/nx-pandas
- rustworkx-backend : https://github.com/thomasjpfan/rustworkx-backend
- Visualisation backend??
- … more to come

Dispatching in Scientific Python ecosystem

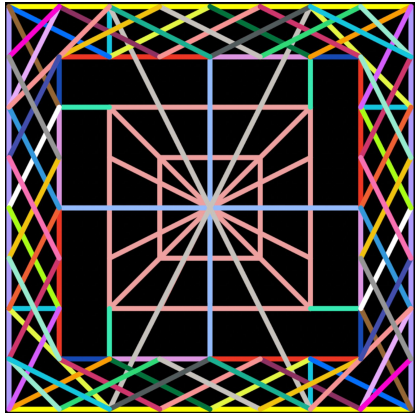
- SPEC 2 : https://scientific-python.org/specs/spec-0002/
- spatch : https://github.com/scientific-python/spatch/issues/1
- Scientific Python discord: https://discord.com/invite/vur45CbwMz
- NetworkX
  - https://networkx.org/documentation/latest/reference/backends.html
  - https://networkx.org/documentation/latest/reference/configs.html
  - Dispatch meetings:https://scientific-python.org/calendars/networkx.ics
  - https://github.com/networkx/networkx/issues?q=is%3Aissue%20state%3Aopen%20label%3ADispatching

- Scikit-image
  - scikit-image-PR#7520
  - https://github.com/betatim/scikit-image/pull/1
  - https://github.com/rapidsai/cucim/issues/829

- NumPy's type-based dispatching
  - https://numpy.org/neps/nep-0037-array-module.html
  - https://numpy.org/neps/nep-0047-array-api-standard.html
  - https://data-apis.org/array-api/latest/

- Scikit-learn
  - https://github.com/scikit-learn/scikit-learn/pull/30250

Thank you :)



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